COPY NO. 114

SRC-II DEMONSTRATION PROJECT
PHASE ZERO
TASK NUMBER 3

DELIVERABLE NUMBER 8

VOL. 5 OF 5

CONCEPTUAL COMMERCIAL PLANT
ECONOMIC ANALYSIS

JULY 31, 1979

THE PITTSBURG & MIDWAY COAL MINING CO.
DENVER, COLORADO

PREPARED FOR

UNITED STATES DEPARTMENT OF ENERGY
UNDER CONTRACT
DE-AC05-780R03055

MASTER

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SECTION 1

SUMMARY

The SRC-II Conceptual Commercial Plant (CCP) is designed to process 33,333 tons of coal per day, and yield approximately 100,000 barrels per day of fuel oil and fuel-oil-equivalent product (BTU basis). For the base case analysis, all products from the SRC-II plant were assumed to be sold at the same price per million BTU's. In actual practice, some lighter products will probably sell at a premium over their fuels value because of their greater utility as a chemical feedstock.

Key assumptions specified by DOE for the base case are as follows:

o	Design Basis	33,333 tons coal/stream day
o	On-Stream Time	328.5 days/year - 90% factor
o	Project Life	25 years
o	Plant Life	20 Years
o	Coal Cost	$1.15/MMBTU
o	Capital and Operating Cost Escalation to Start-Up	6%/year
o	Debt/Equity Ratio	25%/75%
o	Interest Rate	9%
o	Internal Rate of Return on Equity	15% (after tax)
o	Investment Tax Credit	10%
o	Depreciation Life	13 years

Key financial and operating characteristics for the Conceptual Commercial Plant assumed were as follows:

(4th Quarter 1978 Dollars-Millions)

Capital Cost	
Direct Capital Cost	$1,568
Indirect Capital (including Working Capital)	158
Total Capital	$1,726
Annual Operating Expenses	
Coal	$ 323
Direct	65
Indirect	30
Total Operating Costs	$ 418
Operating Characteristics	
Inputs	35696 MMBTU/HR
Outputs	25701 MMBTU/HR
Thermal Efficiency	72%

Highlights from the economic analysis are as follows:

- The calculated base case SRC-II price (expressed in 1978 dollars) required to meet the DOE-specified parameters is $22.55/bbl ($3.76/MMBTU). In 1988 dollars at the time of plant start-up the price is $40.45/bbl ($6.74/MMBTU).

- When considering the conceptual nature of the design and corresponding cost estimates for the base case commercial plant, reliability analysis would indicate a more likely value of $23 to $25/bbl, possibly as high as $30/bbl (1978 dollars) for the first plants.

- Internal Rate of Return and Debt/Equity ratio are two primary sensitivity factors. With other factors held constant, a 12% IRR on equity results in a required product price of $3.36/MMBTU, while an 18% IRR yields a product price of

$4.23/MMBTU. Again, with other factors held constant and increasing the debt from 25% to 65%, the required SRC-II product price is reduced from $3.76/MMBTU to $3.15/MMBTU.

- The derived SRC-II price is most sensitive to thermal efficiency, followed by plant capacity, capital investment and coal prices.

  - A 1% increase in thermal efficiency would permit a reduction of 1% in the price;

  - A 10% increase in capacity would permit a reduction of 6.4% in the price;

  - A 10% reduction in capital would permit a 4.4% reduction in price; and

  - A 10% increase in coal cost would result in a 4% increase in product price.

- The potential ethane and propane production of 1.9 billion pounds per year would carry a significant price premium over fuel value.

1.1 INTRODUCTION

This volume contains six sections and one appendix.

Section 2 - The Base Case results which were derived using the DOE-specified parameters are presented and discussed. Financial Statements are included showing details of income and cash flow in constant and current-dollars over the 25-year project life.

Section 3 - The Sensitivity Analysis around the values for several key base-case parameters and operating estimates are displayed graphically and discussed.

Section 4 - The Alternate Case-Ethylene and Gasoline Production is presented to demonstrate the effect of being able to obtain a premium price for Ethane/Propane and Gasoline.

Section 5 - The Input Parameters specified by DOE, along with key design assumptions are discussed. Important exceptions are noted.

Section 6 - The Reliability Analysis develops the confidence limits around the SRC-II price derived in the base case.

Appendix A - DOE Specified Parameters and Guidelines

SECTION 2
BASE CASE ANALYSIS

The base case is constructed assuming that all products would be sold at their BTU value, although it is expected that some SRC-II products would command higher prices as chemical feedstocks and gasoline blending stocks. The analysis described herein derives the SRC-II price (1978 dollars) necessary to achieve a 15% Internal Rate of Return on the total equity investment. It is determined independently of petroleum market-price projections.

Appendix A contains a copy of Attachments I and II from the June 27, 1979 letter from the DOE/ORO SRC Project Manager. These specify the base case parameters to be used in the analysis of the Conceptual Commercial Plant. Attachment II also covers the parameters to be varied for the Sensitivity Analysis. These parameters as now specified, represent changes from the original contract (DE-AC05-78OR03055). DOE instructions were to use the parameters and guidelines from the June 27th letter and to ignore the corresponding section of the contract.

2.1
COST ELEMENTS

2.1 COST ELEMENTS

The Capital and Operating Expenditures and Product Output as developed in the Conceptual Commercial Plant cost estimates (Deliverable 8, Volume 2) are shown in Tables 2-1 through 2-7, as follows:

- o Table 2-1 shows the elements comprising the total estimated cost of plant construction.

- o Table 2-2 shows all the estimated elements of direct and indirect capital costs in 1978 dollars.

- o Table 2-3 provides detail of the estimated annual expense elements for a normal operating year in 1978 dollars. Note that property taxes and insurance are included in direct expense.

- o Table 2-4 is a cost summary showing calculations for wages, benefits, and G&A expenses. Operating labor is estimated to include 209 operators and 15 shift supervisors. It is estimated that 129 maintenance persons would be required.

- o Table 2-5 displays the elements of estimated Working Capital.

- o Table 2-6 shows the estimated investment tax credit earned in each of the construction years.

- o Table 2-7 indicates the product slate and the estimated thermal efficiency of 72% for the Conceptual Commercial Plant. For the base case, the 5.8 million pounds-per-day of ethane and propane would be priced on a BTU basis.

TABLE 2-1

TOTAL PLANT INVESTMENT BREAKDOWN
(Millions of 1978 Dollars)

Engineering			
a.	Design	$96	
b.	Construction	N/A	
	Total		$96
Land			
a.	Site Acquisition	7.8	
b.	Site Preparation	11.0	
			28.8
Off-Site Utilities			0
Plant Acquisition Costs			
a.	Materials	246.0	
b.	Major Equipment	676.0	
c.	Labor	363.0	
d.	Installation/Erection	168.0	
			1453.0
G & A to Plant Commissioning*			9.6
	Total Plant Investment**		$1587.4

*Expensed

**Includes $260MM Contingency (20%)

TABLE 2-2

DIRECT AND INDIRECT CAPITAL COSTS
(1978 $ Millions)

Total Plant Construction	
Fabrication, Installation, Equipment	$1,560*
Elements of Indirect Capital	
License Fees**	$ 13.175
Initial Charge Catalysts & Chemicals**	20.130*
Equipment Testing**	15.000
Gulf Construction Management (spread over 5 years)	8.000
	$ 56.305
Total Depreciable Capital Investment	$1615.305
LAND	$ 7.8
Total Plant Investment	$1624.105

* Includes 20% Contingency

** Expended in last year of construction

TABLE 2-3

ANNUAL EXPENSE BREAKDOWN
(1978 $ Millions)

Coal		$322.689
Operating Labor*	5.031	
Fringe Benefits*	1.511	
Operating Supplies*	.654	
Maintenance Labor*	4.448	
Fringe Benefits*	1.335	
Maintenance Materials* (2% of Depreciable ex. License Fees)	31.760	
Contract Maintenance*	9.750	
Catalyst & Chemicals*	8.007	
Electricity*	2.960	
Total Operating Expense		65.456
Property Taxes & Insurance*		23.400
Total Direct Expense		411.545
Plant Overhead	6.110	
Allocated G & A	.790	
Total G & A Expense		6.900
Total Annual Expense		$418.445

* Includes 20% Contingency

TABLE 2-4

COST SUMMARY
(1978 $ Millions)

	OPERATING LABOR	MAINTENANCE LABOR
Annual Wages	$ 4.194	$3.707
Fringe Benefits @ 30%	1.258	1.112
Plant Overhead @ 77.3%	3.243	2.867
Allocated	.419	.371
Total Operating and Maintenance Labor, Fringe Benefits, Overhead Costs	$ 9.114	$8.057
Contingency @ 20%	1.090	964
Total	$10.204	$9.021

OTHER DIRECT COSTS

Other Direct Costs	$44.275
Contingency @ 20%	8.855
Total Other Direct Costs	$53.131

TABLE 2-5

WORKING CAPITAL REQUIREMENTS IN 1978 $

				MM $
(A)	Cash required (payroll costs)			1.40
(B)	Accounts Receivable			66.34
(C)	Accounts Payable			
	(1)	Coal	26.89	
	(2)	Catalysts, chemicals, supplies, electricity	3.75	
		Subtotal		30.64
(D)	Finished Goods Inventory			
	(1)	Coal	8.84	
	(2)	Operating Expense	1.79	
		Subtotal		10.63
(E)	Raw Material Inventory			
	(1)	Coal	26.89	
	(2)	Catalysts, chemicals, and others	0.86	
		Subtotal		27.75
(F)	Work in Process Inventory			1.00
(G)	Spare Parts Inventory			24.81
		Total Working Capital Required		101.29

TABLE 2-6

INVESTMENT TAX CREDIT
(1978 $ Million)

Year	Direct Capital	+	Other Capital	=	Total Capital	x0.10=	ITC
1983	78.00		1.60		79.60		7.96
1984	156.00		1.60		157.60		15.76
1985	468.00		1.60		469.60		46.96
1986	624.00		1.60		625.60		62.56
1987	234.00		49.91		283.91		28.39
Totals	1560.00		56.31		1616.31		161.63

TABLE 2-7

INPUT/OUTPUT/EFFICIENCY
(Stream-Day)

Inputs

Coal	1388.875 tons/hr	@ 25.626 MMBtu/Ton	= 35597 MMBtu/Hr
Electricity	10,429 KW	@ 9500 Btu/KWH	= 99 MMBtu/Hr
		Total Power Input	35696 MMBtu/Hr

Outputs

	QUANTITY/DAY	HEAT CONTENT Btu/Llb	OUTPUT MM Btu/Hr
Methane	51 MMSCSD	23,120	1992
Ethane/Propane	5,741,077 lbs	22,008	5265
Butane	878,561 lbs	20,570	753
Naphtha	17,035 bbls	18,280	3954
Fuel Oil	56,024 bbls	17,020	13737
			25701

By-Products

Sulfur	1175 tons/day
Ammonia	182.6 tons/day
Tar Acids	239 Barrels/day

Efficiency - Main Products Only 72%

2.2
PROJECT ECONOMICS

2.2 PROJECT ECONOMICS

2.2.1 Results - Constant-Dollar After Start-Up - Base Case

The results for the computer run with 6% inflation on all capital and operating costs during construction and no inflation following the start-up of operations (constant-dollar case) are shown in Table 2-8. The derived SRC-II price in 1978 dollars is $3.76/MMBTU's or approximately $22.55 per barrel. The current dollar SRC-II price inflated to 1988 dollars is $6.74/MMBTU's.

The following observations can be made from Table 2-8:

- o The constant-dollar income builds rapidly during the first eight years and then levels off from the eighth through thirteenth year as the depreciation rate shifts to straight line. It increases sharply in the fourteenth year when depreciation stops altogether and then increases very slightly year-by-year with the decline in interest expense.

- o The constant-dollar cash flow pattern is substantially different. The cash flow reaches a peak in year two and declines thereafter as depreciation falls. In years eight through thirteen, cash flows do increase slightly along with income but take a sharp drop in year fourteen with the cessation of depreciation. The large cash flow in year twenty represents the recovery of land and working capital.

- o The cumulative constant-dollar cash flow pattern indicates that the payback for the initial investment is achieved in the fifth year of operation. Over the life of the plant, the net cumulative positive cash flow from operations would be 3.75 times the total outlay during construction on an equity basis. The cumulative cash flow from operations on a total investment basis would be 3.31 times the original expenditure.

TABLE 2-8

SUMMARY OF RESULTS - CONSTANT DOLLARS AFTER STARTUP

SRC II COMMERICAL UNIT

500=CURRENT DOLLAR INCOME AFTER TAX
580=1978 DOLLAR INCOME AFTER TAX
590=AVERAGE 1978 DOLLAR INCOME AFTER TAX
510=CURRENT DOLLAR CASH FLOW TO EQUITY
600=1978 DOLLAR CASH FLOW TO EQUITY
610=AVERAGE 1978 DOLLAR CASH FLOW TO EQUITY
520=CUMULATIVE CURRENT DOLLAR CASH FLOW
525=PRESENT VALUE CASH FLOW
365=CURRENT DOLLAR SRC PRICE
560=CONSTANT DOLLAR SRC PRICE
570=AVERAGE CONSTANT DOLLAR SRC PRICE
530=NET PRESENT VALUE CASH FLOW

YEAR	500	580 AV=590	510	600 AV=610	520	525	365	560 AV=570	YEAR
-4	-0.79	-0.59	-80.32	-60.02	-80.32	-80.32	5.03	3.76	-4
-3	-2.60	-1.63	-152.85	-107.75	-233.17	-132.91	5.34	3.76	-3
-2	-7.58	-5.04	-482.30	-320.76	-715.48	-364.69	5.66	3.76	-2
-1	-17.53	-11.00	-686.19	-430.53	-1401.67	-451.18	6.00	3.76	-1
0	-29.91	-17.70	-476.91	-282.28	-1878.57	-272.67	6.36	3.76	0
1	-73.01	-40.77	282.28	157.63	-1596.29	140.34	6.74	3.76	1
2	144.94	80.93	440.75	246.12	-1155.54	190.55	6.74	3.76	2
3	171.51	95.77	417.00	232.85	-738.54	156.77	6.74	3.76	3
4	194.21	108.45	397.12	221.75	-341.43	129.62	6.74	3.76	4
5	213.64	119.29	380.51	212.48	39.08	108.16	6.74	3.76	5
6	230.29	128.59	366.67	204.75	405.76	90.64	6.74	3.76	6
7	244.60	136.58	355.18	198.33	760.94	76.34	6.74	3.76	7
8	251.92	140.67	350.68	195.82	1111.62	65.54	6.74	3.76	8
9	253.33	141.46	352.09	196.61	1463.70	57.22	6.74	3.76	9
10	254.74	142.24	353.50	197.39	1817.20	49.96	6.74	3.76	10
11	256.15	143.03	354.91	198.18	2172.10	43.62	6.74	3.76	11
12	257.55	143.82	356.31	198.97	2528.42	38.08	6.74	3.76	12
13	258.96	144.60	357.72	199.75	2886.14	33.24	6.74	3.76	13
14	325.41	181.71	294.10	164.22	3180.24	23.76	6.74	3.76	14
15	326.82	182.49	295.51	165.01	3475.75	20.76	6.74	3.76	15
16	328.23	183.28	296.92	165.80	3772.66	18.14	6.74	3.76	16
17	329.63	184.07	298.32	166.58	4070.99	15.85	6.74	3.76	17
18	331.04	184.85	299.73	167.37	4370.72	13.85	6.74	3.76	18
19	332.45	185.64	301.14	168.16	4671.86	12.10	6.74	3.76	19
20	333.86	186.43	487.27	272.09	5159.13	17.02	6.74	3.76	20
AVERAGE		148.10		196.49			0.0 COMPOUND GROWTH RATE(%)	3.76	

Table 2-9 shows the annual and cumulative net present value of key elements of income. On the present value basis, even without inflation, the interest and depreciation charges represent a small (17%) portion of the total annual expense by the thirteenth year. On a cumulative net present value basis, these two "fixed" expense elements represent only 27% of the total expenses. The cumulative net present value of the income stream, after fully allowing for depreciation of the plant, is $621.61 million.

2.2.2 Results - Cost and Revenue Inflation (6%)

Table 2-10 is a summary of results using 6% inflation for both cost and revenues. Figure 2-1 displays the current and constant-dollar income and cash flow streams.

Except for an abrupt change in year fourteen due to the cessation of depreciation, current-dollar income and cash flow increase throughout the life of the project. The constant-dollar income and cash flow streams remain virtually level after the ninth year, except for the same discontinuity in year fourteen. With revenues inflating at 6% along with all costs, the constant-dollar earning power is preserved while the constant-dollar SRC-II price remains fixed throughout the life of the project.

Table 2-11 shows the net present value of the key expense categories influencing net income, based on current dollars. The current-dollar Internal Rate of Return is indicated as 19.5%, compared to the 15% specified for the constant-dollar case.

When compared to the constant-dollar case, the operating expense, which is inflating at 6%, has a much greater impact on the net present value of the income stream than depreciation and interest, which are not inflated. By the eighth year of the project when depreciation has shifted over to straight-line, the operating expense represents 87% of the present value effect on income. Over the 20-year life of the project, the operating expense accounts for 77% of the cumulative net

TABLE 2-9

NET PRESENT VALUE OF INCOME ELEMENTS - CONSTANT DOLLARS AFTER STARTUP

620=ANNUAL PV OP EXP
630=CUM. NPV OP EXP
640=ANNUAL PV DEPRECIATION
650=CUM. NPV DEPRECIATION
660=ANNUAL PV INTEREST
670=CUM. NPV INTEREST
680=ANNUAL PV INCOME AFTER TAX
690=CUM. NPV INCOME AFTER TAX

YEAR	620	630	640	650	660	670	680	690	YEAR
-4	0.37	0.37	0.0	0.0	1.20	1.20	-0.79	-0.79	-4
-3	0.43	0.81	0.0	0.0	4.09	5.29	-2.26	-3.05	-3
-2	0.70	1.51	0.0	0.0	10.76	16.05	-5.73	-8.78	-2
-1	2.17	3.68	0.0	0.0	20.88	36.93	-11.53	-20.31	-1
0	6.07	9.75	0.0	0.0	28.13	65.07	-17.10	-37.41	0
1	244.88	254.62	192.21	192.21	27.32	92.39	-36.30	-73.71	1
2	323.97	578.60	141.43	333.64	22.54	114.92	62.66	-11.05	2
3	281.72	860.31	104.06	437.70	18.54	133.46	64.48	53.43	3
4	244.97	1105.29	76.57	514.26	15.20	148.66	63.49	116.92	4
5	213.02	1318.30	56.34	570.60	12.42	161.08	60.73	177.65	5
6	185.23	1503.54	41.45	612.05	10.10	171.18	56.92	234.57	6
7	161.07	1664.61	30.50	642.55	8.18	179.35	52.57	287.15	7
8	140.06	1804.66	24.31	666.86	6.58	185.94	47.09	334.23	8
9	121.79	1926.47	21.14	688.00	5.27	191.20	41.17	375.40	9
10	105.91	2032.38	18.38	706.38	4.18	195.39	36.00	411.41	10
11	92.09	2124.47	15.98	722.37	3.29	198.68	31.48	442.88	11
12	80.08	2204.55	13.90	736.27	2.56	201.24	27.52	470.41	12
13	69.64	2274.19	12.09	748.35	1.96	203.20	24.06	494.47	13
14	60.55	2334.74	0.0	748.35	1.48	204.68	26.29	520.77	14
15	52.66	2387.40	0.0	748.35	1.09	205.77	22.96	543.73	15
16	45.79	2433.19	0.0	748.35	0.77	206.54	20.05	563.79	16
17	39.82	2473.00	0.0	748.35	0.52	207.07	17.51	581.30	17
18	34.62	2507.62	0.0	748.35	0.33	207.39	15.29	596.59	18
19	30.11	2537.73	0.0	748.35	0.17	207.56	13.36	609.95	19
20	26.18	2563.91	0.0	748.35	0.05	207.61	11.66	621.61	20

TABLE 2-10

SUMMARY OF RESULTS - 6% INFLATION - COST AND REVENUE

SRC II COMMERICAL UNIT

500=CURRENT DOLLAR INCOME AFTER TAX
580=1978 DOLLAR INCOME AFTER TAX
590=AVERAGE 1978 DOLLAR INCOME AFTER TAX
510=CURRENT DOLLAR CASH FLOW TO EQUITY
600=1978 DOLLAR CASH FLOW TO EQUITY
610=AVERAGE 1978 DOLLAR CASH FLOW TO EQUITY
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YEAR	500	580 AV=590	510	600 AV=610	520	525	365	560 AV=570	YEAR
-4	-0.79	-0.59	-80.32	-60.02	-80.32	-80.32	5.03	3.76	-4
-3	-2.60	-1.83	-152.85	-107.75	-233.17	-127.92	5.34	3.76	-3
-2	-7.58	-5.04	-482.30	-320.76	-715.48	-337.81	5.66	3.76	-2
-1	-17.53	-11.00	-686.19	-430.53	-1401.67	-402.23	6.00	3.76	-1
0	-29.91	-17.70	-476.91	-282.28	-1878.57	-233.95	6.36	3.76	0
1	-73.02	-40.77	282.28	157.62	-1596.29	115.89	6.74	3.76	1
2	165.01	86.92	460.82	242.76	-1135.47	158.34	7.14	3.76	2
3	212.86	105.78	458.35	227.79	-677.12	131.80	7.57	3.76	3
4	258.11	121.01	461.02	216.15	-216.10	110.95	8.02	3.76	4
5	301.45	133.33	468.32	207.14	252.22	94.32	8.51	3.76	5
6	343.44	143.31	479.83	200.22	732.04	80.88	9.02	3.76	6
7	384.61	151.40	495.20	194.94	1227.24	69.86	9.56	3.76	7
8	420.41	156.13	519.17	192.80	1746.41	61.29	10.13	3.76	8
9	452.00	158.36	550.76	192.96	2297.17	54.42	10.74	3.76	9
10	485.40	160.43	584.16	193.08	2881.33	48.30	11.38	3.76	10
11	520.73	162.37	619.49	193.16	3500.82	42.87	12.07	3.76	11
12	558.08	164.17	656.84	193.22	4157.66	38.04	12.79	3.76	12
13	597.60	165.84	696.36	193.25	4854.02	33.75	13.56	3.76	13
14	704.43	184.42	673.12	176.22	5527.14	27.30	14.37	3.76	14
15	748.66	184.91	717.35	177.17	6244.48	24.35	15.23	3.76	15
16	795.45	185.34	764.14	178.05	7008.62	21.71	16.15	3.76	16
17	844.96	185.73	813.65	178.85	7822.27	19.35	17.12	3.76	17
18	897.36	186.09	866.06	179.60	8688.32	17.23	18.14	3.76	18
19	952.83	186.41	921.52	180.28	9609.84	15.35	19.23	3.76	19
20	1011.53	186.69	1164.94	215.00	10774.78	16.24	20.39	3.76	20
AVERAGE		156.35		194.51			6.00 COMPOUND GROWTH RATE(%)	3.76	

TABLE 2-11

NET PRESENT VALUE OF INCOME
ELEMENTS - 6% INFLATION - COST AND REVENUE

SRC II COMMERICAL UNIT

620=ANNUAL PV OP EXP
630=CUM. NPV OP EXP
640=ANNUAL PV DEPRECIATION
650=CUM. NPV DEPRECIATION
660=ANNUAL PV INTEREST
670=CUM. NPV INTEREST
680=ANNUAL PV INCOME AFTER TAX
690=CUM. NPV INCOME AFTER TAX

YEAR	620	630	640	650	660	670	680	690	YEAR
-4	0.37	0.37	0.0	0.0	1.20	1.20	-0.79	-0.79	-4
-3	0.42	0.79	0.0	0.0	3.94	5.14	-2.18	-2.97	-3
-2	0.65	1.44	0.0	0.0	9.97	15.11	-5.31	-8.28	-2
-1	1.93	3.38	0.0	0.0	18.62	33.72	-10.27	-18.55	-1
0	5.20	8.58	0.0	0.0	24.14	57.86	-14.67	-33.22	0
1	202.21	210.79	158.72	158.72	22.56	80.42	-29.98	-63.20	1
2	272.93	483.72	112.40	271.12	17.91	98.33	56.70	-6.50	2
3	242.12	725.84	79.60	350.72	14.18	112.51	61.21	54.71	3
4	214.79	940.63	56.37	407.08	11.19	123.70	62.12	116.82	4
5	190.54	1131.18	39.92	447.00	8.80	132.50	60.71	177.54	5
6	169.03	1300.21	28.27	475.27	6.89	139.38	57.89	235.43	6
7	149.95	1450.16	20.02	495.28	5.37	144.75	54.26	289.68	7
8	133.03	1583.19	15.36	510.64	4.16	148.91	49.63	339.32	8
9	118.01	1701.19	12.85	523.49	3.20	152.11	44.66	383.97	9
10	104.69	1805.88	10.76	534.24	2.45	154.56	40.14	424.11	10
11	92.87	1898.75	9.00	543.24	1.85	156.41	36.04	460.15	11
12	82.39	1981.14	7.53	550.78	1.39	157.80	32.32	492.47	12
13	73.09	2054.22	6.30	557.08	1.02	158.82	28.97	521.43	13
14	64.84	2119.06	0.0	557.08	0.74	159.56	28.58	550.01	14
15	57.52	2176.58	0.0	557.08	0.53	160.09	25.42	575.43	15
16	51.02	2227.60	0.0	557.08	0.36	160.45	22.60	598.03	16
17	45.26	2272.86	0.0	557.08	0.23	160.69	20.09	618.12	17
18	40.15	2313.02	0.0	557.08	0.14	160.83	17.86	635.97	18
19	35.62	2348.64	0.0	557.08	0.07	160.90	15.87	651.84	19
20	31.60	2380.24	0.0	557.08	0.02	160.92	14.10	665.94	20

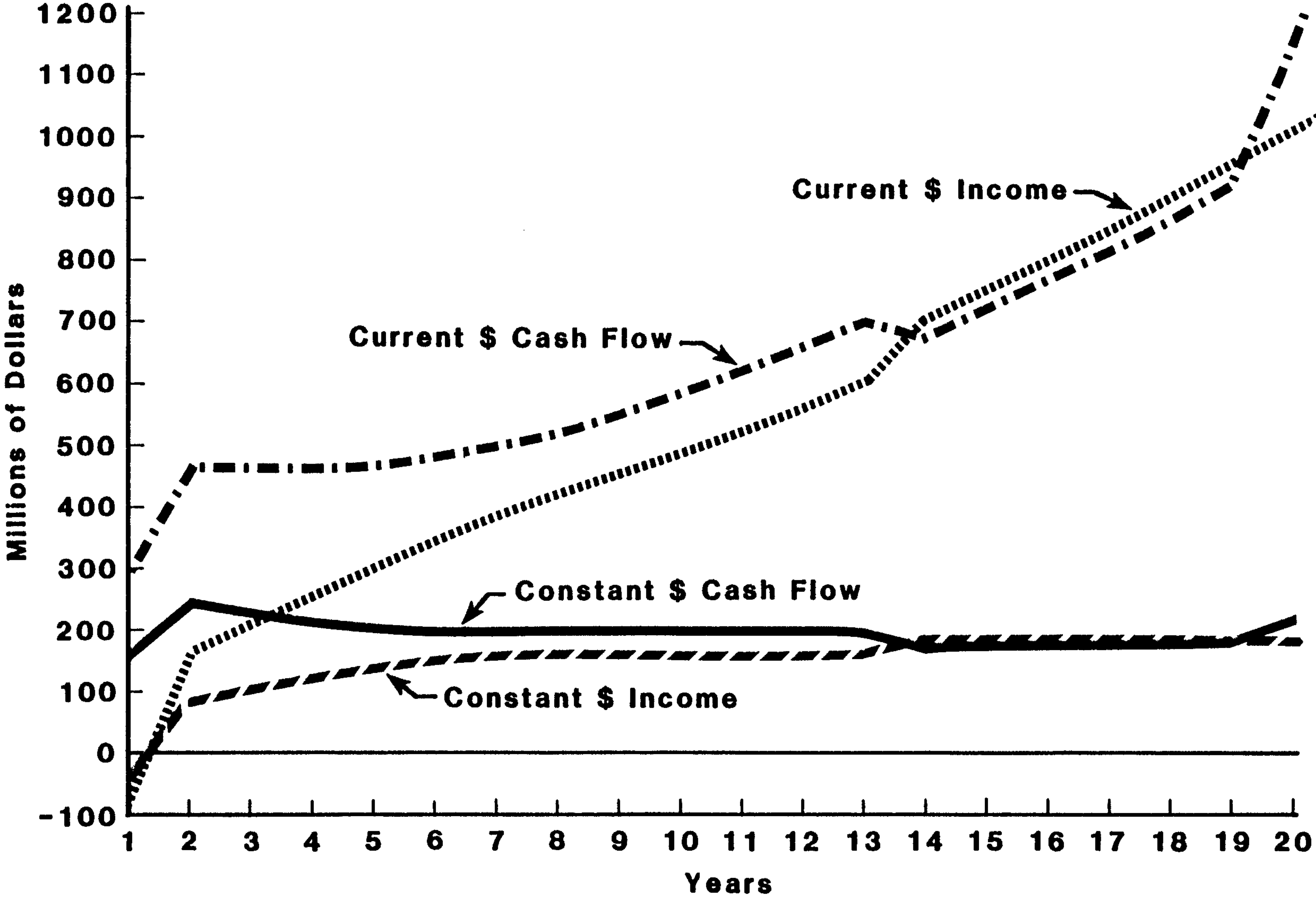


Fig. 2-1. Income and cash flow - 6% inflation - cost and revenue

present value of the total expense. The non-inflating nature of depreciation and interest has little impact. The cumulative net present value of the current-dollar income stream is $665.94 million, only about 7% higher than the constant-dollar case.

2.2.3 Results - Cost Pass-Through - 6% Inflation

Table 2-12 is a summary of results under the parameters specified by DOE. The current-dollar income and cash flows would be the same as under the constant dollar case on a year-by-year comparison because under the DOE guidelines, the current-dollar SRC-II price is defined in such a way as to maintain the current-dollar income and cash flow streams derived in the constant-dollar case, i.e., strict cost pass-through with no inflation of the profit margin. Figure 2-2 displays the current and constant-dollar income and cash flow streams. There is a continuing decline in the constant-dollar streams commencing in year seven and year two, respectively.

The current-dollar SRC-II price must increase at an average growth rate of 3.8% per year to offset the effects of inflation on operating costs. Because of the declining impact of depreciation as a tax shield on the total cost, the SRC-II price initially increases only at a rate of 3.1% and reaches an annual increase of 4.4% by the end of the project. Thus, the constant-dollar SRC-II price would decline over the life of the project under the DOE guidelines.

Figures 2-3 and 2-4 compare the constant-dollar income and cash flow streams respectively, using both the cost pass-through method, and the cost and revenue inflation (6%) method. Figure 2-5 compares the cumulative cash flows for these two cases. The payback will occurr in the fifth year of operation in either case.

Table 2-13 shows the net present value of the key expense categories influencing net income under the cost pass-through method. Note that the cumulative net present value of operating expense accounts for about 80% of the cumulative net present value of the total expense.

TABLE 2-12

SUMMARY OF RESULTS - 6% INFLATION - COST PASS-THROUGH ONLY

SRC II COMMERICAL UNIT

500=CURRENT DOLLAR INCOME AFTER TAX
580=1978 DOLLAR INCOME AFTER TAX
590=AVERAGE 1978 DOLLAR INCOME AFTER TAX
510=CURRENT DOLLAR CASH FLOW TO EQUITY
600=1978 DOLLAR CASH FLOW TO EQUITY
610=AVERAGE 1978 DOLLAR CASH FLOW TO EQUITY
520=CUMULATIVE CURRENT DOLLAR CASH FLOW
525=PRESENT VALUE CASH FLOW
365=CURRENT DOLLAR SRC PRICE
560=CONSTANT DOLLAR SRC PRICE
570=AVERAGE CONSTANT DOLLAR SRC PRICE
530=NET PRESENT VALUE CASH FLOW

YEAR	500	580 AV=590	510	600 AV=610	520	525	365	560 AV=570	YEAR
-4	-0.79	-0.59	-80.32	-60.02	-80.32	-80.32	0.0	0.0	-4
-3	-2.60	-1.83	-152.85	-107.75	-233.17	-132.91	0.0	0.0	-3
-2	-7.58	-5.04	-482.30	-320.76	-715.48	-364.69	0.0	0.0	-2
-1	-17.53	-11.00	-686.19	-430.53	-1401.67	-451.18	0.0	0.0	-1
0	-29.91	-17.70	-476.91	-282.28	-1878.57	-272.67	0.0	0.0	0
1	-73.01	-40.77	282.28	157.63	-1596.29	140.34	6.74	3.76	1
2	144.94	76.35	440.75	232.19	-1155.54	190.55	6.94	3.66	2
3	171.51	85.24	417.00	207.24	-738.54	156.77	7.16	3.56	3
4	194.21	91.05	397.12	186.19	-341.43	129.82	7.39	3.47	4
5	213.64	94.49	380.51	166.30	39.08	108.16	7.64	3.38	5
6	230.29	96.09	366.67	153.00	405.75	90.64	7.90	3.30	6
7	244.60	96.29	355.18	139.82	760.94	76.34	8.18	3.22	7
8	251.92	93.55	350.68	130.23	1111.61	65.54	8.47	3.14	8
9	253.33	88.75	352.09	123.35	1463.70	57.22	8.78	3.08	9
10	254.74	84.19	353.50	116.84	1817.20	49.96	9.11	3.01	10
11	256.15	79.87	354.91	110.66	2172.10	43.62	9.45	2.95	11
12	257.55	75.76	356.31	104.81	2528.42	38.08	9.82	2.89	12
13	258.96	71.86	357.72	99.27	2886.14	33.24	10.21	2.83	13
14	325.41	85.19	294.10	77.00	3180.24	23.76	10.63	2.78	14
15	326.82	80.72	295.51	72.99	3475.74	20.76	11.07	2.73	15
16	328.22	76.48	296.92	69.18	3772.66	16.14	11.53	2.69	16
17	329.63	72.46	298.32	65.58	4070.98	15.85	12.03	2.64	17
18	331.04	68.65	299.73	62.16	4370.71	13.85	12.55	2.60	18
19	332.45	65.04	301.14	58.91	4671.86	12.10	13.11	2.56	19
20	333.86	61.62	487.27	89.93	5159.13	17.02	13.70	2.53	20
AVERAGE		81.25		121.26			3.80	3.04	

COMPOUND GROWTH RATE(%)

TABLE 2-13

NET PRESENT VALUE OF INCOME ELEMENTS - 6% INFLATION - COST PASS-THROUGH ONLY

SRC II COMMERICAL UNIT

620=ANNUAL PV OP EXP
630=CUM. NPV OP EXP
640=ANNUAL PV DEPRECIATION
650=CUM. NPV DEPRECIATION
660=ANNUAL PV INTEREST
670=CUM. NPV INTEREST
680=ANNUAL PV INCOME AFTER TAX
690=CUM. NPV INCOME AFTER TAX

YEAR	620	630	640	650	660	670	680	690	YEAR
-4	0.37	0.37	0.0	0.0	1.20	1.20	-0.79	-0.79	-4
-3	0.43	0.81	0.0	0.0	4.09	5.29	-2.26	-3.05	-3
-2	0.70	1.51	0.0	0.0	10.76	16.05	-5.73	-8.78	-2
-1	2.17	3.68	0.0	0.0	20.88	36.93	-11.53	-20.31	-1
0	6.07	9.75	0.0	0.0	28.13	65.07	-17.10	-37.41	0
1	244.88	254.62	192.21	192.21	27.32	92.39	-36.30	-73.71	1
2	343.41	598.04	141.43	333.64	22.54	114.92	62.66	-11.05	2
3	316.54	914.57	104.06	437.70	18.54	133.46	64.48	53.43	3
4	291.76	1206.34	76.57	514.26	15.20	148.66	63.49	116.92	4
5	268.93	1475.27	56.34	570.60	12.42	161.08	60.73	177.65	5
6	247.88	1723.15	41.45	612.05	10.10	171.18	56.92	234.57	6
7	228.48	1951.64	30.50	642.55	8.18	179.35	52.57	287.14	7
8	210.60	2162.24	24.31	666.86	6.58	185.94	47.09	334.23	8
9	194.12	2356.36	21.14	688.00	5.27	191.20	41.17	375.40	9
10	178.93	2535.29	18.38	706.38	4.18	195.39	36.00	411.41	10
11	164.93	2700.21	15.98	722.37	3.29	198.68	31.48	442.88	11
12	152.02	2852.23	13.90	736.27	2.56	201.24	27.52	470.41	12
13	140.12	2992.35	12.09	748.35	1.96	203.20	24.06	494.47	13
14	129.16	3121.51	0.0	748.35	1.48	204.68	26.29	520.77	14
15	119.05	3240.56	0.0	748.35	1.09	205.77	22.96	543.73	15
16	109.73	3350.29	0.0	748.35	0.77	206.54	20.05	563.79	16
17	101.14	3451.43	0.0	748.35	0.52	207.07	17.51	581.30	17
18	93.23	3544.66	0.0	748.35	0.33	207.39	15.29	596.59	18
19	85.93	3630.59	0.0	748.35	0.17	207.56	13.36	609.95	19
20	79.21	3709.80	0.0	748.35	0.05	207.61	11.66	621.61	20

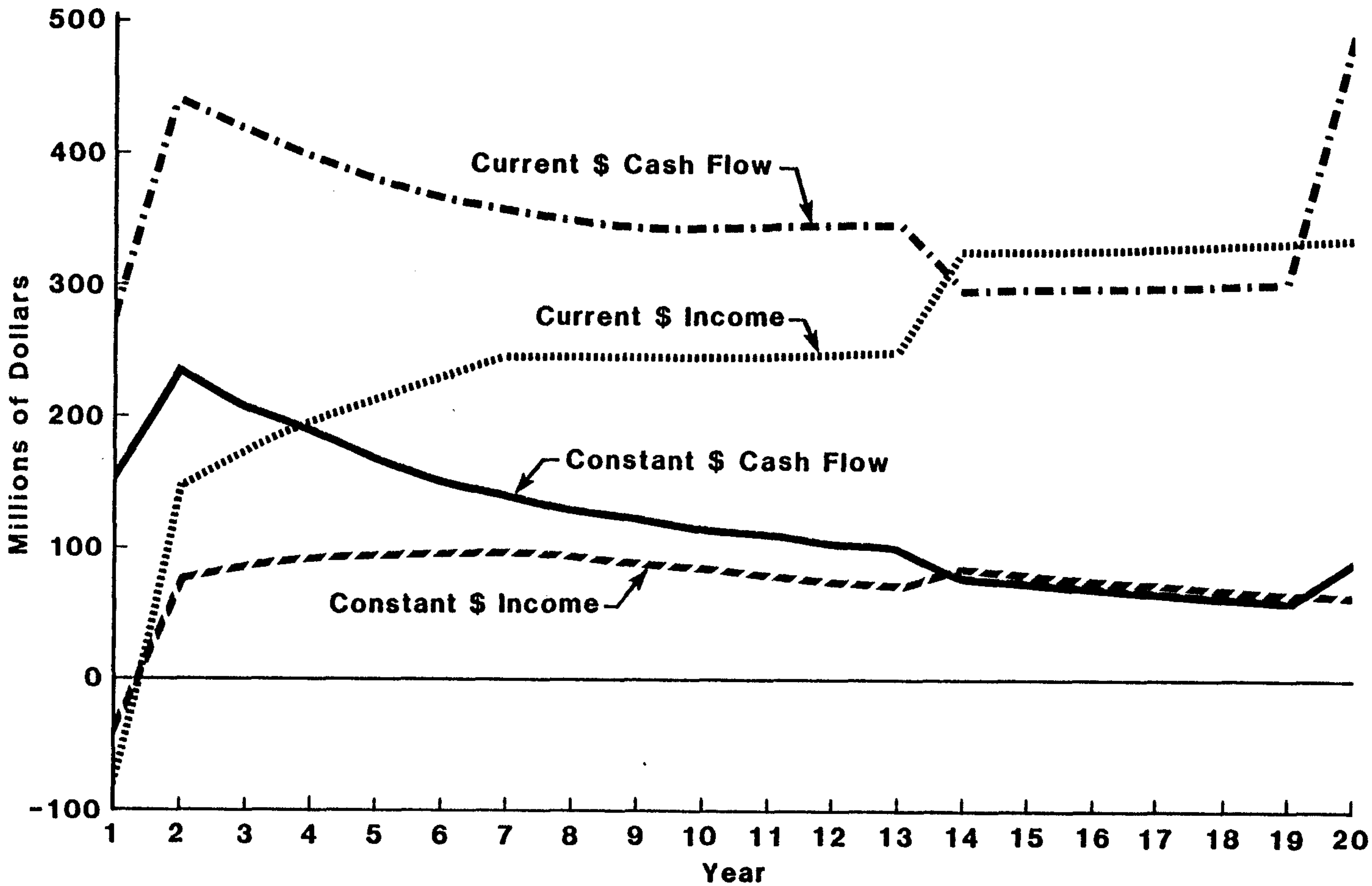


Fig. 2-2. Income and cash flow - 6% inflation - cost pass-through

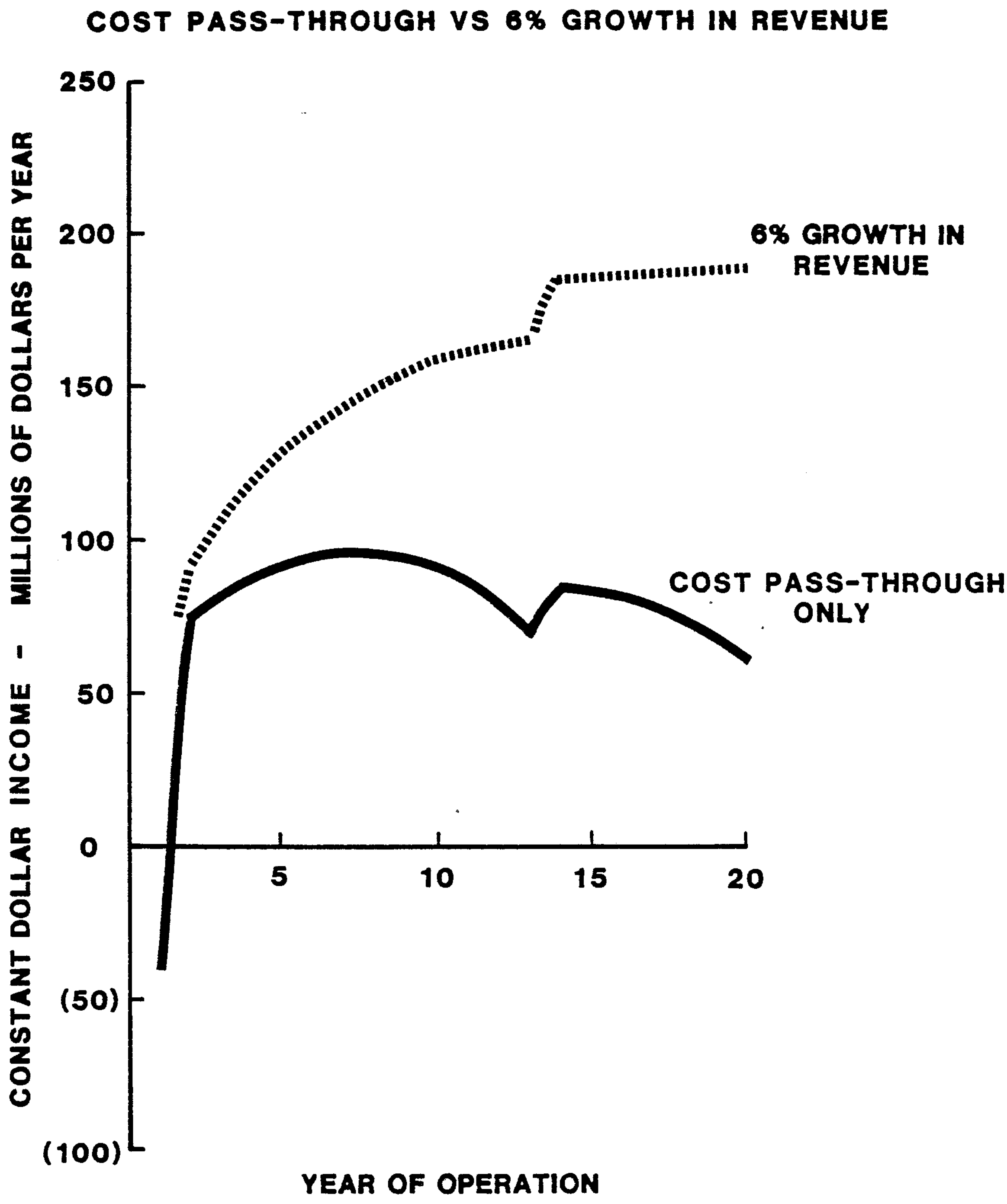


Fig. 2-3. Annual constant dollar income

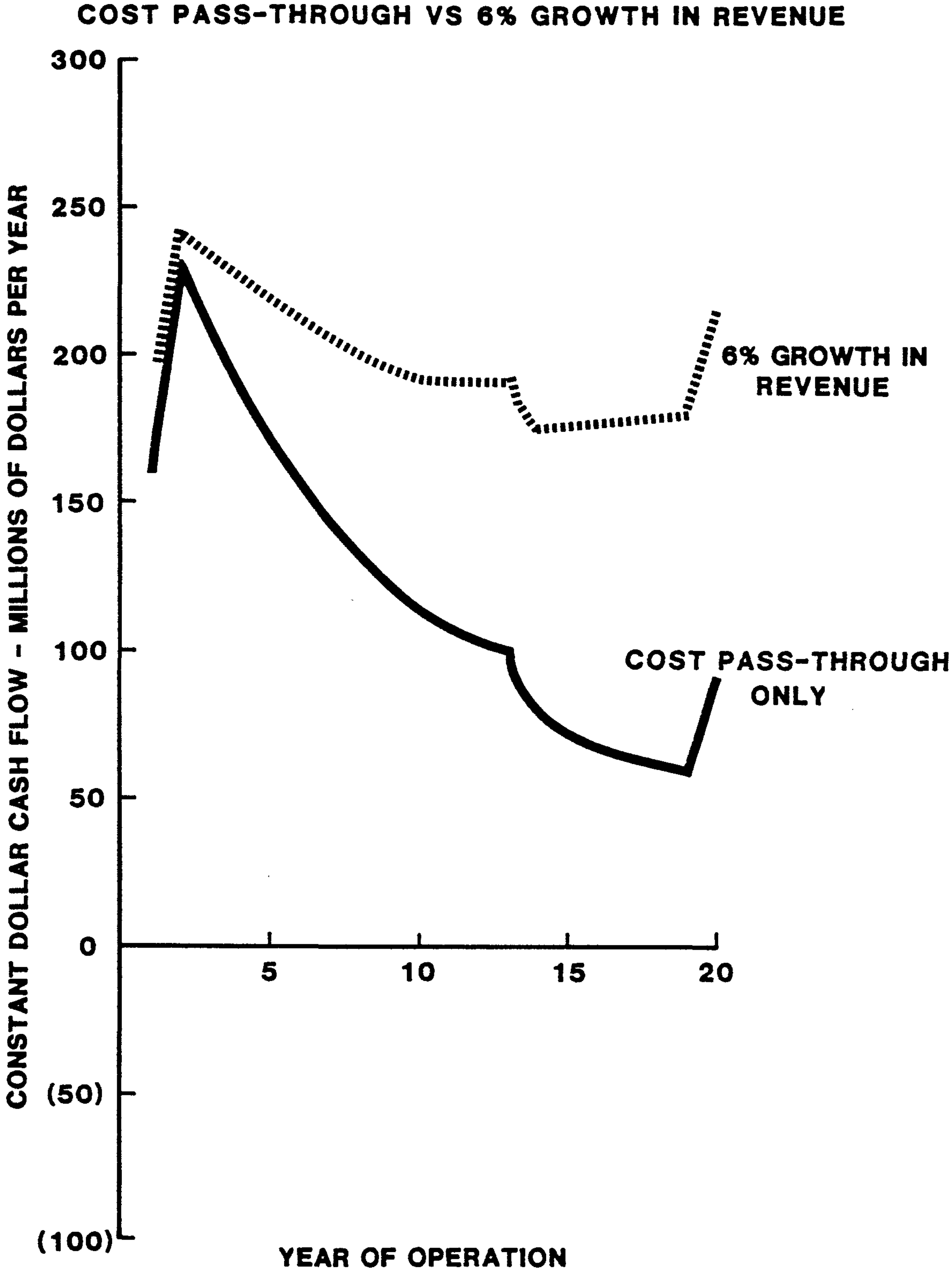


Fig. 2-4. Annual constant dollar cash flow

2.3
FINANCIAL STATEMENTS

2.3 FINANCIAL STATEMENTS

Table 2-14 is the SRC-II Earnings Statement for the constant-dollar base case. Note that there is no co-product revenue shown in the base case.

Table 2-15 is the SRC-II Earnings Statement with 6% inflation of cost and revenues.

Table 2-16 is the SRC-II Earnings Statement with 6% inflation, and strict cost pass-through only for determining the SRC-II price inflation factor under the DOE guidelines. Note that the SRC-II price shown in 1988 is equivalent to $3.76 in 1978 dollars.

For all cases, note that the project incurs the same total operating cost during the first year start-up phase as it did in every other year, even though the plant was only operating at 50% of its designed capacity. The cost of starting up the plant, therefore, is considered to be that portion of operating costs which is in excess of the cost that would apply if it were pro-rated with the production volume. A normal full-year's operating cost would be associated with a production volume that is 90% of the stream-day capacity. Thus, the start-up costs are considered to be four-ninths of the 1988 operating costs incurred, or $76.21 million. In 1978 constant-dollars, this represents $39.49 million out of $88.86 million total constant-dollar operating cost.

TABLE 2-14 (SHEET 1 OF 3)

SRC EARNINGS STATEMENT - CONSTANT DOLLAR AFTER STARTUP

YEAR	1983 -4	1984 -3	1985 -2	1986 -1	1987 0	1988 1	1989 2	1990 3	1991 4
UNIT SALES IN (MM)(MM)BTU						112.55	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	5.03	5.34	5.66	6.00	6.36	6.74	6.74	6.74	6.74
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE						758.35	1365.02	1365.02	1365.02
CO PRODUCT REVENUE									
BY PRODUCT REVENUE						29.71	53.48	53.48	53.48
TOTAL REVENUE						788.06	1418.50	1418.50	1418.50
COAL COST						321.05	577.89	577.89	577.89
OTHER OPERATING COSTS	0.37	0.50	0.93	3.30	10.61	171.48	171.48	171.48	171.48
GROSS MARGIN	-0.37	-0.50	-0.93	-3.30	-10.61	295.52	669.13	669.13	669.13
DEPRECIATION						386.60	327.13	276.80	234.22
INTEREST EXPENSE	1.20	4.70	14.23	31.76	49.20	54.95	52.13	49.31	46.49
EARNINGS BEFORE TAXES	-1.58	-5.20	-15.16	-35.06	-59.81	-146.03	289.87	343.02	388.42
FEDERAL INCOME TAX	-0.79	-2.60	-7.58	-17.53	-29.91	-73.01	144.94	171.51	194.21
EARNINGS AFTER TAXES	-0.79	-2.60	-7.58	-17.53	-29.91	-73.01	144.94	171.51	194.21
CHANGE IN WORKING CAPITAL					174.28				
DEPRECIATION						386.60	327.13	276.80	234.22
CAPITAL INVESTMENT	107.10	203.60	643.07	914.92	635.87				
NEW DEBT	26.77	50.95	160.77	228.73	158.97				
DEBT REPAYMENT						31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	-80.32	-152.85	-482.30	-686.19	-476.91	282.28	440.75	417.00	397.12
CUM. EQUITY NET CASH FLOW	-80.32	-233.17	-715.48	-1401.67	-1878.57	-1596.29	-1155.54	-738.54	-341.43
REMAINING OUTSTANDING DEBT	26.77	77.72	238.49	467.22	626.19	594.88	563.57	532.26	500.95

TABLE 2-14 (SHEET 2 OF 3)

SRC EARNINGS STATEMENT - CONSTANT DOLLAR AFTER STARTUP

YEAR	1992 5	1993 6	1994 7	1995 8	1996 9	1997 10	1998 11	1999 12	2000 13
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE	1365.02	1365.02	1365.02	1365.02	1365.02	1365.02	1365.02	1365.02	1365.02
CO PRODUCT REVENUE									
BY PRODUCT REVENUE	53.48	53.48	53.48	53.48	53.48	53.48	53.48	53.48	53.48
TOTAL REVENUE	1418.50	1418.50	1418.50	1418.50	1418.50	1418.50	1418.50	1418.50	1418.50
COAL COST	577.89	577.89	577.89	577.89	577.89	577.89	577.89	577.89	577.89
OTHER OPERATING COSTS	171.48	171.48	171.48	171.48	171.48	171.48	171.48	171.48	171.48
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
INTEREST EXPENSE	43.68	40.86	38.04	35.22	32.41	29.59	26.77	23.95	21.13
EARNINGS BEFORE TAXES	427.27	460.58	489.20	503.84	506.66	509.47	512.29	515.11	517.93
FEDERAL INCOME TAX	213.64	230.29	244.60	251.92	253.33	254.74	256.15	257.55	258.96
EARNINGS AFTER TAXES	213.64	230.29	244.60	251.92	253.33	254.74	256.15	257.55	258.96
CHANGE IN WORKING CAPITAL									
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
CAPITAL INVESTMENT									
NEW DEBT									
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	380.51	366.67	355.18	350.68	352.09	353.50	354.91	356.31	357.72
CUM. EQUITY NET CASH FLOW	39.08	405.76	760.94	1111.62	1463.70	1817.20	2172.10	2528.42	2886.14
REMAINING OUTSTANDING DEBT	469.64	438.33	407.02	375.71	344.41	313.10	281.79	250.48	219.17

TABLE 2-14 (SHEET 3 OF 3)

SRC EARNINGS STATEMENT - CONSTANT DOLLAR AFTER STARTUP

YEAR	2001 14	2002 15	2003 16	2004 17	2005 18	2006 19	2007 20
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	6.74	6.74	6.74	6.74	6.74	6.74	6.74
EARNINGS STATEMENT (MM)$							
SRC FUEL REVENUE	1365.02	1365.02	1365.02	1365.02	1365.02	1365.02	1365.02
CO PRODUCT REVENUE							
BY PRODUCT REVENUE	53.48	53.48	53.48	53.48	53.48	53.48	53.48
TOTAL REVENUE	1418.50	1418.50	1418.50	1418.50	1418.50	1418.50	1418.50
COAL COST	577.89	577.89	577.89	577.89	577.89	577.89	577.89
OTHER OPERATING COSTS	171.48	171.48	171.48	171.48	171.48	171.48	171.48
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION							
INTEREST EXPENSE	18.32	15.50	12.68	9.86	7.04	4.23	1.41
EARNINGS BEFORE TAXES	650.81	653.63	656.45	659.27	662.09	664.90	667.72
FEDERAL INCOME TAX	325.41	326.82	328.22	329.63	331.04	332.45	333.86
EARNINGS AFTER TAXES	325.41	326.82	328.23	329.63	331.04	332.45	333.86
CHANGE IN WORKING CAPITAL							
DEPRECIATION							
CAPITAL INVESTMENT							
NEW DEBT							
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	294.10	295.51	296.92	298.32	299.73	301.14	487.27
CUM. EQUITY NET CASH FLOW	3180.24	3475.75	3772.66	4070.99	4370.72	4671.86	5159.13
REMAINING OUTSTANDING DEBT	187.86	156.55	125.24	93.93	62.62	31.31	

TABLE 2-15 (SHEET 1 OF 3)

SRC EARNINGS STATEMENT - 6% INFLATION - COST AND REVENUE

YEAR	1983 -4	1984 -3	1985 -2	1986 -1	1987 0	1988 1	1989 2	1990 3	1991 4
UNIT SALES IN (MM)(MM)BTU						112.55	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	5.03	5.34	5.66	6.00	6.36	6.74	7.14	7.57	8.02
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE						758.34	1446.92	1533.73	1625.75
CO PRODUCT REVENUE									
BY PRODUCT REVENUE						29.71	56.69	60.09	63.69
TOTAL REVENUE						788.05	1503.60	1593.82	1689.45
COAL COST						321.05	612.56	649.31	688.27
OTHER OPERATING COSTS	0.37	0.50	0.93	3.30	10.61	171.48	181.77	192.68	204.24
GROSS MARGIN	-0.37	-0.50	-0.93	-3.30	-10.61	295.52	709.27	751.83	796.94
DEPRECIATION						386.60	327.13	276.80	234.22
INTEREST EXPENSE	1.20	4.70	14.23	31.76	49.20	54.95	52.13	49.31	46.49
EARNINGS BEFORE TAXES	-1.58	-5.20	-15.16	-35.06	-59.81	-146.03	330.01	425.72	516.23
FEDERAL INCOME TAX	-0.79	-2.60	-7.58	-17.53	-29.91	-73.02	165.01	212.86	258.11
EARNINGS AFTER TAXES	-0.79	-2.60	-7.58	-17.53	-29.91	-73.02	165.01	212.86	258.11
CHANGE IN WORKING CAPITAL					174.28				
DEPRECIATION						386.60	327.13	276.80	234.22
CAPITAL INVESTMENT	107.10	203.80	643.07	914.92	635.87				
NEW DEBT	26.77	50.95	160.77	228.73	158.97				
DEBT REPAYMENT						31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	-80.32	-152.85	-482.30	-686.19	-476.91	282.28	460.82	458.35	461.02
CUM. EQUITY NET CASH FLOW	-80.32	-233.17	-715.48	-1401.67	-1878.57	-1596.29	-1135.47	-677.12	-216.10
REMAINING OUTSTANDING DEBT	26.77	77.72	238.49	467.22	626.19	594.88	563.57	532.26	500.95

TABLE 2-15 (SHEET 2 OF 3)

SRC EARNINGS STATEMENT - 6% INFLATION - COST AND REVENUE

YEAR	1992 5	1993 6	1994 7	1995 8	1996 9	1997 10	1998 11	1999 12	2000 13
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	8.51	9.02	9.56	10.13	10.74	11.38	12.07	12.79	13.56
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE	1723.30	1826.69	1936.29	2052.47	2175.62	2306.15	2444.52	2591.19	2746.66
CO PRODUCT REVENUE									
BY PRODUCT REVENUE	67.51	71.57	75.86	80.41	85.24	90.35	95.77	101.52	107.61
TOTAL REVENUE	1790.81	1898.26	2012.15	2132.88	2260.85	2396.50	2540.29	2692.70	2854.26
COAL COST	729.57	773.34	819.74	868.92	921.06	976.32	1034.90	1096.99	1162.81
OTHER OPERATING COSTS	216.49	229.48	243.25	257.85	273.32	289.71	307.10	325.52	345.05
GROSS MARGIN	844.75	895.44	949.16	1006.11	1066.48	1130.46	1198.29	1270.19	1346.40
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
INTEREST EXPENSE	43.68	40.86	38.04	35.22	32.41	29.59	26.77	23.95	21.13
EARNINGS BEFORE TAXES	602.89	686.89	769.23	840.82	904.00	970.81	1041.45	1116.17	1195.19
FEDERAL INCOME TAX	301.45	343.44	384.61	420.41	452.00	485.40	520.73	558.08	597.60
EARNINGS AFTER TAXES	301.45	343.44	384.61	420.41	452.00	485.40	520.73	558.08	597.60
CHANGE IN WORKING CAPITAL									
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
CAPITAL INVESTMENT									
NEW DEBT									
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	468.32	479.83	495.20	519.17	550.76	584.16	619.49	656.84	696.36
CUM. EQUITY NET CASH FLOW	252.22	732.04	1227.24	1746.41	2297.17	2881.33	3500.82	4157.66	4854.02
REMAINING OUTSTANDING DEBT	469.64	438.33	407.02	375.71	344.41	313.10	281.79	250.48	219.17

TABLE 2-15 (SHEET 3 OF 3)

SRC EARNINGS STATEMENT - 6% INFLATION - COST AND REVENUE

YEAR	2001 14	2002 15	2003 16	2004 17	2005 18	2006 19	2007 20
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	14.37	15.23	16.15	17.12	18.14	19.23	20.39
EARNINGS STATEMENT (MM)$							
SRC FUEL REVENUE	2911.45	3086.14	3271.30	3467.58	3675.63	3896.17	4129.93
CO PRODUCT REVENUE							
BY PRODUCT REVENUE	114.06	120.91	128.16	135.85	144.00	152.64	161.80
TOTAL REVENUE	3025.52	3207.05	3399.46	3603.43	3819.63	4048.81	4291.73
COAL COST	1232.58	1306.53	1384.93	1468.02	1556.10	1649.47	1748.43
OTHER OPERATING COSTS	365.76	387.70	410.96	435.62	461.76	489.46	518.83
GROSS MARGIN	1427.18	1512.81	1603.57	1699.79	1801.77	1909.88	2024.47
DEPRECIATION							
INTEREST EXPENSE	18.32	15.50	12.68	9.86	7.04	4.23	1.41
EARNINGS BEFORE TAXES	1408.86	1497.31	1590.89	1689.93	1794.73	1905.65	2023.06
FEDERAL INCOME TAX	704.43	748.66	795.45	844.96	897.36	952.83	1011.53
EARNINGS AFTER TAXES	704.43	748.66	795.45	844.96	897.36	952.83	1011.53
CHANGE IN WORKING CAPITAL							
DEPRECIATION							
CAPITAL INVESTMENT							
NEW DEBT							
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	673.12	717.35	764.14	813.65	866.06	921.52	1164.94
CUM. EQUITY NET CASH FLOW	5527.14	6244.48	7008.62	7822.27	8688.32	9609.84	10774.78
REMAINING OUTSTANDING DEBT	187.86	156.55	125.24	93.93	62.62	31.31	

TABLE 2-16 (SHEET 1 OF 3)

SRC EARNINGS STATEMENT - 6% INFLATION - COST PASS-THROUGH ONLY

YEAR	1983 -4	1984 -3	1985 -2	1986 -1	1987 0	1988 1	1989 2	1990 3	1991 4
UNIT SALES IN (MM)(MM)BTU						112.55	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU						6.74	6.94	7.16	7.39
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE						758.35	1406.78	1451.03	1497.95
CO PRODUCT REVENUE									
BY PRODUCT REVENUE						29.71	56.69	60.09	63.69
TOTAL REVENUE						788.06	1463.46	1511.12	1561.64
COAL COST						321.05	612.56	649.31	688.27
OTHER OPERATING COSTS	0.37	0.50	0.93	3.30	10.61	171.48	181.77	192.68	204.24
GROSS MARGIN	-0.37	-0.50	-0.93	-3.30	-10.61	295.52	669.13	669.13	669.13
DEPRECIATION						386.60	327.13	276.80	234.22
INTEREST EXPENSE	1.20	4.70	14.23	31.76	49.20	54.95	52.13	49.31	46.49
EARNINGS BEFORE TAXES	-1.58	-5.20	-15.16	-35.06	-59.81	-146.03	289.87	343.02	388.42
FEDERAL INCOME TAX	-0.79	-2.60	-7.58	-17.53	-29.91	-73.01	144.94	171.51	194.21
EARNINGS AFTER TAXES	-0.79	-2.60	-7.58	-17.53	-29.91	-73.01	144.94	171.51	194.21
CHANGE IN WORKING CAPITAL					174.28				
DEPRECIATION						386.60	327.13	276.80	234.22
CAPITAL INVESTMENT	107.10	203.80	643.07	914.92	635.87				
NEW DEBT	26.77	50.95	160.77	228.73	158.97				
DEBT REPAYMENT						31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	-80.32	-152.85	-482.30	-686.19	-476.91	282.28	440.75	417.00	397.12
CUM. EQUITY NET CASH FLOW	-80.32	-233.17	-715.48	-1401.67	-1878.57	-1596.29	-1155.54	-738.54	-341.43
REMAINING OUTSTANDING DEBT	26.77	77.72	238.49	467.22	626.19	594.88	563.57	532.26	500.95

TABLE 2-16 (SHEET 2 OF 3)

SRC EARNINGS STATEMENT - 6% INFLATION - COST PASS-THROUGH ONLY

YEAR	1992 5	1993 6	1994 7	1995 8	1996 9	1997 10	1998 11	1999 12	2000 13
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	7.64	7.90	8.18	8.47	8.78	9.11	9.45	9.82	10.21
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE	1547.68	1600.39	1656.26	1715.49	1778.27	1844.82	1915.36	1990.13	2069.39
CO PRODUCT REVENUE									
BY PRODUCT REVENUE	67.51	71.57	75.86	80.41	85.24	90.35	95.77	101.52	107.61
TOTAL REVENUE	1615.19	1671.95	1732.12	1795.90	1863.50	1935.17	2011.13	2091.65	2177.00
COAL COST	729.57	773.34	819.74	868.92	921.06	976.32	1034.90	1096.99	1162.81
OTHER OPERATING COSTS	216.49	229.48	243.25	257.85	273.32	289.71	307.10	325.52	345.05
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
INTEREST EXPENSE	43.68	40.86	38.04	35.22	32.41	29.59	26.77	23.95	21.13
EARNINGS BEFORE TAXES	427.27	460.58	489.19	503.84	506.65	509.47	512.29	515.11	517.93
FEDERAL INCOME TAX	213.64	230.29	244.60	251.92	253.33	254.74	256.15	257.55	258.96
EARNINGS AFTER TAXES	213.64	230.29	244.60	251.92	253.33	254.74	256.15	257.55	258.96
CHANGE IN WORKING CAPITAL									
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
CAPITAL INVESTMENT									
NEW DEBT									
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	380.51	366.67	355.18	350.68	352.09	353.50	354.91	356.31	357.72
CUM. EQUITY NET CASH FLOW	39.08	405.75	760.94	1111.61	1463.70	1817.20	2172.10	2528.42	2886.14
REMAINING OUTSTANDING DEBT	469.64	438.33	407.02	375.71	344.41	313.10	281.79	250.48	219.17

TABLE 2-16 (SHEET 3 OF 3)

SRC EARNINGS STATEMENT - 6% INFLATION - COST PASS-THROUGH ONLY

YEAR	2001 14	2002 15	2003 16	2004 17	2005 18	2006 19	2007 20
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	10.63	11.07	11.53	12.03	12.55	13.11	13.70
EARNINGS STATEMENT (MM)$							
SRC FUEL REVENUE	2153.40	2242.46	2336.86	2436.92	2542.99	2655.42	2774.59
CO PRODUCT REVENUE							
BY PRODUCT REVENUE	114.06	120.91	128.16	135.85	144.00	152.64	161.80
TOTAL REVENUE	2267.47	2363.37	2465.02	2572.77	2686.99	2808.06	2936.39
COAL COST	1232.58	1306.53	1384.93	1468.02	1556.10	1649.47	1748.43
OTHER OPERATING COSTS	365.76	387.70	410.96	435.62	461.76	489.46	518.63
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION							
INTEREST EXPENSE	18.32	15.50	12.68	9.86	7.04	4.23	1.41
EARNINGS BEFORE TAXES	650.81	653.63	656.45	659.27	662.09	664.90	667.72
FEDERAL INCOME TAX	325.41	326.82	328.22	329.63	331.04	332.45	333.86
EARNINGS AFTER TAXES	325.41	326.82	328.22	329.63	331.04	332.45	333.86
CHANGE IN WORKING CAPITAL							
DEPRECIATION							
CAPITAL INVESTMENT							
NEW DEBT							
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	294.10	295.51	296.92	298.32	299.73	301.14	487.27
CUM. EQUITY NET CASH FLOW	3180.24	3475.74	3772.66	4070.98	4370.71	4671.86	5159.13
REMAINING OUTSTANDING DEBT	187.86	156.55	125.24	93.93	62.62	31.31	

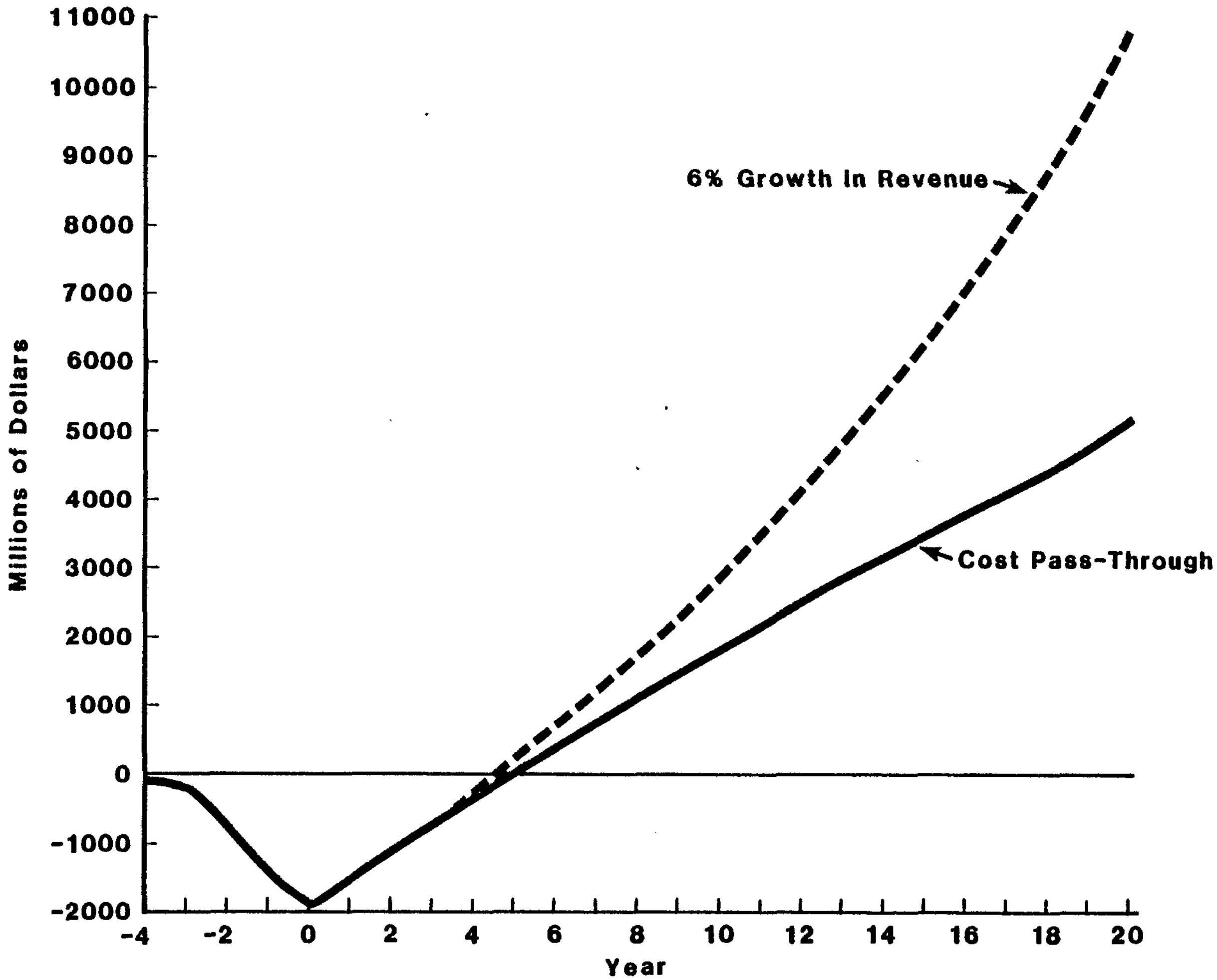


Fig. 2-5. Cumulative cash flow - 6% inflation

SECTION 3
SENSITIVITY ANALYSIS

3.1 SENSITIVITY VARIABLES

The two primary sensitivity variables specified by DOE are the Internal Rate of Return (after tax) on equity and the Debt/Equity ratio. At DOE's instructions, three levels of IRR on equity, i.e., 12, 15 and 18 percent, have been evaluated at four debt/equity ratios, i.e., 0% debt, 25% debt, 50% debt and 65% debt.

The resultant effect is demonstrated in Figure 3-1, where the initial price of the SRC-II product in 1978 dollars is determined by the interaction of the IRR on equity with the debt/equity ratios. With the base case debt/equity ratio of 25%/75%, a change in the required IRR on equity from 12 to 18 percent requires the SRC-II product price to increase from $3.36/MMBTU to $4.23/MMBTU.

Similarly, the product price would also be significantly affected by changes in the level of debt financing, if it were to become available. As the base case debt level of 25% is increased to 65%, the required SRC-II product price is reduced from $3.76/MMBTU to $3.15/MMBTU.

3.2 SECONDARY SENSITIVITY VARIABLES

3.2.1 Coal Price

The base case assumes a coal price of $1.15/MMBTU for delivered washed coal (4th quarter 1978 dollars). Figure 3-2 shows the effect of varying the coal price by about 22% above and below the base price. If the coal price were $1.40/MMBTU, then the SRC-II product price would increase to $4.11/MMBTU from $3.76/MMBTU. A $0.25/MMBTU coal price change results in a $0.35/MMBTU or a 9.3% change in product price.

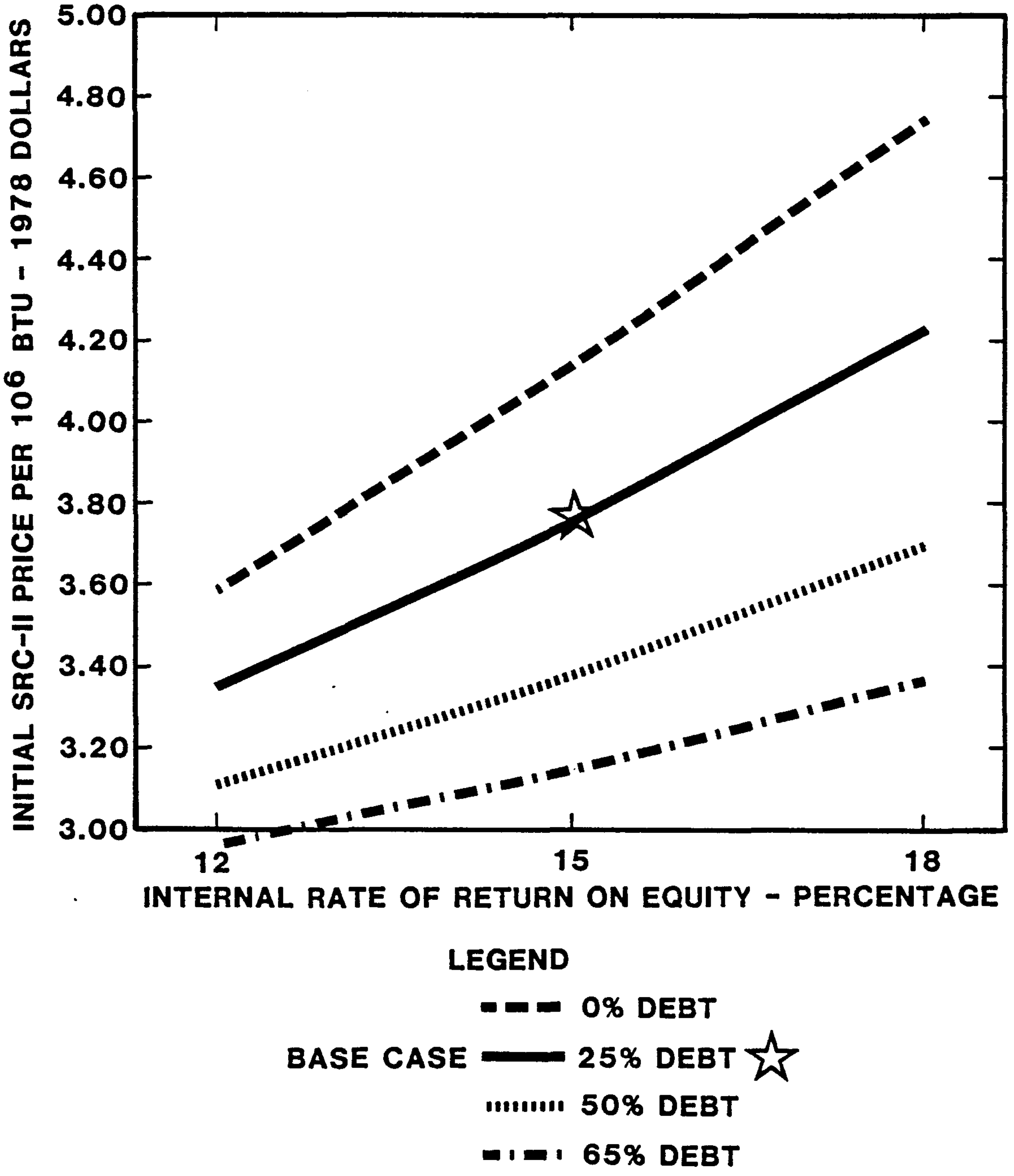


Fig. 3-1. Sensitivity to capital structure

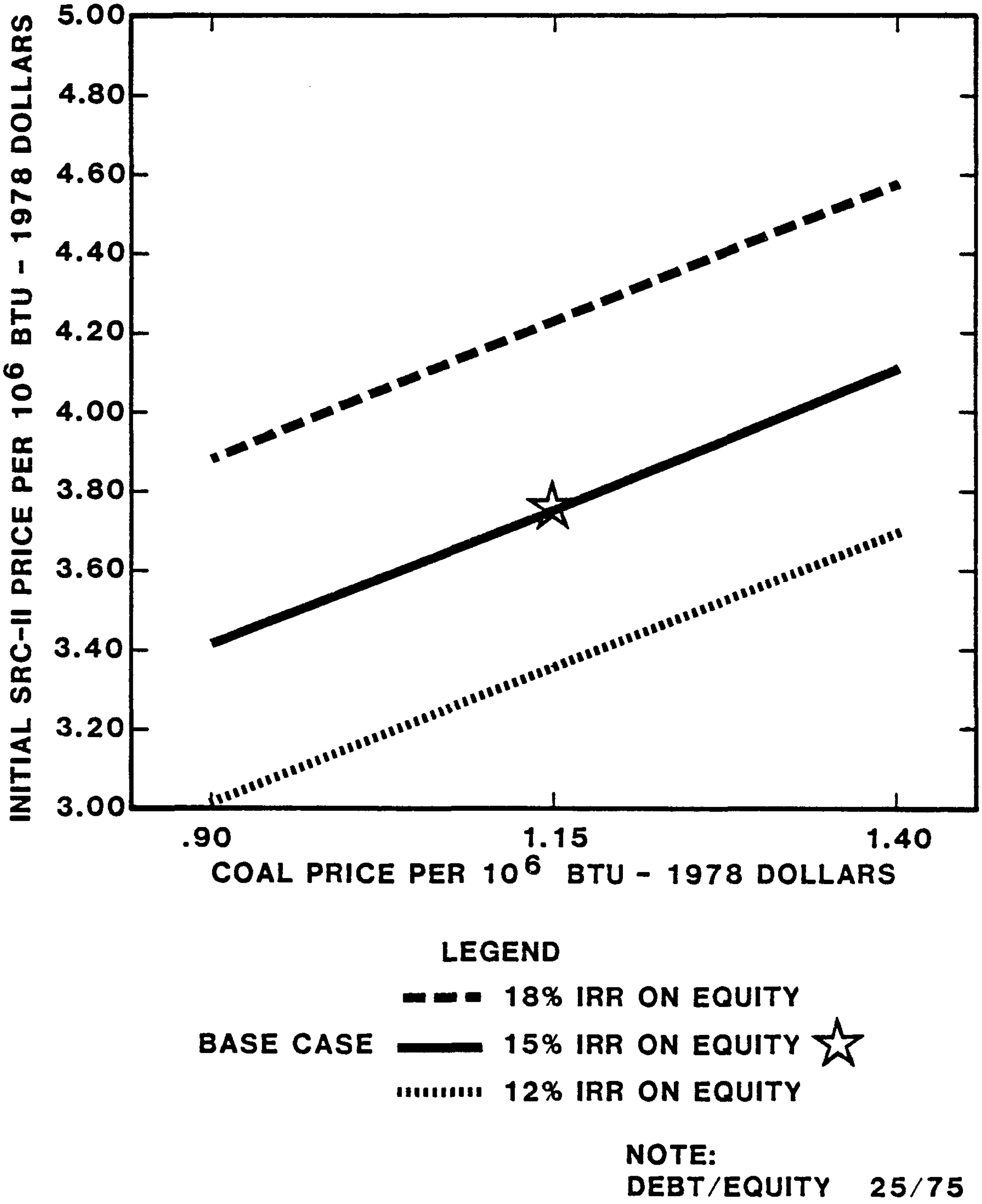


Fig. 3-2. Sensitivity to coal price

3.2.2 Investment Tax Credit

The base case includes the standard 10% investment tax credit. However, an additional 10% tax credit may be allowed on qualifying expenditures under the Energy Act of 1978. As displayed in Figure 3-3, the SRC-II product price could be reduced by 6.9% in that case, or from $3.76/MMBTU to $3.50/MMBTU, while still maintaining the same IRR.

3.2.3 Depreciation Life

In the base case, the plant is depreciated over thirteen years, using double-declining balance, switching to straight-line when appropriate. If a 5-year depreciation period were permitted, the product price, as shown in Figure 3-4, could be reduced to $3.50/MMBTU at the same IRR. Note that either a 20% investment tax credit or a 5-year depreciation life would enable a 7% reduction in SRC-II product price.

3.2.4 Repairs and Replacement Costs

In the base case, annual expense for repairs and replacement is 2% of the original depreciable investment. If this allowance were doubled to 4%, the required product price as shown in Figure 3-5 would increase by $0.17/MMBTU. A doubling of the repairs and replacement allowance would cause a 4.5% increase in the required product price.

3.3 DESIGN FACTOR SENSITIVITIES

3.3.1 Plant Capacity

The plant is designed to process 10,950,000 short tons of coal each year, based on a 90% on-stream factor at 100% of design capacity. A change in either the on-stream factor or the actual capacity realized would have a marked effect on the SRC-II price as shown in Figure 3-6. At 90% of the above throughput, the product price required would increase by $0.26/MMBTU, or about 6.9%. For a 10% improvement, the product price could be reduced by 5.6%.

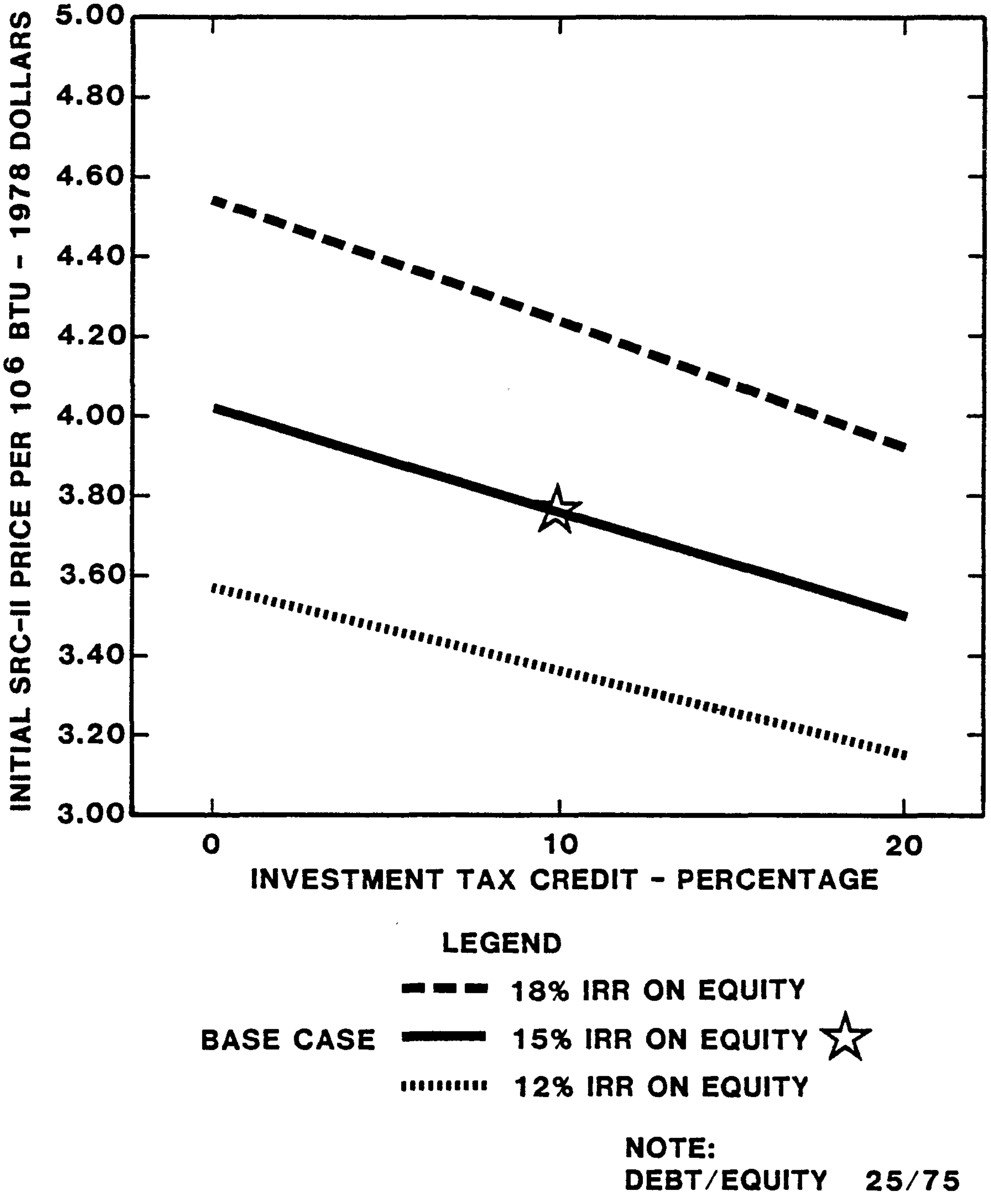


Fig. 3-3. Sensitivity to investment tax credit

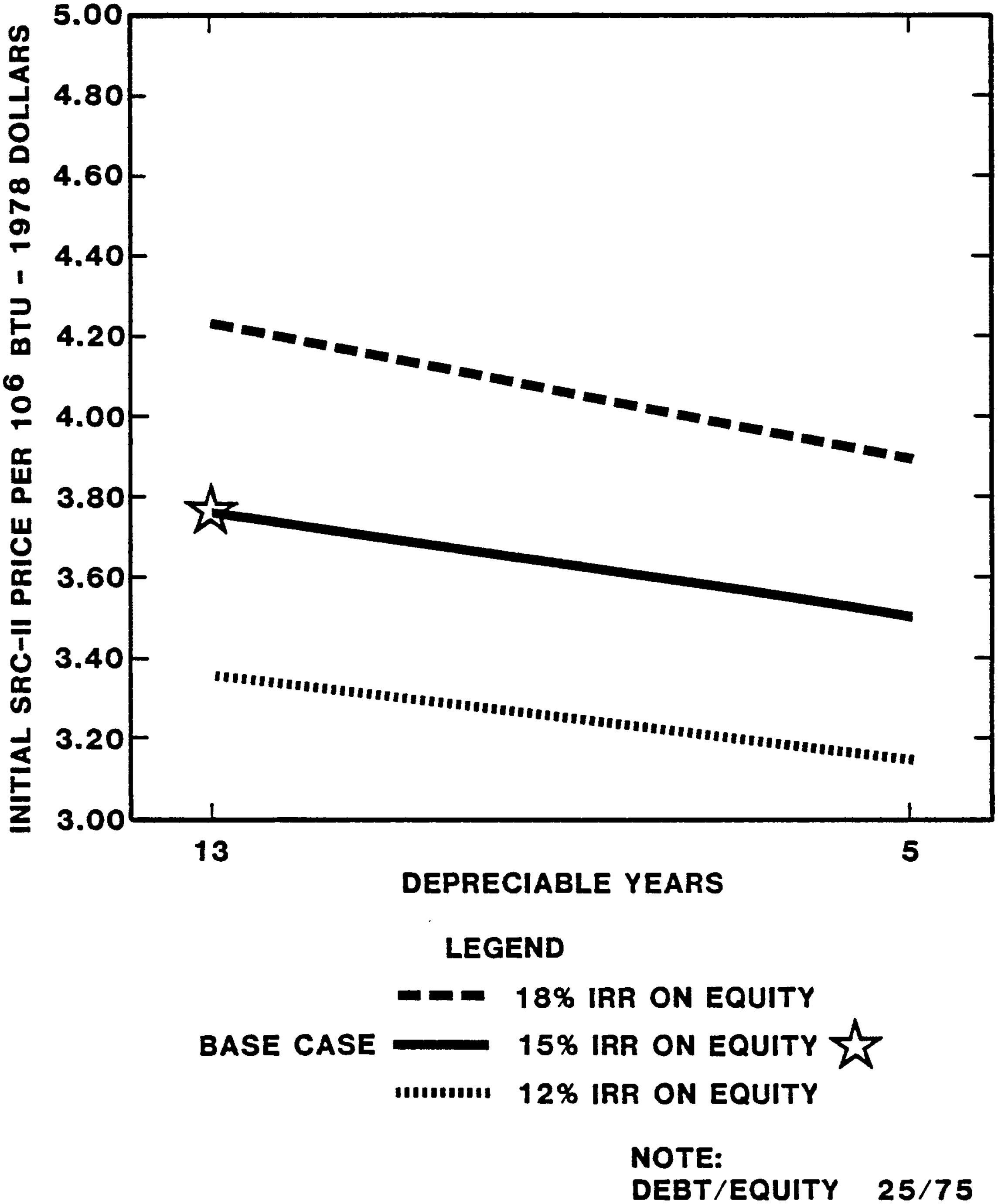


Fig. 3-4. Sensitivity to depreciation life

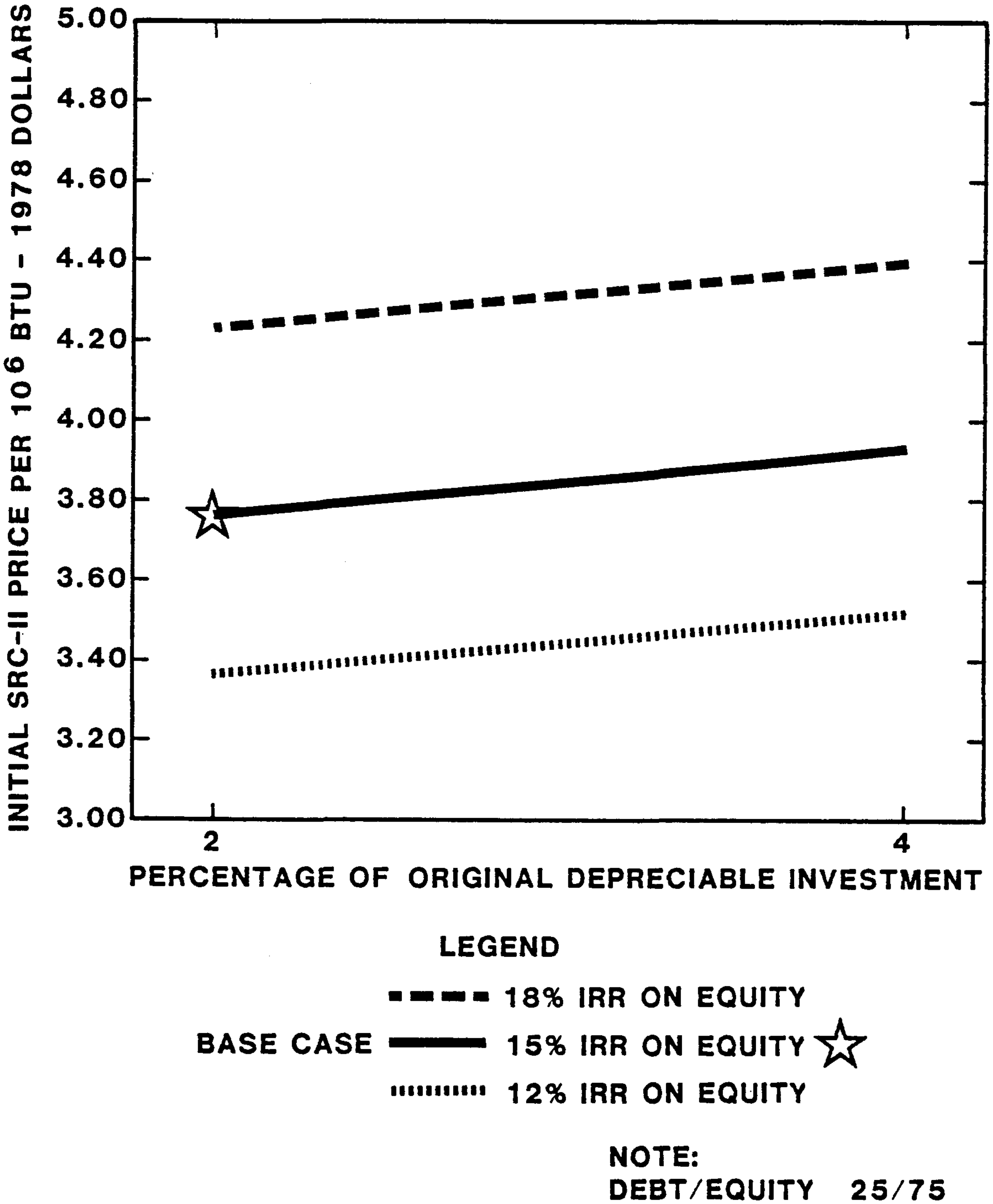


Fig. 3-5. Sensitivity to repairs and replacement costs

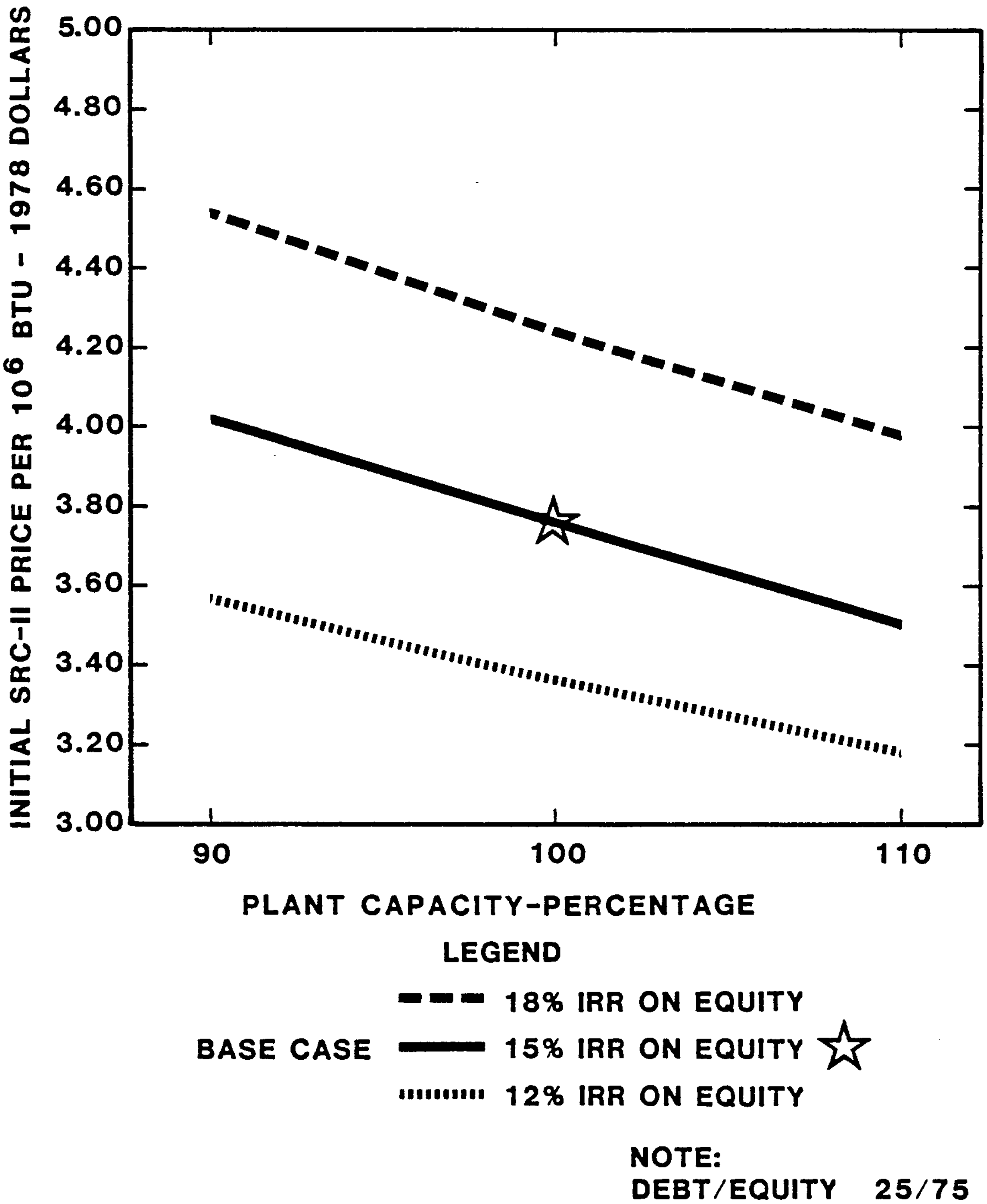


Fig. 3-6. Sensitivity to plant capacity

Either case is possible. Petroleum refineries have experienced capacities exceeding the design rate. Conversely, the on-stream time is probably optimistic for a plant with the corrosive and erosive process streams, coupled with severe operating conditions, encountered in coal liquefaction.

3.3.2 Thermal Efficiency

The thermal efficiency achieved from the plant has a more significant impact on the SRC-II price than plant throughput. A thermal efficiency lower than the design value will reduce the output of products while the same amount of coal is consumed. However, coal usage varies directly with throughput.

In Figure 3-7, at 90% of the design thermal efficiency (i.e., 64.8% instead of 72%) a product price of $4.18/MMBTU (an 11.2% increase over the base case) is required. If thermal efficiency could be improved by 1%, the derived SRC-II product price could be lowered by an equal amount. The value of continuing research and engineering to maximize in thermal efficiency is indicated.

3.3.3 Capital Investment

It has been estimated that the Conceptual Commercial Plant will cost $1,560 million (1978 dollars) to construct.

At this preliminary stage of engineering design, allowances must be made for unforeseen alterations that could influence the actual capital cost. For a 10% change capital cost, the product price required, as shown in Figure 3-8, would change by $0.17/MMBTU, or about 4.5% from base price.

3.3.4 Operating Cost

Operating Cost, including Property Taxes and Insurance, in the base case was $88.9 million. The derived SRC-II price is relatively

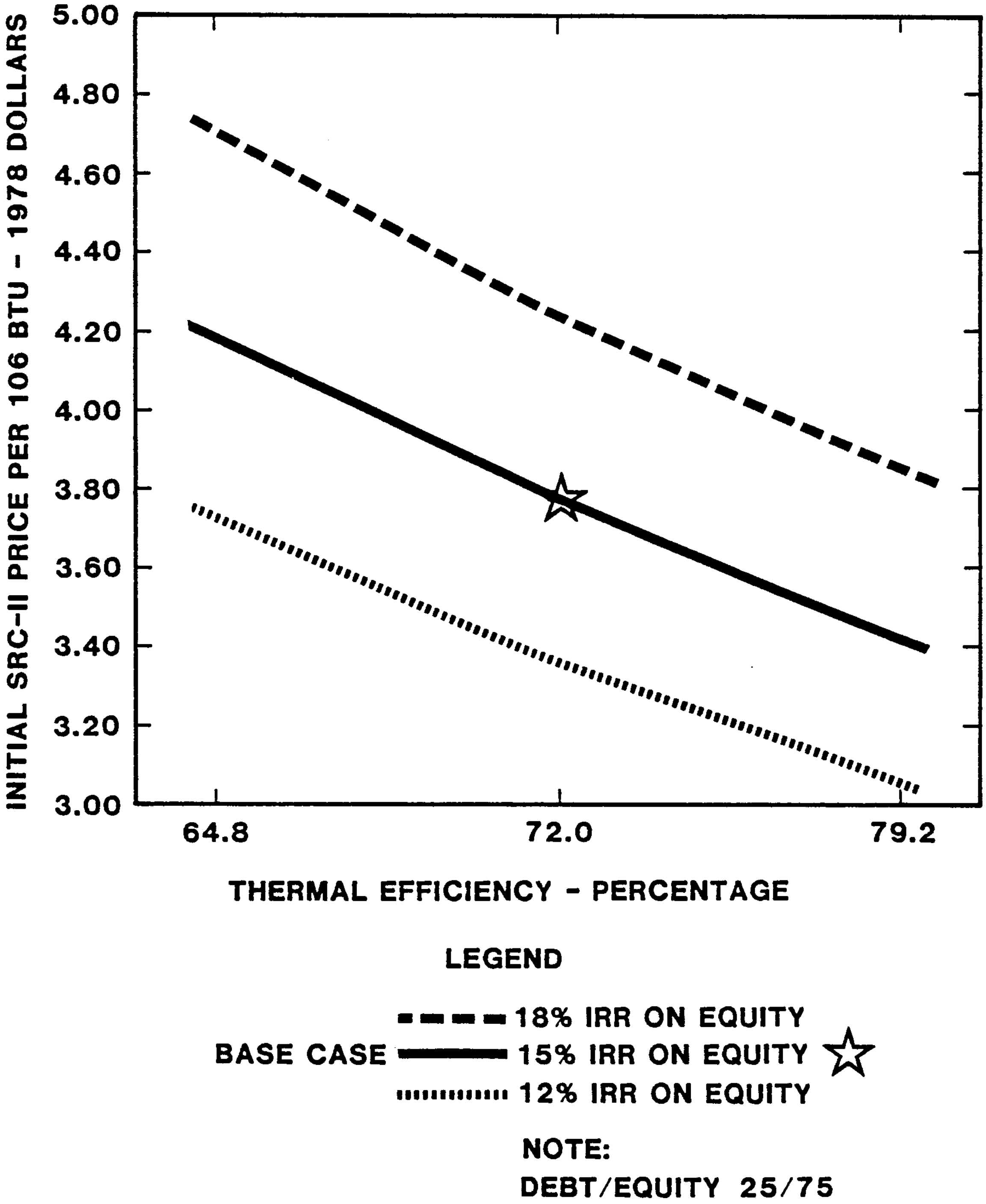


Fig. 3-7. Sensitivity to thermal efficiency

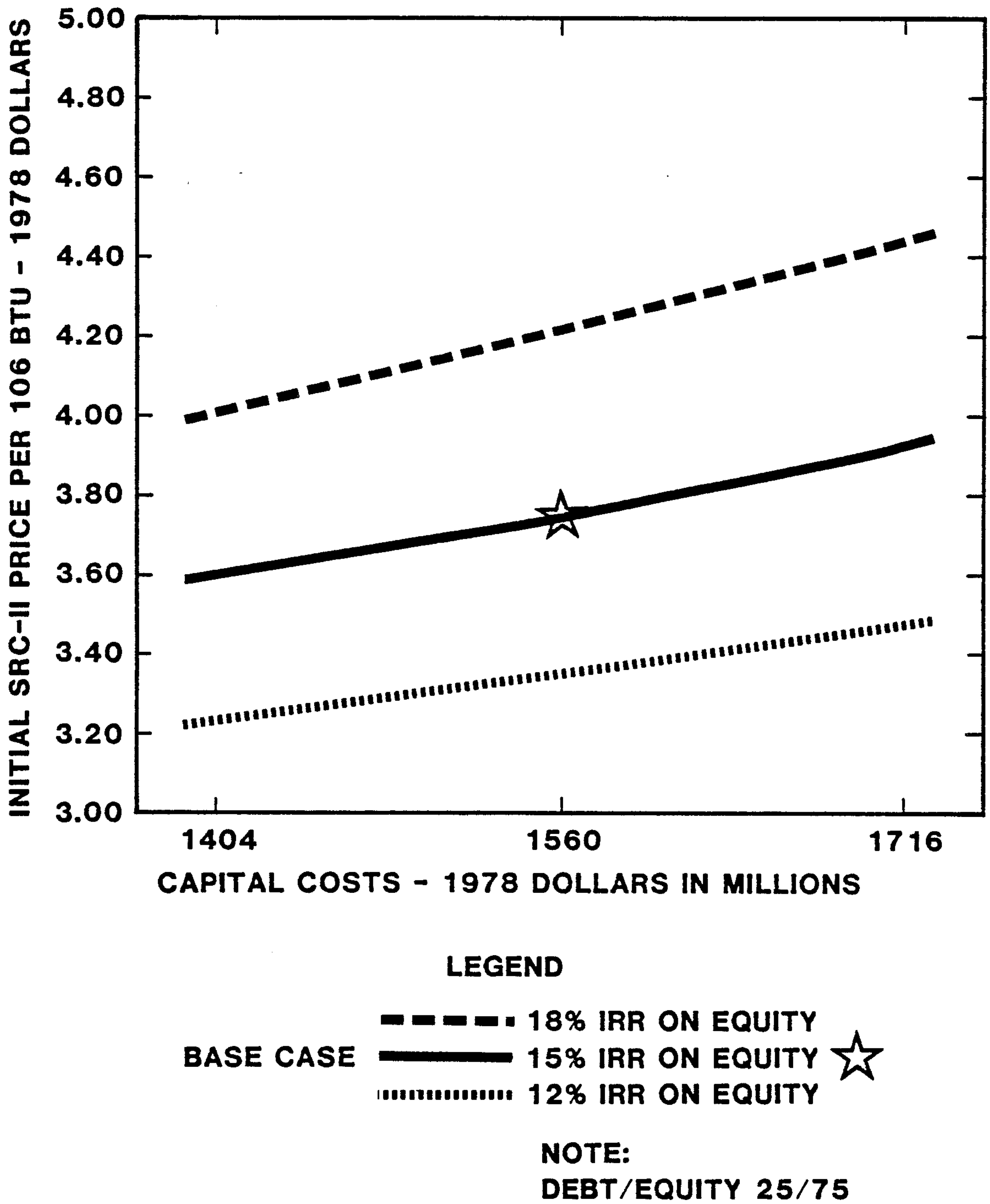


Fig. 3-8. Sensitivity to capital investment

insensitive to deviations in the Operating Cost as is portrayed in Figure 3-9. A 10% change in Operating Cost alters the SRC-II price by only 1.3%.

3.4 COMPARATIVE SENSITIVITIES

Table 3-1 summarizes the relative sensitivities for key variables shown in Figures 3-1 through 3-9. Thermal efficiency has by far the greatest influence on the derived SRC-II price, followed by deviations from the designed plant capacity, capital investment and coal price.

Table 3-2 compares the current-dollar SRC-II price over the 20-year project life for each of the DOE-prescribed sensitivities on the base case.

3.5 EFFECT ON INTERNAL RATE OF RETURN

The above Sensitivity Analysis has examined the impact of different parameters and cost variables on the calculated price of SRC-II fuels. The emphasis has been focused toward the marketplace rather than toward the investor/producer. It has been assumed that the various parameters or variables represented the average SRC-II plant and therefore the derived SRC-II price represented the average or competitive market price available to all.

If the SRC-II price is held constant while the variables are adjusted up or down, the effect on the investors Internal Rate of Return can be seen. This will be a measure of the risk exposure to the investor for failure to build an "average" plant. If this risk exposure is too great, it will ultimately be reflected in the marketplace in the form of higher prices. Conversely, the positive side represents the producer's incentive to do better than average.

To demonstrate the impact on the investor, the SRC-II product price can be fixed at $3.76/MMBTU's, the price determined in the base case. Each of five parameters, Thermal Efficiency, Plant Capacity, Capital

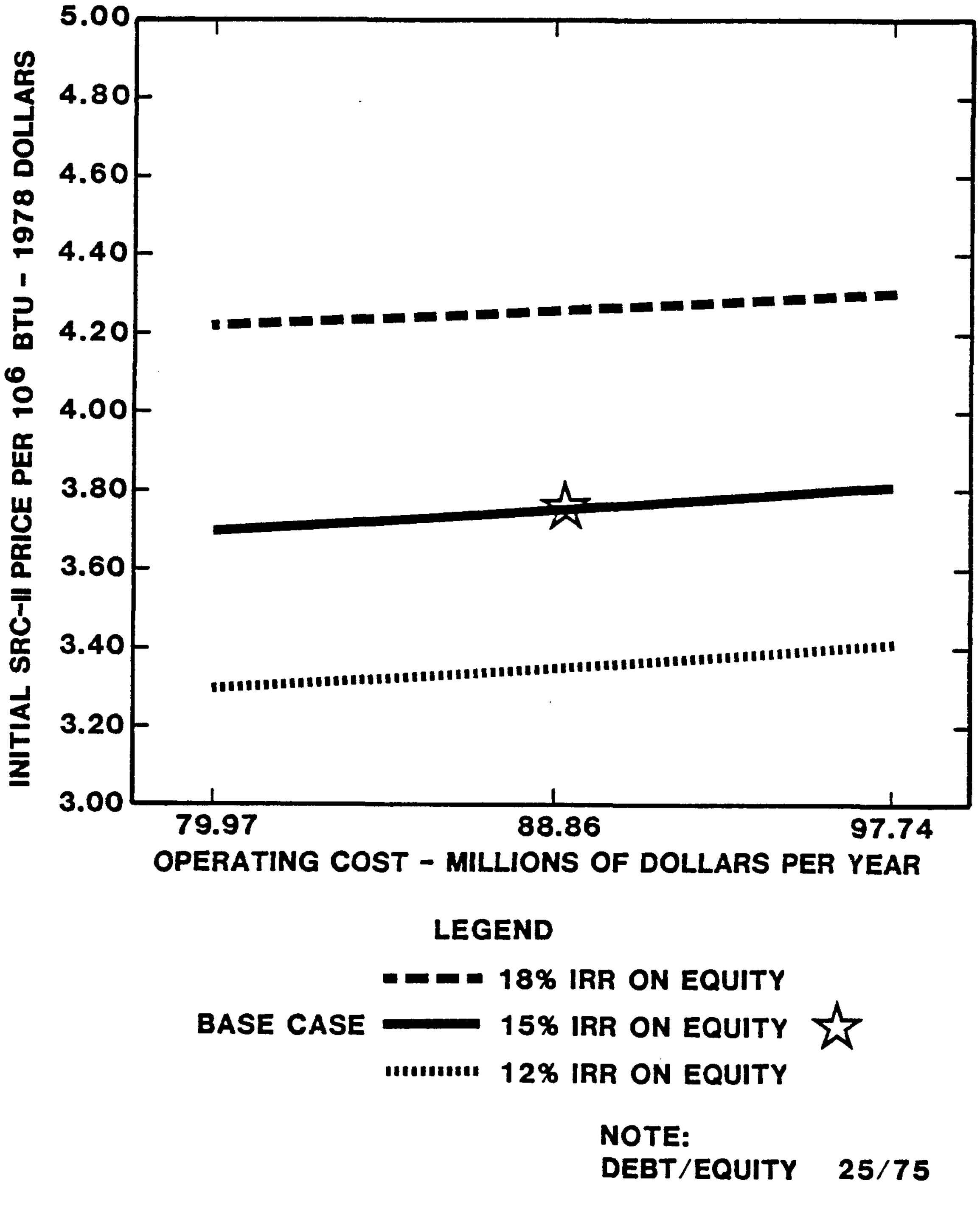


Fig. 3-9. Sensitivity to operating cost

TABLE 3.1

SRC-II SENSITIVITY ANALYSIS

Independent Variable	Figure	Values	Initial SRC Price 1978 $\$/10^6$Btu[2]	Times Interest Earned Ratio	Percent Change In SRC Base Price For 10% Change In Sensitivity Variable
Capital Structure	1, 2	0/100	4.13	--	
(Irron Equity =		25/75[1]	3.76	10.8	
15%)		50/50	3.38	3.8	
		65/35	3.15	2.1	
Internal Rate of	2	12%	3.36		
Return		15%	3.76		
(Debt/Equity =		18%	4.23		
25/75					
Coal Price	3	$\$1.40/10^6$Btu	4.11		--
		$\$1.15/10^6$Btu[1]	3.76		4.0%
		$\$0.90/10^6$Btu	3.42		--
Investment Tax	4	0% ITC	4.02		--
Credit		10% ITC[1]	3.76		0.8%
		20% ITC	3.50		--
Repairs and	5	4% Level	3.93		--
Replacements		2% Level[1]	3.76		0.5%
Plant Capacity	6	90% Level	4.02		--
		100% Level[1]	3.76		6.4%
		110% Level	3.55		--
Thermal	7	64.8% Efficiency	4.18		--
Efficiency		72.0% Efficiency[1]	3.76		10.1%
		79.2% Efficiency	3.42		--
Capital Invest-	8	$1,716 Million	3.93		--
ment		$1,560 Million[1]	3.76		4.4%
		$1,404 Million	3.60		
Depreciation	9	5 yr. life	3.50		--
Life		13 yr. life	3.76		1.1%
Operating Cost	10	$79.97 MM/yr	3.71		--
		88.86 MM/yr	3.76		1.3
		97.74 MM/yr	3.81		--

1 Base Case: Equity Return at 15%, 25/75 Debt-Equity Ratio
2 Initial SRC Price in 1978 Dollars

TABLE 3-2

SENSITIVITY ANALYSIS - YEARLY CURRENT DOLLAR PRICES OF SRC II PRODUCTS

Parameter Changed																	
% Return on Equity	12	12	12	12	15	15	15	15	18	18	18	18	15	15	15	15	15
Debt/Equity Ratio	0/100	25/75	50/50	65/35	0/100	25/75	50/50	65/35	0/100	25/75	50/50	65/35	25/75	25/75	25/75	25/75	25/75
Other Change						BASE CASE							20% INVEST. TAX CREDIT	$0.90/10^6 BTU COAL PRICE	$1.40/10^6 BTU COAL PRICE	5 YEAR DEPREC. PERIOD	4% REPAIRS & REPLACEMENTS
Initial SRC Price in 1978 Dollars	3.59	3.36	3.11	2.96	4.13	3.76	3.38	3.15	4.75	4.23	3.70	3.37	3.50	3.42	4.11	3.50	3.93
Current Price in Year:																	
1988	6.44	6.01	5.57	5.30	7.40	6.74	6.06	5.64	8.51	7.58	6.62	6.04	6.28	6.12	7.36	6.27	7.04
1989	6.64	6.22	5.78	5.51	7.60	6.95	6.27	5.85	8.71	7.78	6.83	6.24	6.48	6.29	7.60	6.47	7.27
1990	6.86	6.44	6.00	5.72	7.82	7.16	6.48	6.07	8.93	8.00	7.05	6.46	6.70	6.47	7.86	6.69	7.50
1991	7.09	6.67	6.23	5.96	8.05	7.40	6.72	6.30	9.16	8.23	7.28	6.69	6.93	6.66	8.13	6.92	7.75
1992	7.34	6.91	6.47	6.20	8.30	7.64	6.96	6.54	9.41	8.48	7.52	6.94	7.18	6.86	8.42	7.17	8.02
1993	7.60	7.17	6.73	6.46	8.56	7.90	7.22	6.80	9.67	8.74	7.78	7.20	7.44	7.07	8.73	7.43	8.30
1994	7.87	7.45	7.01	6.74	8.84	8.18	7.50	7.08	9.94	9.01	8.06	7.47	7.71	7.30	9.06	7.70	8.60
1995	8.17	7.74	7.30	7.03	9.13	8.47	7.79	7.37	10.24	9.31	8.35	7.76	8.01	7.54	9.40	8.00	8.91
1996	8.48	8.05	7.61	7.34	9.44	8.78	8.10	7.68	10.55	9.62	8.66	8.07	8.32	7.79	9.77	8.31	9.25
1997	8.80	8.38	7.94	7.67	9.77	9.11	8.43	8.01	10.87	9.94	8.99	8.40	8.64	8.06	10.15	8.63	9.60
1998	9.15	8.73	8.29	8.02	10.11	9.45	8.78	8.36	11.22	10.29	9.34	8.75	8.99	8.34	10.57	8.98	9.98
1999	9.52	9.10	8.66	8.38	10.48	9.82	9.14	8.73	11.59	10.66	9.71	9.12	9.36	8.65	11.00	9.35	10.38
2000	9.91	9.49	9.05	8.78	10.87	10.21	9.54	9.12	11.98	11.05	10.10	9.51	9.75	8.97	11.46	9.74	10.80
2001	10.33	9.90	9.46	9.19	11.29	10.63	9.95	9.53	12.40	11.47	10.51	9.93	10.17	9.31	11.95	10.16	11.25
2002	10.77	10.34	9.90	9.63	11.73	11.07	10.39	9.97	12.84	11.91	10.95	10.36	10.61	9.67	12.47	10.60	11.73
2003	11.23	10.81	10.37	10.10	12.19	11.53	10.86	10.44	13.30	12.37	11.42	10.83	11.07	10.05	13.02	11.06	12.23
2004	11.72	11.30	10.86	10.59	12.69	12.03	11.35	10.93	13.80	12.87	11.91	11.32	11.57	10.45	13.60	11.56	12.76
2005	12.25	11.82	11.38	11.11	13.21	12.55	11.87	11.45	14.32	13.39	12.43	11.85	12.09	10.88	14.22	12.08	13.33
2006	12.80	12.38	11.94	11.67	13.77	13.11	12.43	12.01	14.87	13.94	12.99	12.40	12.64	11.34	14.88	12.63	13.93
2007	13.39	12.97	12.53	12.26	14.35	13.69	13.02	12.60	15.46	14.53	13.58	12.99	13.23	11.82	15.57	13.22	14.57
Compound Growth Rate, %	3.93	4.13	4.36	4.51	3.55	3.80	4.10	4.32	3.19	3.49	3.85	4.12	4.00	3.52	4.02	4.01	3.90

Investment, Coal Price, and Operating Costs can then be varied plus or minus 10% to find the effect on the Internal Rate of Return on equity. Figure 3-10 shows these results. The base case values of these five parameters are: 72% for Thermal Efficiency, 100% for Design Capacity, $88.9 million/year for Operating Costs, $1,560 million for Direct Capital costs, and $1.15/MMBTU's for Coal Price.

Some parameters have a stronger impact than others, with Thermal Efficiency clearly the strongest. A 10% increase in the thermal efficiency to 79.2% results in a 16.3% increase in the IRR, or a 17.44% return on equity. A 10% increase in the plant capacity to 110% of design results in an IRR of 16.54%, a 10.3% increase. Coal Price is slightly more important than Capital Investment, with Operating Cost having the least impact. A 10% increase in the Operating Cost results in an absolute drop of only 0.33% in the IRR.

3.6 CONCLUSIONS

3.6.1 Cost Of Capital

Sensitivity studies on Thermal Efficiency, Plant Capacity and Capital and Operating Costs as it affects the Internal Rate of Return on the Conceptual Commercial Plant, demonstrates that the first commercial plants will undoubtedly have a higher Cost of Capital because:

A. The technology and plant design will not be as advanced as in later plants and hence, the costs will be greater in constant dollars and the efficiencies lower.

B. The uncertainty as to the improvements that can be made in plant design for each plant will create substantial additional risk for the investor.

Eventually, the cumulative experience should reach a point where each new plant could be similar in design to the last, i.e., the capital and operating costs will have reached their optimum level. At this point,

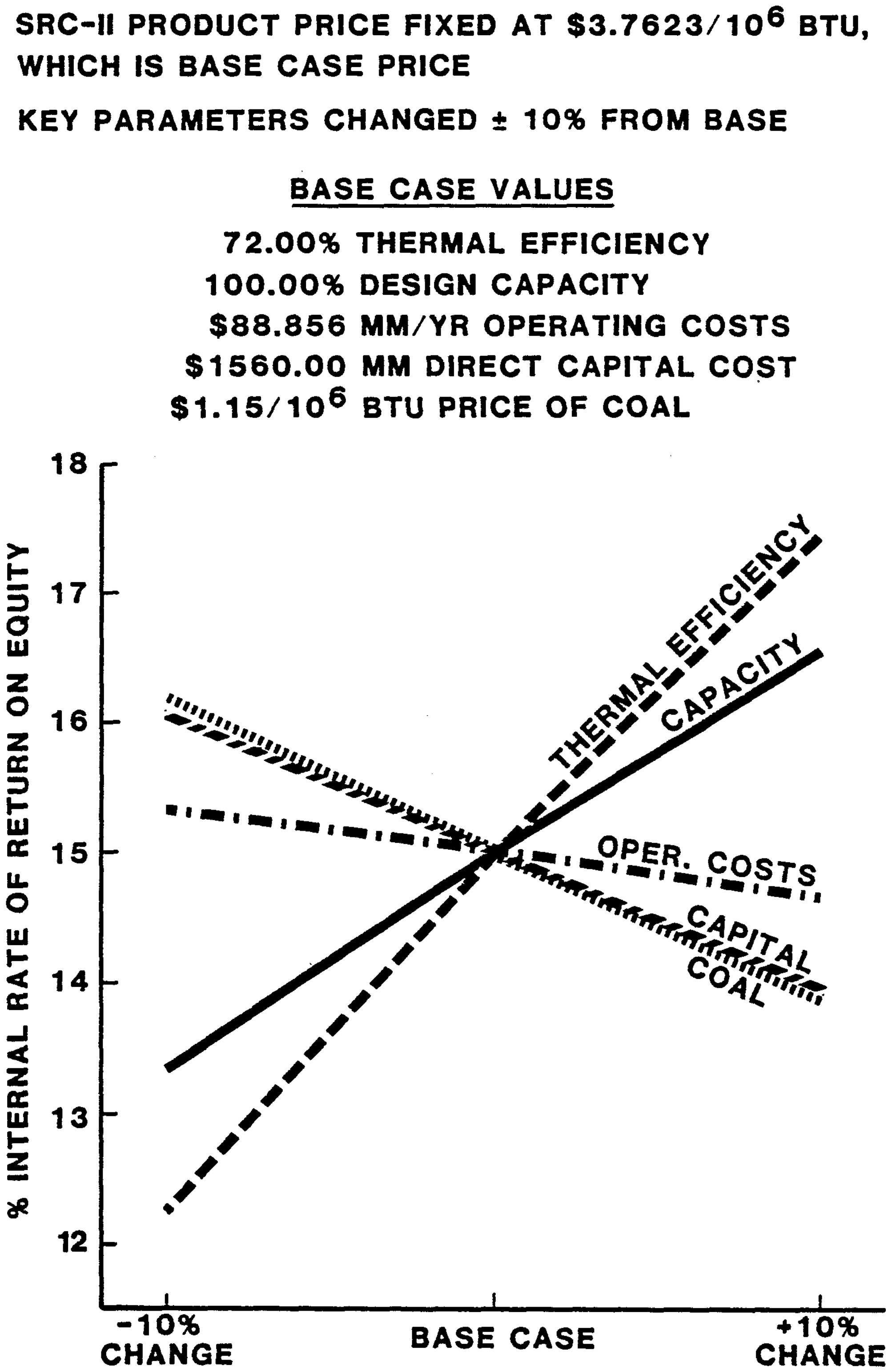


Fig. 3-10. Sensitivity of ROE to changes in key parameters

uncertainty will reach its minimum and the Cost of Capital will approach its riskless value.

Figure 3-11 depicts this concept. If the riskless Cost of Capital were 15%, the Capital Cost under uncertainty might be 18% or more. The curves slope downward from left to right to reflect declining costs and increasing thermal efficiency and operability that should come with experience. The calculated SRC-II price in real terms should follow a path between these two curves (Line E), as the perceived risk for each successive plant declines and competition grows. It is possible that combinations of relatively high capital costs, low thermal efficiency and reduced on-stream time could push the required SRC-II price as high as $5.00/MMBTU for the first plants.

3.6.2 Incentives

For the early plants, the full economic price of SRC-II fuel oil may be higher than that for competing fuels because of the greater capital and operating costs and the greater required Cost of Capital. Government incentives, in the form of Investment Tax Credits, accelerated depreciation or price guarantees, may be used to address the higher-risk aspects of these plants until a combination of accumulated experience and the rising real cost of petroleum make incentives unnecessary. This assumes a market in which the price of imported oil is not reduced by cartel action to make synthetic fuels uneconomical under any circumstances.

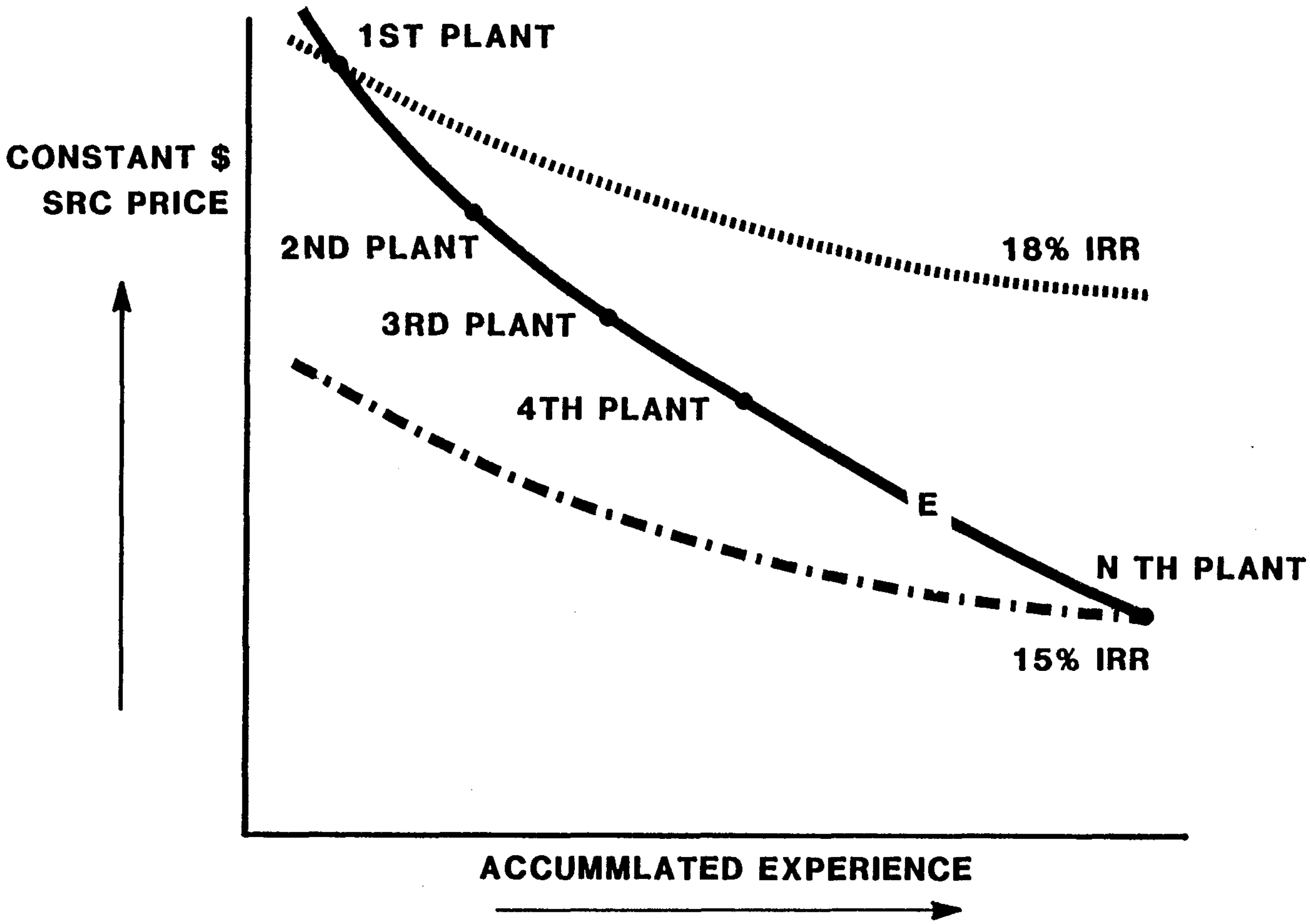


Fig. 3-11. Cumulative experience vs. cost of capital

SECTION 4

ALTERNATE CASE - ETHYLENE AND GASOLINE PRODUCTION

The prime objective of SRC-II process development is to provide a fuel alternative that, in the foreseeable future, could be economically competitive with petroleum products and other coal alternatives in selected applications. SRC-II fuel oil is expected to replace petroleum in markets such as the large East Coast oil-burning utilities where environmentally acceptable utilization of coal is difficult and expensive. By the year 2000, few electric power generation installations will rely on petroleum, so the opportunity for SRC-II fuel oil depends on whether or not it represents the best utilization of coal for a given utility.

The base case analysis indicated that, under the DOE guidelines, the Conceptual Commercial Plant would be economically competitive with petroleum products when the price of petroleum exceeds $22.55/bbl. in 1978 dollars. According to the Sherman H. Clark Associates forecast (Volume 9, Deliverable 9), which appears to be roughly in line with other available external forecasts, this will occur sometime in the mid-1980's. Beyond this time, potential foreign supply restrictions and increased domestic production costs support the assumption that the price of crude could escalate in real dollars up to five to six percent per year. Most energy analysts anticipate that the real cost of coal will increase at a lesser annual rate. Based on the economic evaluation, the cost of SRC-II products could escalate at a lower rate than coal.

The SRC-II process could produce selected products, such as ethane/propane, which can be sold as chemical feedstocks, and naphtha, which could be converted to high-octane unleaded gasoline. These products could have a greater value than their fuel-oil equivalent value on a BTU basis (See Volume 7, Deliverable 9). The particular end-use markets may justify a premium for these as feedstocks or gasoline (due to, for example, location, guaranteed supply, premium quality). The impact of this may be that SRC-II fuel oils in turn could become increasingly more competitive, both as an alternate to petroleum, and with other forms of coal utilization.

In the long run, the competitive impact of many SRC-II coal-liquefaction plants could reduce the real inflation rate of the chemical feedstocks and gasoline products, and bring them more in line with the real cost increases in coal. It is also possible that, as the price differential between the SRC-II fuel oils and petroleum-derived chemical feedstocks and gasoline magnifies, this differential may reach a level that would allow economic conversion of increasingly greater portions of the fuel-oil-range products into transporation and aviation products.

Two potential chemical feedstock scenarios are analyzed below, using the upgrading of ethane/propane example:

A. <u>The price of the chemical feedstocks maintain a fixed premium over their petroleum-based counterparts</u>. In this scenario, chemical feedstocks would increase in price in direct proportion to petroleum price increases. To define the value of the chemical feedstocks, a crude oil price of $22.55/bbl ($3.76/MMBTU, the same as that derived for the base-case plant in Section 2) has been assumed. The derived ethane/propane transfer price is $5.19/MMBTU's based on analysis in Deliverable 9, Volume 7, Section 2. There is a resulting potentially positive benefit to the other SRC-II product prices of about 10% initially.

Case A is portrayed in Figure 4-1. Ethane and propane would continued to maintain a premium over petroleum prices as chemical feedstocks. SRC-II would be expected to experience less constant-dollar price escalation than petroleum. Because of the premium obtained for ethane and propane, the calculated price for other SRC-II products could maintain the required return at a lower level of constant-dollar price escalation.

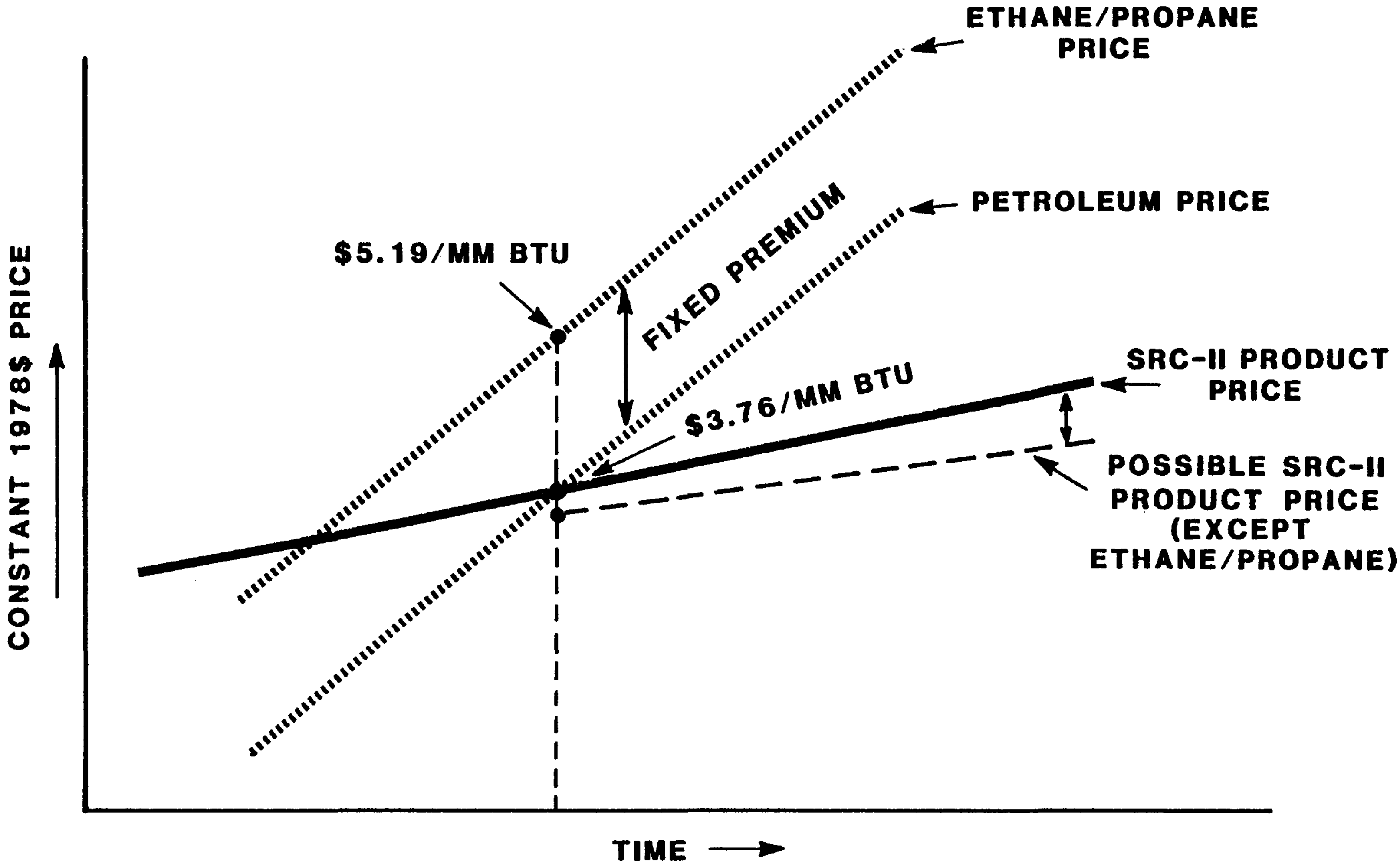


Fig. 4-1. Case A - Ethane/propane maintain fixed premium above petroleum

B. <u>The price of the chemicals feedstock maintains a fixed premium over the basic SRC-II fuel oils price</u>. This ratio was derived by comparing the $5.19/MMBTU price that could be achievable for ethane and propane as a chemical feedstock, versus the $3.76/MMBTU price derived in the base case for SRC-II fuel oil. Case B implies that the ethane/propane price would not follow petroleum prices but that prices of both the ethane/ propane and the SRC-II fuel oil would increase together in a fixed ratio, as coal and capital costs experience real inflationary increases. In effect, therefore, the 38% premium obtainable by ethane and propane is distributed evenly through out the SRC-II product line, resulting in a net potential benefit of 7.7% on all products. Case B is illustrated in Figure 4-2.

The only difference that appears in the SRC-II Earnings Statement between the two chemical feedstock cases and the base case is in the revenue breakdown. The total revenue stays the same. Tables 4-1 and 4-2 reproduce the SRC-II Earning Statements showing the revenue split for cases A and B, respectively.

If, instead of lowering the price of part or all of the SRC-II product line, the entire benefit of the higher value received for ethane/propane were to accrue to the investor, the Internal Rate of Return on equity would be 17% instead of the 15% calculated for the base case.

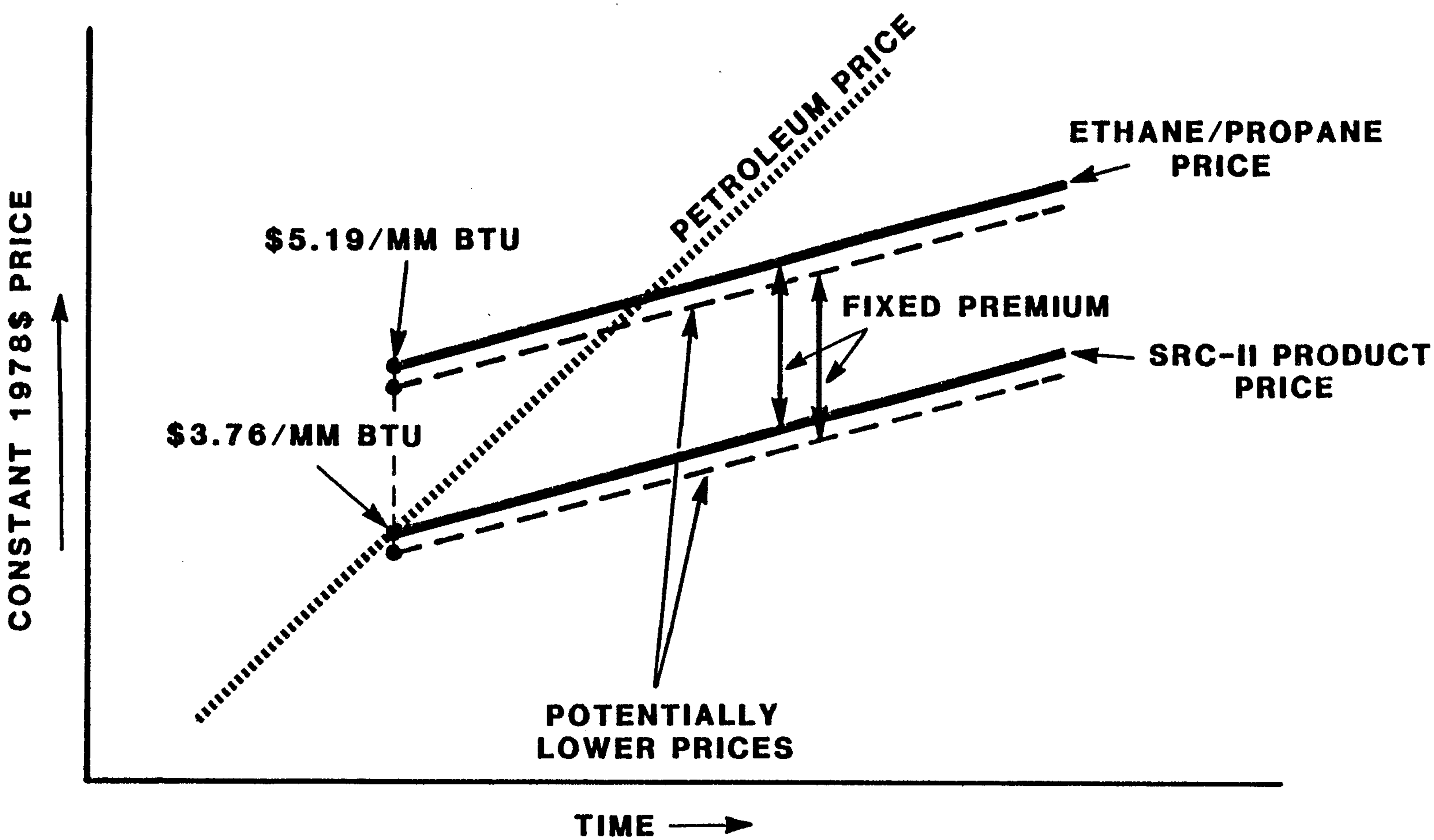


Fig. 4-2. Case B - Ethane/propane maintain fixed premium above other SRC-II product prices

TABLE 4-1 (SHEET 1 OF 3)

SRC EARNINGS STATEMENT

ETHYLENE & GASOLINE PRODUCTION ALTERNATIVE - CASE A

YEAR	1983 -4	1984 -3	1985 -2	1986 -1	1987 0	1988 1	1989 2	1990 3	1991 4
UNIT SALES IN (MM)(MM)BTU						112.55	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU						6.08	6.26	6.46	6.67
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE						543.79	1008.77	1040.51	1074.15
CO PRODUCT REVENUE						214.55	398.00	410.52	423.80
BY PRODUCT REVENUE						29.71	56.69	60.09	63.69
TOTAL REVENUE						788.05	1463.46	1511.12	1561.64
COAL COST						321.05	612.56	649.31	688.27
OTHER OPERATING COSTS	0.37	0.50	0.93	3.30	10.61	171.48	181.77	192.68	204.24
GROSS MARGIN	-0.37	-0.50	-0.93	-3.30	-10.61	295.52	669.13	669.13	669.13
DEPRECIATION						386.60	327.13	276.80	234.22
INTEREST EXPENSE	1.20	4.70	14.23	31.76	49.20	54.95	52.13	49.31	46.49
EARNINGS BEFORE TAXES	-1.58	-5.20	-15.16	-35.06	-59.81	-146.03	289.87	343.01	388.42
FEDERAL INCOME TAX	-0.79	-2.60	-7.58	-17.53	-29.91	-73.02	144.93	171.51	194.21
EARNINGS AFTER TAXES	-0.79	-2.60	-7.58	-17.53	-29.91	-73.02	144.93	171.51	194.21
CHANGE IN WORKING CAPITAL					174.28				
DEPRECIATION						386.60	327.13	276.80	234.22
CAPITAL INVESTMENT	107.10	203.80	643.07	914.92	635.87				
NEW DEBT	26.77	50.95	160.77	228.73	158.97				
DEBT REPAYMENT						31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	-80.32	-152.85	-482.30	-686.19	-476.91	282.28	440.75	417.00	397.11
CUM. EQUITY NET CASH FLOW	-80.32	-233.17	-715.48	-1401.67	-1878.57	-1596.29	-1155.54	-738.54	-341.43
REMAINING OUTSTANDING DEBT	26.77	77.72	238.49	467.22	626.19	594.88	563.57	532.26	500.95

TABLE 4-1 (SHEET 2 OF 3)

SRC EARNINGS STATEMENT

ETHYLENE & GASOLINE PRODUCTION ALTERNATIVE - CASE A

YEAR	1992 5	1993 6	1994 7	1995 8	1996 9	1997 10	1998 11	1999 12	2000 13
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	6.89	7.12	7.37	7.64	7.92	8.21	8.53	8.86	9.21
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE	1109.81	1147.60	1187.67	1230.14	1275.16	1322.68	1373.46	1427.08	1483.92
CO PRODUCT REVENUE	437.87	452.78	468.59	485.34	503.11	521.93	541.89	563.05	585.47
BY PRODUCT REVENUE	67.51	71.57	75.86	80.41	85.24	90.35	95.77	101.52	107.61
TOTAL REVENUE	1615.19	1671.95	1732.12	1795.90	1863.50	1935.16	2011.12	2091.64	2176.99
COAL COST	729.57	773.34	819.74	868.92	921.06	976.32	1034.90	1096.99	1162.81
OTHER OPERATING COSTS	216.49	229.48	243.25	257.85	273.32	289.71	307.10	325.52	345.05
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
INTEREST EXPENSE	43.68	40.86	38.04	35.22	32.41	29.59	26.77	23.95	21.13
EARNINGS BEFORE TAXES	427.27	460.57	489.19	503.83	506.65	509.47	512.29	515.10	517.92
FEDERAL INCOME TAX	213.63	230.29	244.60	251.92	253.33	254.73	256.14	257.55	258.96
EARNINGS AFTER TAXES	213.63	230.29	244.60	251.92	253.33	254.73	256.14	257.55	258.96
CHANGE IN WORKING CAPITAL									
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
CAPITAL INVESTMENT									
NEW DEBT									
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	380.51	366.67	355.18	350.68	352.09	353.49	354.90	356.31	357.72
CUM. EQUITY NET CASH FLOW	39.08	405.75	760.93	1111.60	1463.69	1817.18	2172.09	2528.40	2886.12
REMAINING OUTSTANDING DEBT	469.64	438.33	407.02	375.71	344.41	313.10	281.79	250.48	219.17

TABLE 4-1 (SHEET 3 OF 3)

SRC EARNINGS STATEMENT

ETHYLENE & GASOLINE PRODUCTION ALTERNATIVE - CASE A

YEAR	2001 14	2002 15	2003 16	2004 17	2005 18	2006 19	2007 20
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	9.59	9.98	10.40	10.85	11.32	11.82	12.35
EARNINGS STATEMENT (MM)$							
SRC FUEL REVENUE	1544.16	1608.02	1675.71	1747.47	1823.52	1904.15	1989.60
CO PRODUCT REVENUE	609.24	634.43	661.14	689.45	719.46	751.27	784.99
BY PRODUCT REVENUE	114.06	120.91	128.16	135.85	144.00	152.64	161.80
TOTAL REVENUE	2267.46	2363.36	2465.02	2572.77	2686.99	2808.06	2936.39
COAL COST	1232.58	1306.53	1384.93	1468.02	1556.10	1649.47	1748.43
OTHER OPERATING COSTS	365.76	387.70	410.96	435.62	461.76	489.46	518.83
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION							
INTEREST EXPENSE	18.32	15.50	12.68	9.86	7.04	4.23	1.41
EARNINGS BEFORE TAXES	650.81	653.63	656.45	659.26	662.08	664.90	667.72
FEDERAL INCOME TAX	325.41	326.81	328.22	329.63	331.04	332.45	333.86
EARNINGS AFTER TAXES	325.41	326.81	328.22	329.63	331.04	332.45	333.86
CHANGE IN WORKING CAPITAL							
DEPRECIATION							
CAPITAL INVESTMENT							
NEW DEBT							
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	294.10	295.50	296.91	298.32	299.73	301.14	487.27
CUM. EQUITY NET CASH FLOW	3180.22	3475.72	3772.63	4070.96	4370.69	4671.82	5159.09
REMAINING OUTSTANDING DEBT	187.86	156.55	125.24	93.93	62.62	31.31	

TABLE 4-2 (SHEET 1 OF 3)

SRC EARNINGS STATEMENT

ETHYLENE & GASOLINE PRODUCTION ALTERNATIVE - CASE B

YEAR	1983 -4	1984 -3	1985 -2	1986 -1	1987 0	1988 1	1989 2	1990 3	1991 4
UNIT SALES IN (MM)(MM)BTU						112.55	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU						6.25	6.44	6.64	6.86
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE						559.34	1037.61	1070.25	1104.86
CO PRODUCT REVENUE						199.01	369.17	380.78	393.09
BY PRODUCT REVENUE						29.71	56.69	60.09	63.69
TOTAL REVENUE						788.06	1463.46	1511.12	1561.64
COAL COST						321.05	612.56	649.31	688.27
OTHER OPERATING COSTS	0.37	0.50	0.93	3.30	10.61	171.48	181.77	192.68	204.24
GROSS MARGIN	-0.37	-0.50	-0.93	-3.30	-10.61	295.53	669.13	669.13	669.13
DEPRECIATION						386.60	327.13	276.60	234.22
INTEREST EXPENSE	1.20	4.70	14.23	31.76	49.20	54.95	52.13	49.31	46.49
EARNINGS BEFORE TAXES	-1.58	-5.20	-15.16	-35.06	-59.81	-146.03	289.68	343.02	388.42
FEDERAL INCOME TAX	-0.79	-2.60	-7.58	-17.53	-29.91	-73.01	144.94	171.51	194.21
EARNINGS AFTER TAXES	-0.79	-2.60	-7.58	-17.53	-29.91	-73.01	144.94	171.51	194.21
CHANGE IN WORKING CAPITAL					174.28				
DEPRECIATION						386.60	327.13	276.60	234.22
CAPITAL INVESTMENT	107.10	203.80	643.07	914.92	635.87				
NEW DEBT	26.77	50.95	160.77	228.73	156.97				
DEBT REPAYMENT						31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	-80.32	-152.85	-482.30	-686.19	-476.91	282.28	440.75	417.00	397.12
CUM. EQUITY NET CASH FLOW	-80.32	-233.17	-715.48	-1401.67	-1878.57	-1596.29	-1155.54	-738.54	-341.42
REMAINING OUTSTANDING DEBT	26.77	77.72	238.49	467.22	626.19	594.88	563.57	532.26	500.95

TABLE 4-2 (SHEET 2 OF 3)

SRC EARNINGS STATEMENT

ETHYLENE & GASOLINE PRODUCTION ALTERNATIVE - CASE B

YEAR	1992 5	1993 6	1994 7	1995 8	1996 9	1997 10	1998 11	1999 12	2000 13
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	7.09	7.33	7.58	7.85	8.14	8.45	8.77	9.11	9.48
EARNINGS STATEMENT (MM)$									
SRC FUEL REVENUE	1141.54	1180.42	1221.63	1265.31	1311.62	1360.70	1412.73	1467.88	1526.34
CO PRODUCT REVENUE	406.14	419.97	434.64	450.18	466.65	484.12	502.63	522.25	543.05
BY PRODUCT REVENUE	67.51	71.57	75.86	80.41	85.24	90.35	95.77	101.52	107.61
TOTAL REVENUE	1615.19	1671.95	1732.12	1795.90	1863.51	1935.17	2011.13	2091.65	2177.00
COAL COST	729.57	773.34	819.74	868.92	921.06	976.32	1034.90	1096.99	1162.81
OTHER OPERATING COSTS	216.49	229.48	243.25	257.85	273.32	289.71	307.10	325.52	345.05
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
INTEREST EXPENSE	43.68	40.86	38.04	35.22	32.41	29.59	26.77	23.95	21.13
EARNINGS BEFORE TAXES	427.27	460.58	489.20	503.84	506.66	509.48	512.29	515.11	517.93
FEDERAL INCOME TAX	213.64	230.29	244.60	251.92	253.33	254.74	256.15	257.56	258.96
EARNINGS AFTER TAXES	213.64	230.29	244.60	251.92	253.33	254.74	256.15	257.56	258.96
CHANGE IN WORKING CAPITAL									
DEPRECIATION	198.18	167.69	141.89	130.07	130.07	130.07	130.07	130.07	130.07
CAPITAL INVESTMENT									
NEW DEBT									
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	380.51	366.67	355.18	350.68	352.09	353.50	354.91	356.32	357.72
CUM. EQUITY NET CASH FLOW	39.09	405.76	760.94	1111.62	1463.71	1817.21	2172.11	2528.43	2886.15
REMAINING OUTSTANDING DEBT	469.64	438.33	407.02	375.71	344.41	313.10	281.79	250.48	219.17

TABLE 4-2 (SHEET 3 OF 3)

SRC EARNINGS STATEMENT

ETHYLENE & GASOLINE PRODUCTION ALTERNATIVE - CASE B

YEAR	2001 14	2002 15	2003 16	2004 17	2005 18	2006 19	2007 20
UNIT SALES IN (MM)(MM)BTU	202.60	202.60	202.60	202.60	202.60	202.60	202.60
UNIT PRICE $/(MM)BTU	9.86	10.27	10.70	11.16	11.64	12.16	12.70
EARNINGS STATEMENT (MM)$							
SRC FUEL REVENUE	1588.31	1653.99	1723.62	1797.43	1875.66	1958.59	2046.49
CO PRODUCT REVENUE	565.10	588.47	613.24	639.50	667.33	696.84	728.11
BY PRODUCT REVENUE	114.06	120.91	128.16	135.85	144.00	152.64	161.80
TOTAL REVENUE	2267.47	2363.37	2465.02	2572.77	2686.99	2808.06	2936.40
COAL COST	1232.58	1306.53	1384.93	1468.02	1556.10	1649.47	1748.43
OTHER OPERATING COSTS	365.76	387.70	410.96	435.62	461.76	489.46	518.83
GROSS MARGIN	669.13	669.13	669.13	669.13	669.13	669.13	669.13
DEPRECIATION							
INTEREST EXPENSE	18.32	15.50	12.68	9.86	7.04	4.23	1.41
EARNINGS BEFORE TAXES	650.82	653.63	656.45	659.27	662.09	664.91	667.72
FEDERAL INCOME TAX	325.41	326.82	328.23	329.64	331.04	332.45	333.86
EARNINGS AFTER TAXES	325.41	326.82	328.23	329.64	331.04	332.45	333.86
CHANGE IN WORKING CAPITAL							
DEPRECIATION							
CAPITAL INVESTMENT							
NEW DEBT							
DEBT REPAYMENT	31.31	31.31	31.31	31.31	31.31	31.31	31.31
NET CASH FLOW TO EQUITY	294.10	295.51	296.92	298.33	299.73	301.14	487.27
CUM. EQUITY NET CASH FLOW	3180.25	3475.76	3772.68	4071.00	4370.73	4671.88	5159.15
REMAINING OUTSTANDING DEBT	187.86	156.55	125.24	93.93	62.62	31.31	

SECTION 5
EXPLANATION OF PARAMETERS & ASSUMPTIONS

5.1 PARAMETER - DOE

The DOE-specified parameters for the Conceptual Commercial Plant, as covered in Appendix A, are generally straightforward with the exception of Inflation, Contingency, Working Capital, Operating Losses, and Interest during construction, which are discussed further.

5.1.1 Summary of Key Assumptions

Figure 5-1 correlates the parameters listed above with the project schedule dates. The top diagram depicts the procedure for determining the DOE-specified cost-pass-through basis for the SRC-II price inflation. Six percent inflation is applied to the year-end 1978 SRC-II price for the five pre-construction years and five contruction years to arrive at year-end 1988 SRC-II price. This price is applied to the entire year's production in 1988. Note that because the inflation factor is applied to the year-end price, the phases in the inflation diagram appear to slip one year into the next phase of the project.

The middle diagram indicates timing of Revenues and the point at which Working Capital is added. The third diagram shows debt build-up and repayment, the period during which interest is borrowed, and the time frames for positive and negative earnings and cash flows. All three diagrams are drawn to the same time scale and can be directly compared.

5.1.2 DOE-Prescribed Method of Determining Price Escalation

The DOE has directed that for this analysis, six percent inflation is applied to all Costs, including those of coal, capital, and operations and overhead. The deflation index to develop constant-dollar values is also 6%.

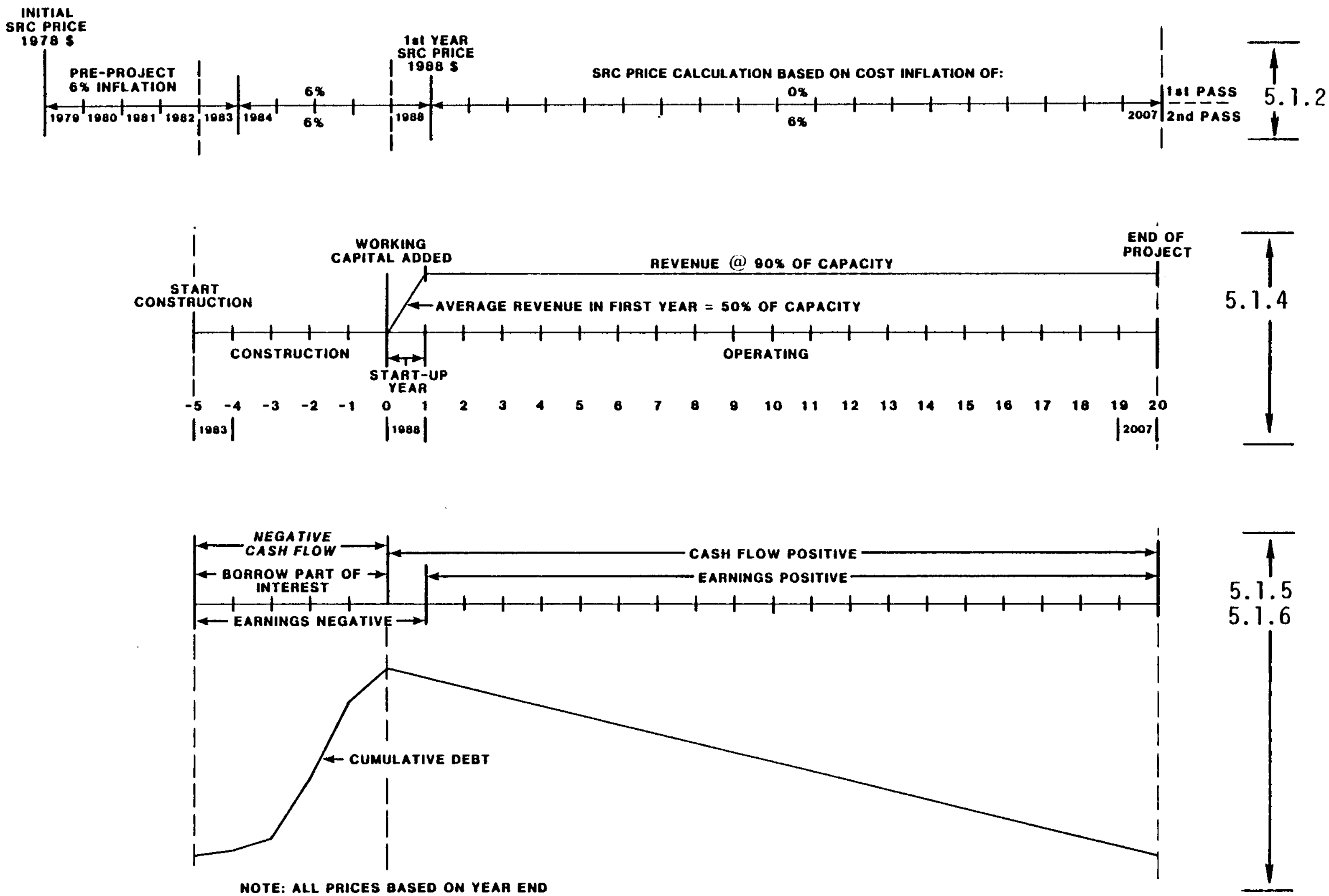


Fig. 5-1. Key assumption diagram

In calculating the income and cash flow streams under inflation, DOE has specified that the price of SRC-II products would increase only at a rate sufficient to maintain the cash flows previously derived assuming no inflation after start-up (the base case). This would be equivalent to strict pass-through of cost increases with no provision for inflating margins. Under this method, general inflation at 6% is assumed prior to and during the construction period. A constant-dollar SRC-II price is calculated in 1988 dollars which will provide a 15% Internal Rate of Return on equity. A 6% inflation factor is then applied from 1988 to 2007 to the Operating, G&A and Coal Expenses. The annual revenue (and corresponding SRC-II price) is adjusted to maintain the same annual net cash flow to equity, after repayment of debt, that was derived without inflation during the operating phase.

As a result of this process, under 6% inflation, the cash flows will yield 15% Internal Rate of Return on equity in current dollars. The real IRR in constant dollars is slightly under 9%. Using this process, the real, constant-dollar IRR would decline as higher rates of inflation were encountered. This is unrealistic in view of the necessity of maintaining return on investment under inflation.

5.1.3 Contingency

A 20% contingency allowance is applied to all Capital and Direct Operating Costs Estimates, but is not applied to Plant Overhead and G&A Expenses. It is assumed that these would be similar to known expenses for a refinery of similar size.

At the conceptual level of engineering in the plant design, it is not possible to accurately account for all capital and operating costs. The 20% contingency is an allowance for probable omissions.

5.1.4 Working Capital

Working Capital is added as a single sum just prior to plant start-up. Sufficient Working Capital is provided to cover all Inventory requirements, Cash, Accounts Receivable, and Accounts Payable. Inventory is expressed in 1987 dollars and everything else in 1988 dollars. Under the assumption of LIFO accounting, no additional inventory investment would be recorded throughout the life of the project since the level of actual inventory products would not change.

Cash is one month's normal operating payroll discounted back to 1988 dollars. Accounts Payable is one month's normal operating volume of purchases of coal, operating supplies, maintenance materials, catalysts and chemicals, and office supplies, all expressed in 1988 dollars. Accounts Receivable consists of two elements: by-product revenue and revenue from sale of fuel products. The volumes in both cases are taken from those which occur during a normal operating year. Normal operating years are considered to be 1989 and beyond; 1988 being the year of start-up.

In effect, Cash, Accounts Receivable, and Accounts Payable are added prior to start-up, but will not be fully employed until the first full year of operation, i.e, the second operating year. This increases the derived SRC-II price slightly. On the other hand, during an inflationary period, increments of Cash, Accounts Receivable, and Accounts Payable would be added in each operating year as Revenue, Payroll, and Supply Expense increase with inflation. The fact that this has not been done for the purposes of this economic analysis tends to result in a lower derived SRC-II price. The net effect is a slight increase in the derived SRC-II price over what would be expected had the Working Capital elements been added in a pattern more closely representing actual experience.

5.1.5 Operating Losses

For tax purposes, it has been assumed that the SRC-II plant is a division of a parent corporation. Hence, operating losses incurred during and after construction are written off against other income of the parent corporation. This reduces any losses on the books of the SRC-II plant by the extent of tax savings realized. This reduction in cash flow requirements results in a lower derived SRC-II price than the case where losses are carried forward.

5.1.6 Interest During Construction

The interest on debt and other pre-start-up expenses incurred during the construction period are treated as Capital Expenditures for determining the total amount of debt. In other words, during the construction period, for a debt/equity ratio of 25%/75%, 25% of the interest expense is added to debt, which in turn increases the interest again, etc. This results in a very complex interest formula which is to be applied during the construction period only. The formula is shown on page A-13 of Appendix A of this volume. Sufficient cash flow is maintained during all operating years to provide repayment of the debt.

5.2 KEY DESIGN PARAMETERS

Assumptions which were not specified by DOE include the Electric Power Conversion Factor, Indirect Capital Cost, Heat Content of Coal, Thermal Efficiency, Coal Feed, and Transportation Costs.

5.2.1 Electric Power Conversion

Kilowatts of electricity are converted into BTU's at the rate of 9,500 BTU's per kilowatt-hour. This conversion rate is normally achievable in converting coal into kilowatts of power. Use of this conversion rate implies comparable efficiency between internally and externally generated power.

The economic analysis is concerned only with the cost of coal and electrical power as inputs and the value of the product slate obtained. Thus, reported efficiency (BTU's-in divided by BTU's-out) drops out of the economic equation. An increase in thermal efficiency would be reflected in the economic analysis as increased output for the same input cost.

5.2.2 Indirect Capital Cost

Construction management costs are estimated to be $8 million over the five-year construction period. Included in the last year of construction is $15 million for miscellaneous start-up costs representing equipment shake-down. (Pre-start-up expenses for technical service, administration, training, etc., are included in G&A expenses during the construction period and are expensed rather than capitalized.) Also included are $1,175,000 for license fees and $23,535,000 for the initial charge of catalyst and chemicals as part of total Capital Costs.

5.2.3 Heat Content of Coal

For a specified tonnage of coal throughput, the BTU content of the coal will affect only the amount of product yields. The Coal Price per million BTU's was specified by DOE. Thus the cost of the coal is not affected by differing BTU values. (In actual practice, however, the price paid for coal is influenced by a number of factors other than BTU content.) Other things being equal, the higher the BTU content of the coal, the more throughput for a given amount of capital.

The design basis for the Conceptual Commercial Plant is Powhatan coal with the BTU content of 12,813 BTU's per pound.

5.2.4 Thermal Efficiency

The plant thermal efficiency used for the economic analysis was 72%. The Conceptual Commercial Plant Design (Volume 2) shows a plant thermal efficiency of 71.358%. This Conceptual Design description states that it is reasonable to expect that an absolute increase in efficiency from 1 to 1½% can be obtained by some process changes and engineering optimization.

5.2.5 Coal Feed

All of the economic analysis is based upon the coal-feed rate specified by DOE, which is 33,333 tons per stream-day instead of the 33,500 tons per stream-day shown in the Conceptual Commercial Plant Design (Deliverable 8, Volume 2).

5.2.6 Transportation Cost

Transportation costs have not been included in this economic analysis. Transportation costs to the end user, depending on distance and mode of shipment, could range up to $3.00/bbl to major East Coast customers.

5.3 OTHER DOE-SPECIFIED PARAMETERS

Some additional clarification is warranted as to how the following parameters were handled.

5.3.1 G&A Expense

G&A expense was provided by the DOE in the form of a percentage of operating and maintenance labor. This includes a plant manager and staff (technical services, human resources, etc.) as well as allocated charges for services provided at the Corporate Headquarters (Legal, Auditing, Tax Management, etc.). It also includes office supplies. This percentage was originally calculated by developing a detailed list of personnel required and estimating the amount of the Corporate overhead charges.

5.3.2 Property Taxes and Insurance

Property taxes and insurance have been included in Direct Costs for this analysis rather than in G&A to maintain consistency between the G&A account and the DOE specifications.

5.3.3 Coal Expense

Coal expense is a major factor in this analysis. Originally, the DOE specified price was $1.00/MMBTU. In April 1979, DOE increased the coal price to $1.15/MMBTU's. This change resulted in an increase of 20¢/MMBTU's in the derived SRC-II price.

Coal was assumed to increase in price at the assumed rate of inflation. While coal is governed by different supply-demand factors than petroleum, it is reasonable to expect that supply constraints, caused by Federal regulations, the inability of the transportation system to handle increases in coal movements, etc., may result in some appreciation in the coal price in real terms.

5.3.4 Residual Value

The plant is assumed to have a 20-year operating life with no residual value. Maintenance and repairs are expensed in the current year. There is no capital replacement after the start-up; therefore, the plant is fully depreciated after thirteen years.

5.4 FOOTNOTES TO DOE-SPECIFIED PARAMETERS

5.4.1 Direct Operating Capital During Construction

The DOE-specified parameters did not allow for any direct operating costs during construction to cover the training of operating personnel. It would be appropriate to include 6% of a normal year's operating cost in the fourth year of construction, and 13% in the fifth (last) year. This would add about 2¢/MMBTU to the derived SRC-II price.

5.4.2 Working Capital

Adding some elements of Working Capital prior to start-up that would not be fully employed until the second year of operation (first year of full production), is inconsistent with actual industry practice.

Cash, Accounts Receivable, and Accounts Payable would normally build up with the level of operation and would continue to increase with inflating costs and revenues. Inventory is appropriately added prior to start-up and would not increase with inflation under LIFO accounting methods.

5.4.3 Capital Repairs

Under the DOE guidelines, no capital repairs are considered. The plant is fully depreciated at the end of thirteen years and has no residual value at the end of twenty years. Normally, a plant of this type would have an indefinite life as capital replacements and improvements were made. Some of the cash flow would be plowed back to cover these capital improvements and replacements, and by the latter half of the project, depreciation from additions to capital would nearly offset declining depreciation from older equipment.

5.5 AREAS OF EXCEPTION

There are two key areas where the prescribed methodology is not consistant with normal industry practice.

5.5.1 Inflation of SRC-II Price

As demonstrated in the economic analysis, the DOE-specified method for inflating the SRC-II price results in an erosion of the constant-dollar earnings and cash flows. The Internal Rate of Return would decline about one percentage point for every percentage point increase in the inflation rate.

Review of industry practice indicates that during inflationary periods, most firms will attempt, insofar as the market allows, to increase prices at a rate that at least partially offsets the decline in the real return on investment. This is necessary to avoid erosion of capital and to generate funds for replacement of equipment at the inflated prices.

5.5.2 Leveraged Economics

In practice, it is a well-accepted principle that the investment decision should be separated from the financing decision. This practice is followed by most large companies, particularly with projects of this magnitude. Since the parent corporation is assuming all responsibility for the debt, it has in fact taken additional risks in borrowing part of the capital, and accordingly the benefits of leverage should accrue to it. Leveraged economics are therefore not appropriate for project evaluation, particularly if high levels of debt are employed, unless two criteria are met:

a. The project is not reflected on the parent corporation's consolidated balance sheet;

b. The project debt is payable solely out of project revenues and initial capital contributions, i.e., the debt is truly non-recourse to the corporation.

On the basis of existing knowledge of future SRC-II technology, it is highly unlikely that non-recourse financing will be be available for initial commercial development. Thus, the minimum acceptable Internal Rate of Return should be based on the Cost of Capital which includes the cost of debt financing at an industry-average level, and some adjustment for risk and inflation. This IRR should be applied to the total investment, not just the equity portion.

Figure 5-2 demonstrates that as the percentage of debt employed in the SRC-II project increases, the ability to cover the interest costs rapidly declines. For a project returning 15% on equity, the margin of safety or times-interest-earned ratio declines rapidly from 10.8 times for 25 percent debt to 2.1 times for 65 percent debt. The petroleum and chemicals industries historically have relatively low acceptable levels of debt and must maintain high earnings coverage. It is unlikely that the SRC-II project would be able or allowed to carry more debt than is normal for the industry.

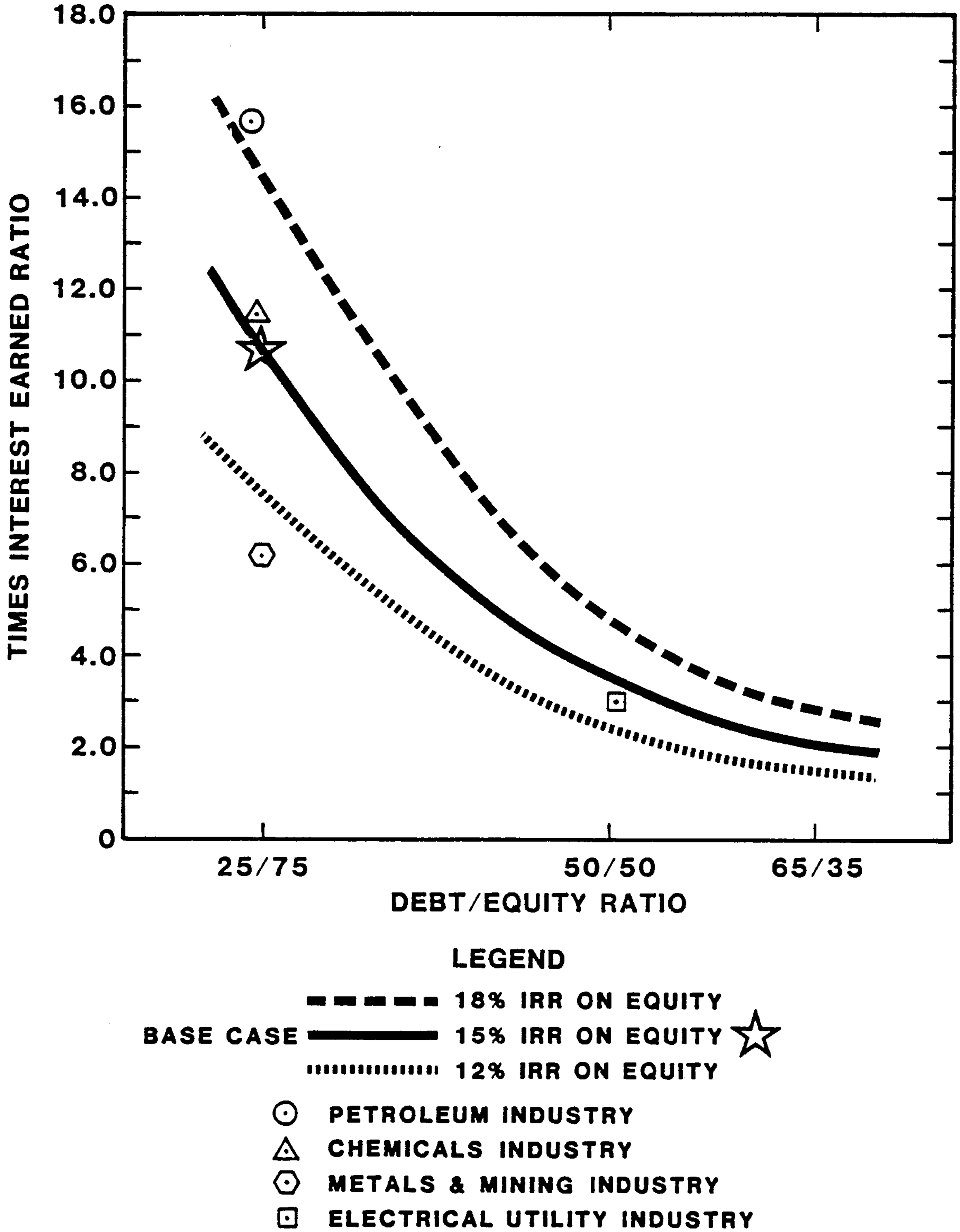


Fig. 5-2. Comparable ability to meet annual interest expense

SRC-II

RELIABILITY ANALYSIS

PREPARED FOR

PITTSBURG & MIDWAY

COAL MINING CO.

BY

R. H. BARRETT

GULF OIL CORPORATION
GULF MANAGEMENT SCIENCES GROUP
JULY, 1979

Table of Contents

List of Illustrations

I. Summary

The Gulf Management Sciences Group (GMSG) in Pittsburgh was asked to provide assistance in performing the reliability analysis for the conceptual commercial SRC-II plant as required by the Department of Energy. Prior to our involvement in the project, an economic evaluation model had been developed which uses Monte Carlo simulation to derive probability distributions for certain variables of interest. Of primary concern was the distribution for the constant SRC-II price (dollars per million BTU) that would have to be obtained over a twenty year horizon in order to receive a 15% return on investment.

A preliminary meeting was held to determine what input variables had enough uncertainty so as to require probability distributions. The meeting resulted in the selection of the following key variables:

1) % operating time for the first year,
2) % operating time for successive years,
3) % of design capacity that is realized,
4) thermal efficiency %,
5) total capital cost of the plant, and
6) direct annual operating costs.

GMSG was to develop probability distributions for these variables, run the economic evaluation model, derive the probability distribution for the SRC-II price, and interpret the results.

It was decided that the best way to obtain the distributions would be through interviews of knowledgeable experts using the technique known as subjective probability assessment. Each subject was interviewed individually and the responses they gave to a series of questions provided a basis for the derivation of probability

distributions for each stochastic (uncertain) input variable.

The resulting distributions for each subject were then mathematically combined as discussed in chapter VI. to yield one probability curve for each variable. These combined distributions are shown on pages 4 through 9. Of particular interest in interpreting the graphs are the following items:

1. The mean represents the weighted average of all possible values for a stochastic variable. To illustrate this concept, consider a variable that can take on the values 1, 2, or 3 with probabilities .1, .4, and .5 respectfully. Since this variable can assume only discrete values with corresponding probabilities of occurrence, an exact mean can be calculated: (.1 x 1) + (.4 x 2) + (.5 x 3) = 2.4. In the case of continuous distributions, such as those represented in this study, it is not always possible to calculate an exact mean. In this situation, Monte Carlo simulation is used to randomly select values from the distribution (500 values were taken) and then a simple average is computed to determine an approximate mean.

2. The mode of the distribution is the single point estimate of the most likely value. For the discrete example discussed above, the mode would be 3 since that value has the highest probability of occurring. But as was true for the mean, the mode of a continuous distribution can only be approximated via Monte Carlo techniques.

3. The median represents the point where it is equally likely that the true value will be below this point as above it. In other words, from a probability standpoint, the median divides the distribution into two equal parts. For the discrete example, the median is 2.5 since there is a .5 probability that the actual value will be below 2.5 and a .5 probability that it will exceed 2.5. As before, the median for the continuous distribution can only be approximated.

4. The shape and range of the distribution are also very important in that they show just how far above and below the mean and mode the actual value of the variable

might be as estimated by the experts. The end points of the curve represent the values that capture 90% of the probability distribution. In other words, for first year operating time percentage, there is only a 5% chance that the actual value will fall below 32% and a 5% chance that it will exceed 87%.

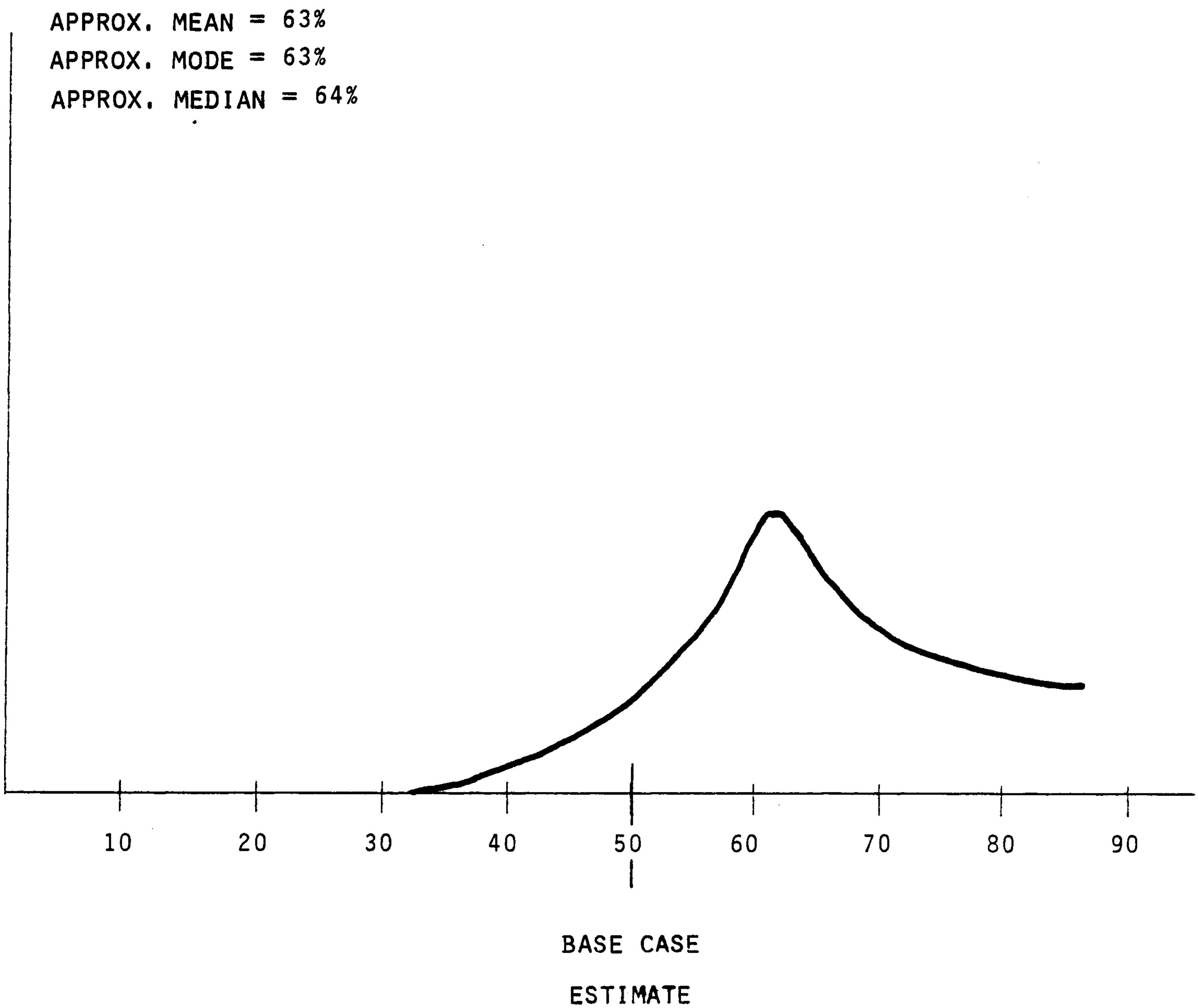
5. The base case estimate denotes the contractors single point estimate of the mode for the stochastic variable which was used as the base case number in the deterministic economic evaluation model. The following are the values for the base case estimates:

% Operating Time (Year 1)	50%
% Operating Time (Year N)	90%
% Design Capacity	100%
Thermal Efficiency %	72%
Capital Costs (excluding indirect capital)	$1.56 billion
Direct Operating Costs (excluding indirect operating and coal costs)	$88.9 million

In conclusion, the modes of the combined distributions indicate that the respondents in general felt that the base case estimates represented the most probable outcomes except for operating time in year one and thermal efficiency. On the other hand, with the exception of operating time in year one, the respondents consistently judge that there is a significant chance that the n^{th} plant would not preform as well as the base case for each of the variables that were projected. This is indicated by the skewness in the distribution and the resultant statistical mean. The chart on page 11 of the price of SRC-II, expressed in dollars per million BTU, best illustrates this skewness where the approximate mode of the combined distributions of $3.90 per million BTU is in general agreement with the base case estimate of $3.76. However skewness of this distribution, that is, the extended right hand side tail, contributes to the calculated mean of $4.13 per million BTU, approximately 10% higher than the base case estimate. This conclusion is probably the result of respondent concerns with regard to the preliminary nature of the conceptual design and estimates and the incorporated assumptions with regard to technical, system, and equipment improvements expected to be available for the commercial plant.

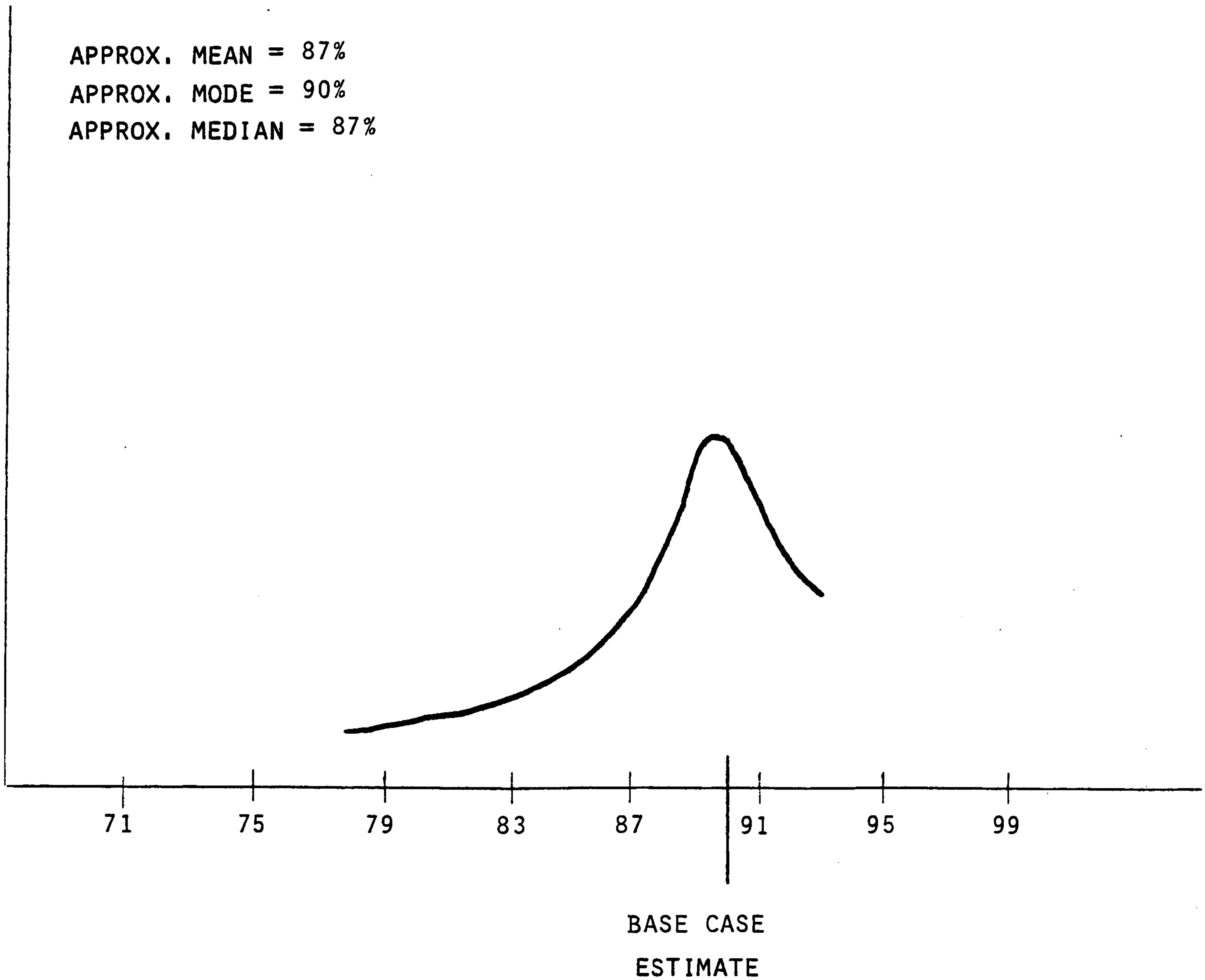
% OPERATING TIME (YEAR 1)

COMBINED DISTRIBUTIONS



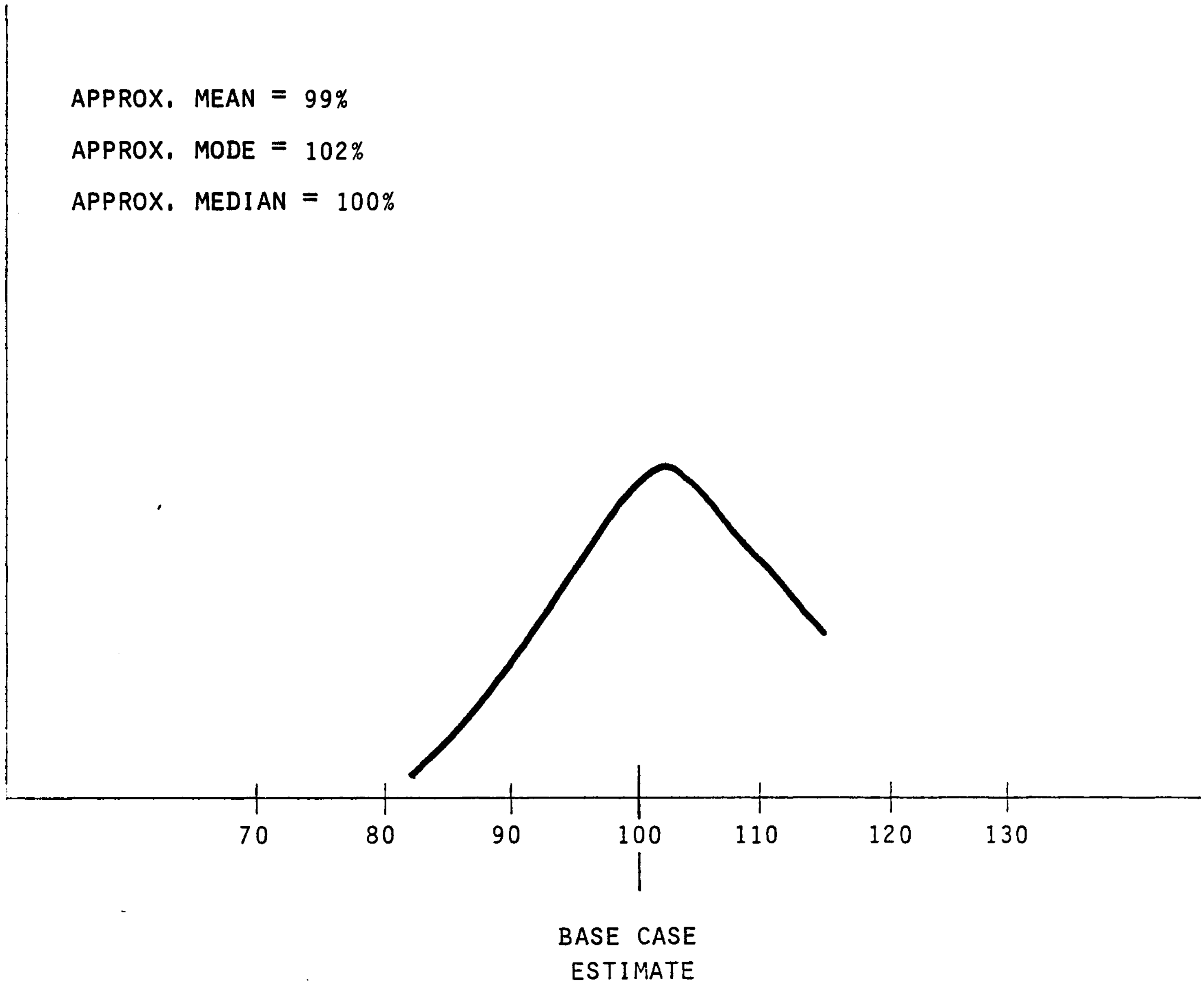
% OPERATING TIME (YEAR N)

COMBINED DISTRIBUTIONS



% DESIGN CAPACITY

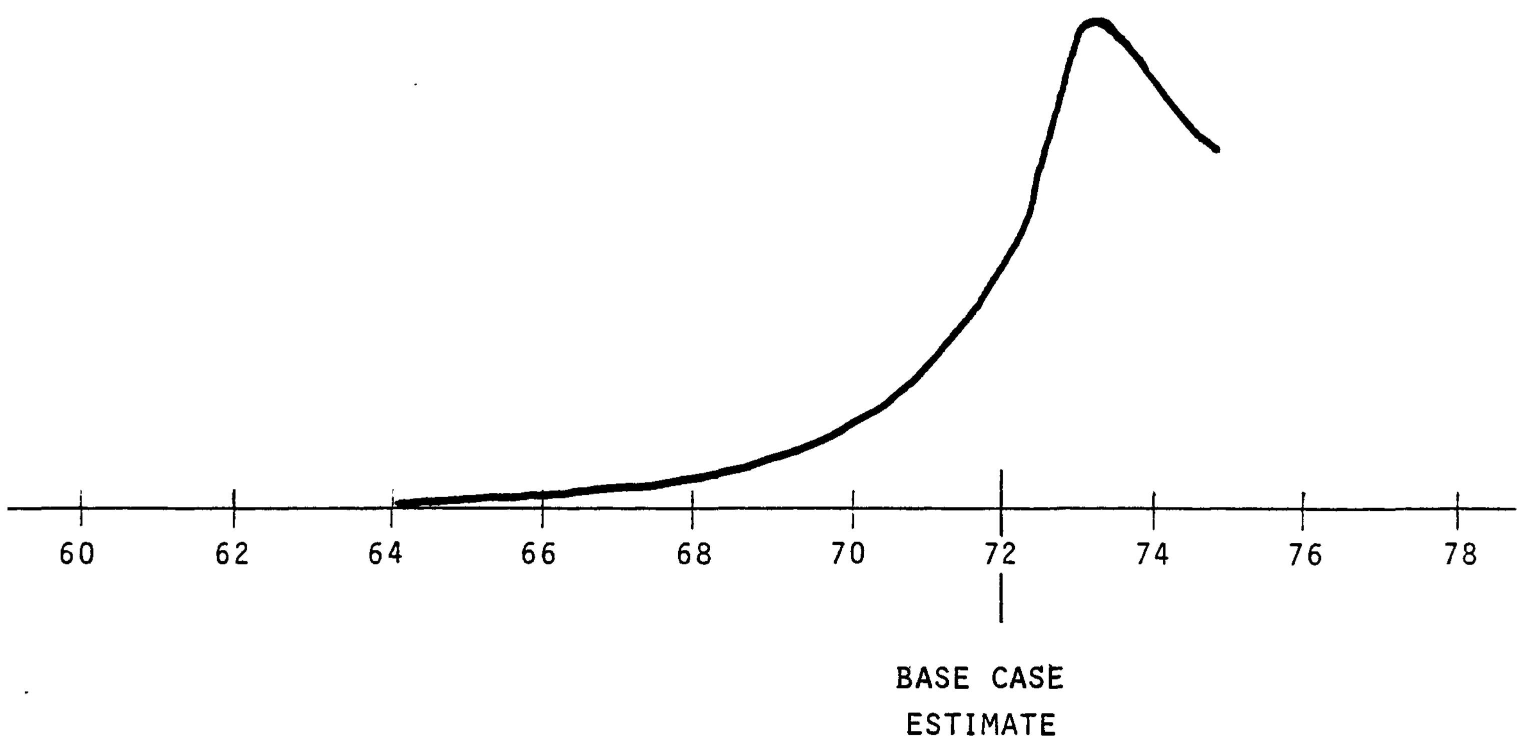
COMBINED DISTRIBUTIONS



THERMAL EFFICIENCY %

COMBINED DISTRIBUTIONS

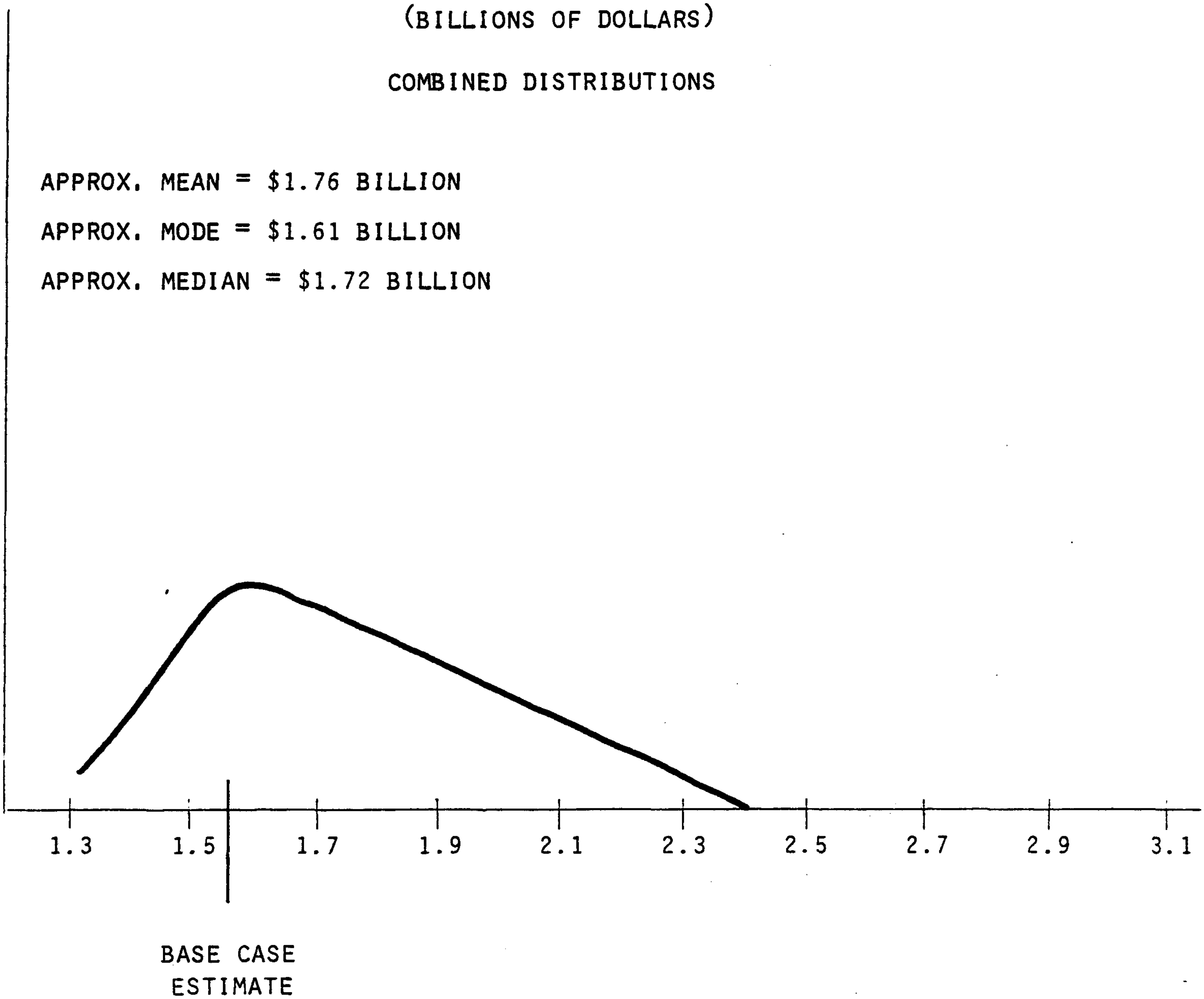
APPROX. MEAN = 72%
APPROX. MODE = 73%
APPROX. MEDIAN = 72%



CAPITAL COSTS

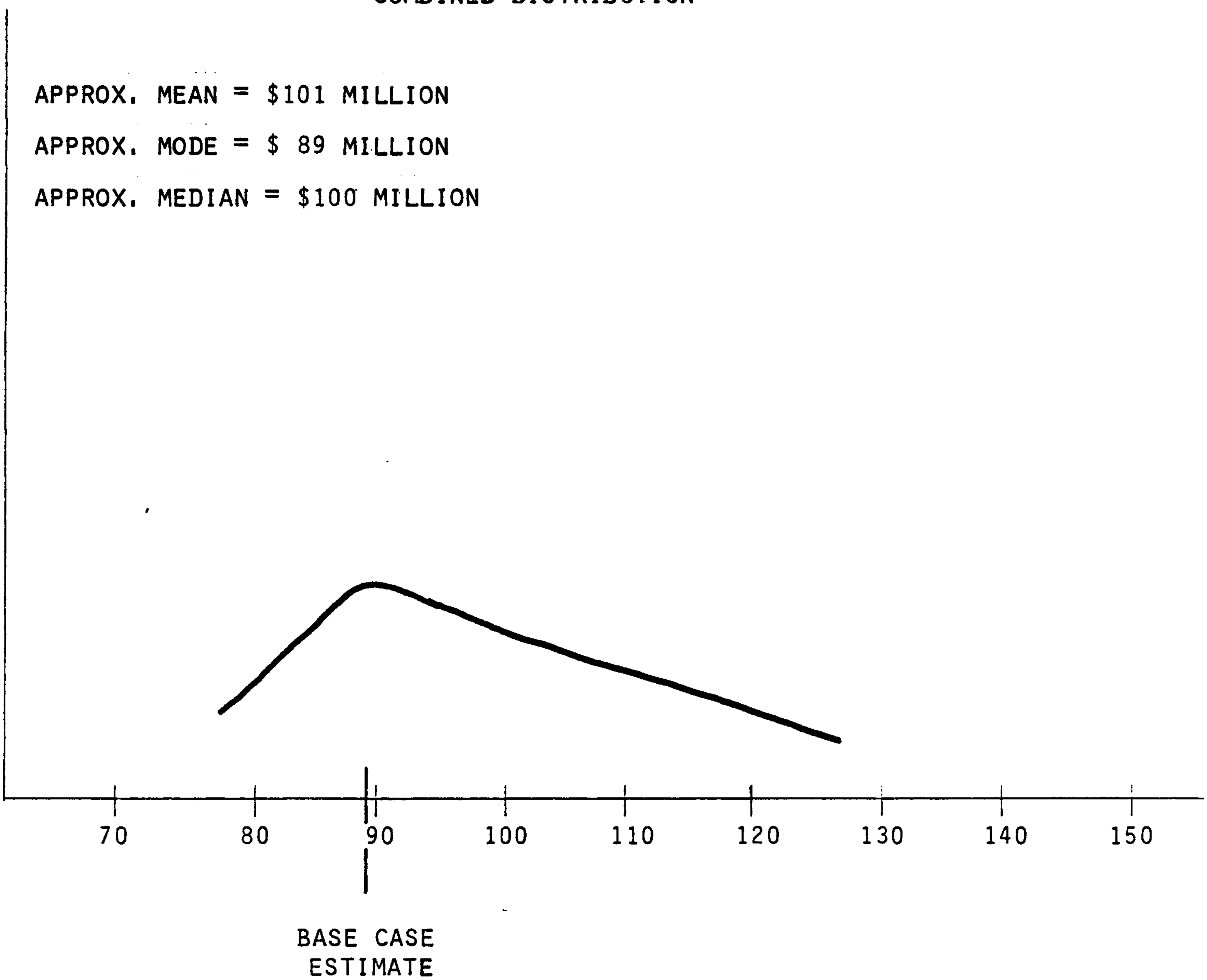
(BILLIONS OF DOLLARS)

COMBINED DISTRIBUTIONS



DIRECT OPERATING COSTS
(MILLIONS OF DOLLARS)

COMBINED DISTRIBUTION



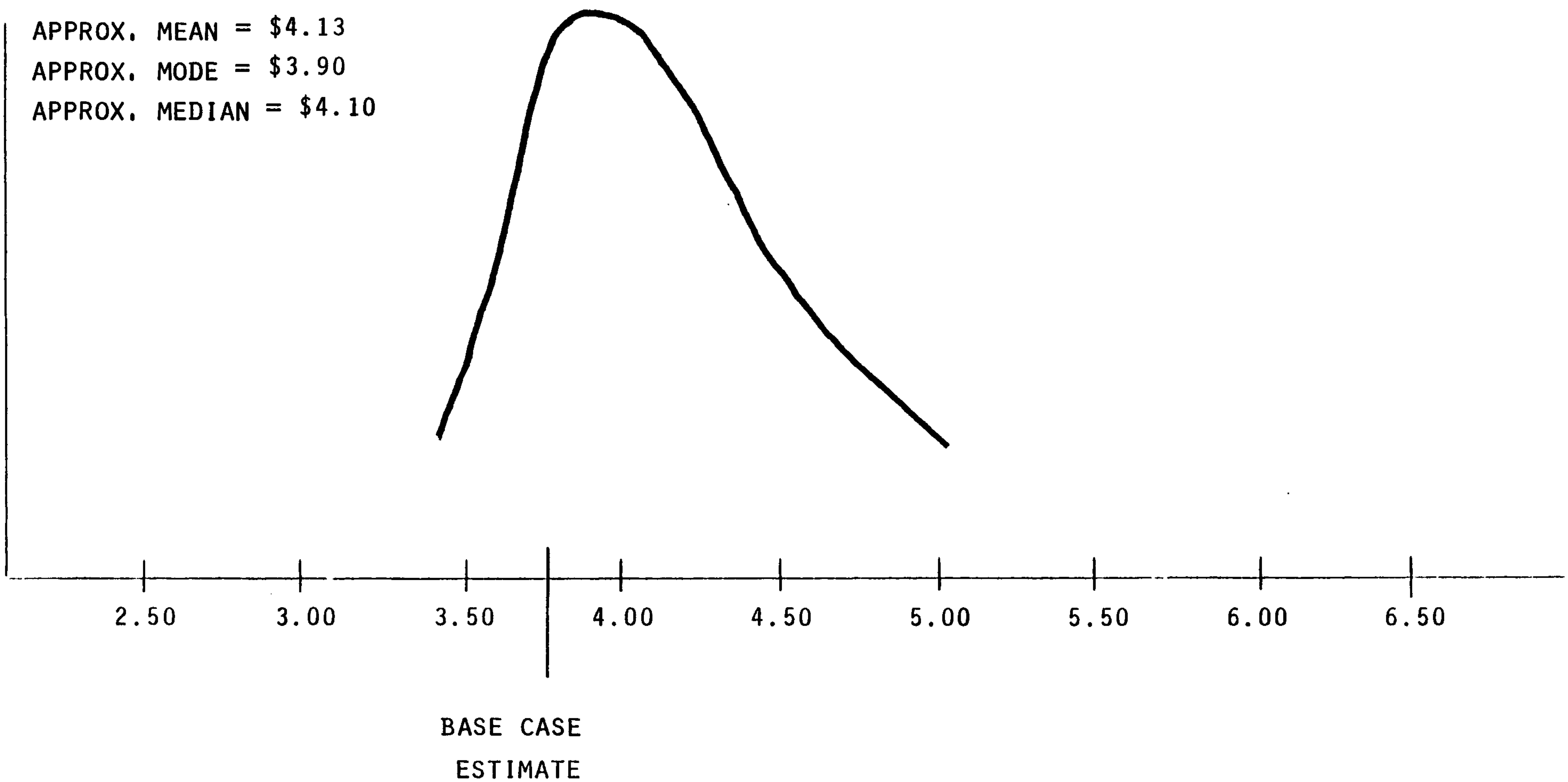
A trial and error approach was taken in attempting to determine the shape and parameters of the various distributions as discussed in chapter V. The fitted distributions were then used as input to the economic evaluation model with the resulting output distribution for the initial SRC-II price being shown on page 11. The base case estimate of the SRC-II price, $3.76, does not necessarily represent their most likely estimate of the price. This value was calculated by running the economic evaluation model deterministically using the base case estimates for the input variables. Unfortunately, combining the modes, or most likely estimates, using some mathematical formula does not guarantee that the resulting value is itself a mode.

The cumulative probability table for the initial SRC-II price, shown on page 12, is one of the most important results of the study. The table shows the approximate probability that the initial SRC-II price will exceed or be less than a certain value. For example, there is about a 56% chance that the actual SRC-II price will exceed $4.00, or conversely there is a 44% chance that the price will be less than $4.00. The range of SRC-II prices reflected in this table result from the variation in estimates of future costs and performance as well as technological developments.

The chapters that follow present a more detailed analysis of the methodology employed in this study.

INITIAL PRICE OF SRC-II
(DOLLARS PER MILLION BTU)

COMBINED DISTRIBUTION



INITIAL PRICE OF SRC-II
CUMULATIVE PROBABILITY TABLE

VALUE	PROB. OF BEING LESS THAN VALUE (%)	PROB. OF BEING MORE THAN VALUE (%)
3.00	0.0	100.0
3.20	0.2	99.8
3.40	2.6	97.4
3.60	11.6	88.4
3.80	25.0	75.0
4.00	44.0	56.0
4.20	60.2	39.8
4.40	74.2	25.8
4.60	83.2	16.8
4.80	90.6	9.4
5.00	94.6	5.4
5.20	98.2	1.8
5.40	99.2	0.8
5.60	99.6	0.4
5.80	100.0	0.0

II. IDENTIFICATION OF STOCHASTIC VARIABLES

A Planning meeting was held on April 26, 1979 in Denver where representatives of the Gulf Management Sciences Group met with members of the SRC-II project team. The purpose of the meeting was to determine what input variables to the existing economic evaluation model would require probability distributions in order to arrive at a reasonable approximation of the probability distribution for the output variable SRC-II price.

The economic evaluationmodel, developed by Gulf, utilizes a software package called PAUS which was developed by Bonner & Moore Associates, Inc. of Houston, Texas for performing risk analysis using Monte Carlo simulation. The discussion revealed that there are three basic equations in the model which contain at least one stochastic variable (see page 16).

These equations define coal expense, output of the plant, and revenue. The last, revenue, is also a function of the SRC-II price, which is the ultimate solution variable in the model and has a probability distribution derived by successive iterations of the simulation routine. These three derived stochastic variables, along with the operating expense and capital cost (the other two stochastic input variables which are carried through the model as independent variables), are used to develop the income and cash flow streams.

Five hundred iterations were made in the simulation runs to derive the probability distribution for the SRC-II price. For each iteration the computer would randomly select a value for each stochastic input variable from its probability distribution, and then make three passes through the basic model to find the SRC-II price that results in a net present value of zero using a 15% discount factor. The resulting five hundred values for the SRC-II price were then used to determine the probability distribution for the SRC-II price that was shown on page 11.

The uncertain input quantities in the model were identified and defined as follows:

1) Percentage of Time the Plant Operates

   This actually encompasses two variables -- one for the first year of production and a second variable for all successive years. A value of 100% would represent operating the plant 365 days a year whereas an onstream factor of 90% would represent 328 days operating time.

2) Percentage of Design Capacity Realized

   The plant has a design capacity of 33,333 tons per stream day, which is also the expected capacity estimated in the base case. It was assumed that any major downward shifts in this design capacity would be overcome by investing more capital to improve the process, but minor deviations might be tolerated. Additionally, it is quite possible that actual performance could exceed design, resulting in a percentage greater than 100.

3) Thermal Efficiency

   The thermal efficiency of the plant is defined as BTU output divided by BTU input where the BTU input includes both coal and purchased electrical power. A conversion rate of 9500/BTU KWHR was assumed.

4) Total Capital Costs

   Capital costs include all depreciable capital investments as well as engineering and testing; in other words, this is the total plant investment.

5) Total Annual Direct Operating Expense

   This variable was defined to include operating labor and benefits, maintenance labor and benefits, catalysts and chemicals, operating supplies, maintenance materials, electricity, contract maintenance, property taxes, and insurance. Specifically excluded are overhead costs and coal expense.

In addition to identifying the stochastic variables requiring probability distributions, three global assumptions which underlie the entire reliability analysis were defined:

1) This analysis is the conceptual commercial plant. This implies that the demo and expanded demo have been successfully operated, the technological problems have been solved, and that several other commercial plants have already been constructed and are functioning. The uncertainty in the projections arises from the difficulty in estimating in 1978 how much technological improvement will be made in the plant design and how accurate the cost estimates will prove to be for a plant that may not be built for 20 years. Since we are dealing with the n^{th} commercial plant, we have eleminated all considerations that the technology will not work at all.
2) All dollar values are represented in 1978 dollars.
3) The plant produces only fuels, no chemical feedstocks, and the SRC-II price is based solely on BTU output.

Model Equations

1. CEXP = (M)(UP)(THRU)(365 days/yr)(CA)(COST)

CEXP	= D135	= coal expense per year (MM$/yr)
M	= .033333	= design mass flow rate of coal (MM tons/d)
UP	= XT (stochastic variable)	= fraction of time the plant operates
THRU	= XK (stochastic variable)	= fraction of design capacity that is realized
CA	= 25.626	= conversion of tons of coal to BTU's (MM BTU/ton)
COST	= X133	= coal cost ($/MM BTU)

$$\frac{\text{MM\$}}{\text{yr}} = \left(\frac{\text{MM tons}}{\text{day}}\right)\left(\frac{\text{days}}{\text{yr}}\right)\left(\frac{\text{MM BTU}}{\text{ton}}\right)\left(\frac{\$}{\text{MM BTU}}\right)$$

2. OUT = [(M)(CA) + (POW)(CB)](365 days/yr)(E)(UP)(THRU)

OUT	= D140	= BTU output (MM MM BTU/yr)
POW	= XKWP	= purchased power (MM MM KWHR/d)
CB	= XKWF	= conversion of KWHR to BTU's (BTU/KWHR)
E	= XN (stochastic variable)	= thermal efficiency of the plant

$$\frac{\text{MM MM BTU}}{\text{yr}} = \left[\left(\frac{\text{MM tons}}{\text{day}}\right)\left(\frac{\text{MM BTU}}{\text{ton}}\right) + \left(\frac{\text{MM MM KWHR}}{\text{d}}\right)\left(\frac{\text{BTU}}{\text{KWHR}}\right)\right]\left(\frac{\text{days}}{\text{yr}}\right)$$

3. REV = (PSRC)(OUT) + (RBY)(UP)(THRU)

REV	= D370	= total revenue (MM$/yr)
PSRC	= D365 (solution variable)	= SRC-II price ($/MM BTU - current dollars)
RBY	= X141	= by-product revenue (MM$/yr - current dollars)

$$\frac{\text{MM\$}}{\text{yr}} = \left(\frac{\$}{\text{MM BTU}}\right)\left(\frac{\text{MM MM BTU}}{\text{yr}}\right) + \left(\frac{\text{MM \$}}{\text{yr}}\right)$$

III. THE INTERVIEW PROCESS

In order to determine the underlying probability distributions, five experts in the field were interviewed. The interview process involved six distinct steps. The first of these was a motivational exercise in which the subject was told the importance of what was about to be done and asked to carefully think through his answers. The motivational step was followed by a discussion of the methodology that was being used (i.e., what would take place in these interviews) and a description of how the model works. If the subject was not familiar with probabilities or Monte Carlo simulation, a brief explanation was provided.

The third step is called conditioning. At this juncture the importance of defining any assumptions that are being made and any particular scenarios that are envisioned when responding to questions about one of the variables was stressed. Anchoring was also discussed at this point. Anchoring is a common bias that is introduced when one has in mind a most likely or mean value for some variable and bases all the responses to questions concerning the variable on this central value. This tends to produce distributions that are closely centered around a value when in reality the true distribution covers a much wider range. By explaining this common bias, it was hoped that the subjects would conciously attempt to overcome their anchoring.

The last three steps in the process were repeated for each quantity that required a probability distribution. The first of these is structuring, which merely involves defining the quantity and stating any assumptions that are to be made. At this point the subject would be sure to resolve any unanswered questions and would state any additional assumptions he was making.

The next step was to actually encode the distribution. The result of this step was a list of values that have a .05, .10, .25, .50, .75, .90, and .95 probability of occurring. After obtaining this list of values, the final step is to verify the consistency of the answers. This was typically done by asking the subject if he felt that the unknown quantity was equally likely to fall in any of the four quartiles he had previously defined. The tails of the distribution were verified in a similar manner. If the subject felt there was a greater chance of the value falling in one quartile as opposed to another, the encoding process was repeated until a point of indifference was encountered. Appendix A shows a typical dialogue for the encoding and verifying phases of the interview.

IV. RESULTS OF THE INTERVIEW PROCESS

Appendix B contains the actual forms used during the encoding process. At the top of each form is the code name (A, B, C, D, and E) of the subject being interviewed and the quantity for which he is providing a distribution. Below this is a probability line on which the subject's responses to the questions were recorded. The seven points (responses) corresponding to probabilities for the occurrence of a value were then plotted on the graph on the upper half of the form and a curve was drawn through the points creating a cumulative density function.

The cumulative density function may be interpreted by selecting a point on the curve and drawing lines perpendicular to each axis from this point. The point at which the line intercepts the vertical axis denotes the probability that the actual value for the given quantity will be less than the value represented by the point at which the other perpendicular intercepts the horizontal axis. Variations of this analysis can be used to determine the cumulative probability associated with a certain value, or the value corresponding to a given cumulative probability.

In order to determine the approximate shape of the distribution, the cumulative density function was divided into intervals. The change in probability within an interval represented a point on the graph at the bottom of the page. After plotting one point for each interval, a curve was drawn through the points thereby approximating a probability distribution for the variable.

At this point, the assumptions that were made and particular scenarios that were envisioned by the subjects while discussing each variable will be presented. A distribution for percentage operating time for the first year is not available for subject B since this quantity was included in the list of stochastic input variables subsequent to the interview session with this subject. Additionally, assumptions may not be presented for each subject since only unusual scenarios were recorded.

A. % Operating Time -- Year 1

Subject A assumed a three month start-up with one or two system failures which would cost eight weeks delay.

Subject C envisioned a three month pre-operating shakedown with an additional month for repairs and modifications.

Subject E felt that the conceptual commerical plant should have few start-up problems, and should therefore achieve a high operating time percentage.

B. % Operating Time -- Successive Years

Subject A assumed operating time would be greater than 80% or you wouldn't build the plant.

Subject B was pessimistic again due to the series operation of the systems and stated that plants of this type typically run at 80%.

Subject C thinks there will be a three week turnaround for general maintenance and one week of down time for unscheduled maintenance.

Subject E was optimistic about the operating time, but offset the optimism with a lower distribution for design capacity percentage.

C. % Design Capacity

Subjects A and B both feel that this plant should run like a refinery -- over capacity.

Subject C assumed that the contractor was not required to guarantee capacity and that there is a 3% - 5% safety margin in the equipment design.

D. Thermal Efficiency

Subject A is rather pessimistic in that he can't foresee any significant breakthroughs that will improve thermal efficiency. He also believes there will be a push for more liquids which reduces the thermal efficiency.

Subjects C, D, and E all foresee a great deal of technological improvements which should improve thermal efficiency.

E. Total Capital Costs

Subject B stated that plants are rarely built for less than the estimate and envisioned scenarios similar to the cost escalation of the Alaskan pipeline.

Subject C assumed that the contractor would be on a cost plus contract with incentives.

F. Total Annual Direct Operating Costs

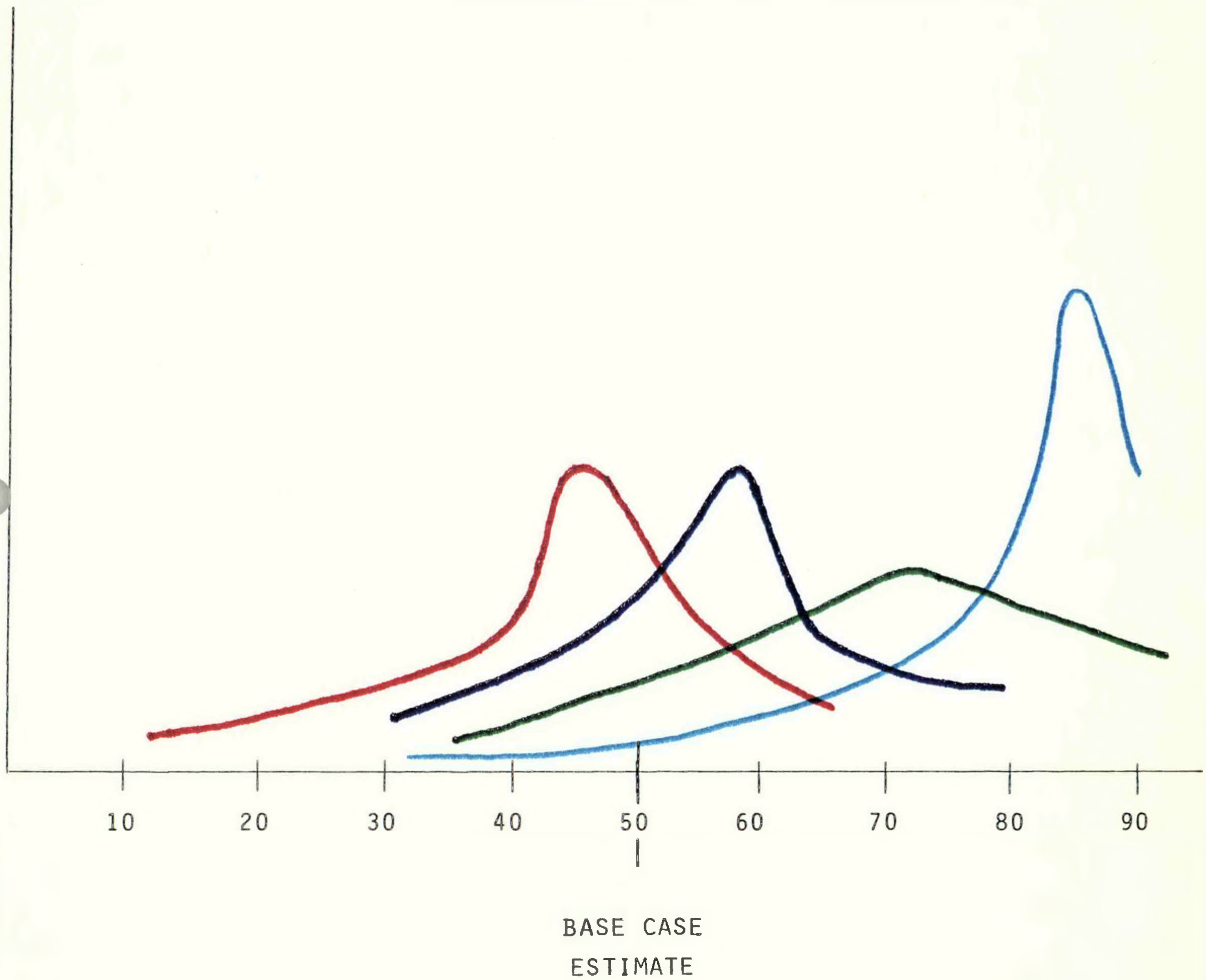
Subject A believes that current estimates of the labor costs are too low.

Subject B believed that a portion of these costs would be dependent on the capital costs -- specifically insurance, maintenance, and taxes.

Pages 22 through 28 contain the graphs of the individual distributions which should be interpreted in the manner discussed on pages 2 and 3.

% OPERATING TIME (YEAR 1)

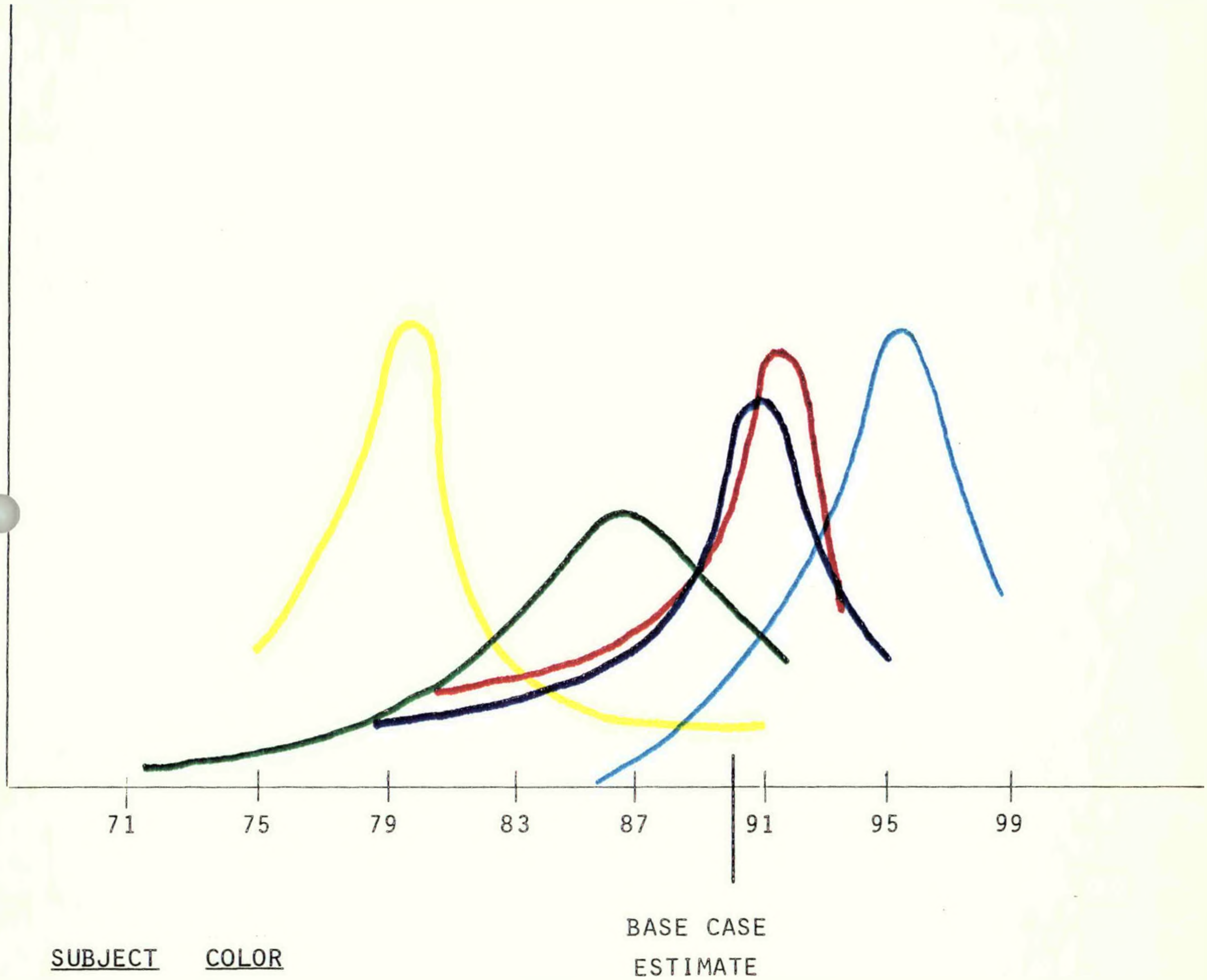
INDIVIDUAL SUBJECT'S DISTRIBUTIONS



SUBJECT	COLOR
A	BLUE
C	RED
D	GREEN
E	LIGHT BLUE

% OPERATING TIME (YEAR N)

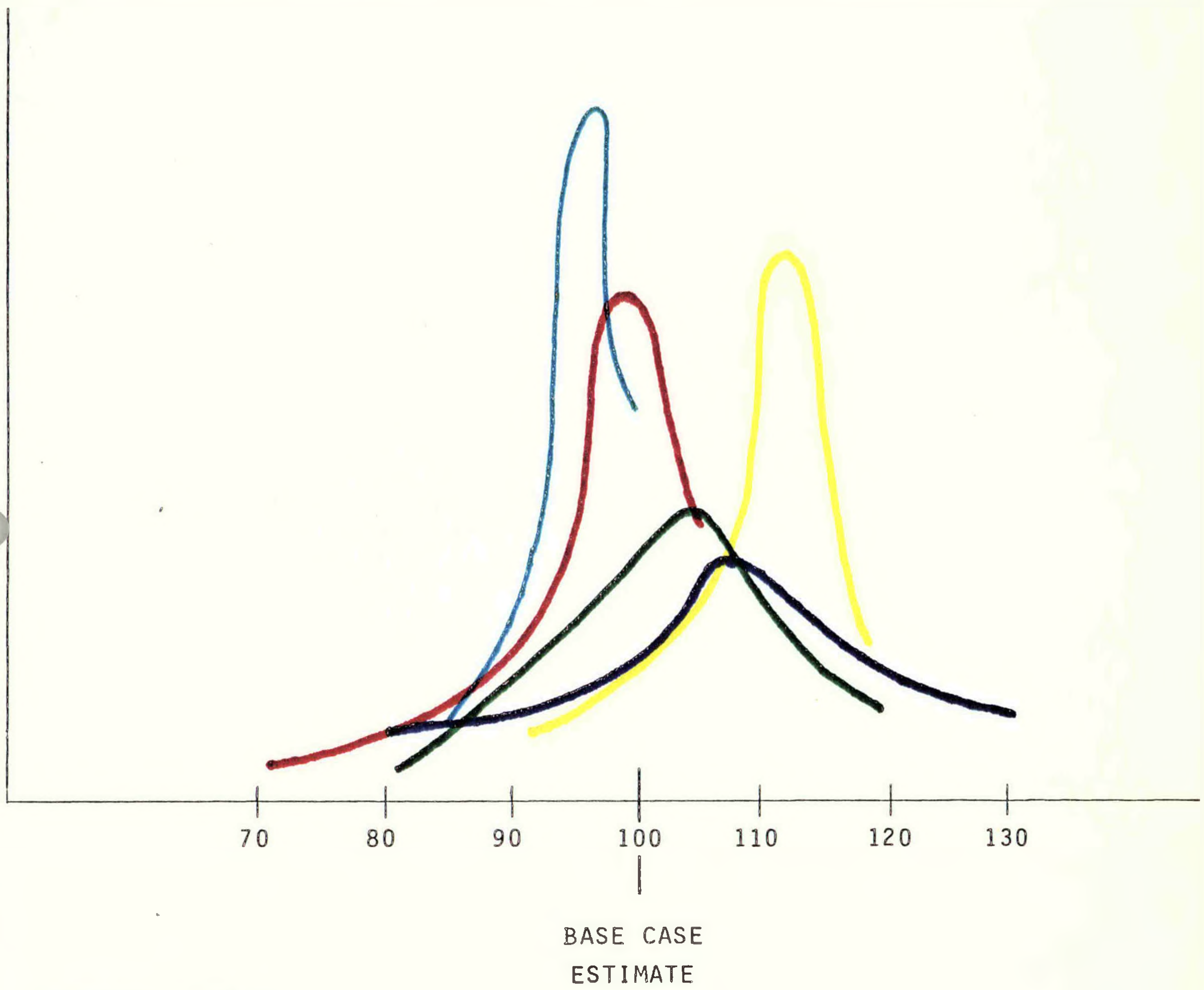
INDIVIDUAL SUBJECT'S DISTRIBUTIONS



SUBJECT	COLOR
A	BLUE
B	YELLOW
C	RED
D	GREEN
E	LIGHT BLUE

% DESIGN CAPACITY

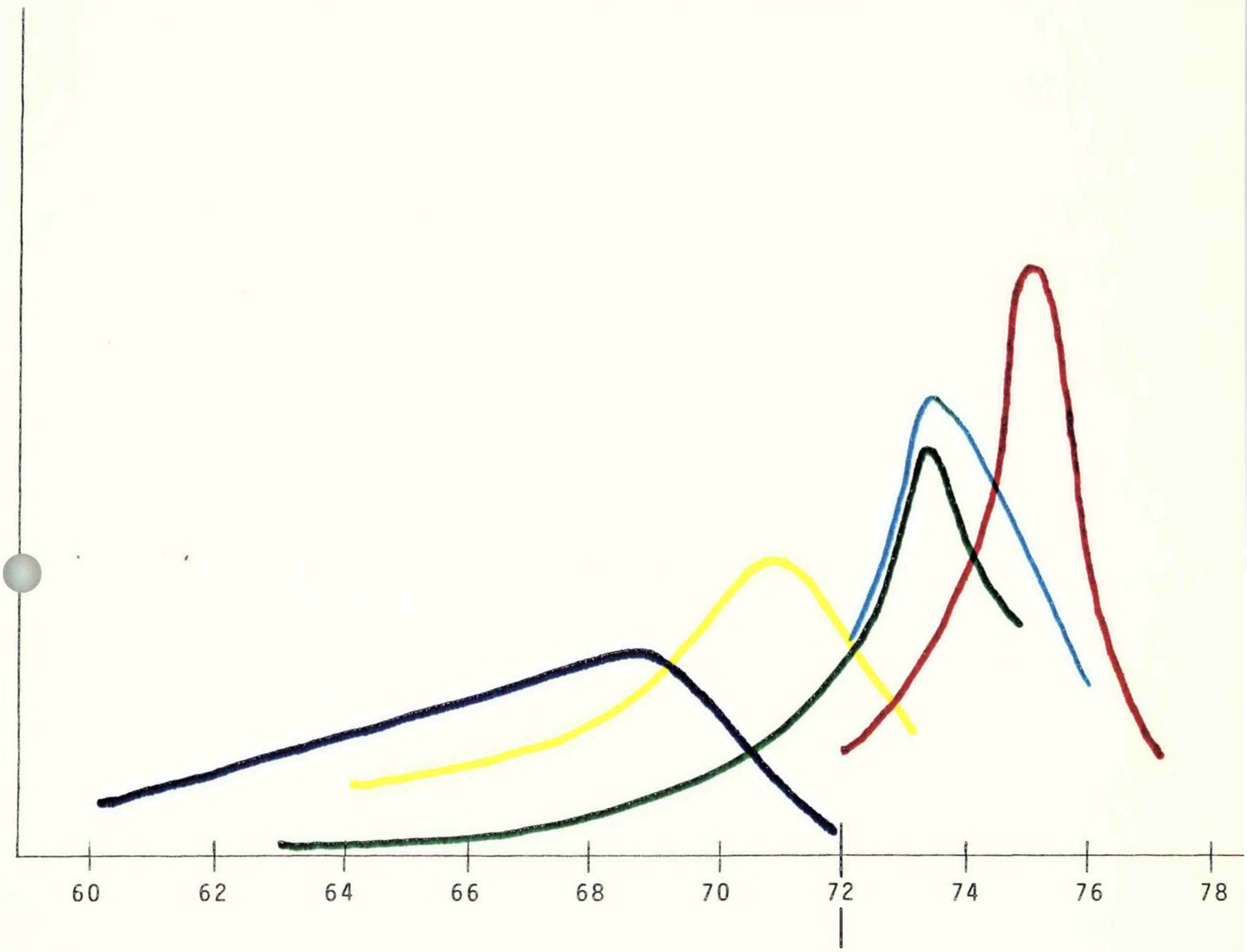
INDIVIDUAL SUBJECT'S DISTRIBUTIONS



SUBJECT	COLOR
A	BLUE
B	YELLOW
C	RED
D	GREEN
E	LIGHT BLUE

THERMAL EFFICIENCY %

INDIVIDUAL SUBJECT'S DISTRIBUTIONS

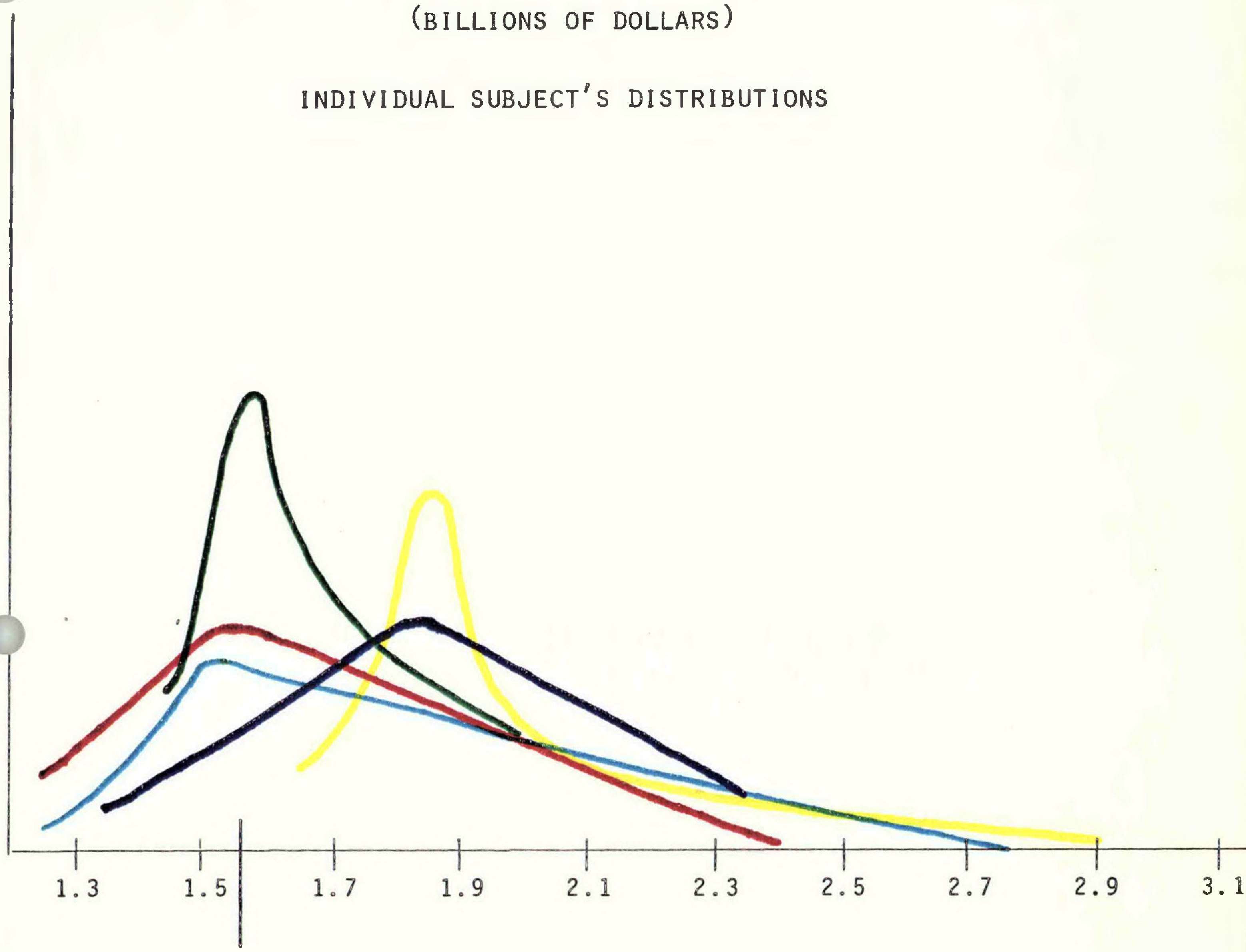


SUBJECT	COLOR
A	BLUE
B	YELLOW
C	RED
D	GREEN
E	LIGHT BLUE

CAPITAL COSTS

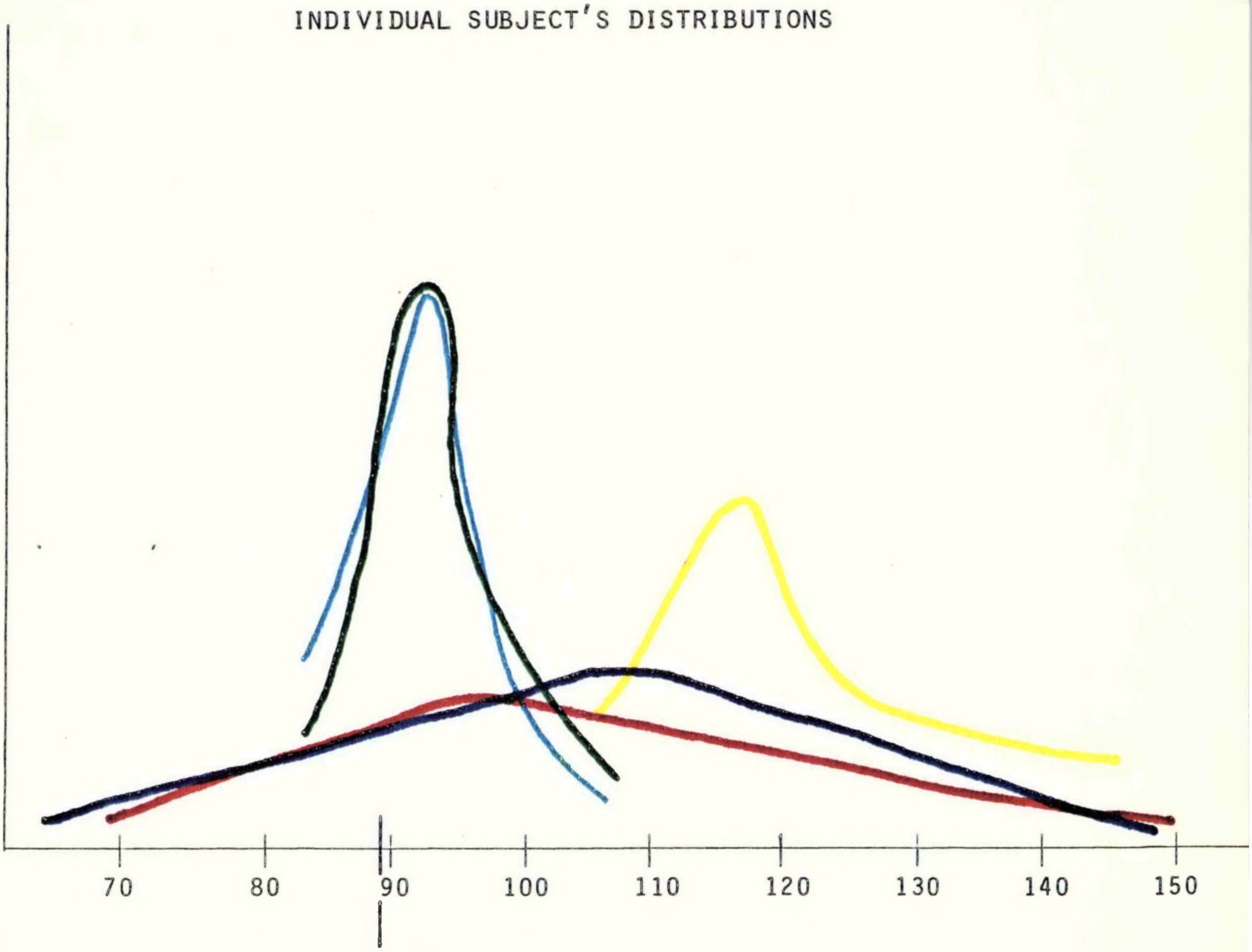
(BILLIONS OF DOLLARS)

INDIVIDUAL SUBJECT'S DISTRIBUTIONS

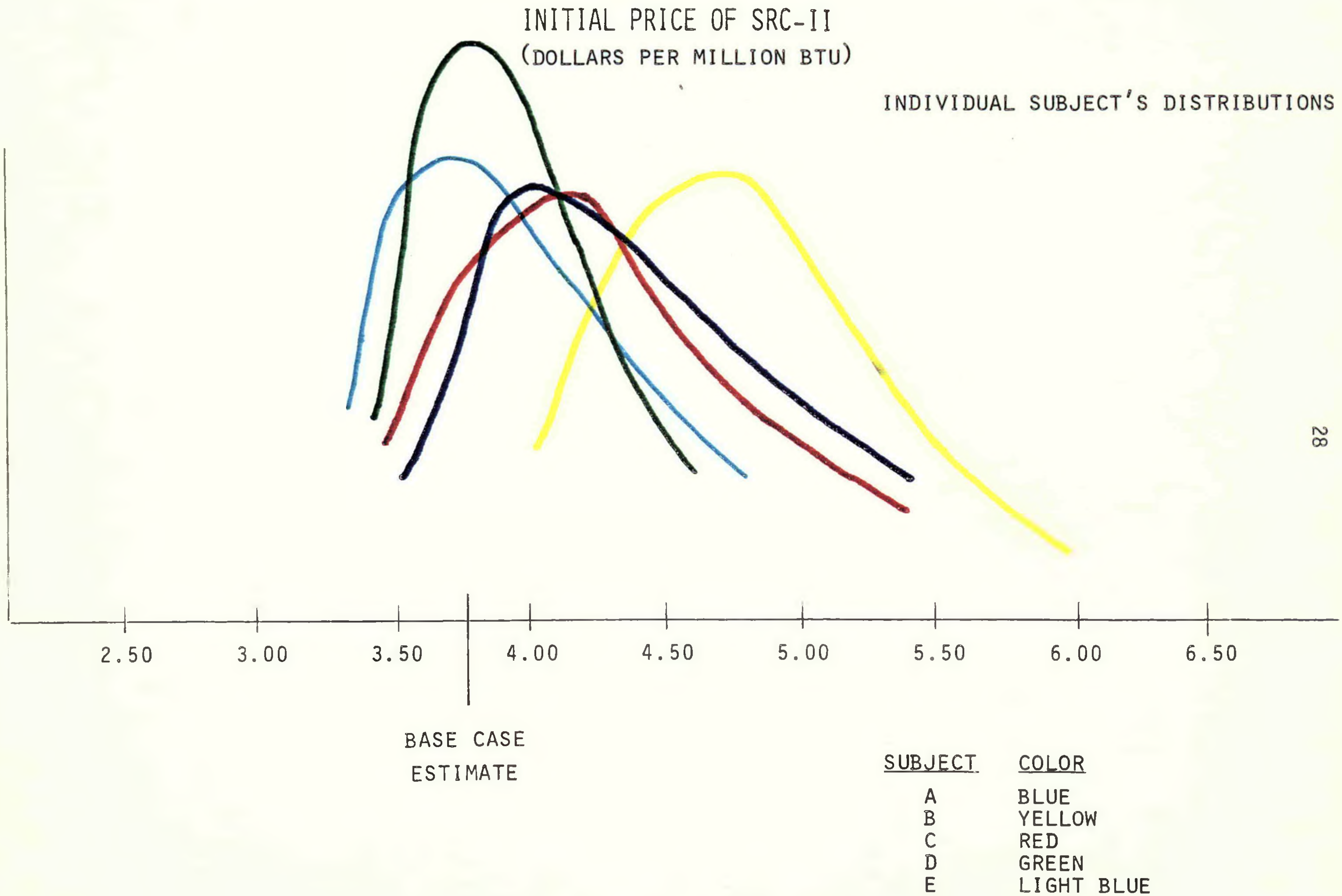


SUBJECT	COLOR
A	BLUE
B	YELLOW
C	RED
D	GREEN
E	LIGHT BLUE

DIRECT OPERATING COSTS
(MILLIONS OF DOLLARS)



SUBJECT	COLOR
A	BLUE
B	YELLOW
C	RED
D	GREEN
E	LIGHT BLUE



INITIAL PRICE OF SRC-II
(DOLLARS PER MILLION BTU)
INDIVIDUAL SUBJECT'S DISTRIBUTIONS
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
BASE CASE
ESTIMATE
SUBJECT COLOR
A BLUE
B YELLOW
C RED
D GREEN
E LIGHT BLUE

V. DETERMINING THE SHAPE AND PARAMETERS OF THE DISTRIBUTIONS

The PAUS risk analysis program accepts a number of different input distributions. The problem is to select the distribution which best fits the sample points. The graphs of the individual probability distributions shown in Appendix B were used to estimate the shape and parameters of the distributions, then a trail and error procedure was used to improve on that starting point. The charts on pages 31 and 32 show the results of this procedure for the individual subjects' distributions and the combined distributions respectively.

The column marked VARIABLE identifies each distribution. The prefixes A, B, C, D, and E represent each subject. The variables are as follows:

X120	Total Capital Costs
X130	Total Annual Direct Operating Costs
XN	Thermal Efficiency %
XK	% Design Capacity
XT1	% Operating Time -- Year 1
XT2	% Operating Time -- Successive Years

The next two columns denote the type of distribution being fitted, and the parameters required by PAUS. The following distributions were used in the trial and error process:

TRIA1 - triangular distribution where the parameters represent the low value, high value, most likely value, and the area between the low and high values.

BETA1 - approximate beta distribution with parameters representing the minimum, maximum, and most likely values.

NORMAL - normal distribution where the parameters are the mean and standard deviation.

Following the parameter column are columns showing the actual versus the observed or fitted values for each of the seven data points. Comparison of the actual and observed values for each point shows how accurately the fitted distributions really are as evidenced by the small difference in these two numbers.

Distribution Fit for Individual Subjects

Variable	Trial Distribution Type	PAUS Parameters	.05 Act	.05 Obs	.10 Act	.10 Obs	.25 Act	.25 Obs	.50 Act	.50 Obs	.75 Act	.75 Obs	.90 Act	.90 Obs	.95 Act	.95 Obs
A-X12Ø	TRIA1	1.34 2.34 1.84 .9	1.34	1.34	1.44	1.44	1.69	1.63	1.84	1.84	2.04	2.05	2.24	2.24	2.34	2.34
A-X13Ø	TRIA1	64 139 102 .9	62	64	77	71.2	87	85.6	102	102	117	118	127	132	142	139
A-XN	TRIA1	60 72 69 .9	60	60	62	61.4	64	64	67	67.1	69	69.4	70	71.1	72	72
A-XK	BETA1	60 140 108	80	82.2	85	87.1	94	95.8	110	106	115	115	125	123	130	127
A-XT1	BETA1	6 93 59	30	30.6	35	36	45	45.5	58	56.4	62	66.7	75	74.9	80	79.1
A-XT2	BETA1	70 97 91	78	80.2	80	82.2	85	85.4	90	98	92	92	94	94.1	95	95
B-X12Ø	BETA1	1.54 3.94 1.86	1.64	1.65	1.74	1.71	1.84	1.85	1.94	2.10	2.44	2.42	3.24	2.74	3.54	2.93
B-X13Ø	BETA1	97 167 116	104	104	107	106	113	112	117	120	129	129	139	138	146	142
B-XN	BETA1	64 73.7 70.8	65	67.2	66	67.9	68	69	70	70.3	71.5	71.4	72.5	72.2	73	72.6
B-XK	BETA1	75 122 111.5	91	92.7	94	96.1	105	102	110	108	113	113	117	117	119	119
B-XT1		NOT ASSESSED														
C-XT2	TRIA1	74 95 80	75	76.2	76	77	78	78.8	80	81.2	82	83.9	88	86.4	92	87.8
C-X12Ø	BETA1	1.24 2.44 1.54 .9	1.24	1.24	1.34	1.33	1.44	1.50	1.64	1.73	1.84	2.04	2.14	2.30	2.44	2.44
C-X13Ø	BETA1	57 227 97	67	70.3	77	76.6	87	90.1	102	109	127	131	147	152	177	164
C-XN	BETA1	71 77 75	72	72.9	73	73.3	73.5	74	75	74.7	75.5	75.4	76	76	76.5	76.2
C-XK	BETA1	45 109 100	70	71.7	80	76.8	85	85.2	101	93.8	102	100	104	104	105	106
C-XT1	TRIA1	0 75 45 1	10	13	15	18.4	25	29	45	41.1	50	51.3	60	60	65	64.4
C-XT2	BETA1	73 95 92	80	82.2	82	84	85	86.9	90	89.8	92	92.1	93	93.5	94	94
D-X12Ø	BETA1	1.24 2.34 1.54	1.44	1.35	1.49	1.39	1.54	1.48	1.64	1.61	1.84	1.75	1.94	1.88	2.04	1.95
D-X13Ø	BETA1	72 117 92	82	80.6	85	82.9	89	87.3	92	92.7	97	98.3	102	103	107	106
D-XN	BETA1	60 76 73	63	66.3	67	67.5	71	69.6	73	71.7	74	73.4	74.5	74.5	75	75
D-XK	BETA1	70 130 102	80	84.4	88	87.9	93	94.1	102	101	108	019	116	115	120	118
D-XT1	TRIA1	45 92 74 .9	35	45	50	49.9	60	59.6	70	70.6	82	79.9	88	88	92	92
D-XT2	BETA1	65 100 86	71	74.7	75	76.8	82	80.7	86	85	89	89.2	91	92.5	92	94.2
E-X12Ø	TRIA1	1.24 2.64 1.54 .9	1.24	1.24	1.44	1.34	1.54	1.53	1.74	1.80	2.14	2.16	2.34	2.48	2.84	2.64
E-X13Ø	BETA1	77 117 92	83	83.1	85	85	87	88.6	92	93.4	95	98.4	100	103	107	105
E-XN	NORMAL	74 1.3	72	71.8	72.5	72.3	73	73.1	74	74	75	74.9	75.5	75.7	76	76.1
E-XK	BETA1	80 103 97	86	88.2	90	89.8	94	92.5	96	95.5	98	98.1	100	100	101	101
E-XT1	BETA1	0 95 85	31	41.1	52	49	68	62.1	83	74.7	87	84.1	89	89.3	90	91.8
E-XT2	BETA1	83 100 96	85	89.3	90	90.5	93	92.6	95	94.8	97	96.7	98	98	99	98.7

Distribution Fit for the Combined Distributions

Variable	Trial Distribution		.05		.10		.25		.50		.75		.90		.95	
	Type	PAUS Parameters	Act	Obs	Act	Obs	Act	Obs	Act	Obs	Act	Obs	Act	Obs	Act	Obs
X120	TRIA1	1.32 2.34 1.59 .9	1.32	1.32	1.43	1.40	1.55	1.55	1.72	1.74	1.97	2.00	2.17	2.23	2.42	2.34
X130	TRIA1	77 127 92 .9	77.3	77.0	81.0	80.9	87.5	88.6	97.0	98.4	118	111	123	122	126	127
XN	BETA1	62 76.5 73	64.0	67.3	68.5	68.3	71.4	70.1	73.0	72.0	74.0	73.6	74.6	74.8	74.7	75.3
XK	TRIA1	83 115 100 .9	82.0	83.0	87.7	86.1	93.7	92.4	102	99.4	108	106	112	112	115	115
XT1	NORMAL	65 15	32.0	40.3	45.7	45.8	57.7	54.9	64.0	65.0	77.0	75.1	84.0	84.2	87.3	89.7
XT2	BETA1	65 95 90	77.7	77.2	78.3	79.4	84.0	83.3	88.7	87.3	91.0	90.5	92.7	92.5	93.3	93.3

VI. COMBINING DISTRIBUTIONS

Due to the differing opinions demonstrated by the graphs of the stochastic variables shown in chapter IV, it became necessary to decide upon a method for combining the distributions in some defensible manner. The tables on pages 34 and 35 summarize the results of the following methodology:

1) Record all the data points (responses to the interview questions) for each subject (i.e., A, B, C, D, and E) and for each variable (i.e., X120, X130, ... XT2).

2) For each probability level (i.e., 5%, 10%, 25%, ... 95%) and for each variable, calculate a mean (simple average) and standard deviation (statistical measure of dispersion about the mean). Refer to the table titled "Combined Distributions (First Pass)" for the results of this calculation.

3) In a similar manner, record in a second table all data points that fall within one standard deviation of the mean calculated in step 2. By recording only those points within one standard deviation of the mean, outlier points (points significantly different from the mean) are dropped from consideration. The points dropped, therefore, represent points that appear to be either overly optimistic or overly pessimistic.

4) Calculate a new mean and standard deviation for these data points (see page 35). This new mean now becomes the point to be used in fitting a distribution as discussed in chapter V. Each of these data points is placed on an encoding form as shown in Appendix C with the derived probability distributions appearing on pages 4 through 9.

Combined Distributions (First Pass)

Variable	Subject	Observations .05	.10	.25	.50	.75	.90	.95
X120	A	1.34	1.44	1.69	1.84	2.04	2.24	2.34
	B	1.64	1.74	1.84	1.94	2.44	3.24	3.54
	C	1.24	1.34	1.44	1.64	1.84	2.14	2.44
	D	1.44	1.49	1.54	1.64	1.84	1.94	2.04
	E	1.24	1.44	1.54	1.74	2.14	2.34	2.84
	Mean	1.38	1.49	1.61	1.76	2.06	2.38	2.64
	Std. Dev.	.17	.15	.16	.13	.25	.50	.58
X130	A	62	77	87	102	117	127	142
	B	104	107	113	117	129	139	146
	C	67	77	87	102	127	147	177
	D	82	85	89	92	97	102	107
	E	83	85	87	92	95	100	107
	Mean	79.6	86.2	92.6	101	113	123	136
	Std. Dev.	16.4	12.3	11.4	10.2	16.2	21.3	29.6
XN	A	60	62	64	67	69	70	72
	B	65	66	68	70	71.5	72.5	73
	C	72	73	73.5	75	75.5	76	76.5
	D	63	67	71	73	74	74.5	75
	E	72	72.5	73	74	75	75.5	76
	Mean	66.4	68.1	69.9	71.8	73.0	73.7	74.5
	Std. Dev.	5.4	4.6	3.9	3.3	2.7	2.5	1.9
XK	A	80	85	94	110	115	125	130
	B	91	94	105	110	113	117	119
	C	70	80	85	101	102	104	105
	D	80	88	93	102	108	116	120
	E	86	90	94	96	98	100	101
	Mean	81.4	87.4	94.2	104	107	112	115
	Std. Dev.	7.9	5.3	7.1	6.1	7.2	10.2	11.9
XT1	A	30	35	45	58	62	75	80
	B	-	-	-	-	-	-	-
	C	10	15	25	45	50	60	65
	D	35	50	60	70	82	88	92
	E	31	52	68	83	87	89	90
	Mean	26.5	38.0	49.5	64.0	70.3	78.0	81.8
	Std. Dev.	11.2	17.1	18.9	16.3	17.3	13.6	12.3
XT2	A	78	80	85	90	92	94	95
	B	75	76	78	80	82	88	92
	C	80	82	85	90	92	93	94
	D	71	75	82	86	89	91	92
	E	85	90	93	95	97	98	99
	Mean	77.8	80.6	84.6	88.2	90.4	92.8	94.4
	Std. Dev.	5.3	6.0	5.5	5.6	5.5	3.7	2.9

Combined Distributions (Second Pass)

Variable	Subject	Observations						
		.05	.10	.25	.50	.75	.90	.95
X120	A	1.34	1.44	1.69	1.84	2.04	2.24	2.34
	B	-	-	-	-	-	-	-
	C	1.24	1.34	1.44	1.64	1.84	2.14	2.44
	D	1.44	1.49	1.54	1.64	1.84	1.94	2.04
	E	1.24	1.44	1.54	1.74	2.14	2.34	2.84
	Mean	1.32	1.43	1.55	1.72	1.97	2.17	2.42
	Std. Dev.	.10	.06	.10	.10	.15	.17	.33
X130	A	-	77	87	102	117	127	142
	B	-	-	-	-	129	139	146
	C	67	77	87	102	127	-	-
	D	82	85	89	92	97	102	107
	E	83	85	87	92	-	-	107
	Mean	77.3	81.0	87.5	97.0	118	123	126
	Std. Dev.	9.0	4.6	1.0	5.8	14.6	18.9	21.4
XN	A	-	-	-	-	-	-	-
	B	65	66	68	70	71.5	72.5	73
	C	-	-	73.5	75	75.5	76	-
	D	63	67	71	73	74	74.5	75
	E	-	72.5	73	74	75	75.5	76
	Mean	64.0	68.5	71.4	73.0	74.0	74.6	74.7
	Std. Dev.	1.4	3.5	2.5	2.2	1.8	1.5	1.5
XK	A	80	85	94	-	-	-	-
	B	-	-	-	-	113	117	119
	C	-	-	-	101	102	104	105
	D	80	88	93	102	108	116	120
	E	86	90	94	-	-	-	-
	Mean	82.0	87.7	93.7	102	108	112	115
	Std. Dev.	3.5	2.5	.6	.7	5.5	7.2	8.4
XT1	A	30	35	45	58	62	75	80
	B	-	-	-	-	-	-	-
	C	-	-	-	-	-	-	-
	D	35	50	60	70	82	88	92
	E	31	52	68	-	87	89	90
	Mean	32.0	45.7	57.7	64.0	77.0	84.0	87.3
	Std. Dev.	2.6	9.3	11.7	8.5	13.2	7.8	6.4
XT2	A	78	80	85	90	92	94	95
	B	75	76	-	-	-	-	92
	C	80	82	85	90	92	93	94
	D	-	75	82	86	89	91	92
	E	-	-	-	-	-	-	-
	Mean	77.7	78.3	84.0	88.7	91.0	92.7	93.3
	Std. Dev.	2.5	3.3	1.7	2.3	1.7	1.5	1.5

VII. VALUE OF RESEARCH

There is one other valuable piece of information that can be obtained from the model and that is the value of research. The PAUS system has a feature which performs sensitivity analysis by holding all but one of the stochastic variables at their means. That one variable is allowed to assume selected values from its probability distribution and the effect on various output variables can then be determined.

The table on page 38 summarizes just such an analysis. The right hand column shows the effect that a 10% increase in any of the six input variables will have on the SRC-II price. This information can be used to determine the benefits of research, the effect of adding a new piece of equipment, or the effect of an estimating error for one of the stochastic input variables. The following are two examples of possible applications:

1) If capital costs rise from $1.76 billion to $2.20 billion (a 25% increase), what will be the effect on the SRC price?

$$\text{\% change in price} = \frac{25\%}{10\%} \times 3.987\%$$

$$= 9.968\% \text{ increase}$$

$$\text{new SRC-II price} = \$4.13 \times 109.968\%$$

$$= \$4.54$$

2) If it will cost an additional $50 million in capital costs to increase thermal efficiency by one percentage point, should we make the investment?

$$\text{\% increase in capital cost} = \frac{.050}{1.76} = 2.84\%$$

$$\text{\% increase in thermal efficiency} = \frac{1}{72} = 1.39\%$$

$$\% \text{ change in price} = \left(\frac{2.84}{10} \times 3.987\%\right) - \left(\frac{1.39}{10} \times 8.667\%\right)$$

$$= .07\% \text{ decrease}$$

$$\text{new SRC-II price} = \$4.13 \times 99.93\%$$

$$= \$4.13 \text{ (no appreciable change)}$$

Value of Research

Variable	Effect
% Operating Time (year 1) Initial Price of SRC-II	10% increase = 0.404% decrease
% Operating Time (year n) Initial Price of SRC-II	10% increase = 0.776% decrease
% Design Capacity Initial Price of SRC-II	10% increase = 5.487% decrease
Thermal Efficiency % Initial Price of SRC-II	10% increase = 8.667% decrease
Capital Costs (Billions of $) Initial Price of SRC-II	10% increase = 3.987% increase
Direct Operating Costs (Millions of $) Initial Price of SRC-II	10% increase = 1.292% increase

VIII. SOURCES OF ERROR

There are six possible sources of error that can be identified with this study as discussed below.

1) Inappropriate choice of subjects to be interviewed.

   Care was taken to select knowledgeable experts who are currently involved in the SRC-II project, but there still exists the possibility that a nonrepresentative group was chosen.

2) Bias.

   Inherent biases that a subject may have are difficult to overcome, but every effort was made during the interviews to cut through biases and check the consistency of the responses.

3) Reliance on base case numbers.

   The subjects were aware of the estimated values for each quantity that were used in the base case. As a result, the probability distributions for each quantity often reflect the subject's feelings towards these base case estimates.

4) Inaccurate estimate of future costs.

   It is most difficult to estimate in 1978 what the costs will be for a plant that may not be built for twenty years.

5) Inaccurate estimate of technological improvements.

   As with future costs, it is equally difficult to envision technological advances and break-throughs over the next twenty years.

6) Shifting of the means.

   After the interview process had been completed, the contractors revised their estimates for capital costs (from \$1.62 billion to \$1.56 billion) and direct operating costs (from \$112 million to \$88.9 million).

Time constraints prohibited our repeating the interview process to determine whether or not the subject's distributions had changed, so each was contacted by phone. All interviewees agreed that merely shifting the mean of their distributions downward by the difference in the base case estimates would adequately reflect their position. This is of questionable statistical validity, but the error (if any) and resulting change in the SRC-II price would be minimal.

APPENDIX A

Sample Interview[1]

The following dialogue illustrates how to obtain a judgmental probability distribution for an unknown population proportion *p*. With this as background, I hope you will see how you might generate your own judgmental distribution for the proportion *p* of θ_1 urns from the vague impression suggested in Modification 1. The persons of the dialogue are a decision analyst and his client or subject, who takes the part of the decision maker or an expert agent delegated by the decision maker.

Analyst. I should like to show you how you can obtain a judgmental probability distribution for some unknown proportion *p*. I want to choose a context that is sufficiently meaningful to you, because I want to probe into *your* judgments rather than into someone else's. Let's consider the population of medical doctors in the U.S. who are nonteetotalers. Now suppose we let *p* be the proportion of these imbibers who consumed more scotch than bourbon in the past year. Incidentally, do you know much about the drinking pattern of doctors?

Subject. Not much. The usual, I suppose. I know three or four doctors personally, but I imagine doctors are not much different from lawyers or dentists or engineers. The trouble is that I would not know how to answer your question for any of those groups. I don't have the foggiest notion what *p* is.

Analyst. Good. I wanted to take just such an example.

Subject. I suppose you want me to give a best guess at *p*. I don't know if I could even do that.

[1] Raiffa, Howard. "Introductory Lectures on Choice under Uncertainity", Addison - Wesley, July, 1970.

Analyst. No, I don't want you to do that. In fact, I don't think it's very meaningful to talk about a 'best' guess. Best for what? Let me start off with some warming-up questions. Do you think it's more likely that p is less than .10 or above .10?

Subject. That's easy! Above.

Analyst. Is it more likely that p is above .90 or below?

Subject. Below.

Analyst. Those were easy. See, you do know something about p. Now I want you to think hard about the next one. Give me a value such that it would be extremely hard for you to make up your mind to choose above it or below it. In other words, I want you to give me a value such that you will think it equally likely that p falls below or above it.

Subject. (After some thought.) I would say .60. But, boy, am I vague about this. I *think* more doctors prefer scotch. You know, the upwardly mobile group and all that sort of thing.

Analyst. Don't fret about this too much; if you want to change your mind later on, that's all right with me. You have now told me that you think it is equally likely that p is less than .60 or more than .60.

Subject. That's right. But don't ask me to define what 'equally likely' means.

Analyst. By 'equally likely' in this context I mean that you are indifferent between receiving a very desirable prize conditional on p being below .60 and receiving this identical prize conditional on p being above .60. Or, more dramatically, if your life depended on it, you would just as soon opt for $p \leq .60$ as $p \geq .60$. Are you with me?

Subject. So far, so good.

Analyst. Essentially you have now told me, *and* yourself, that .60 divides the interval from zero to 1.0 into two judgmentally equally likely parts.

Now I am going to ask you to repeat this process of judgmentally subdividing different intervals into two equally likely parts. For example, do you think it is more likely that p is less than .20 or is between .20 and .60?

Subject. Between .20 and .60.

Analyst. Between zero and .58 or between .58 and .60?

Subject. Between zero and .58.

Analyst. All right, now give me a number such that you think it is judgmentally equally likely that p is between zero and that number or between that number and .60.

Subject. What happens if p is greater than .60?

Analyst. As things stand now, you lose. Look, if you tell me the number is p^*, then this means that you think your chances of winning the prize are just as good if you choose the interval zero to p^* as they are if you choose the interval p^* to .60. If p is greater than .60, you would not get the prize no matter which side of p^* you choose because p would not be in either interval.

Subject. All right, let's see. I'll say than .50 divides the interval zero to .60 into two equally likely parts.

Analyst. Once you had given me the number .60, would it have been easier for you if I had posed my last request this way: 'Look, suppose I tell you that p is less than .60. Knowing this, how would you divide the interval zero to .60 into two equally likely parts?'

Subject. Are these the same questions?

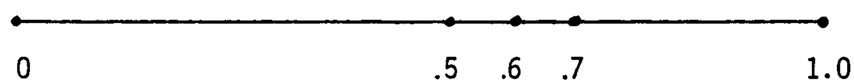
Analyst. I think so. Think about it.

Subject. I suppose they are the same. The second way seems easier, but second ways always seem easier to me.

Analyst. Let's go on. Suppose I tell you that *p* is greater than .60. Then how would you divide the interval .60 to 1.00 into two equally likely parts?

Subject. Hmm -- .70. From .60 to .70 is just as likely as above .70. But I really feel uncomfortable about the .50 and .70 because the .60 is so shaky. I feel I'm building on a sponge. I hope you realize these numbers are mighty shaky.

Analyst. I hope you realize that I realize that. You are doing fine. You have now given me three numbers, .60, .50, and .70. Let me draw an interval from zero to 1.00 and place these point on it:



Now you have told me that so far as you are concerned, you believe it is just as likely that *p* lies in any one of the four intervals (0 to .50), (.50 to .60), (.60 to .70), and (.70 to 1.00).

Subject. I guess I said that.

Analyst. Now I am just checking up. I don't want to catch you and it certainly is not my intention to embarrass you, but it is important to look at these things from many different angles. For example, would you rather bet that *p* lies in the interval (.50 to .70), or outside this interval?

Subject. I think I would bet that it lies inside the interval. But now I'm being inconsistent, am I not?

Analyst. Yes, you are, but almost everyone else is too. I want you to think about it more. It will help if you try consciously to be consistent.

Subject. Well, I don't want to change the .60. I feel shakiest about the .70. I suppose I'd be willing to live with .68. So far as I'm concerned, it's a 50-50 bet that *p* lies in the interval (.50 to .68).

Analyst. Would you be willing to say that it is equally likely that p lies in the interval (.60 to .68) as in the interval (.68 to 1.00)?

Subject. All right, I'll go along with this. But if we did it all over again and if I erased this conversation from my memory, I can imagine that instead of ending up with the numbers .50, .60, and .68, I could have ended up with numbers like .52, .64, and .74.

Analyst. Well, these are in the same ballpark. Could you imagine ending up with numbers like .20, .40, and .55?

Subject. No. Not really. But what would you do if I said 'Yes'?

Analyst. I would push you further and use some averaging process that would pull the three numbers you have given me further apart. But let's go on. I'll refer to the number .60 as your judgmental .50-fractile, the number .50 as your judgmental .25-fractile, and *Aside to the reader.* Symbolically I shall write this as

$$p_{.25} = .50, \qquad p_{.50} = .60, \qquad p_{.75} = .68.$$

A few more numbers will help me. How would you divide the interval (0 to .50) into two equally likely parts?

Subject. .42.

Analyst. *Aside.* This means $p_{.125} = .42$.
Now divide the interval (.00 to .42).

Subject. You are pushing me pretty far.

Analyst. Well, suppose I told you that p is less than .42. Would you rather bet on (.00 to .21) or on (.21 to .42)?

Subject. On the latter, of course. All right, use .36.

Analyst. *Aside.* This means $p_{.0625} = .36$.
Now let's pass quickly to the high end. Divide (.68 to 1.00).

Subject. Use .75.

Analyst. *Aside.* This means $p_{.875} = .75$.

All right, divide (.75 to 1.00).

Subject. Use .80.

Analyst. *Aside.* This means $p_{.9375} = .80$

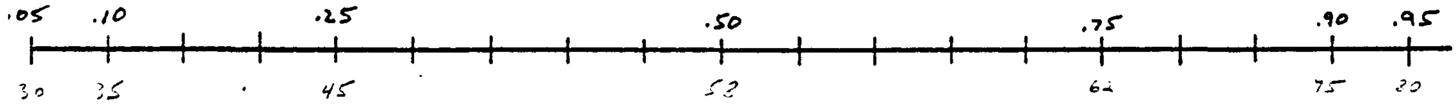
Let's summarize your judgmental responses in a table:

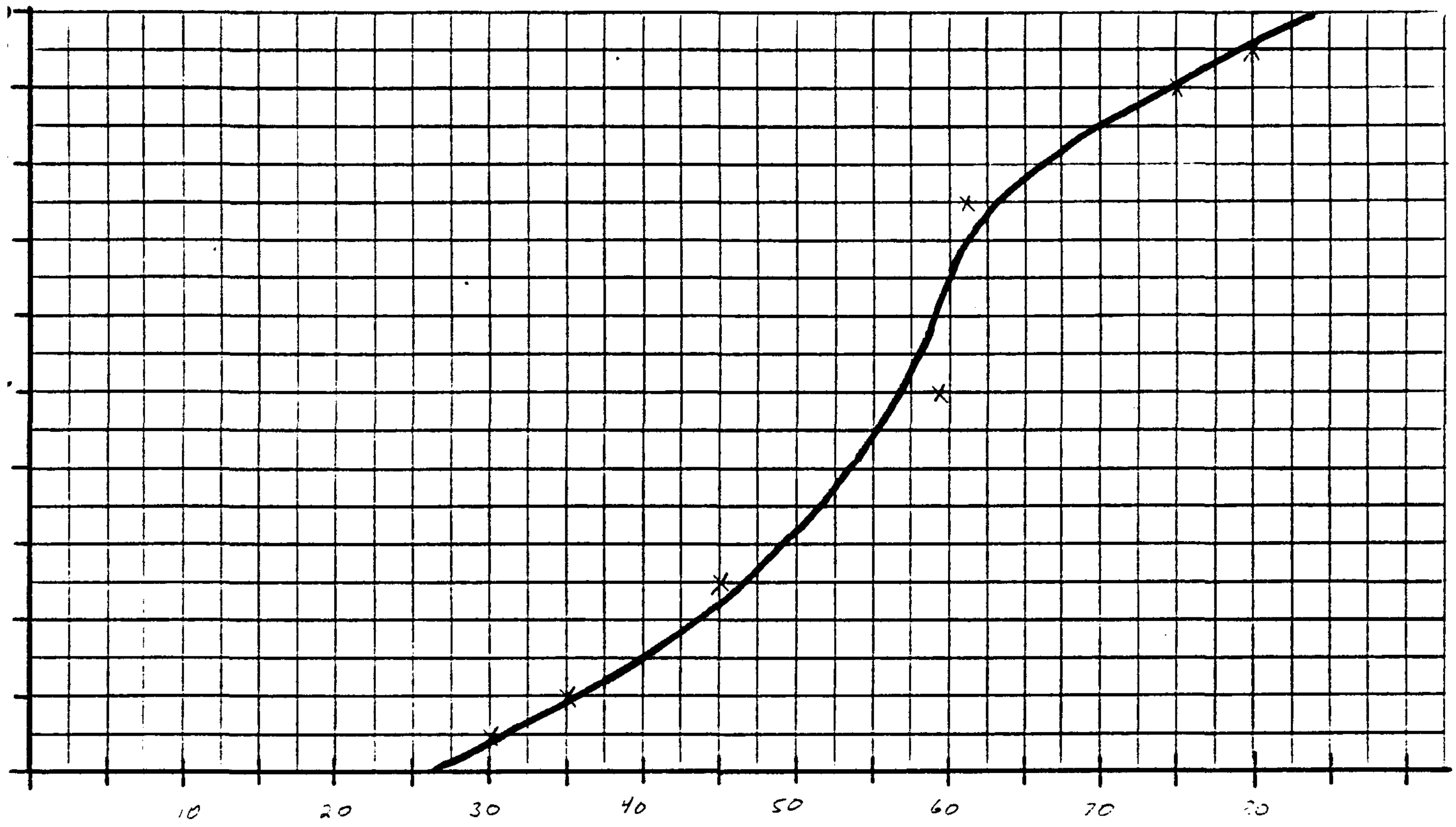
Fractile k	Judgmental Fractile value p_k
.0625	.36
.125	.42
.25	.50
.50	.60
.75	.68
.875	.75
.9375	.80

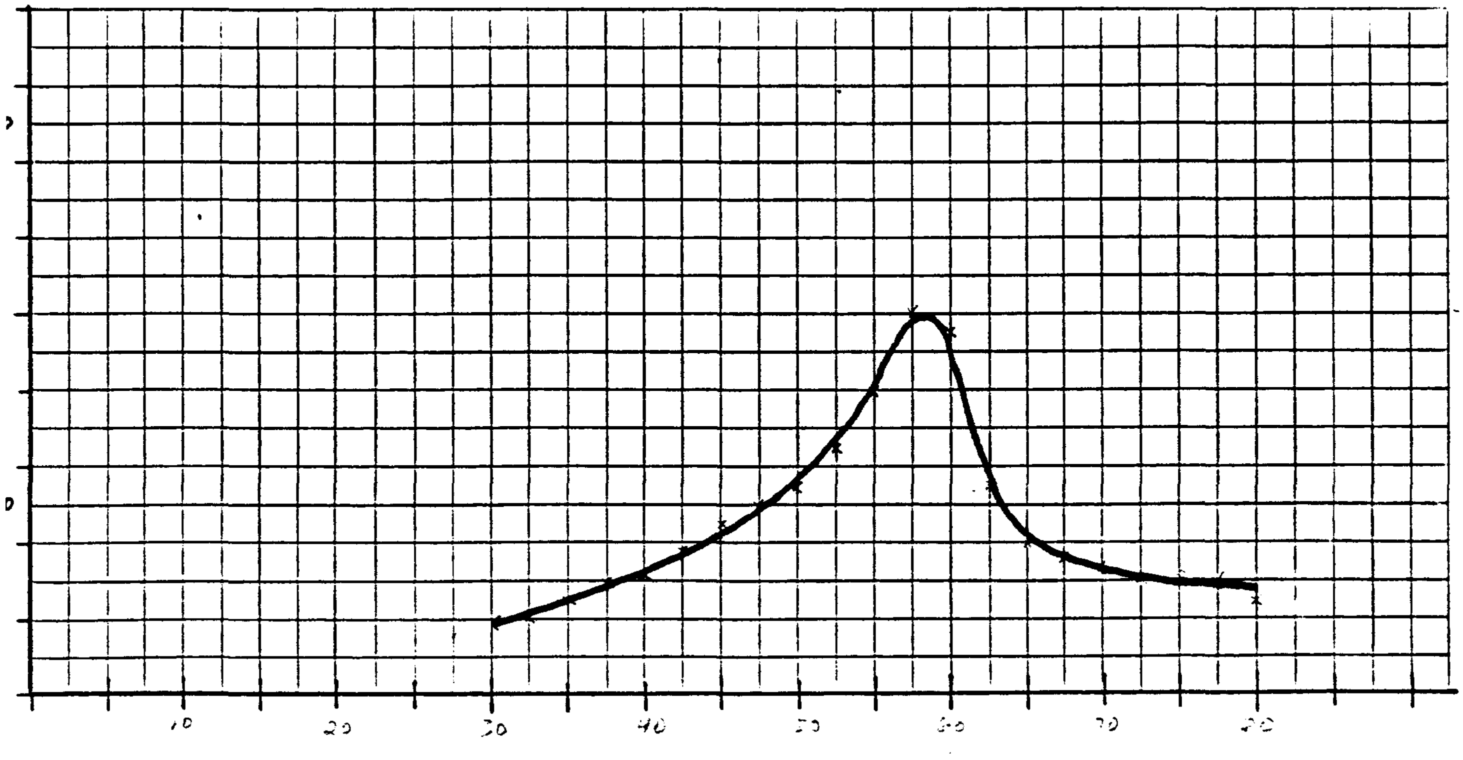
APPENDIX B

QUANTITY % OPERATING TIME ([illegible])

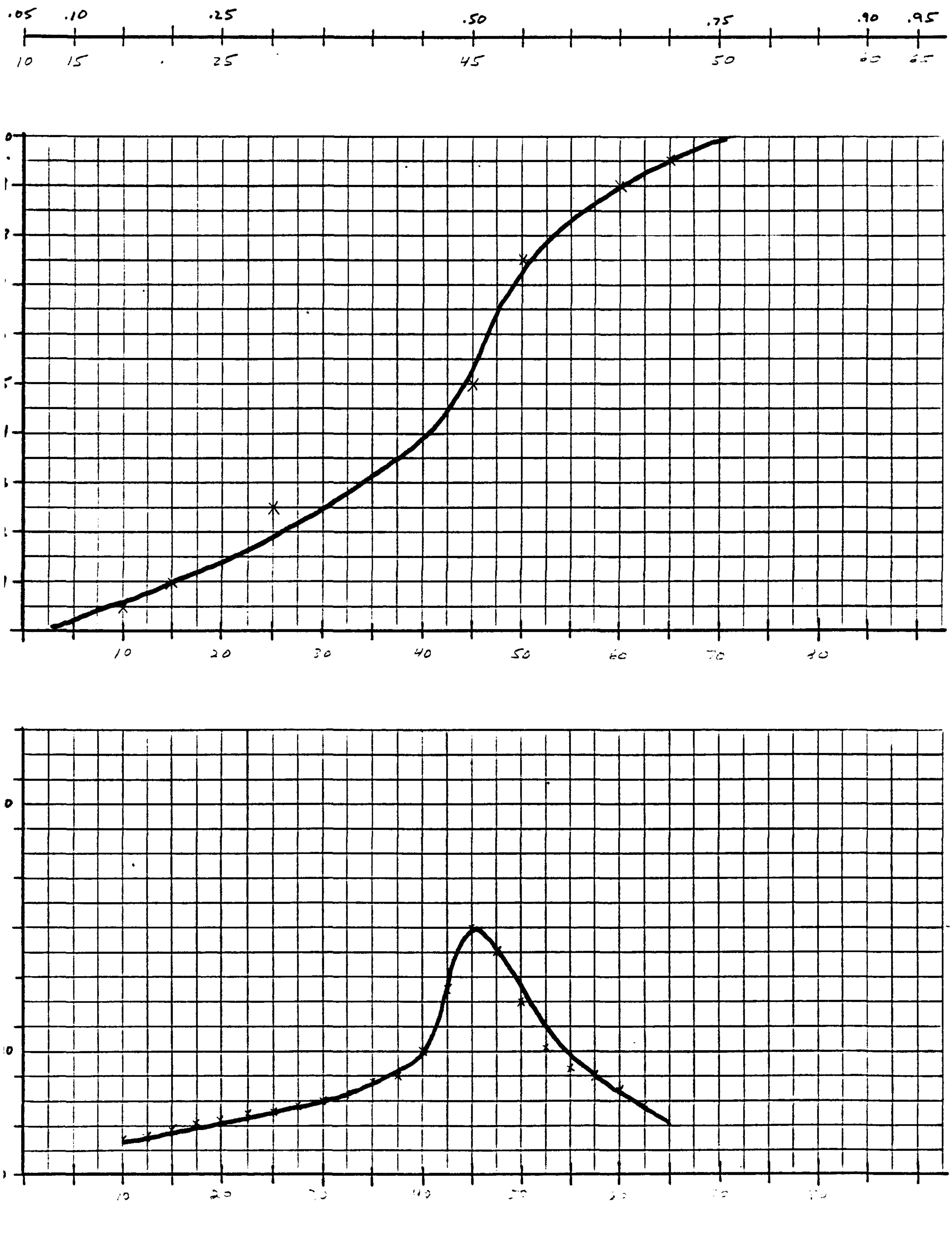
SUBJECT SUBJECT A ([illegible])





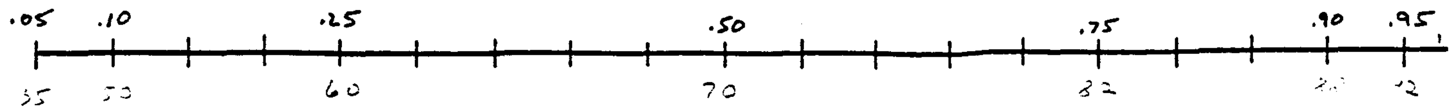


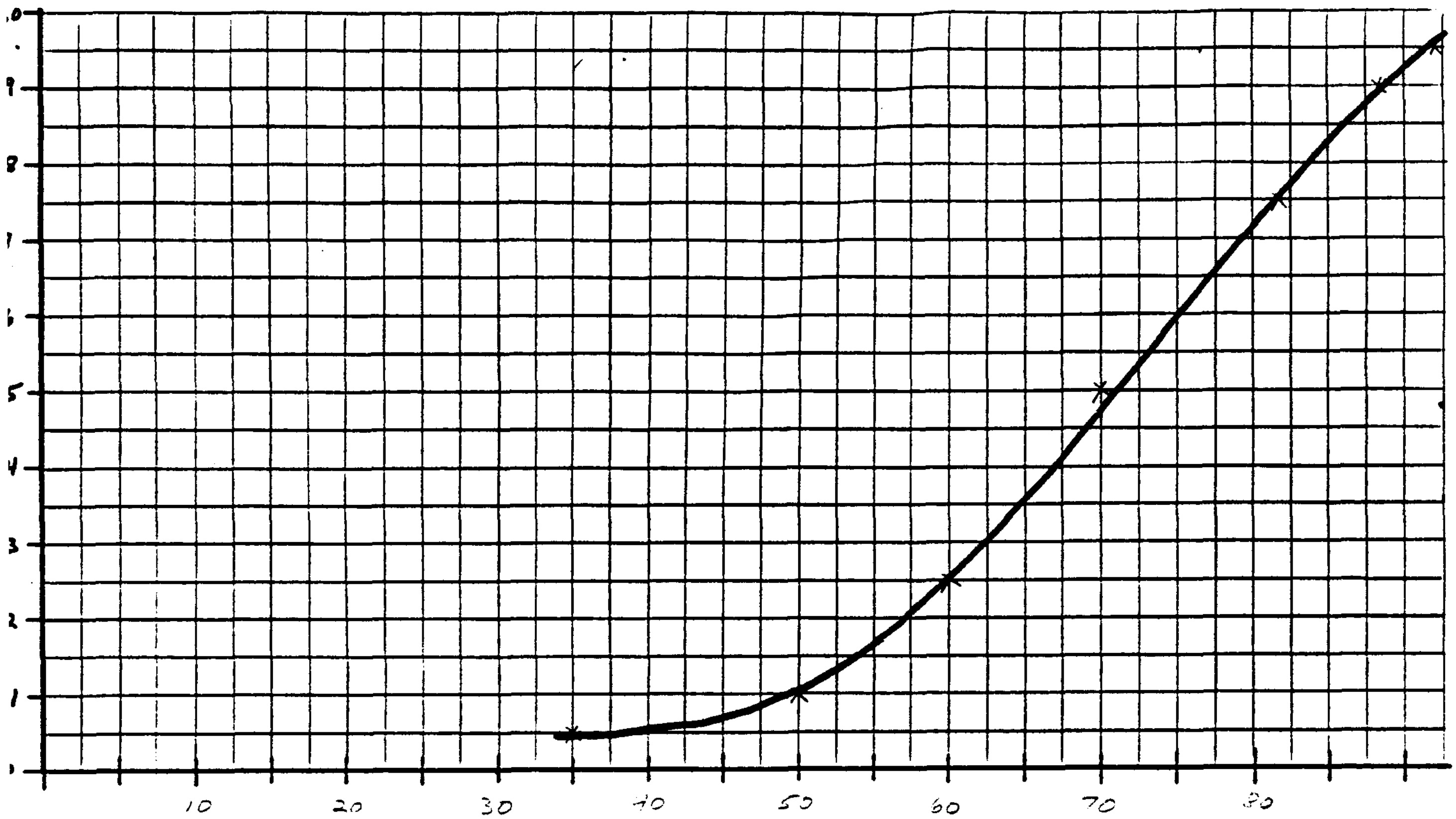
QUANTITY % OPERATING TIME (YEAR 1)
SUBJECT SUBJECT C (RED)

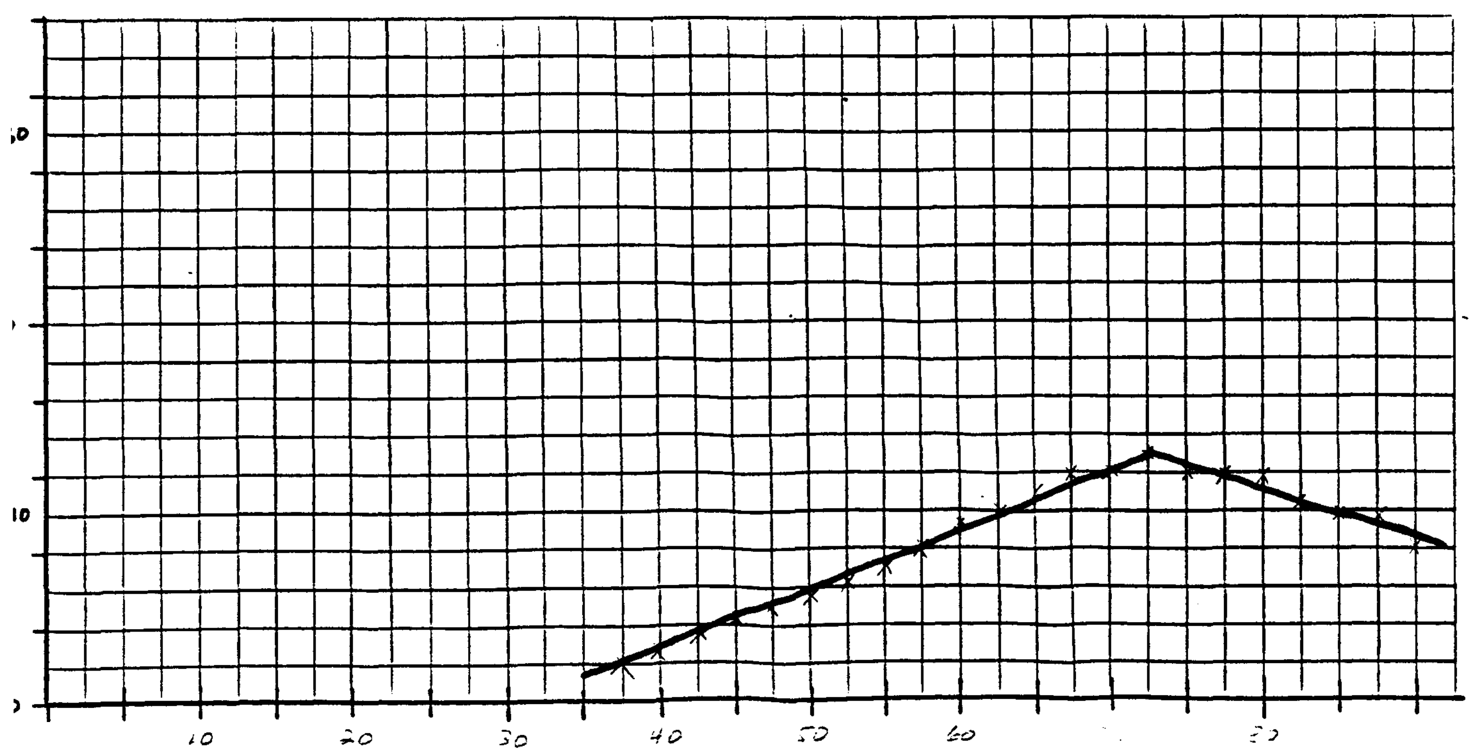


QUANTITY % OPERATING TIME (YEAR 1)

SUBJECT SUBJECT D (GREEN)

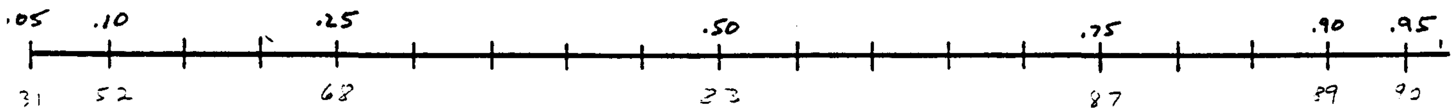


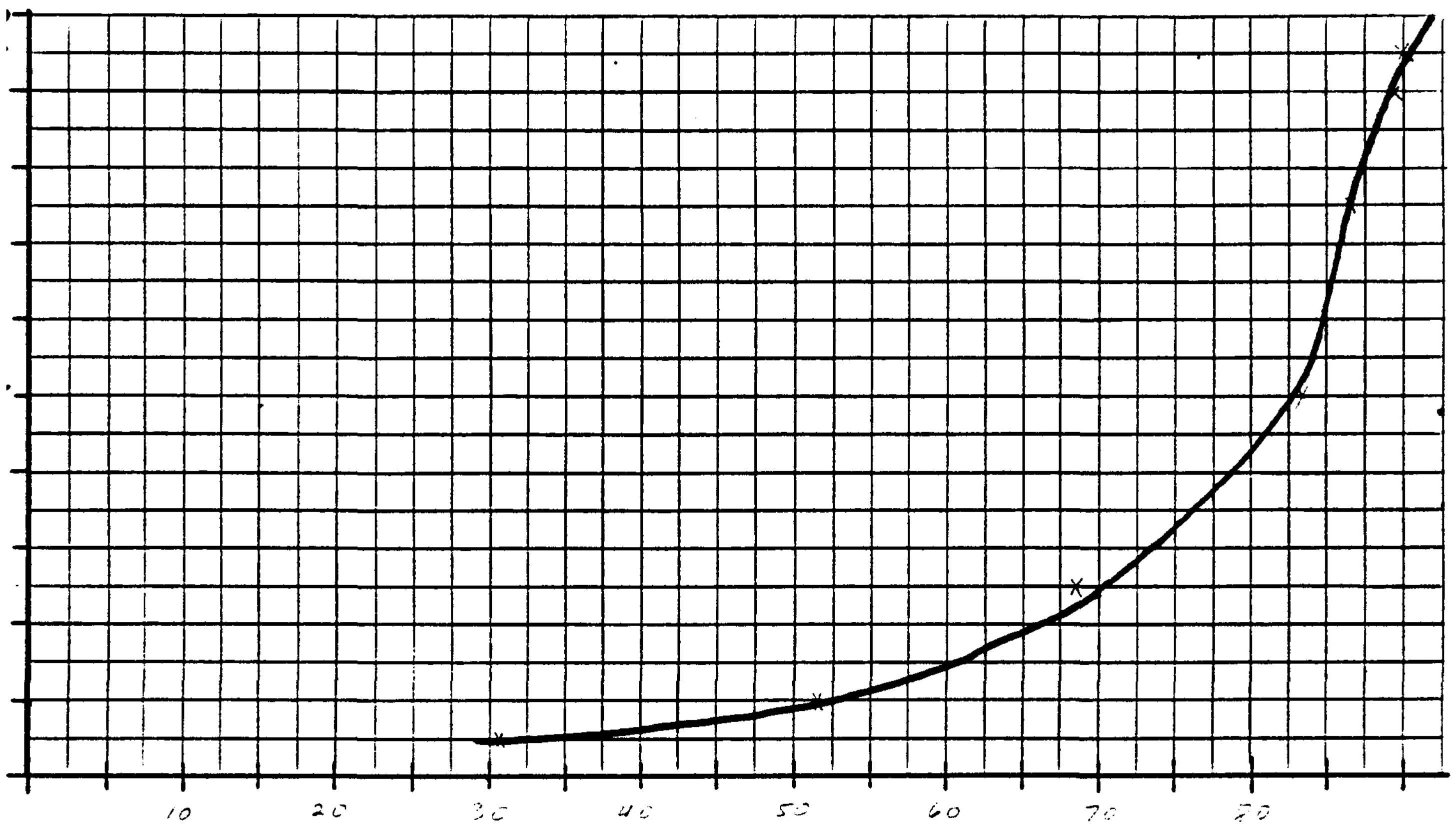


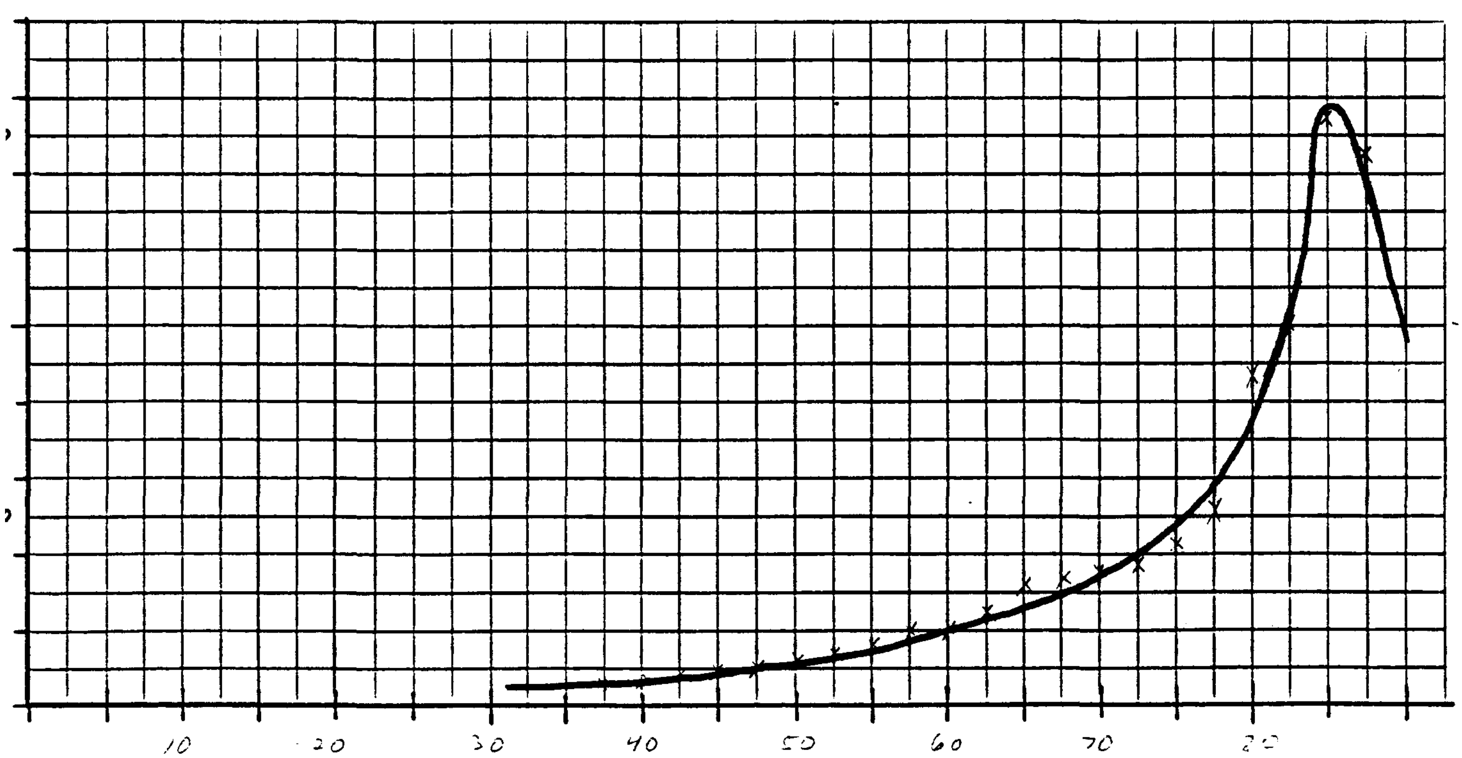


QUANTITY % OPERATING TIME (YEAR 1)

SUBJECT SUBJECT E (BROWN)

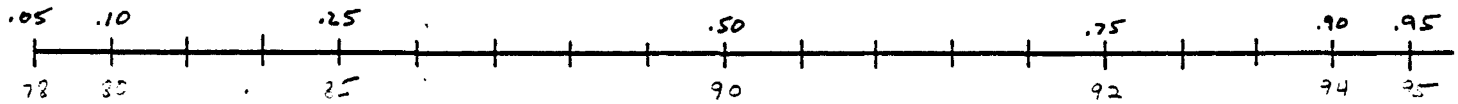


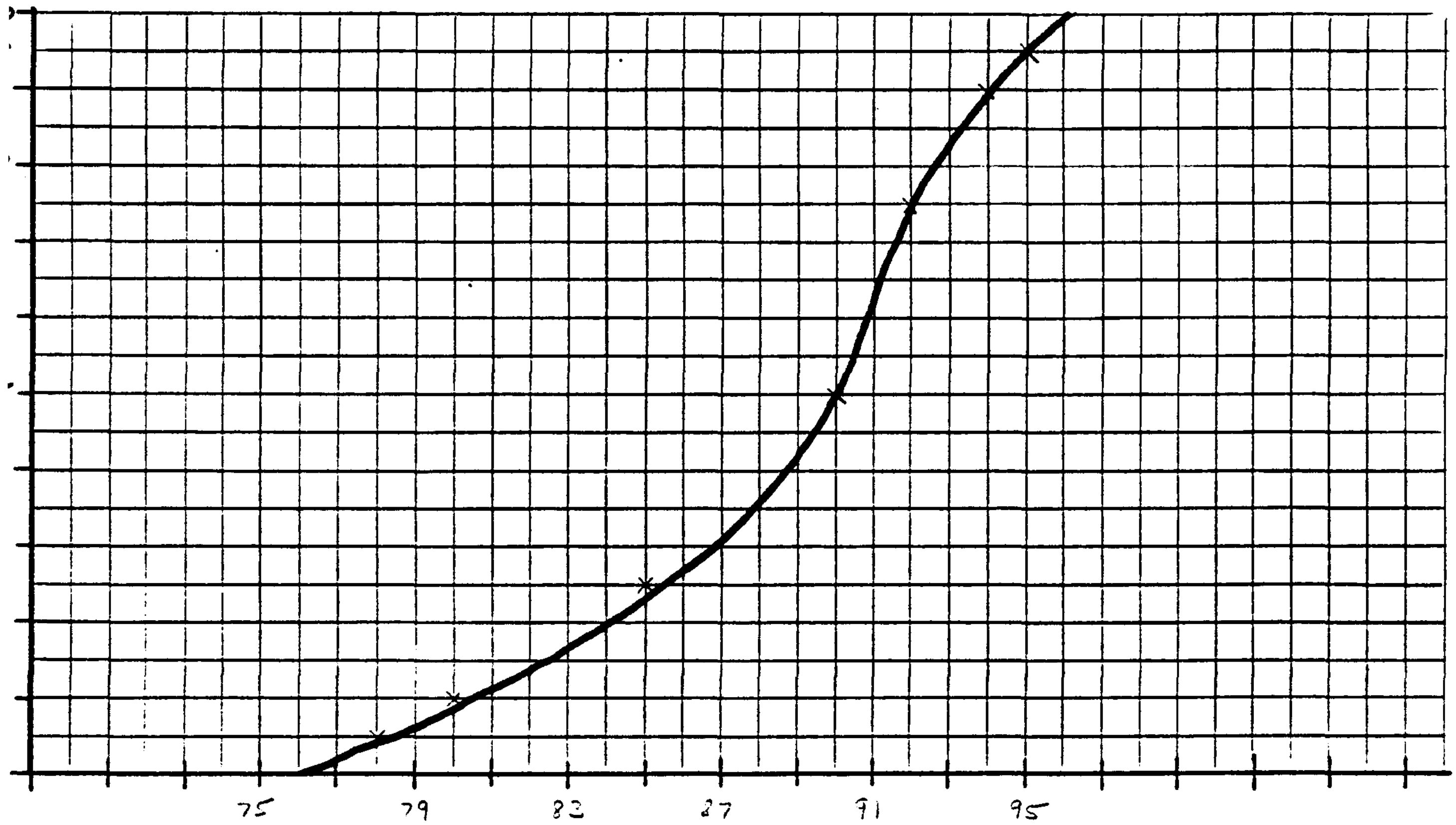


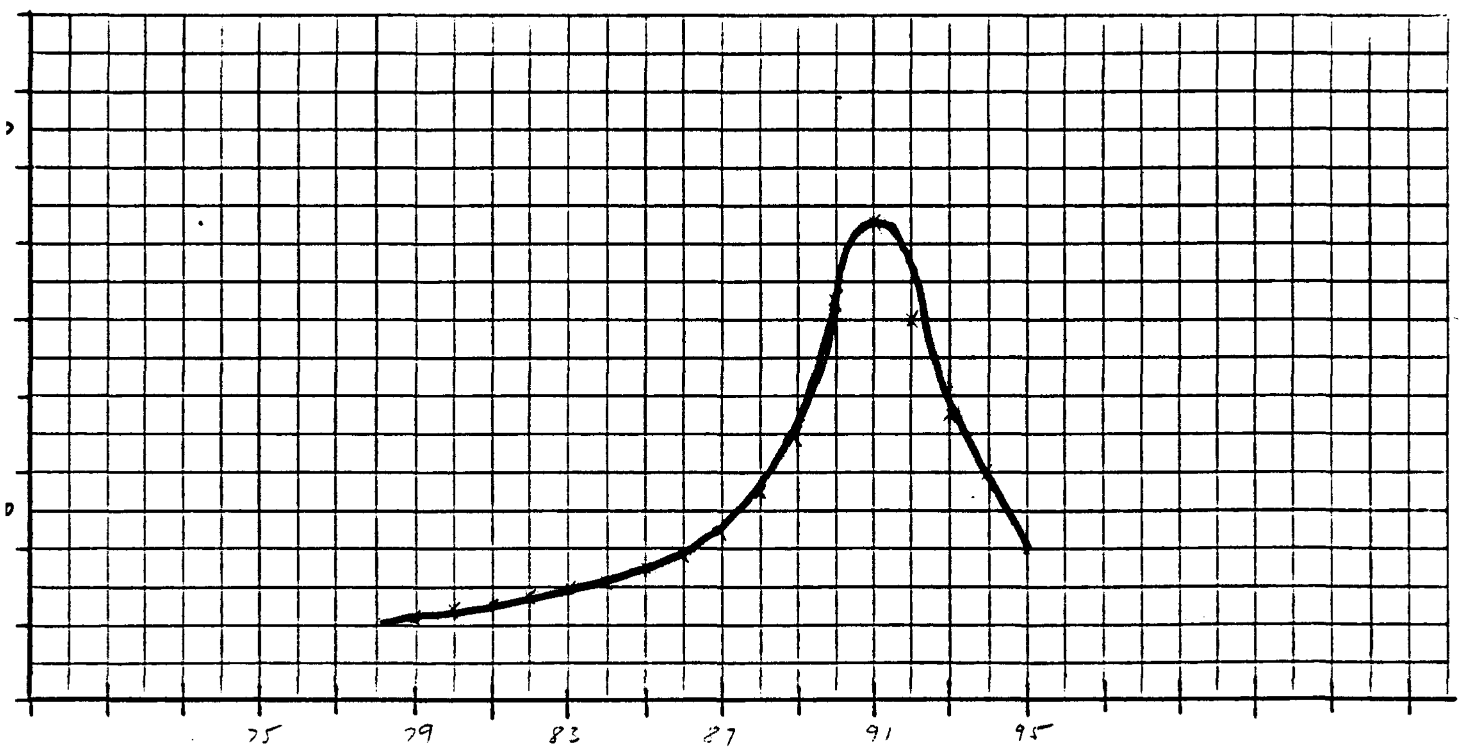


QUANTITY % OPERATING TIME (YEAR N)

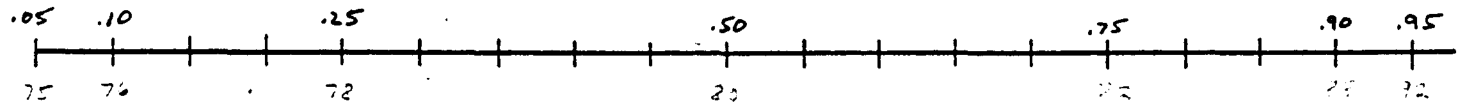
SUBJECT SUBJECT A (BLUE)

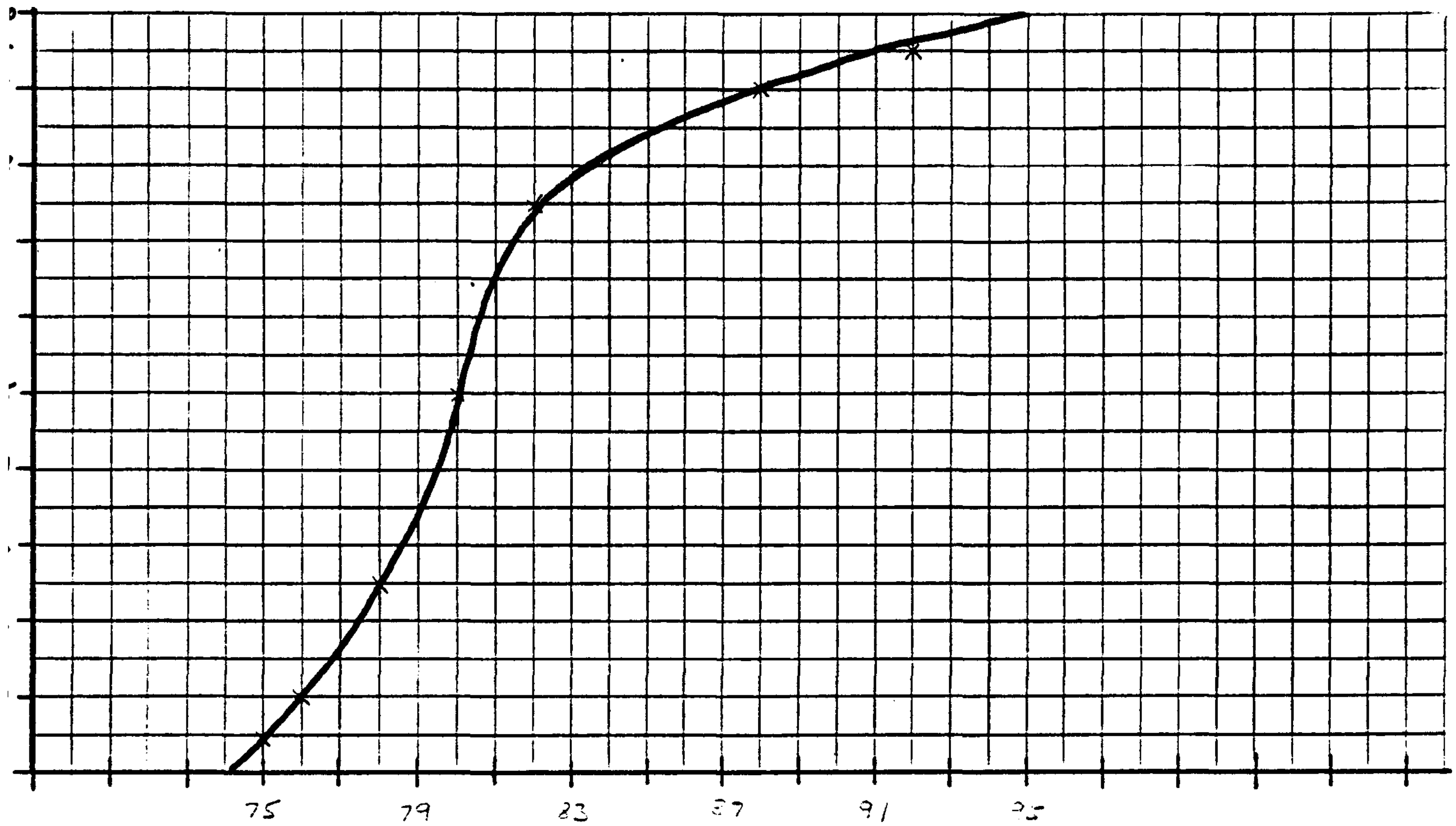


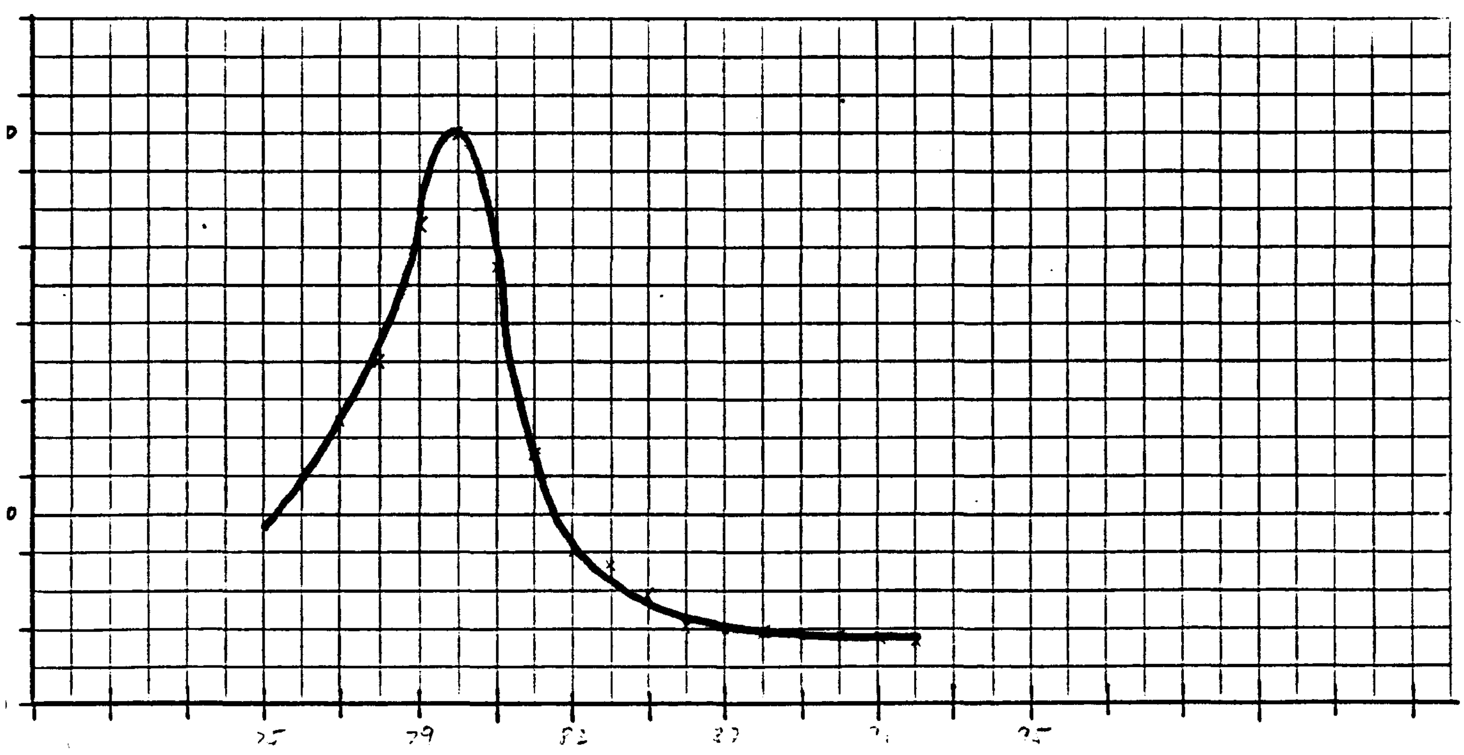




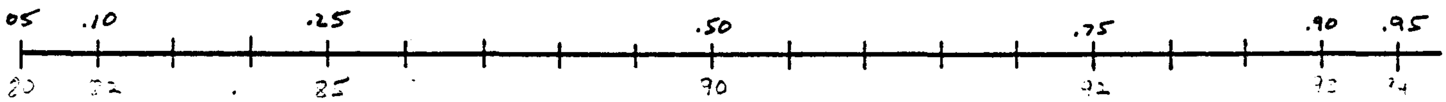
QUANTITY % OPERATING TIME (YEAR N)
SUBJECT SUBJECT C (YELLOW)

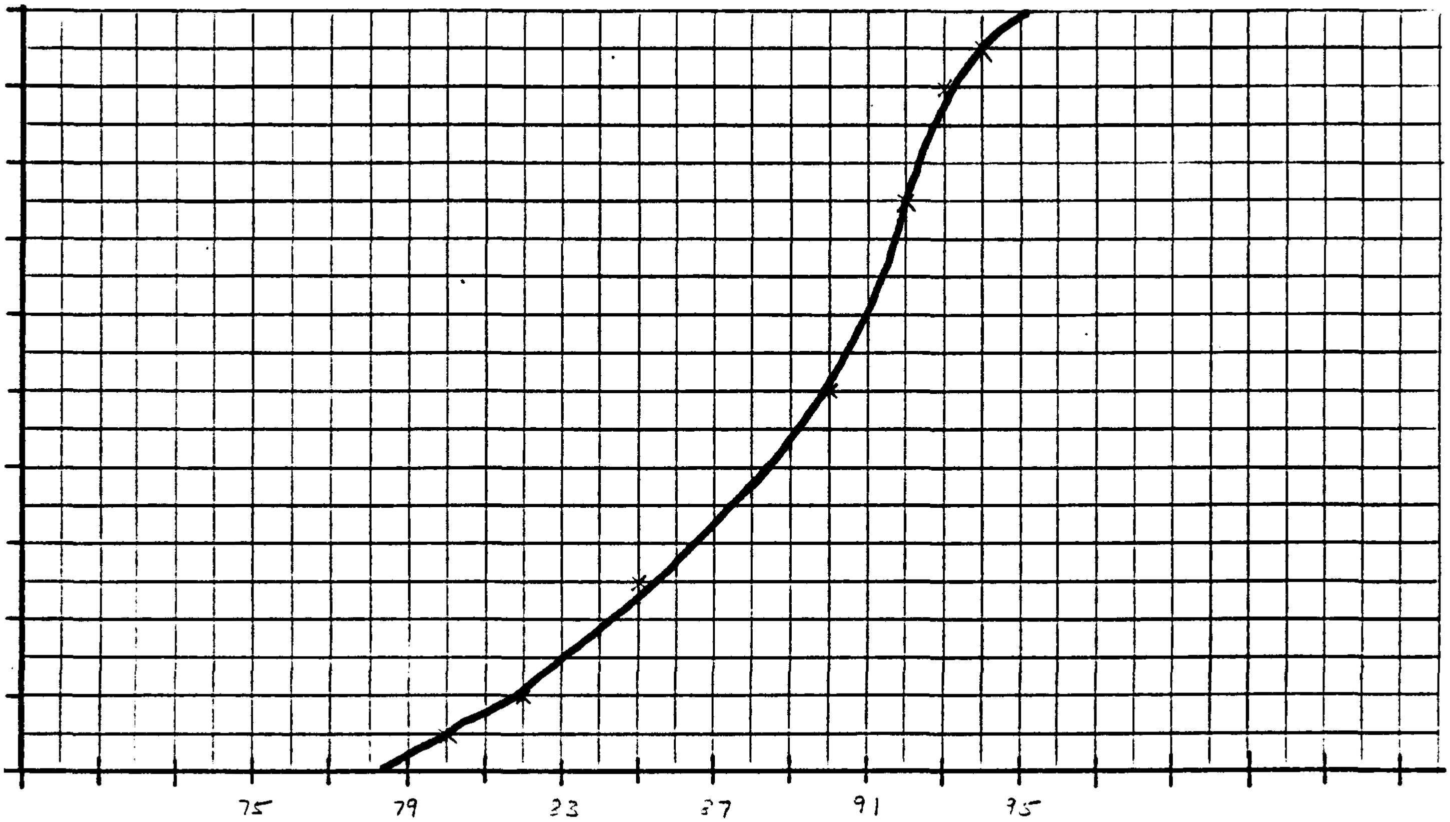


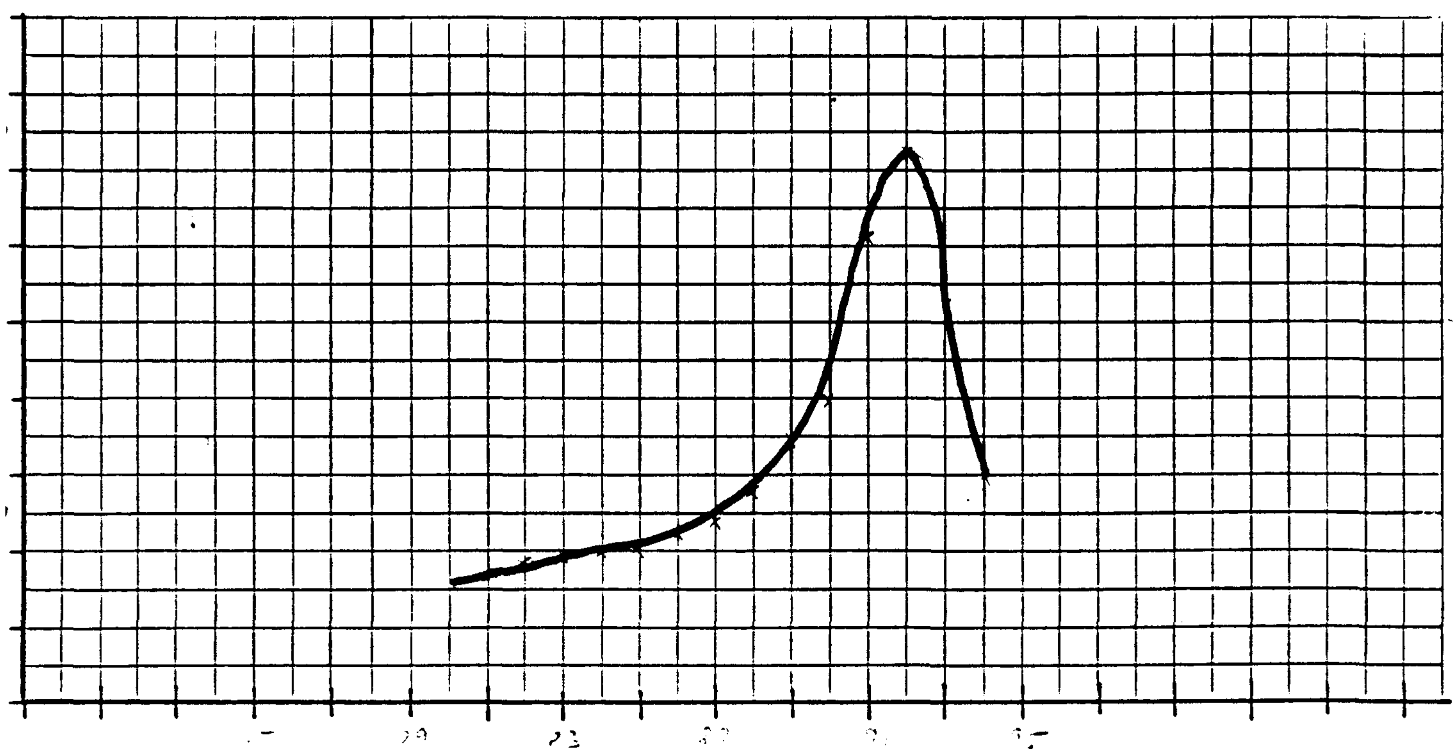




QUANTITY % OPERATING TIME (YEAR N)
SUBJECT SUBJECT C (RED)

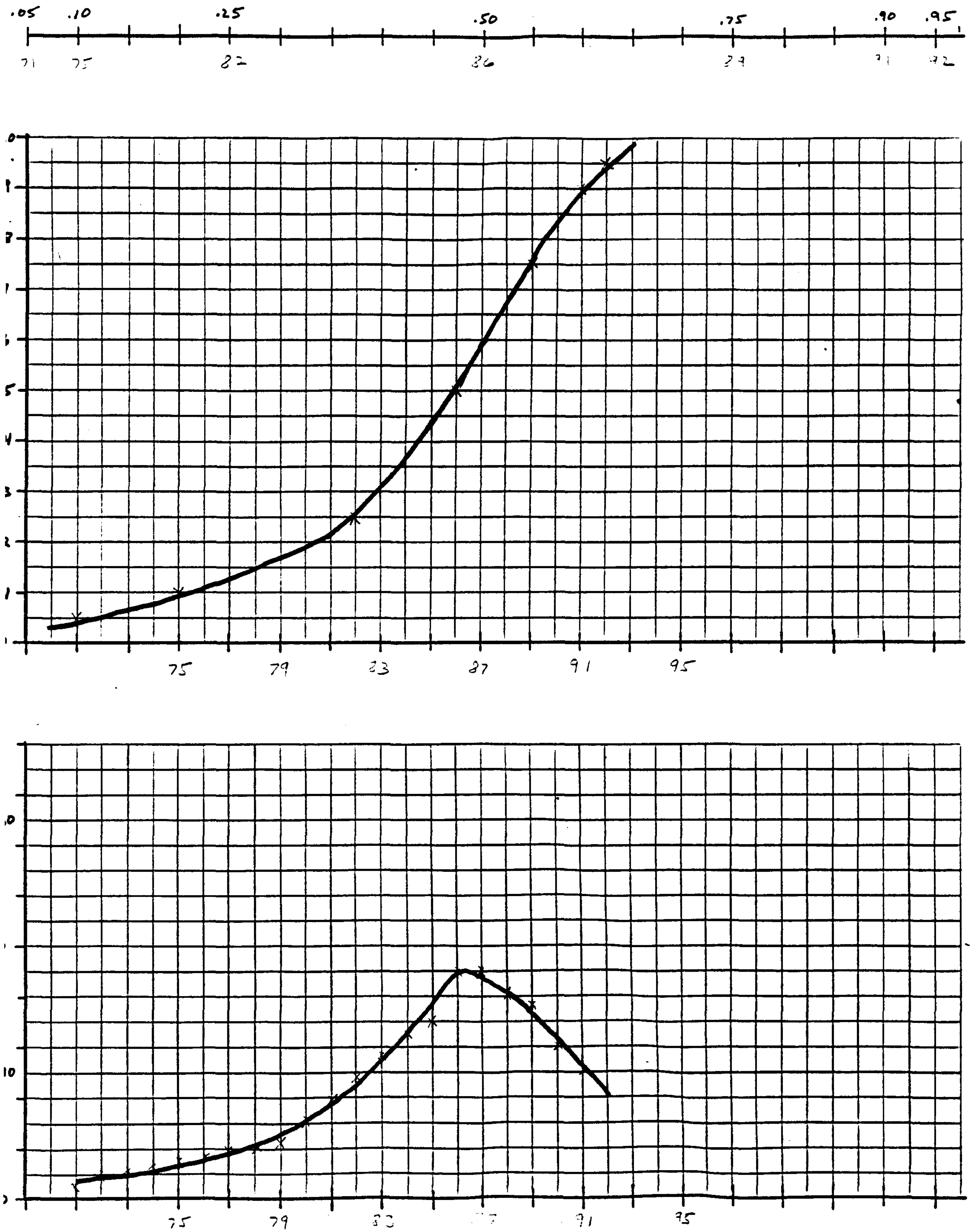




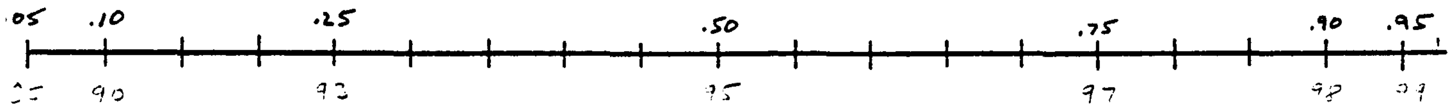


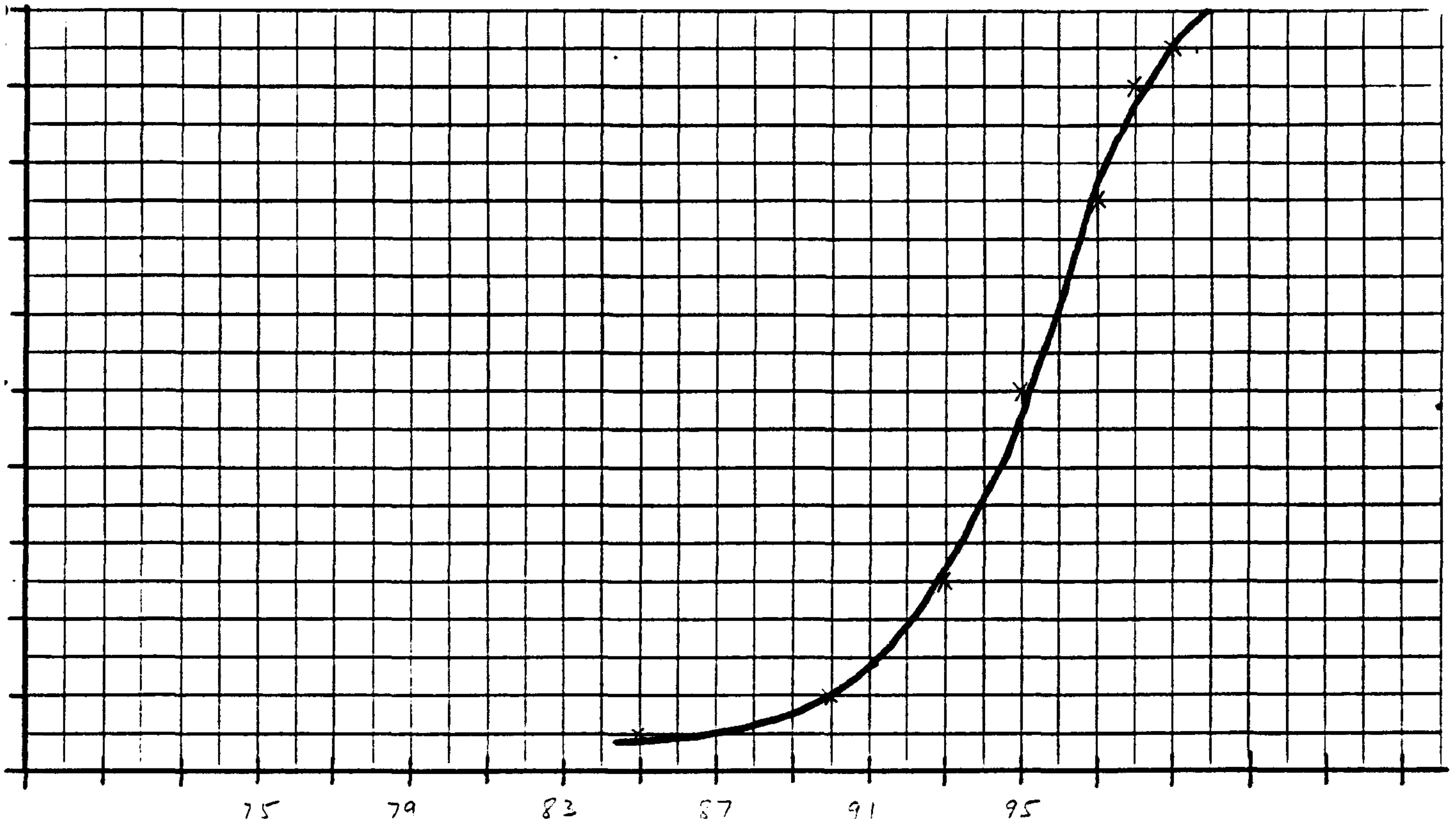
QUANTITY % OPERATING TIME (YEAR N)

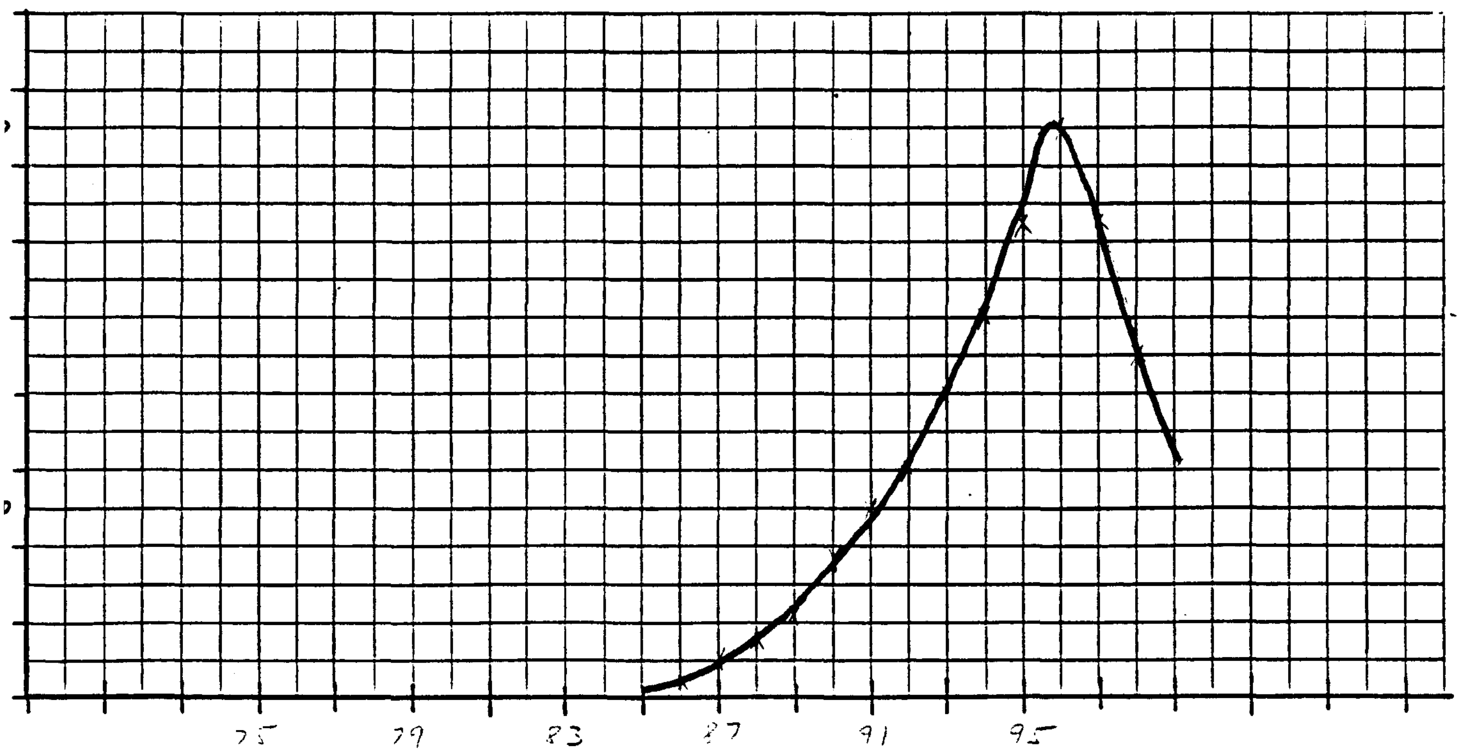
SUBJECT SUBJECT D (GREEN)



QUANTITY % OPERATING TIME (YEAR N)
SUBJECT SUBJECT E (BROWN)

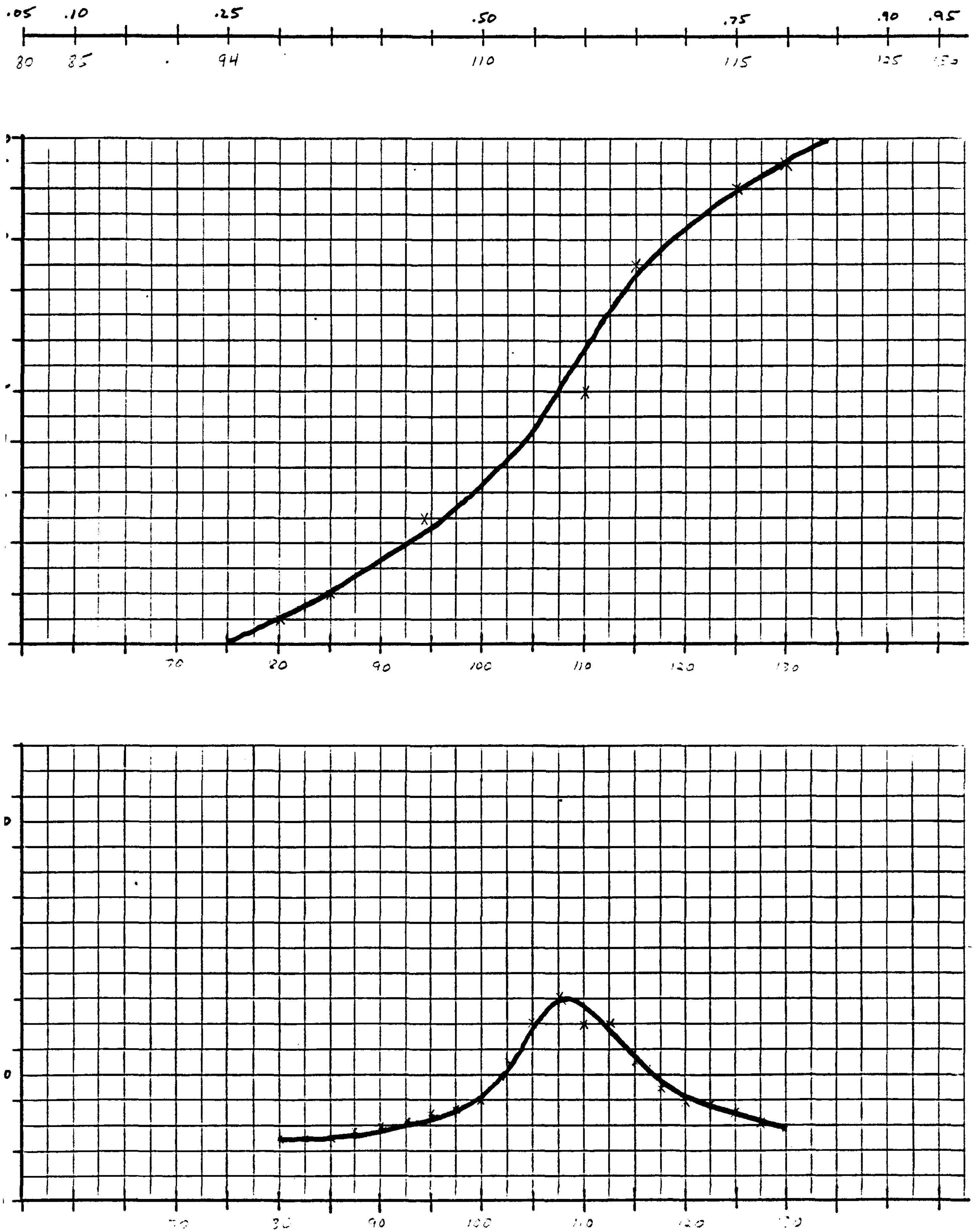






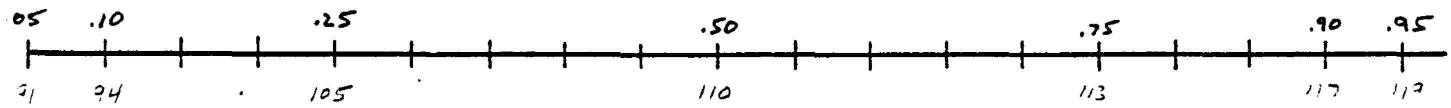
QUANTITY % DESIGN CAPACITY

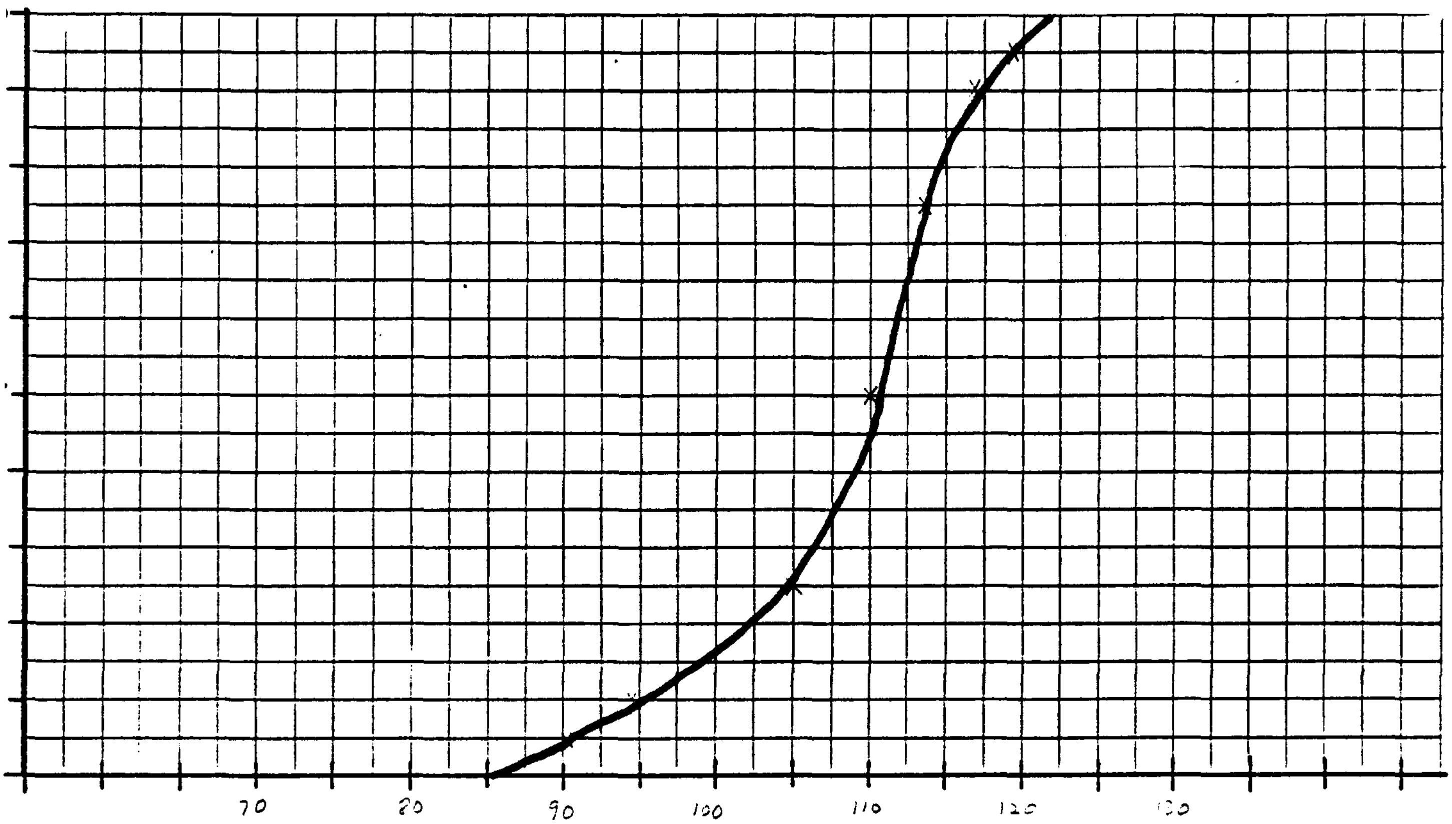
SUBJECT SUBJECT A (BLUE)

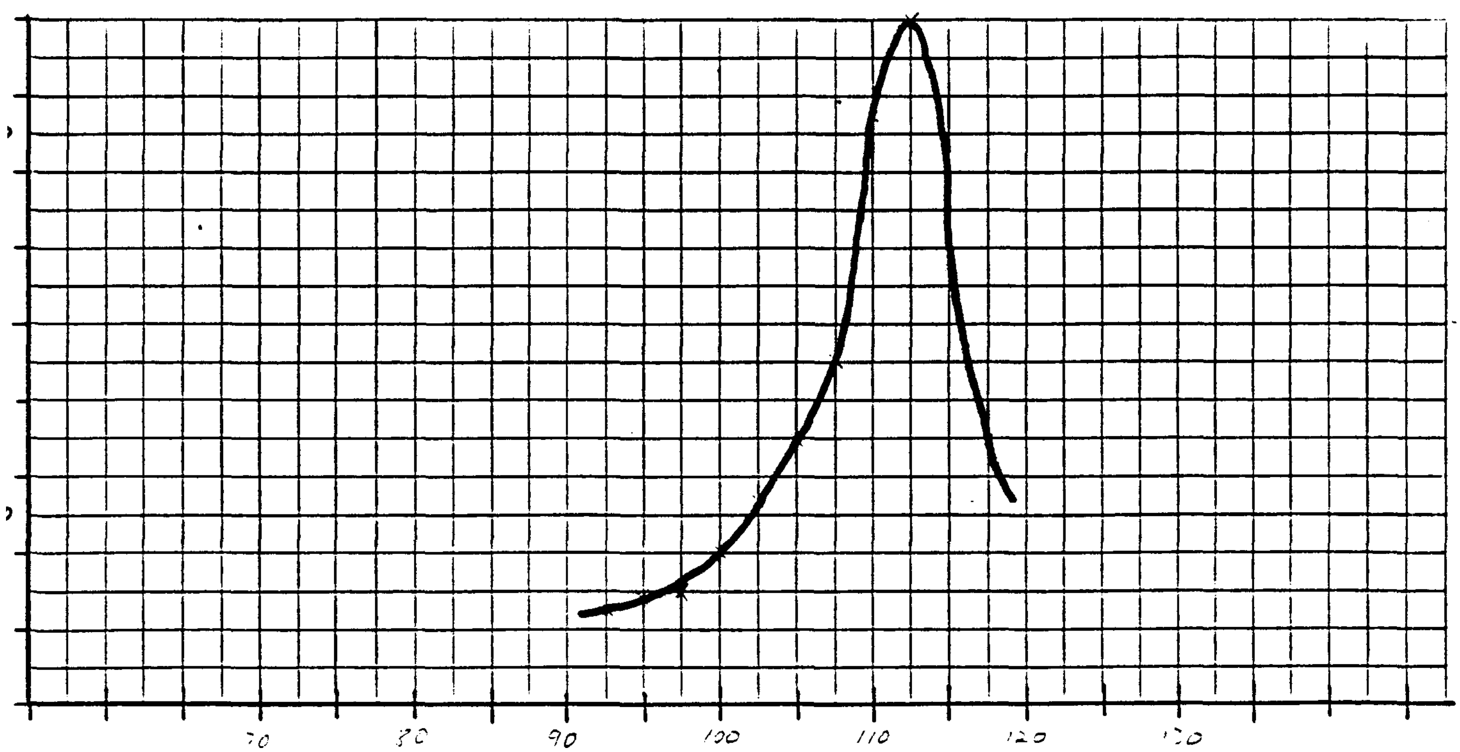


QUANTITY % DESIGN CAPACITY

SUBJECT SUBJECT C ([illegible])

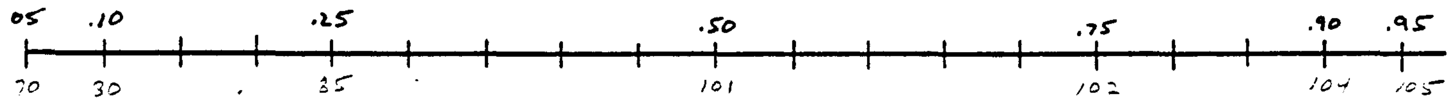


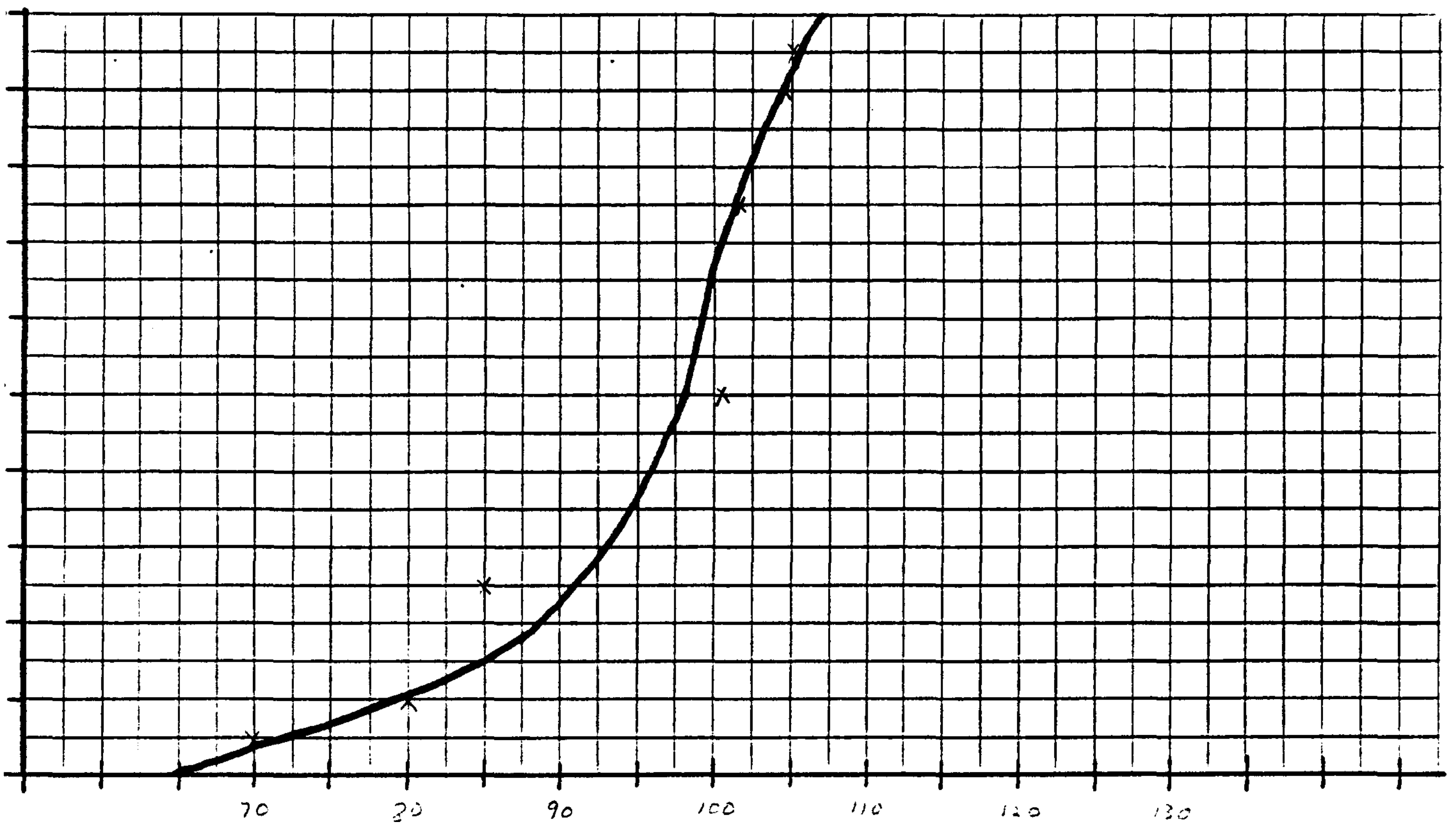


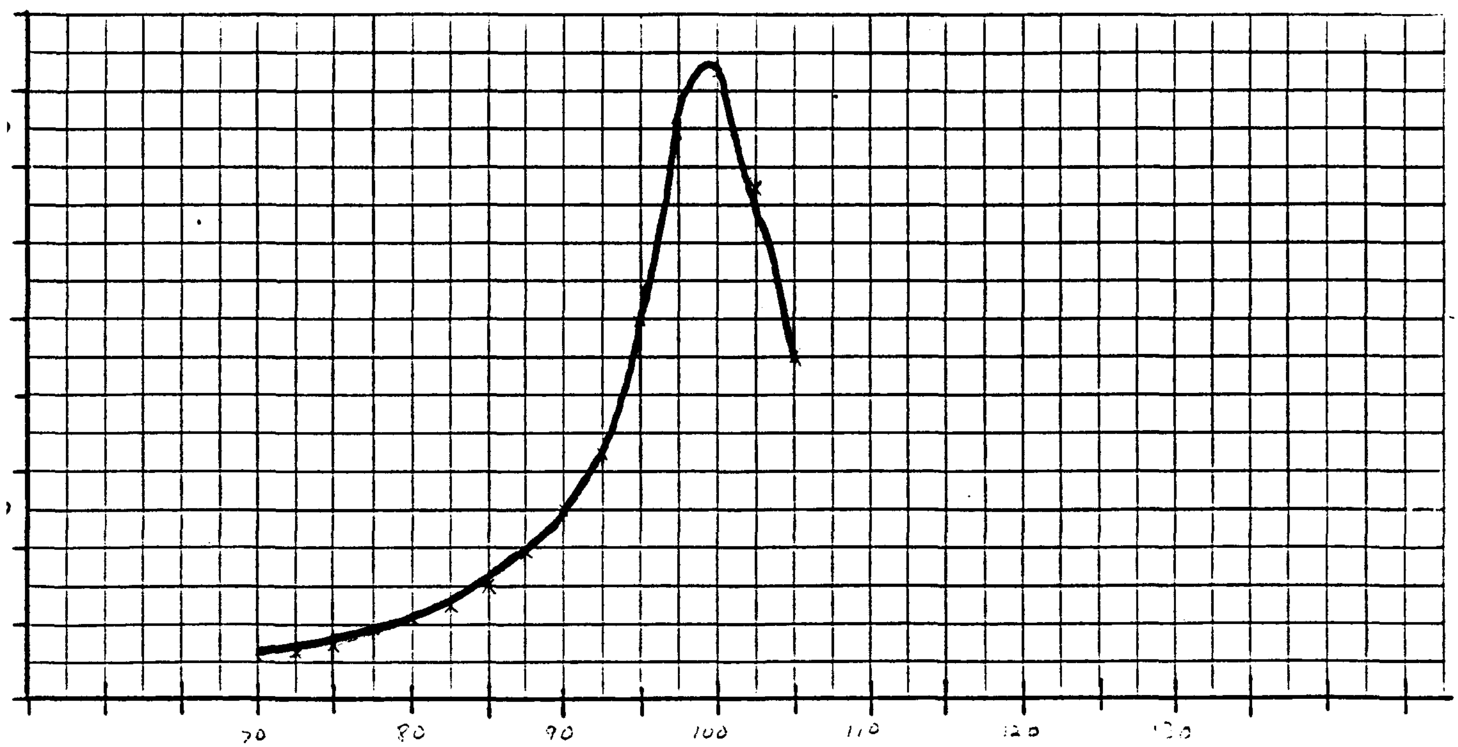


QUANTITY % DESIGN CAPACITY

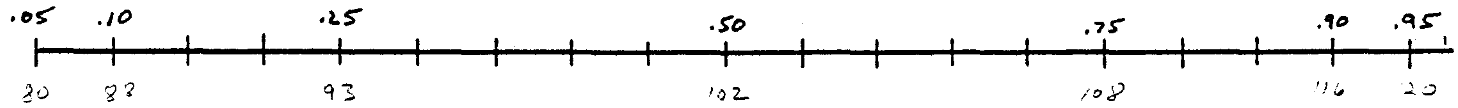
SUBJECT SUBJECT C (RED)

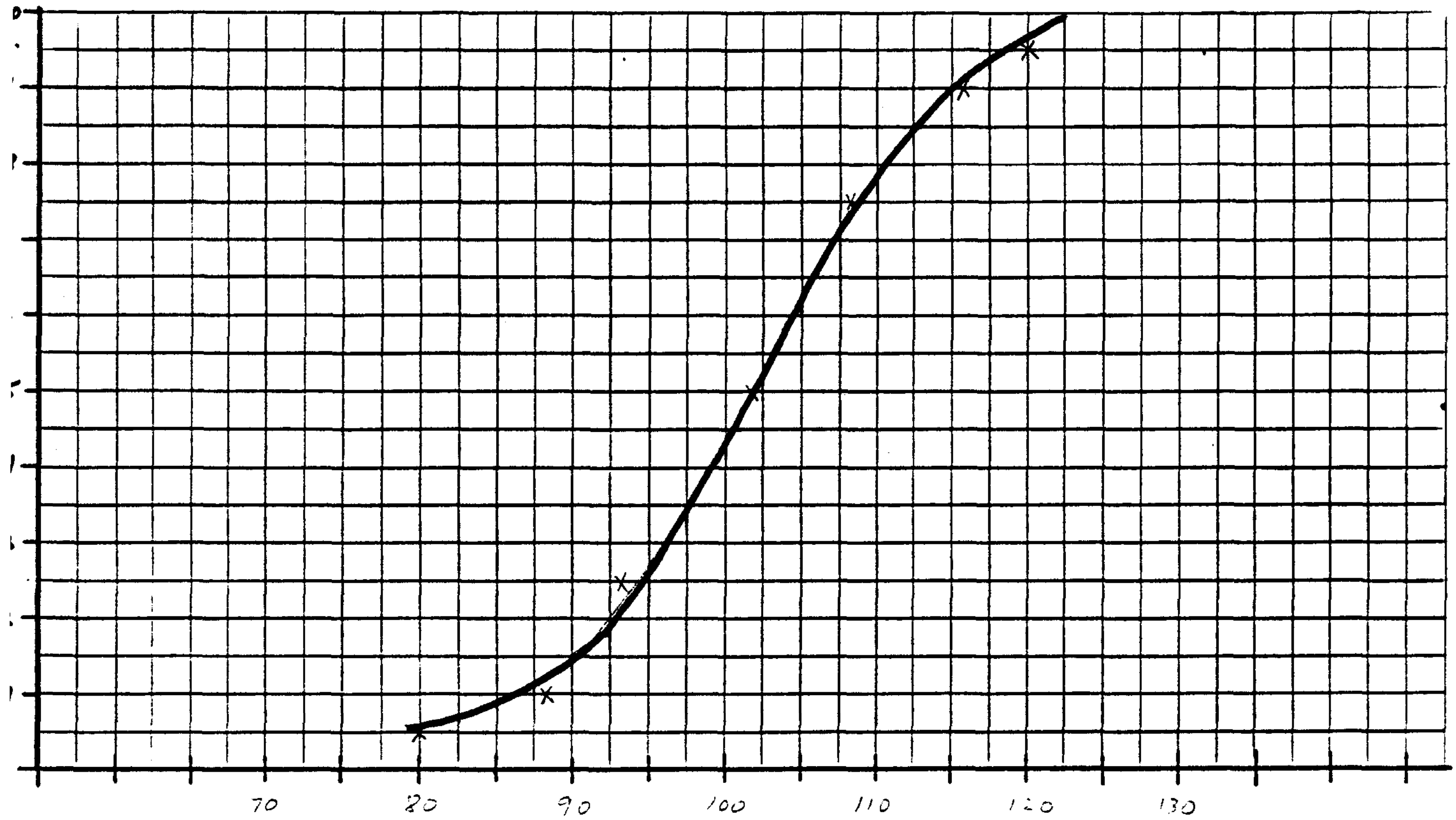


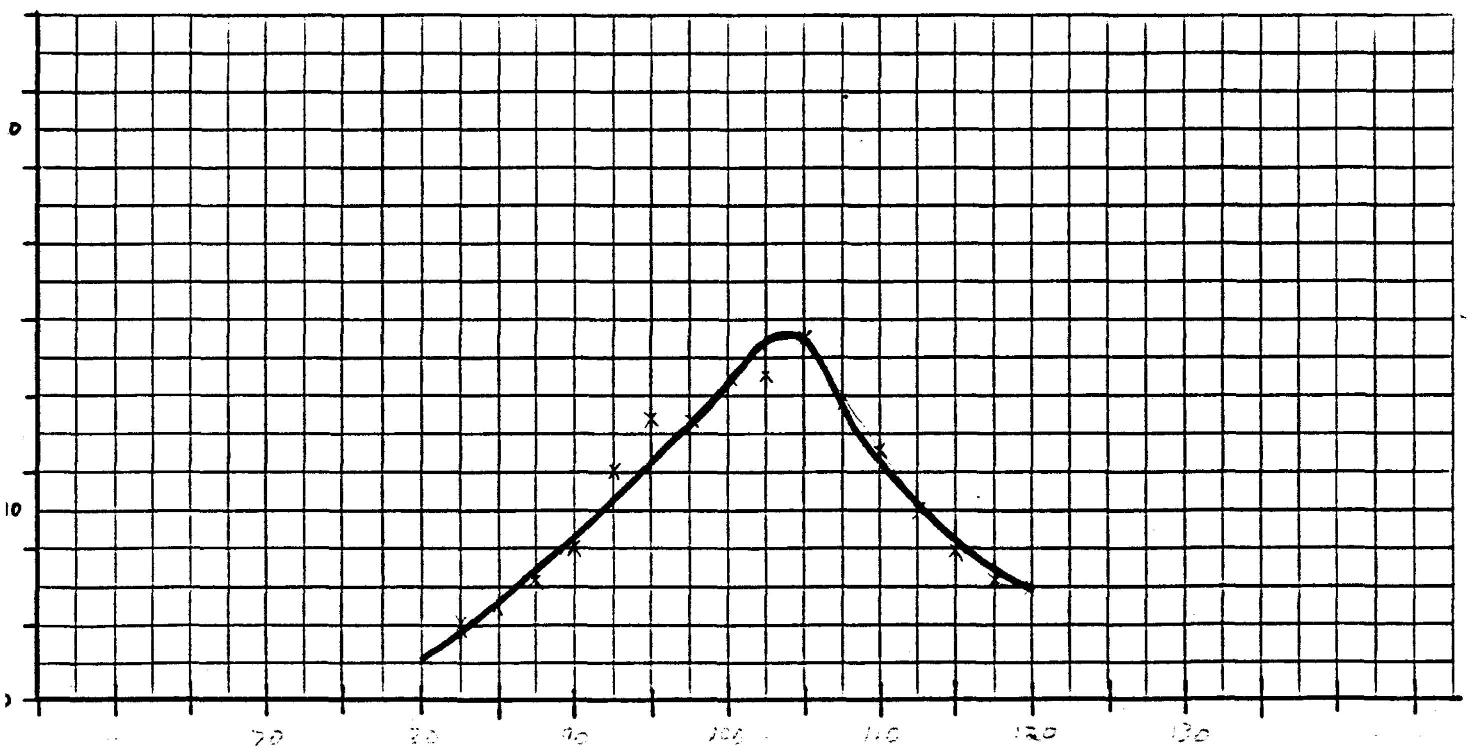




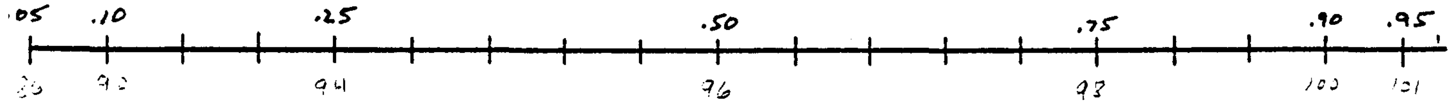
QUANTITY % DESIGN CAPACITY
SUBJECT SUBJECT D (GREEN)

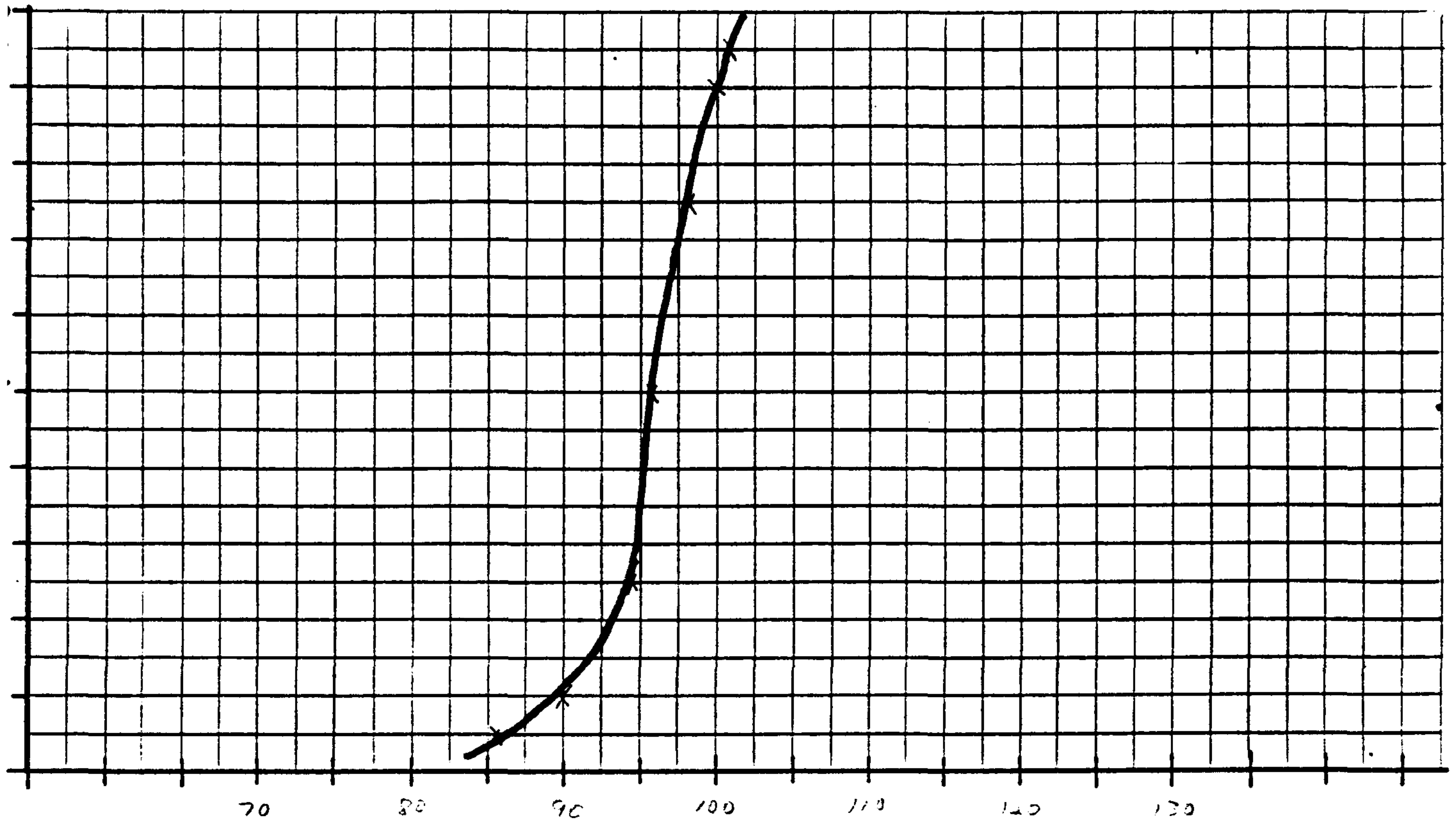


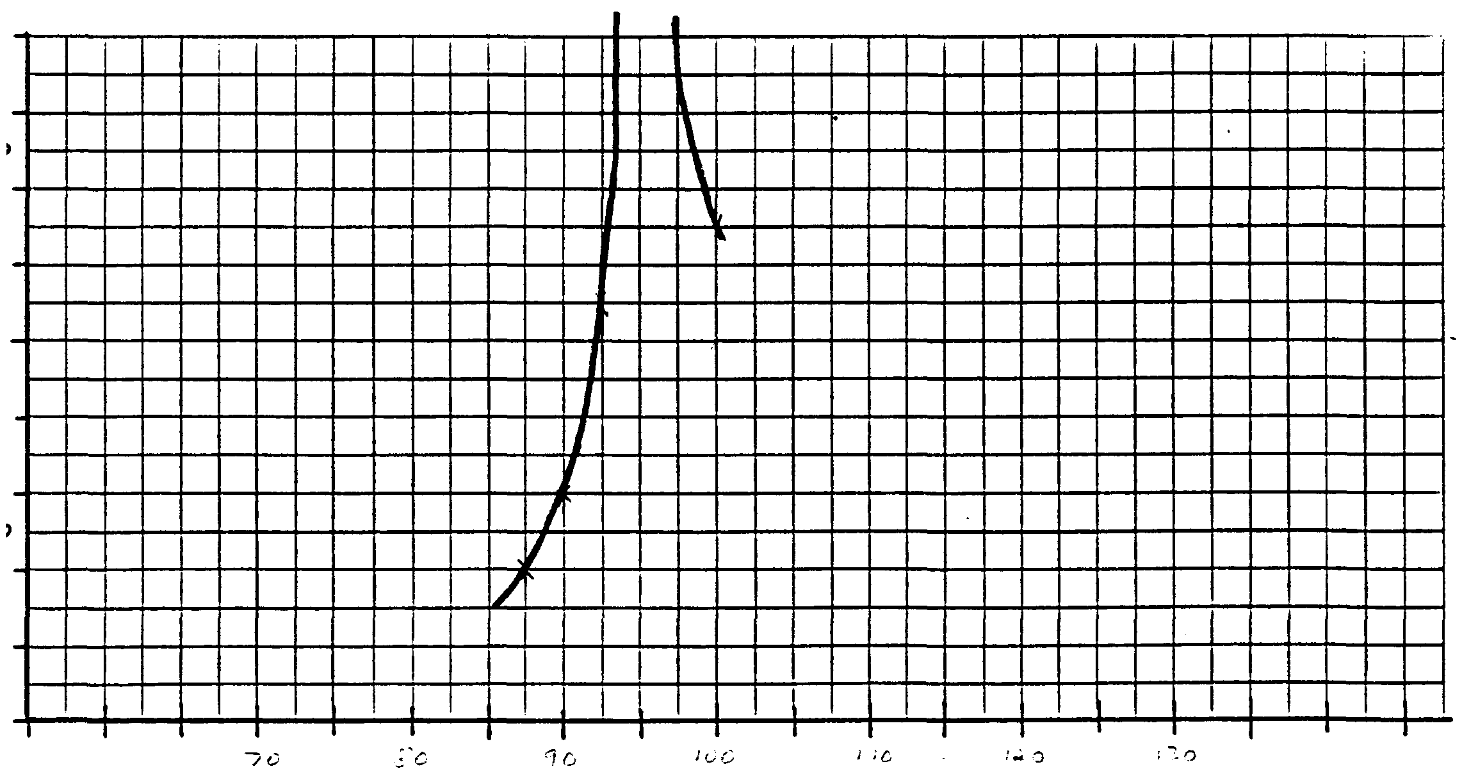




QUANTITY % DESIGN CAPACITY
SUBJECT SUBJECT E (BROWN)

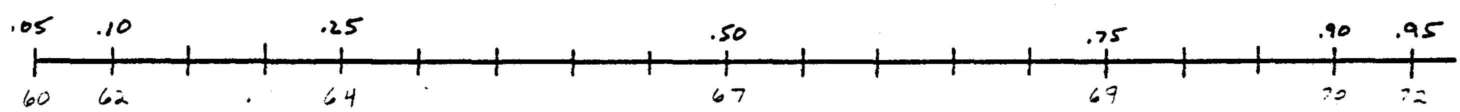


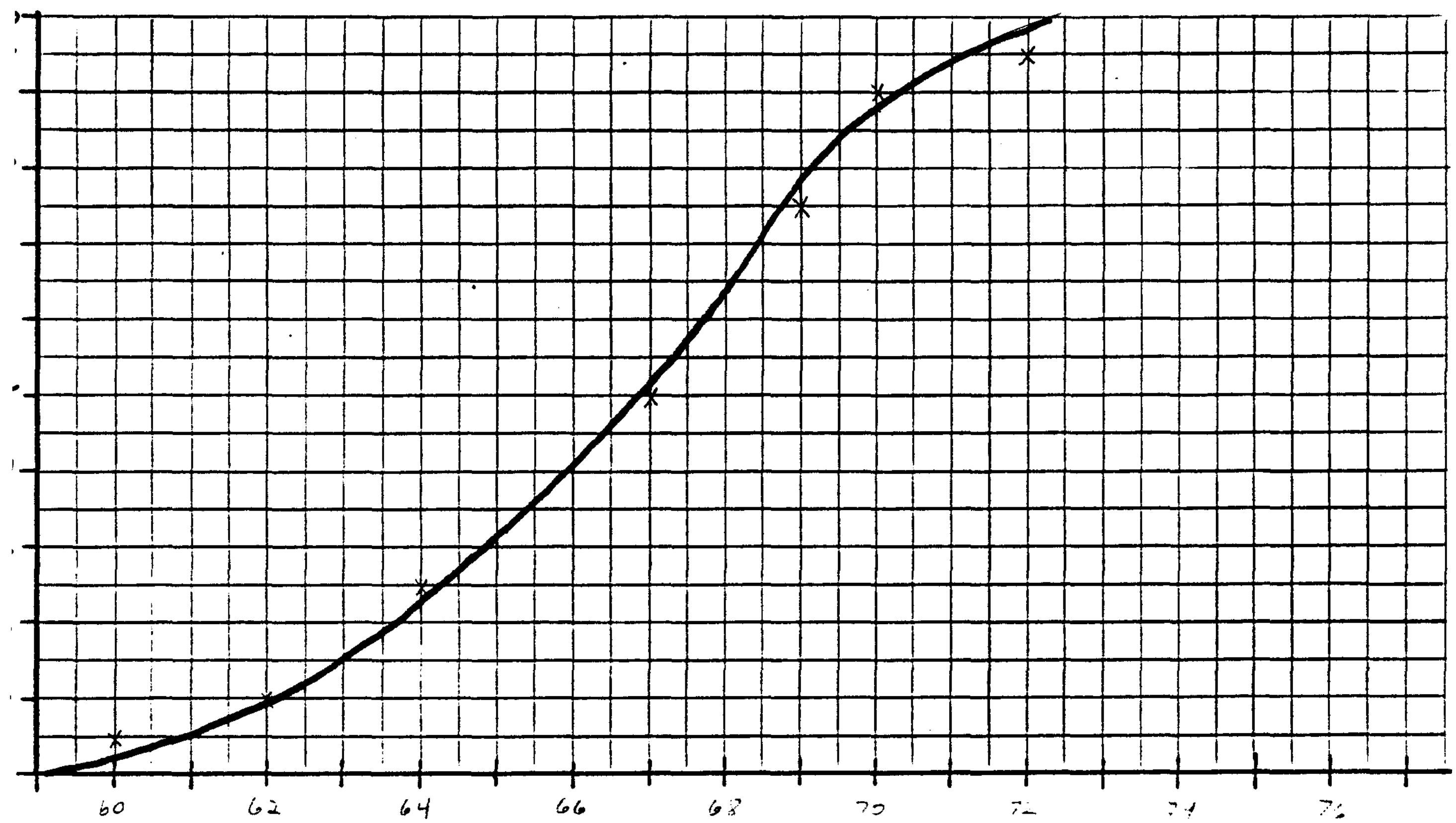


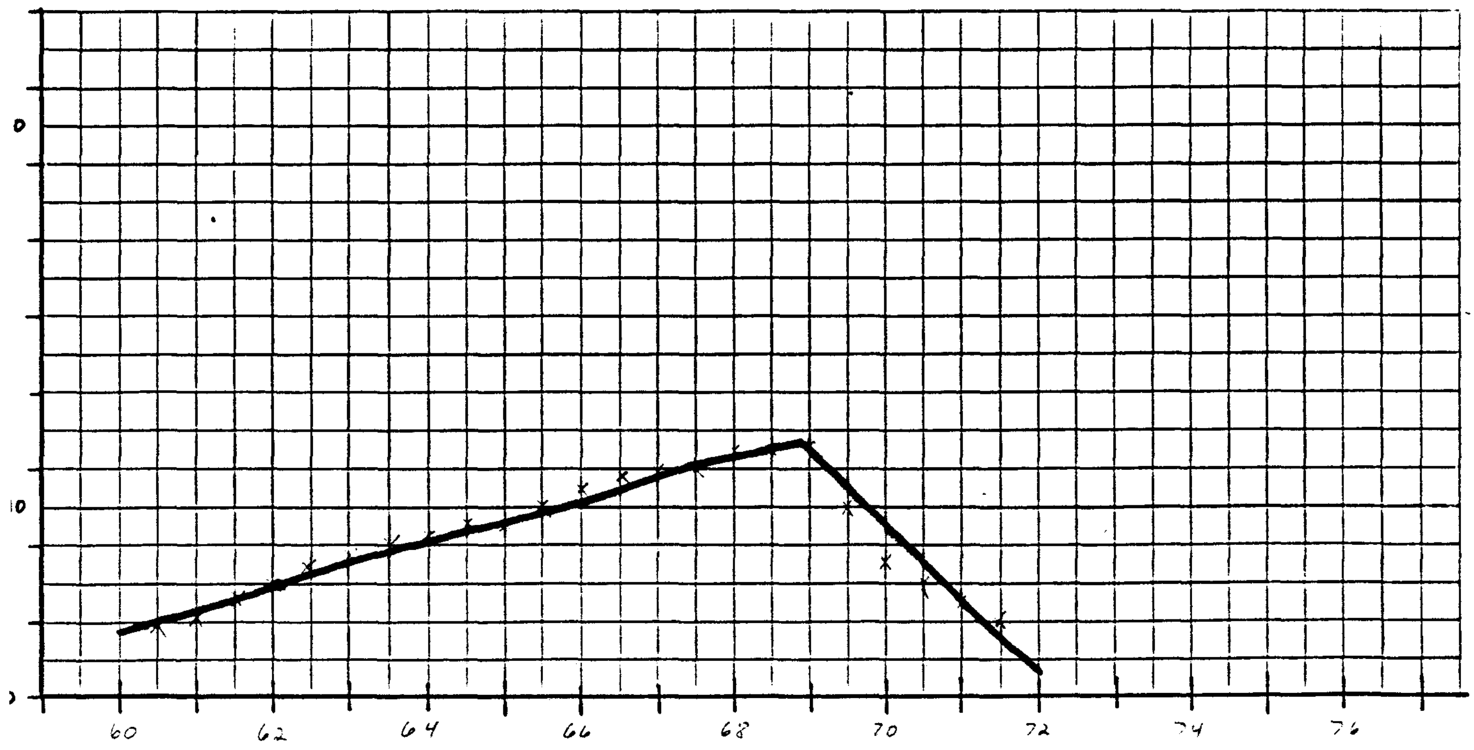


QUANTITY THERMAL EFFICIENCY %

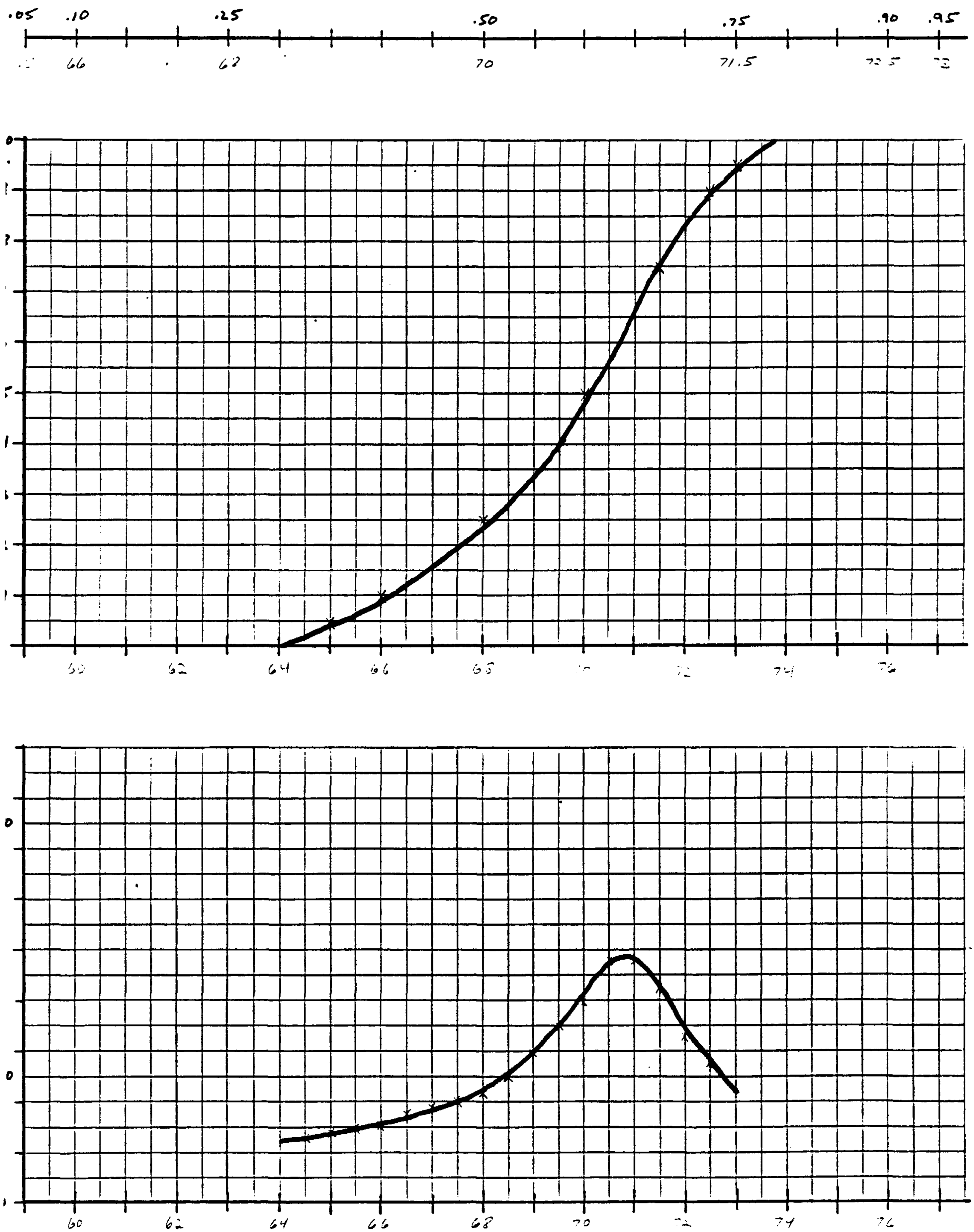
SUBJECT SUBJECT A (BLUE)



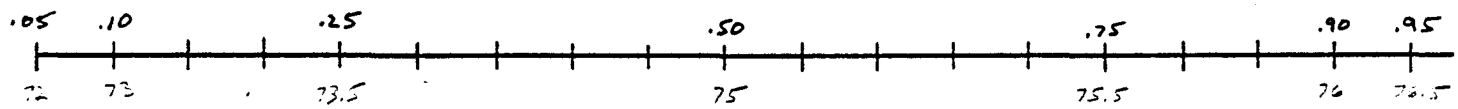


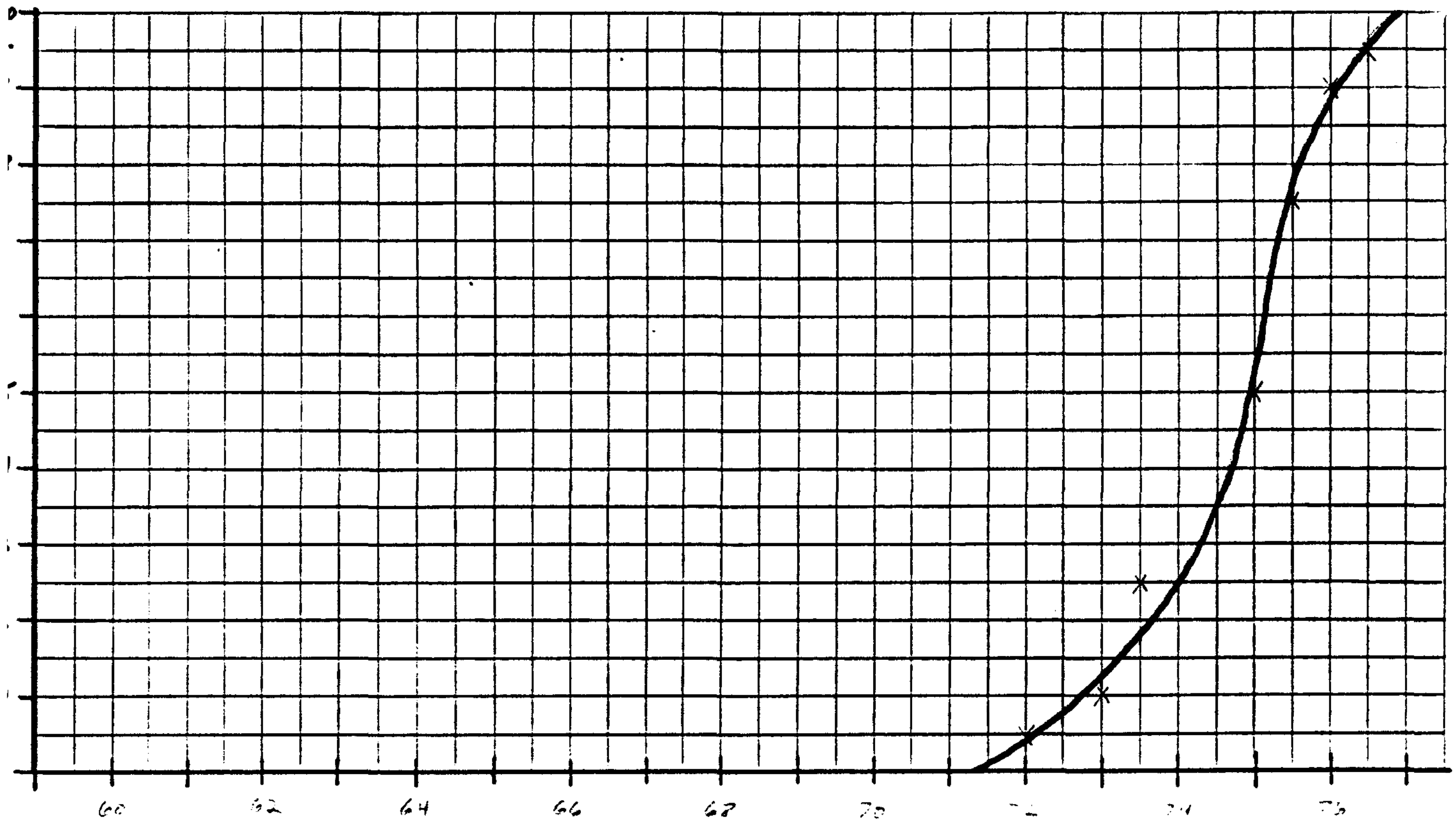


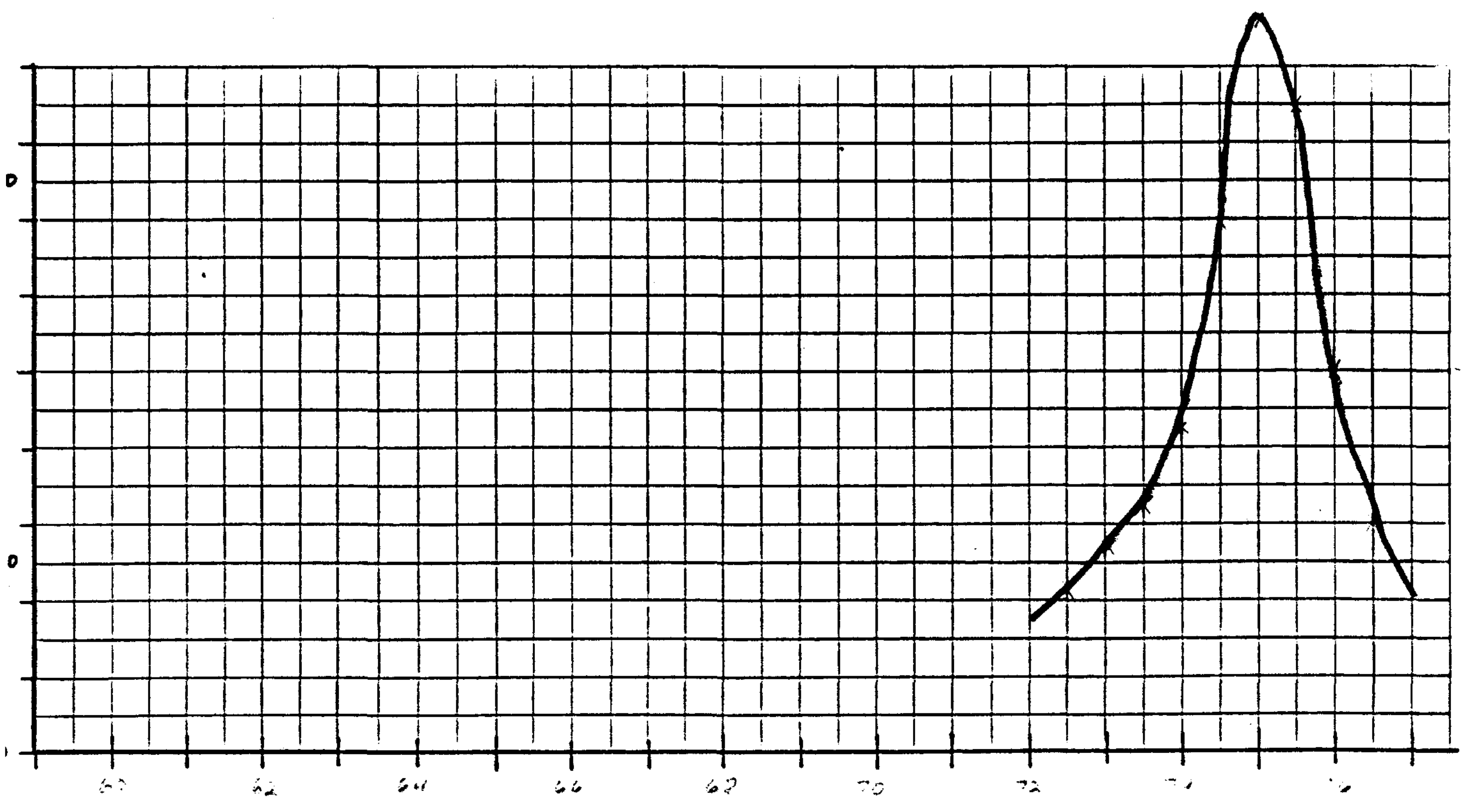
QUANTITY THERMAL EFFICIENCY %
SUBJECT SUBJECT B (YELLOW)



QUANTITY THERMAL EFFICIENCY %
SUBJECT SUBJECT C (RED)

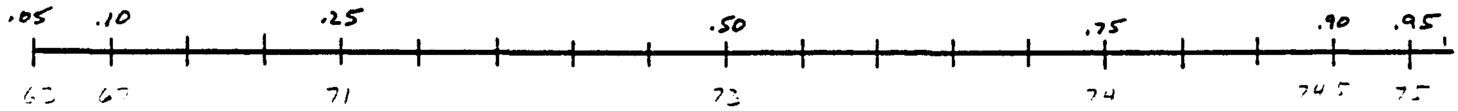


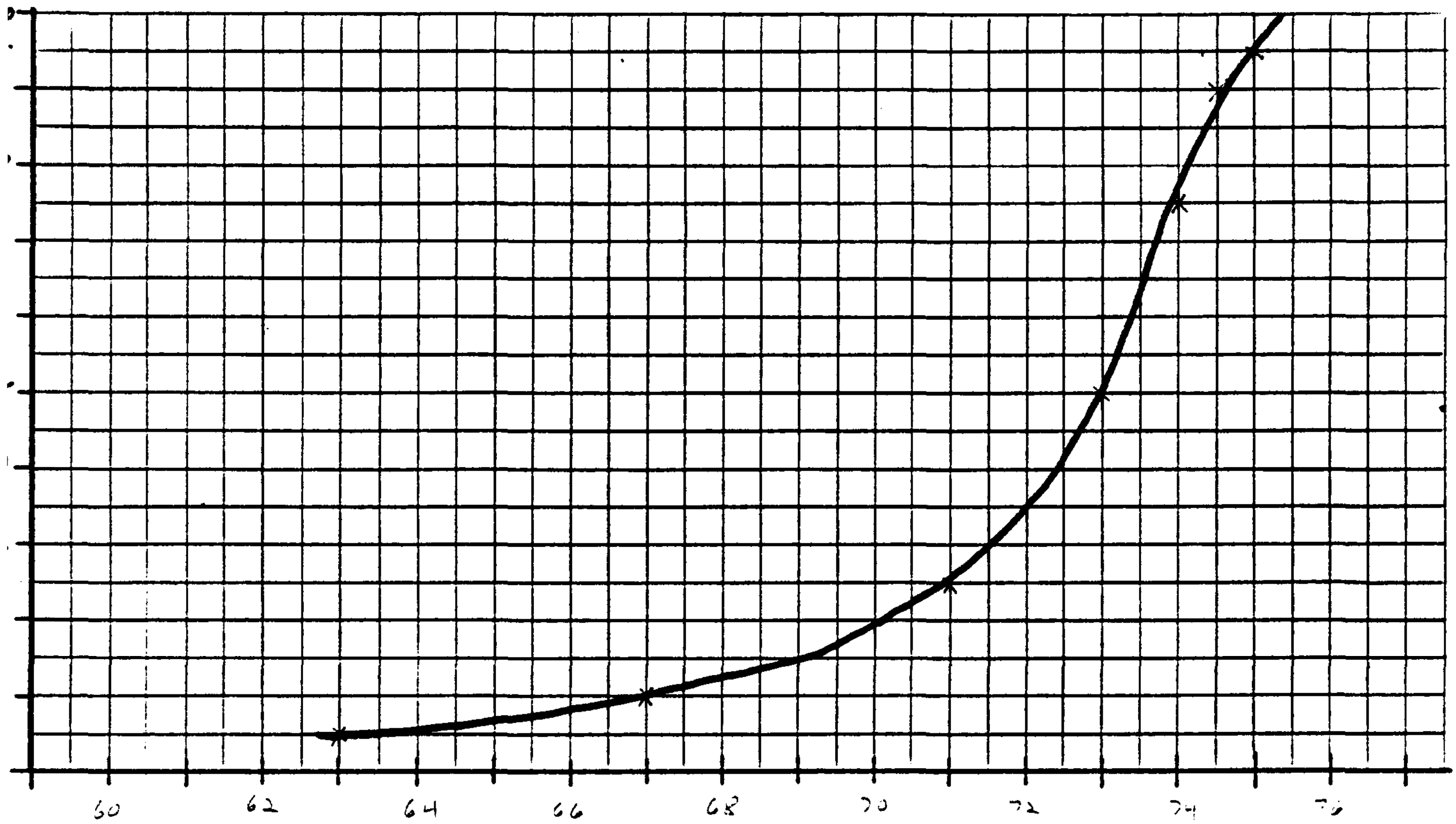


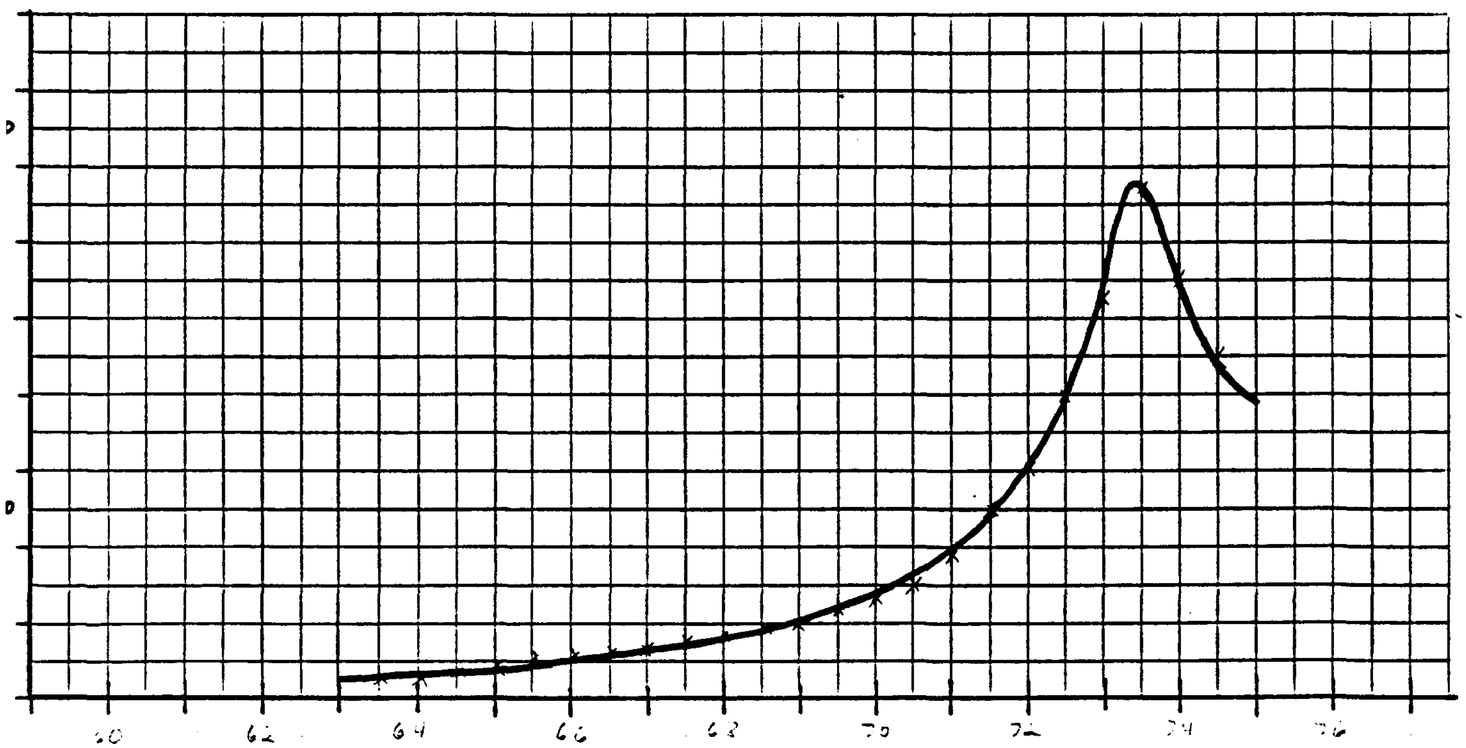


QUANTITY Thermal Efficiency %

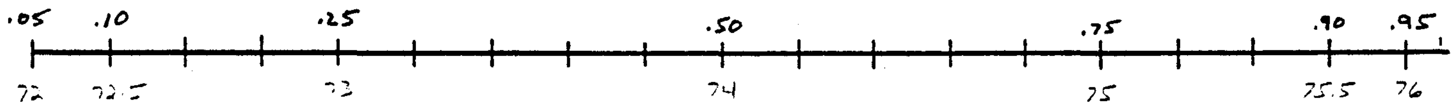
SUBJECT Subject D (Green)

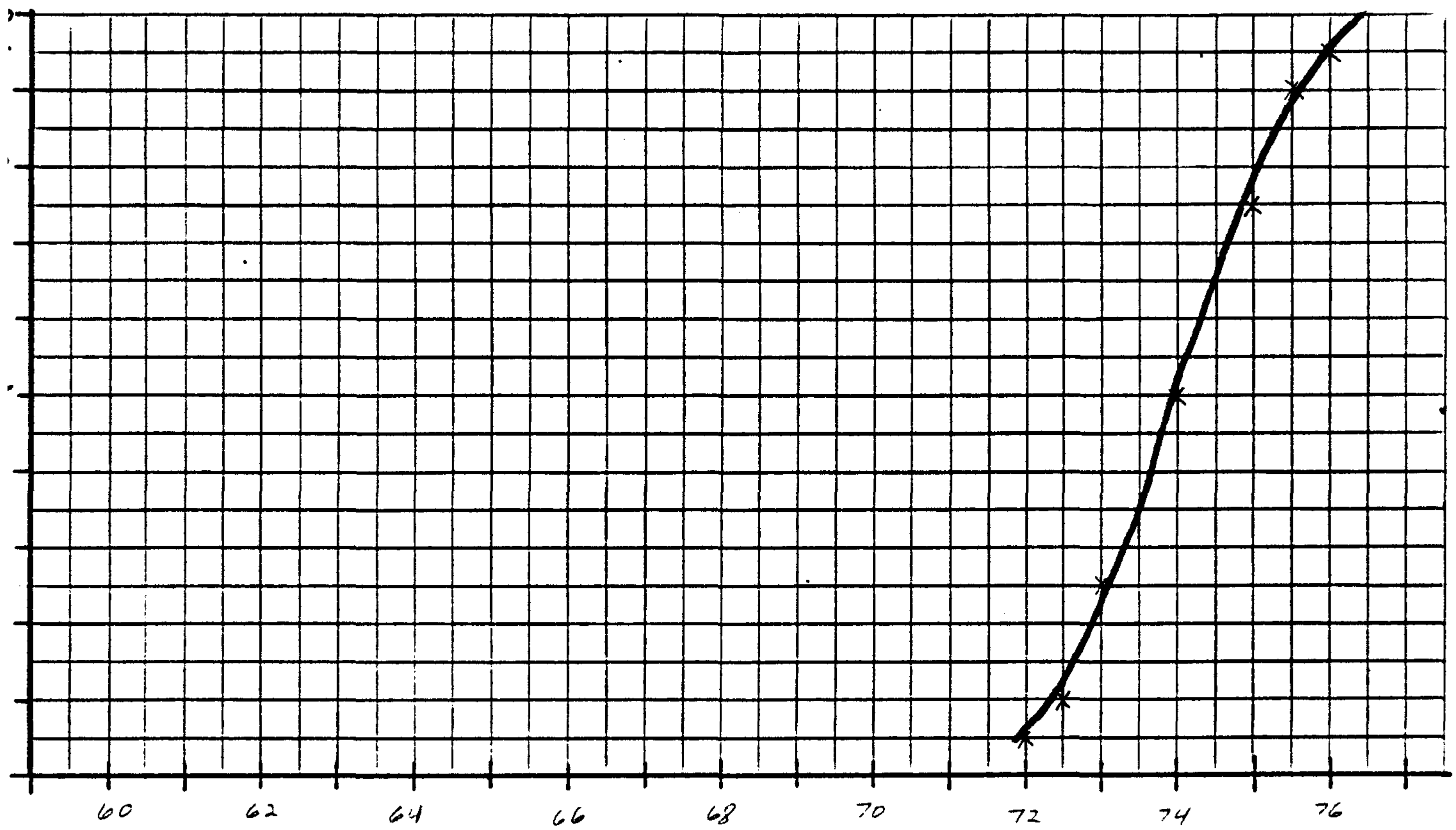


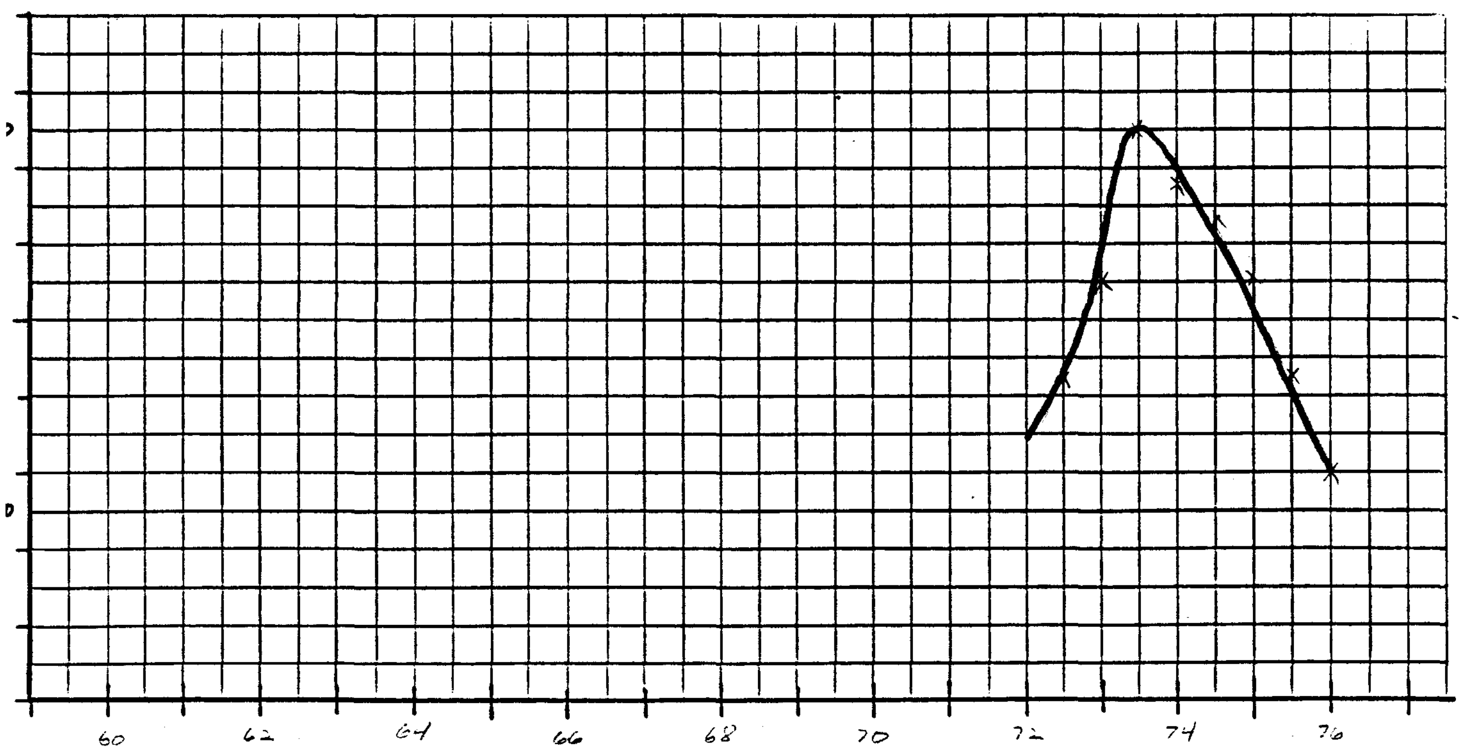




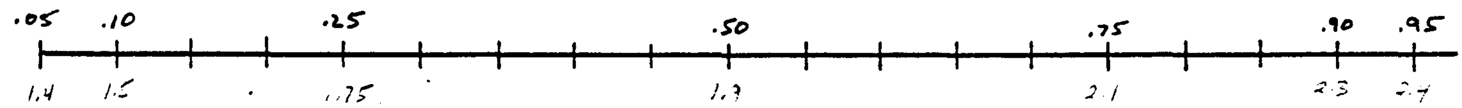
QUANTITY THERMAL EFFICIENCY %
SUBJECT SUBJECT E (BROWN)

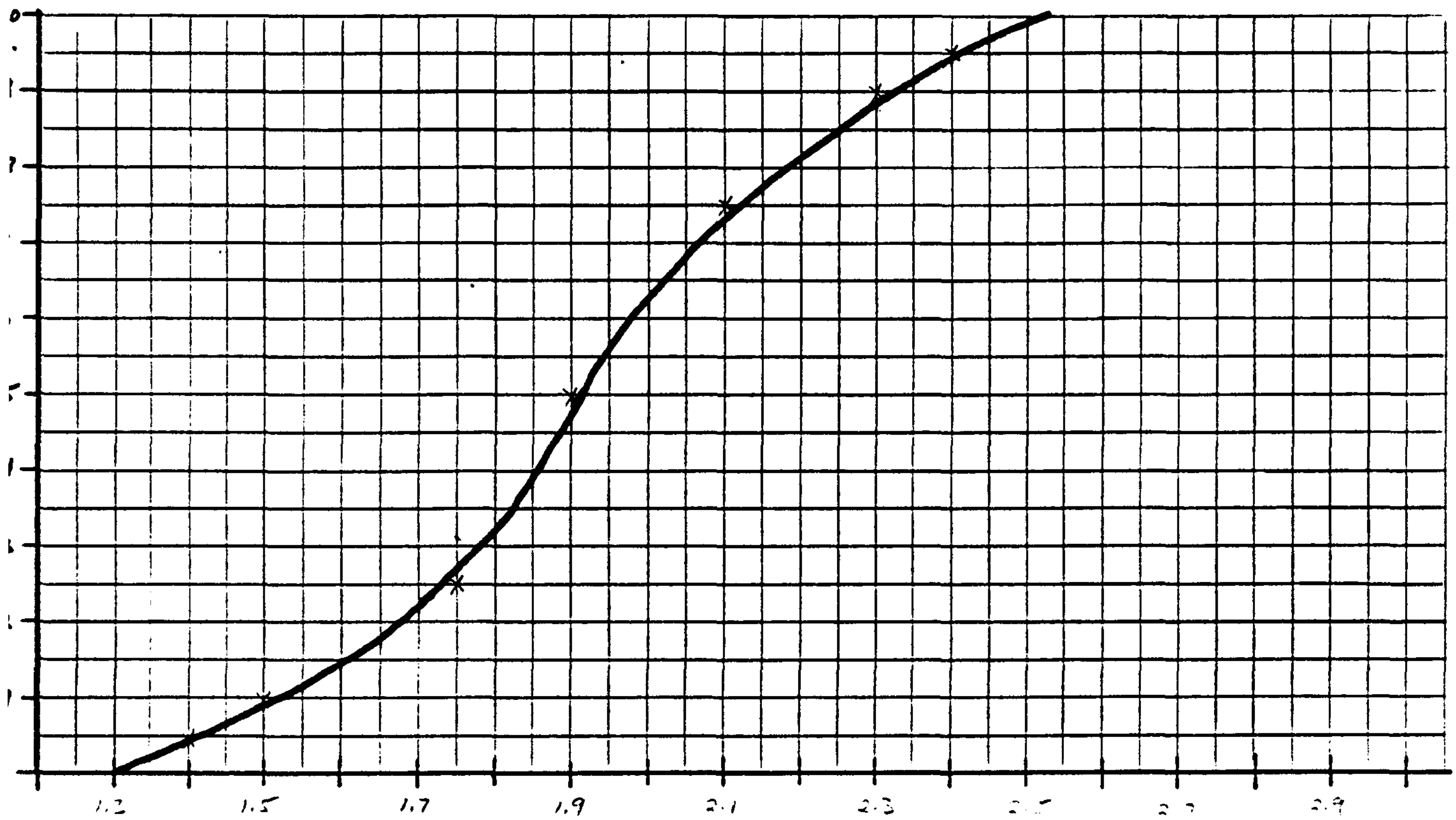


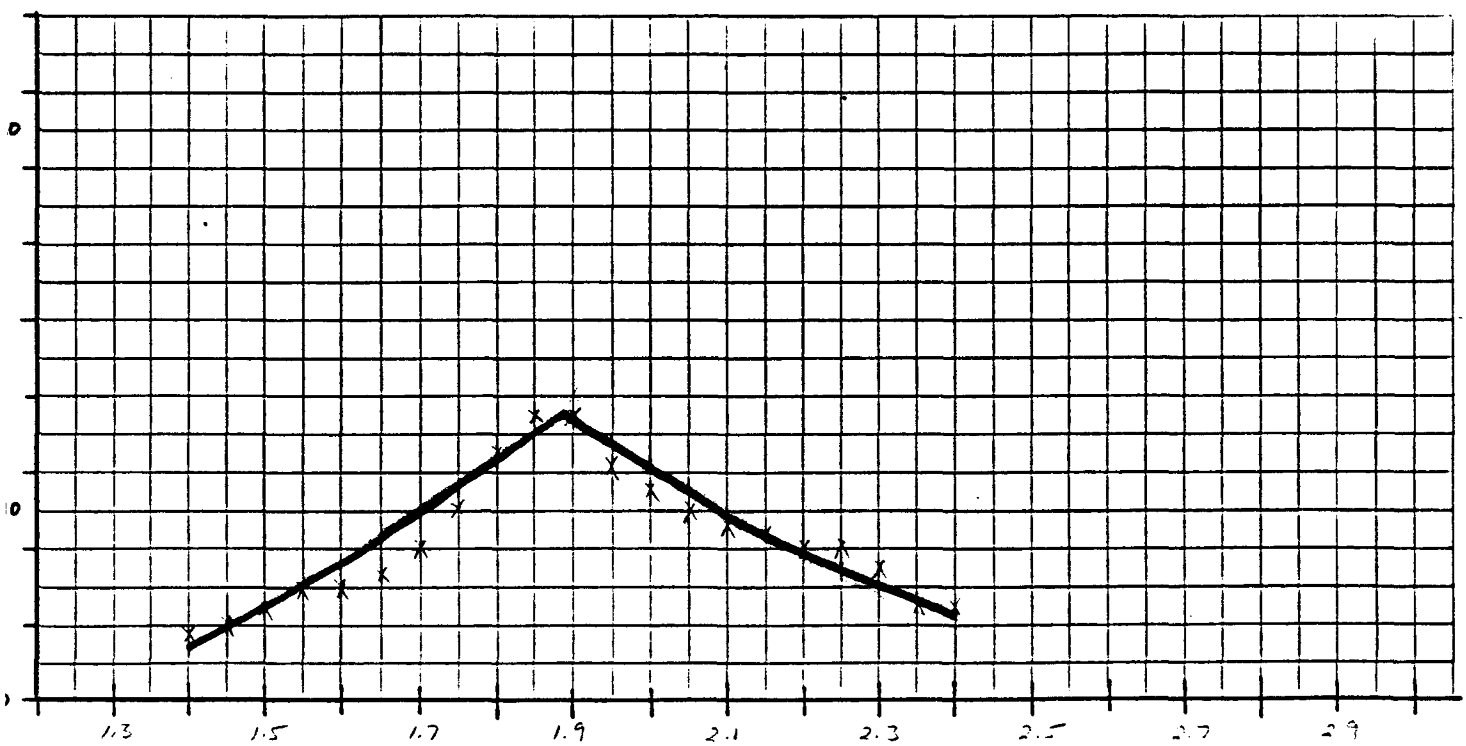




QUANTITY CAPITAL COSTS
SUBJECT SUBJECT A (BLUE)

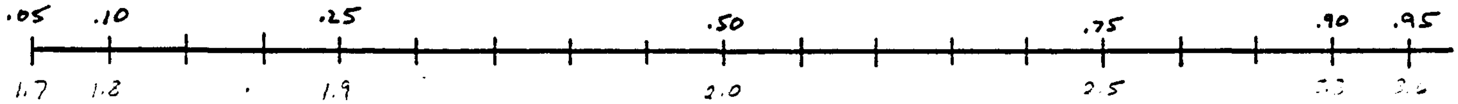


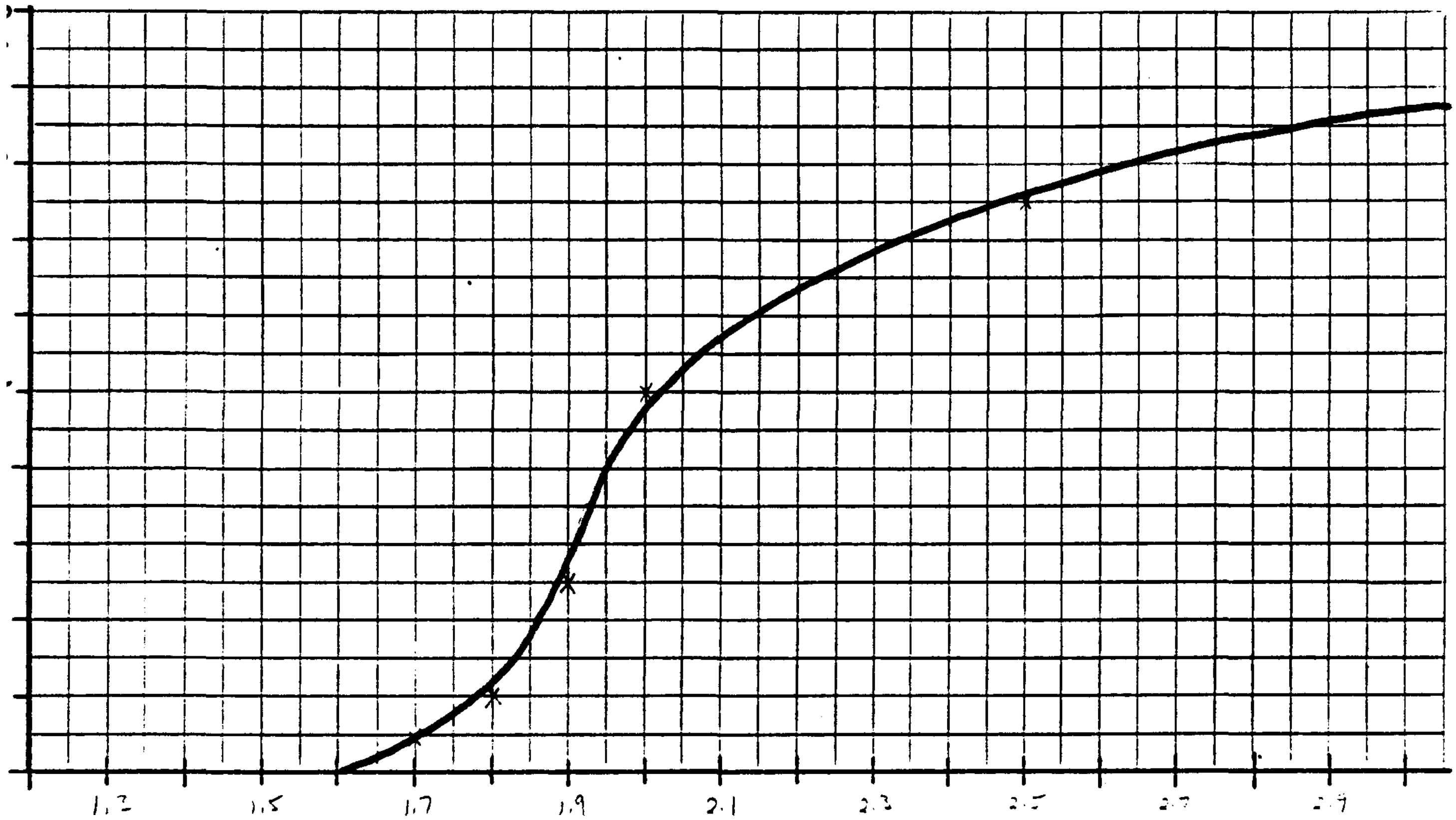


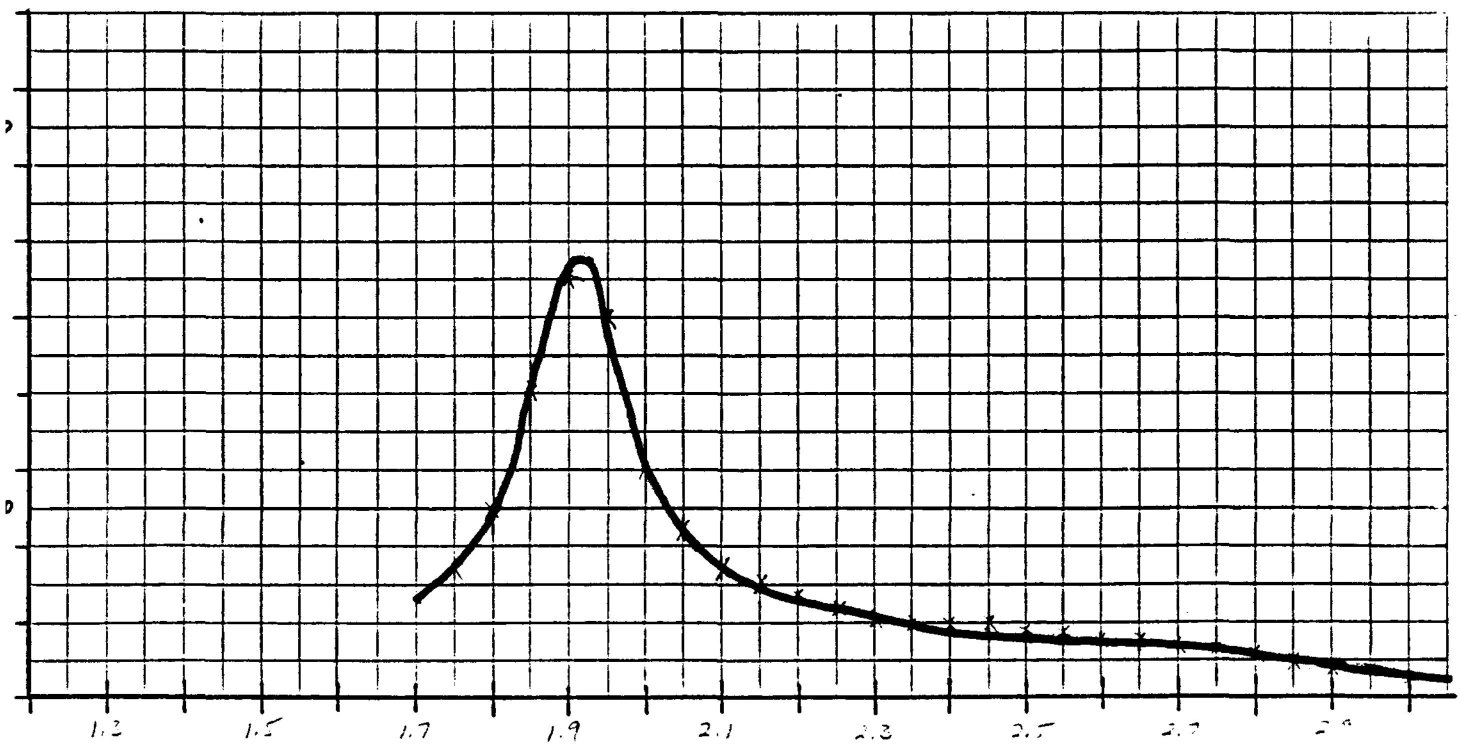


QUANTITY CAPITAL COSTS

SUBJECT SUBJECT B (YELLOW)

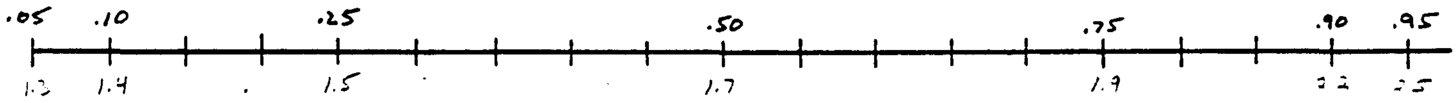


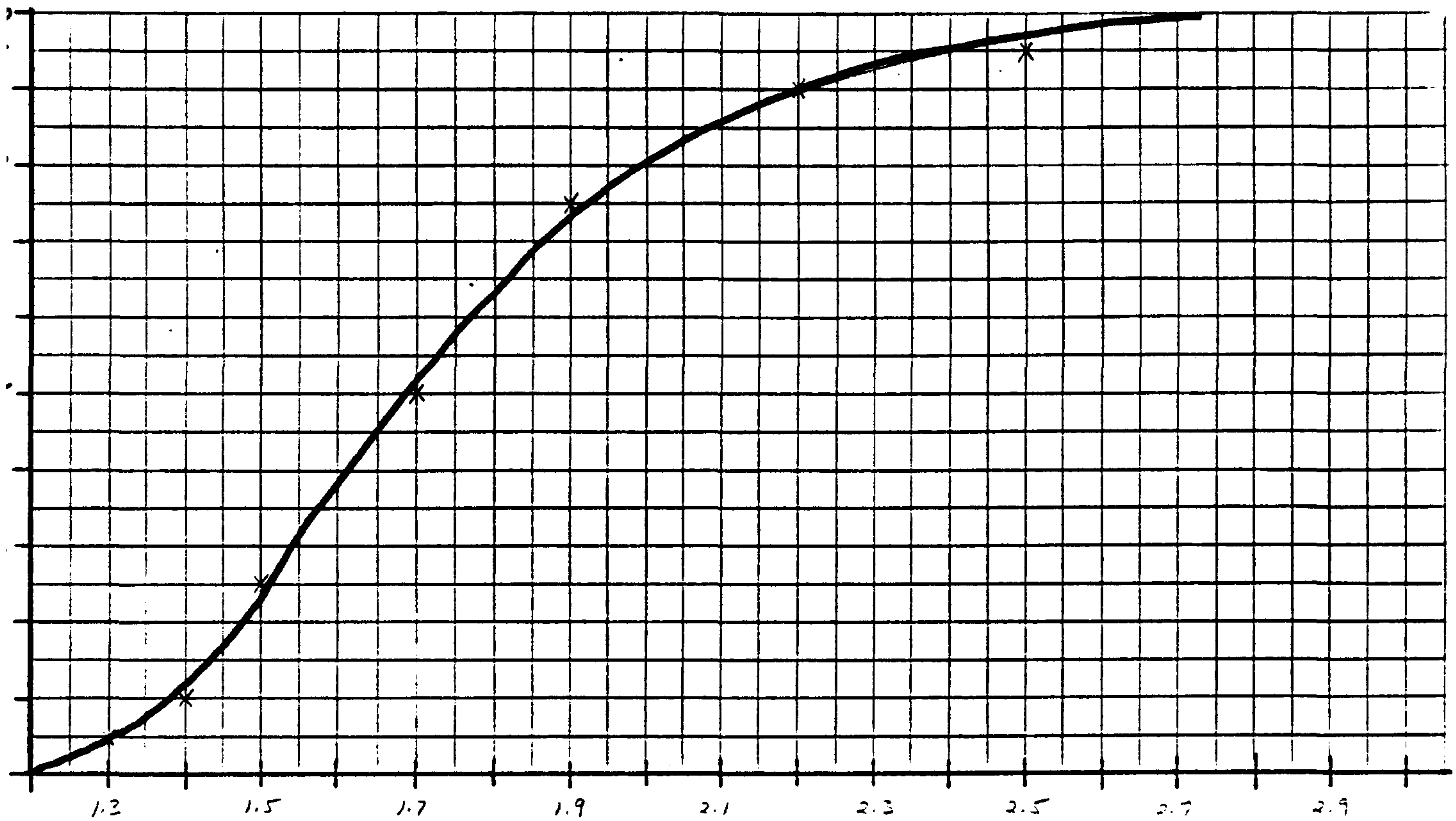


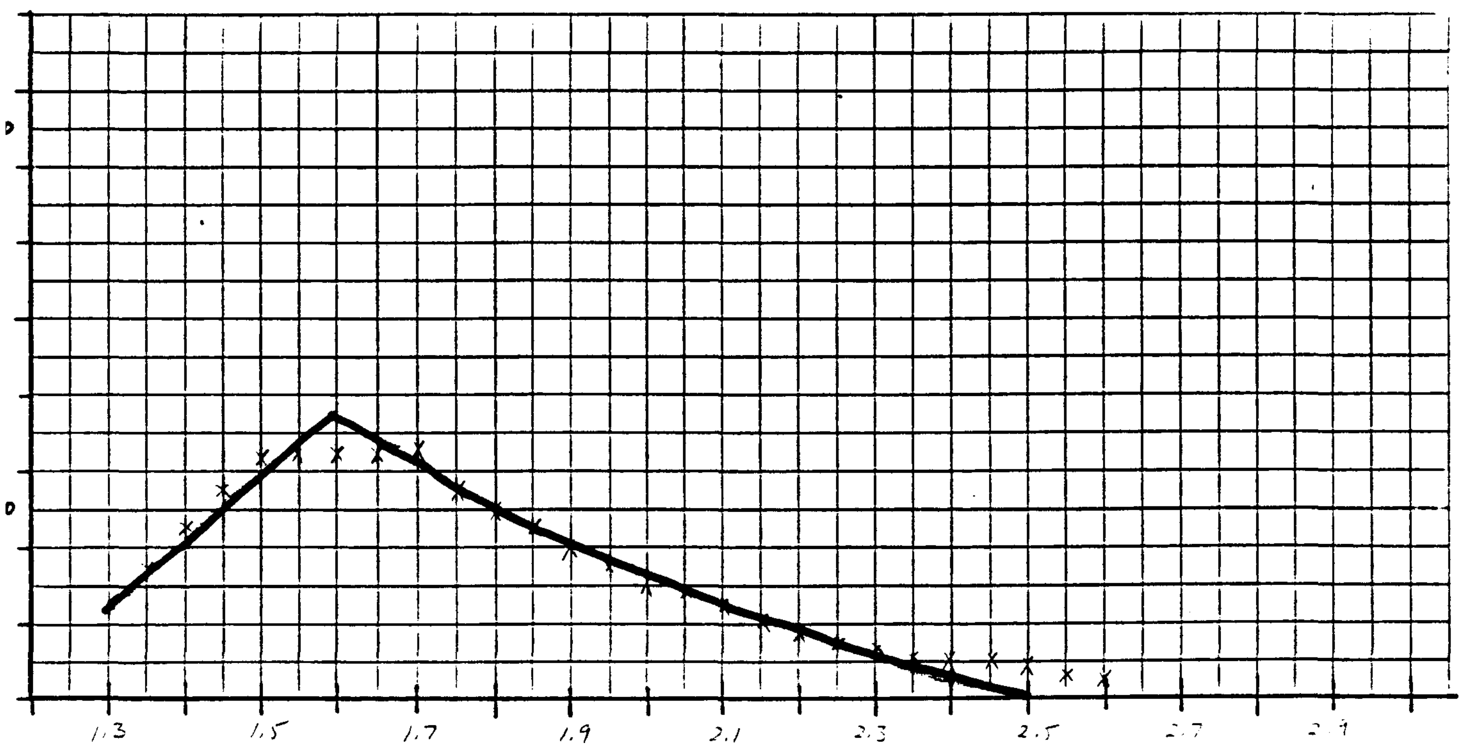


QUANTITY CAPITAL COSTS

SUBJECT SUBJECT C (RED)

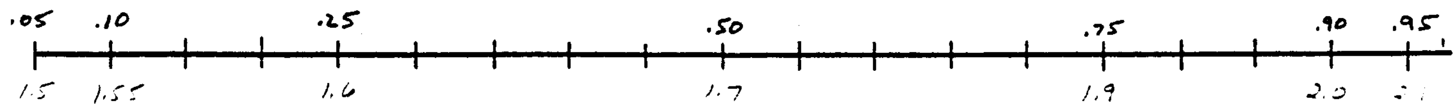


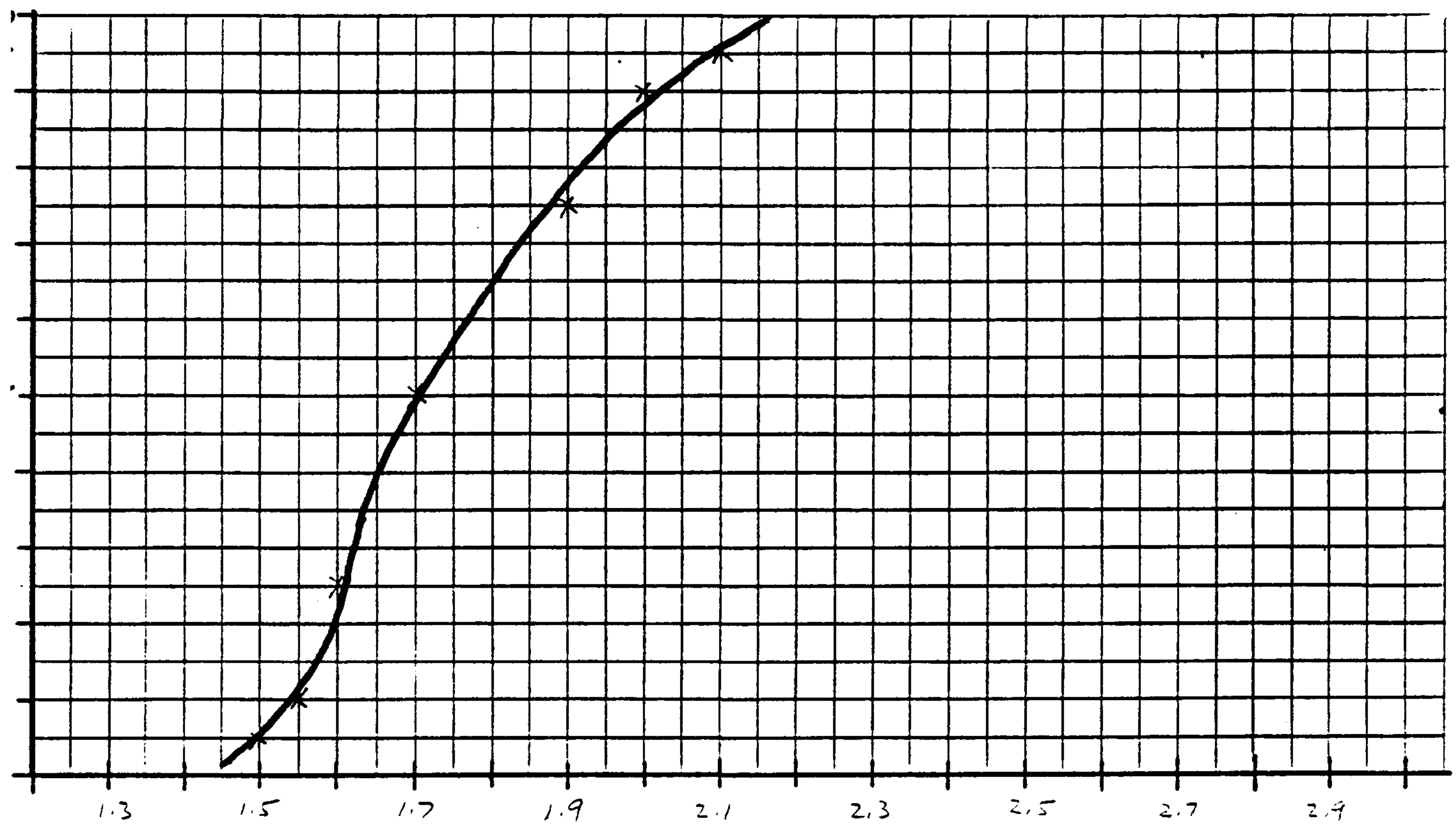




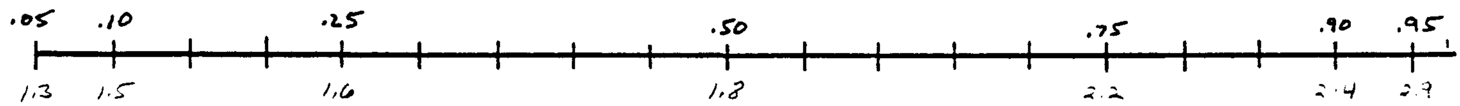
QUANTITY: Capital Costs

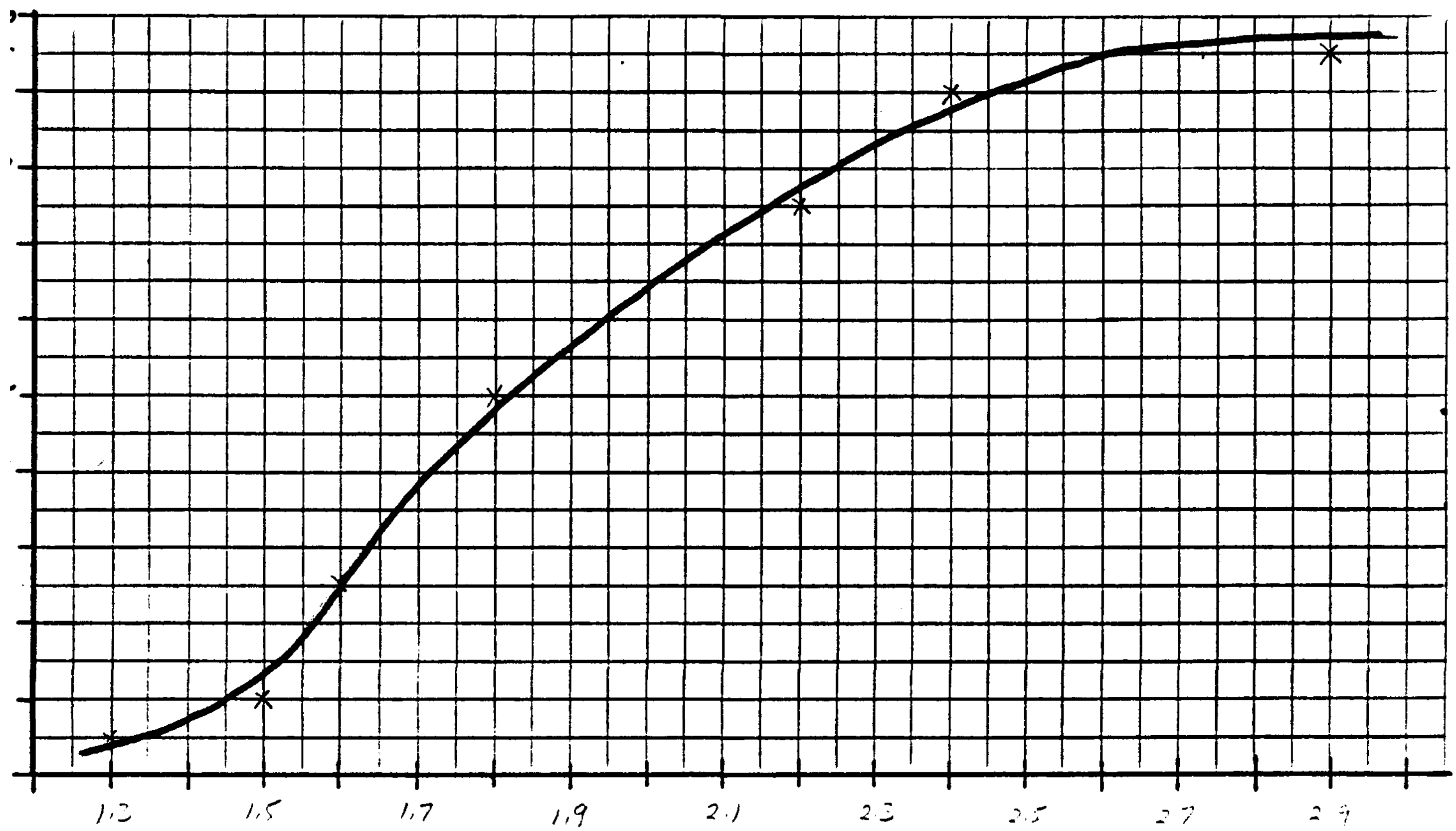
SUBJECT: Subject D (Green)

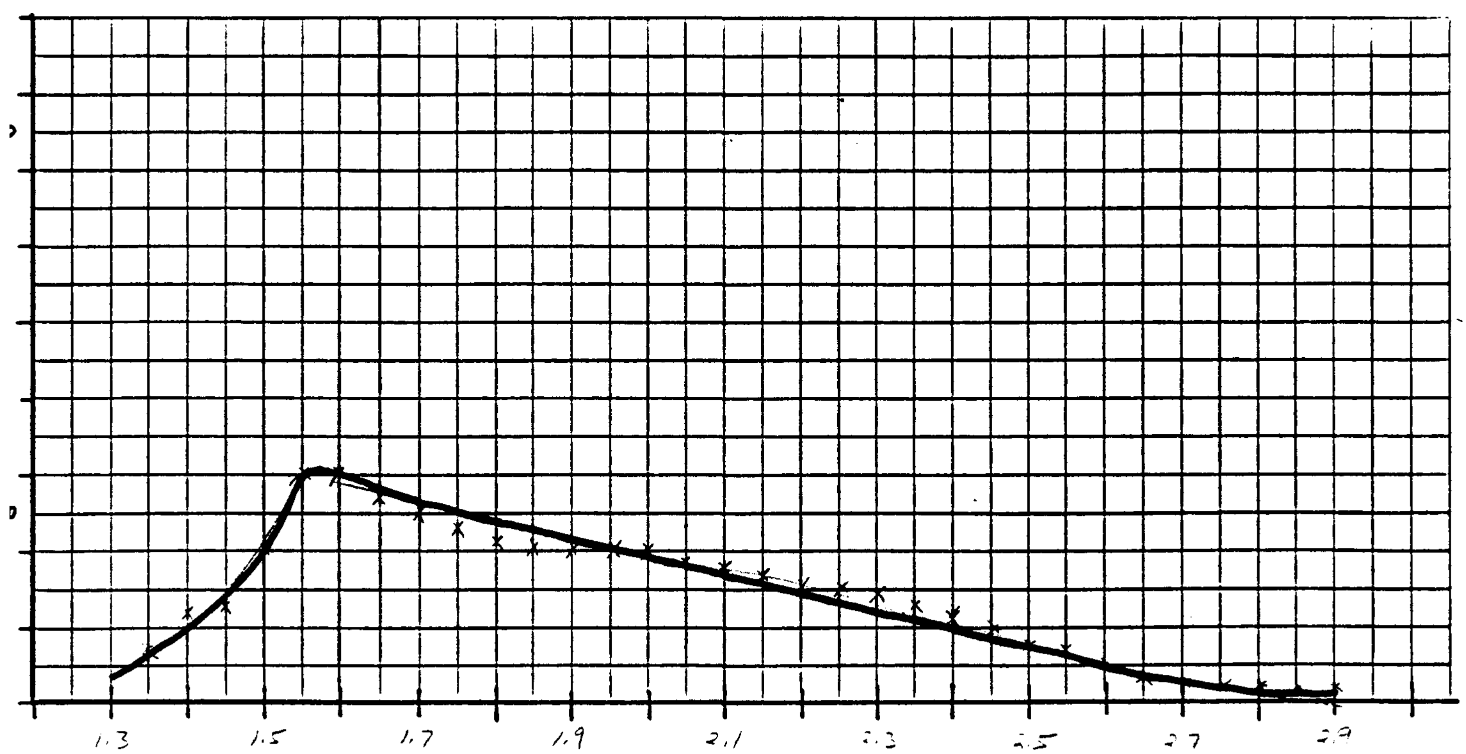




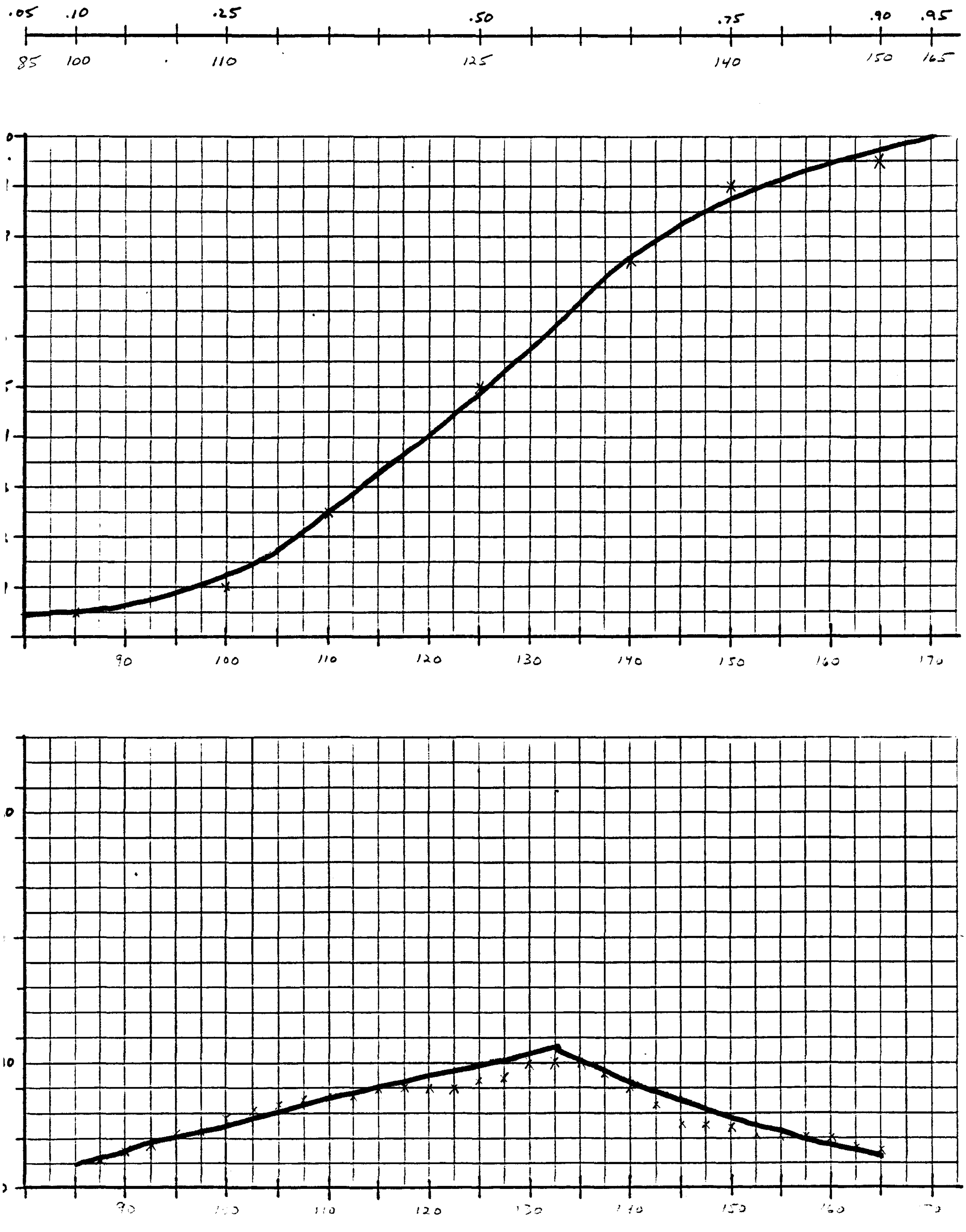
QUANTITY CAPITAL COSTS
SUBJECT SUBJECT E (BROWN)





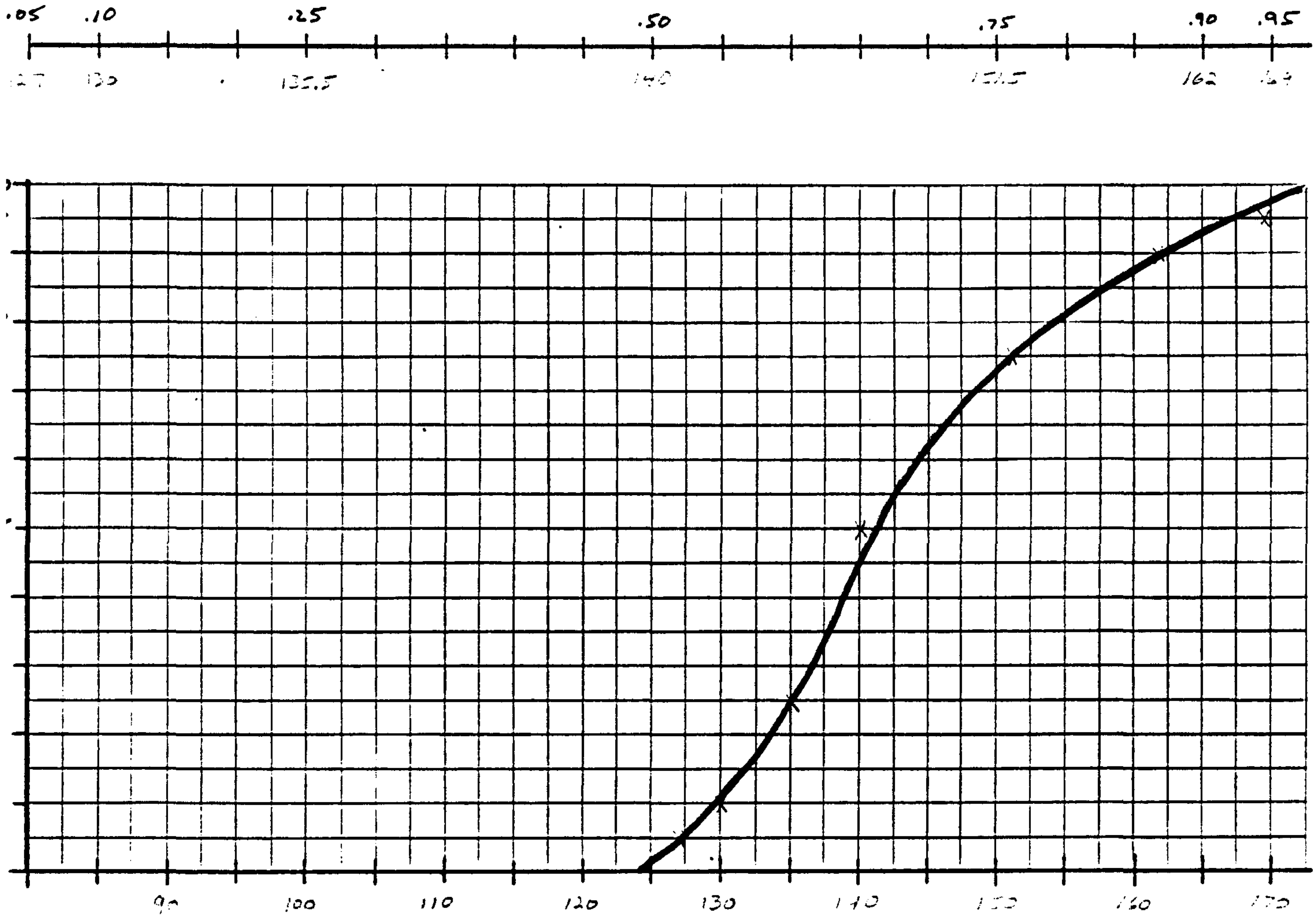


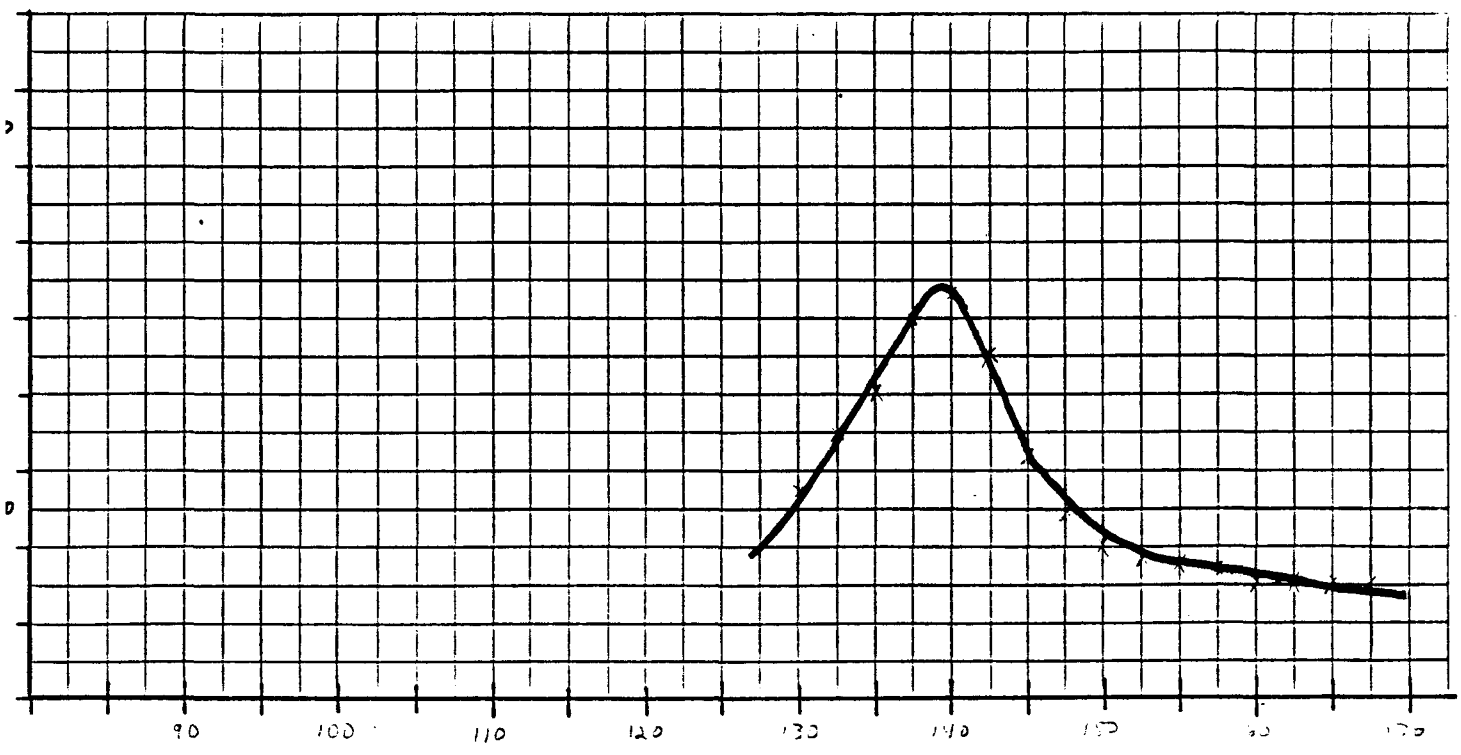
QUANTITY Direct operating costs
SUBJECT Subject A (Blue)



QUANTITY DIRECT OPERATING COSTS

SUBJECT SUBJECT B (YELLOW)





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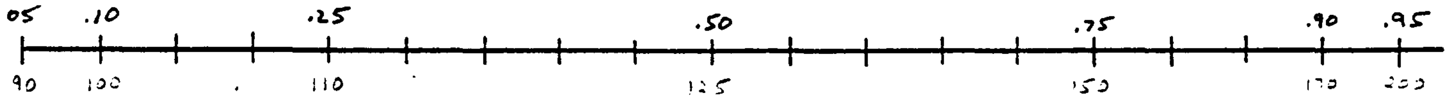
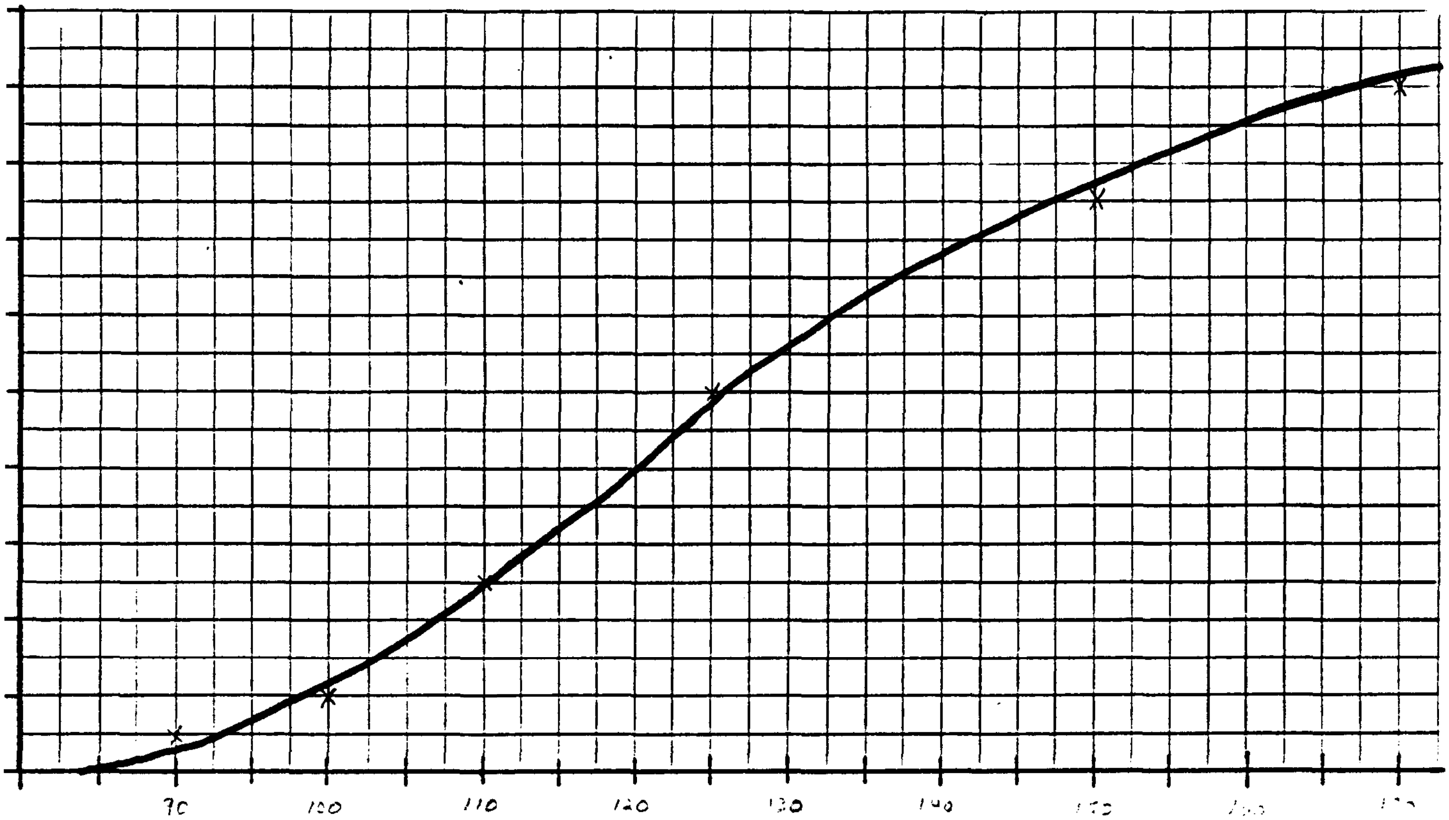
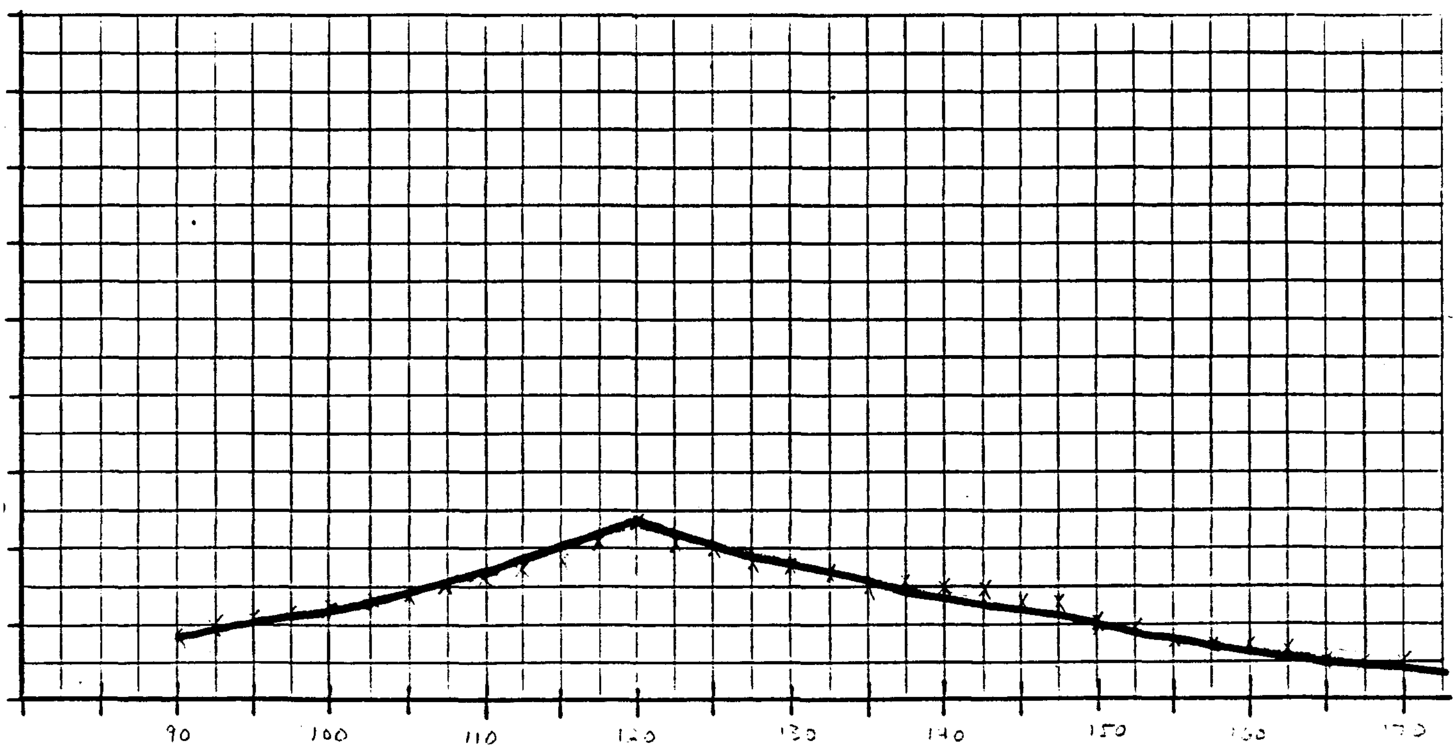
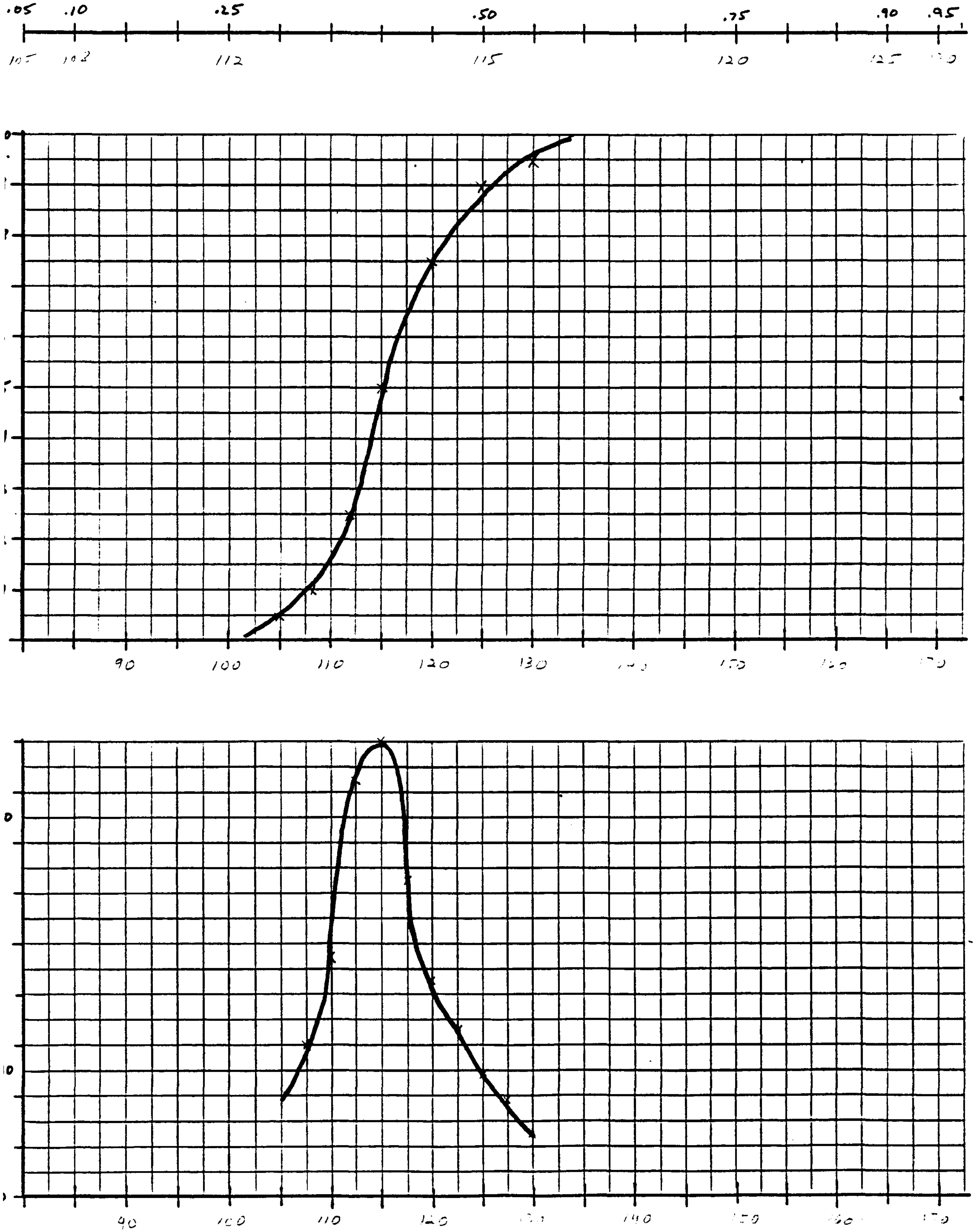
SUBJECT SUBJECT C (RED)





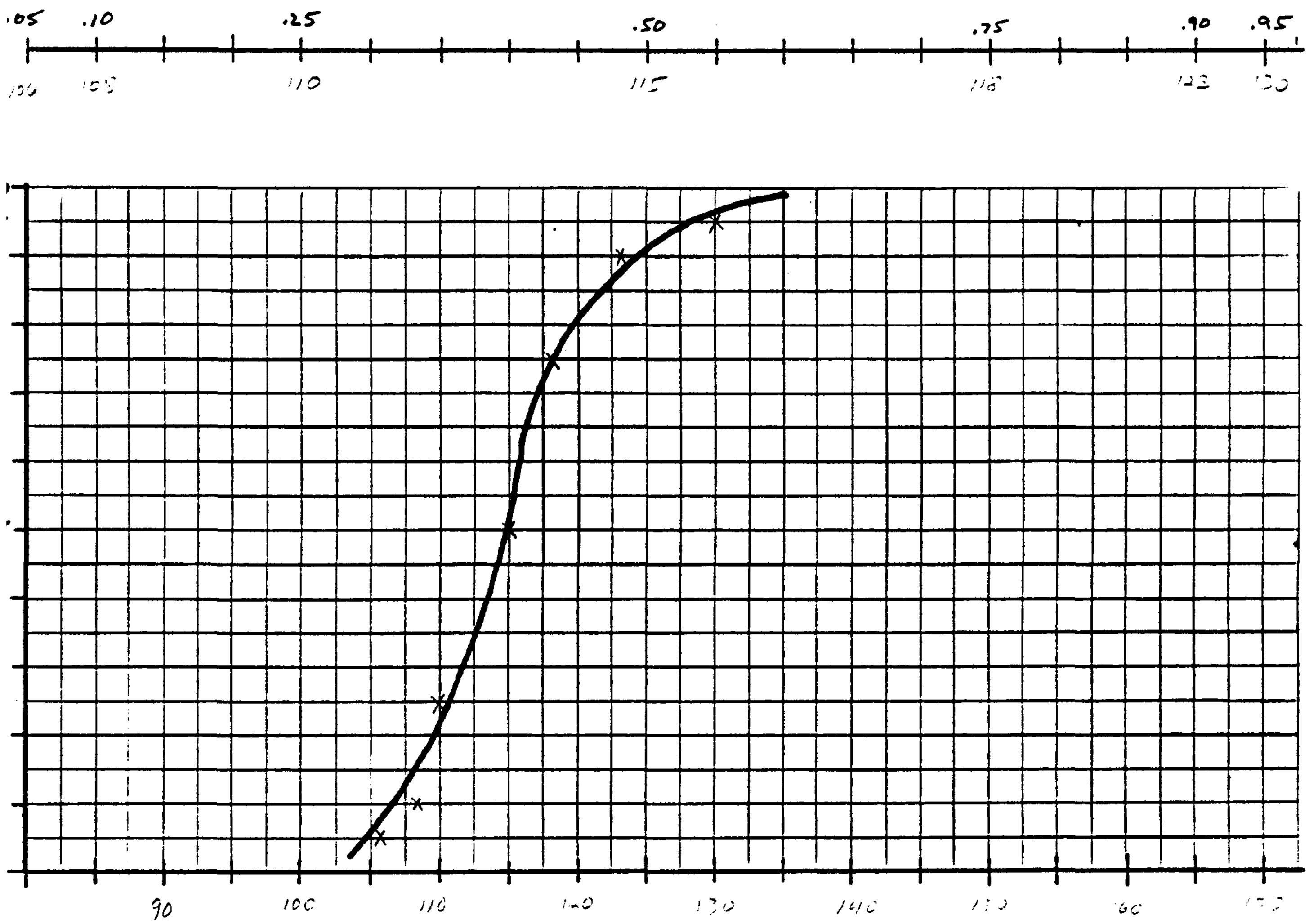


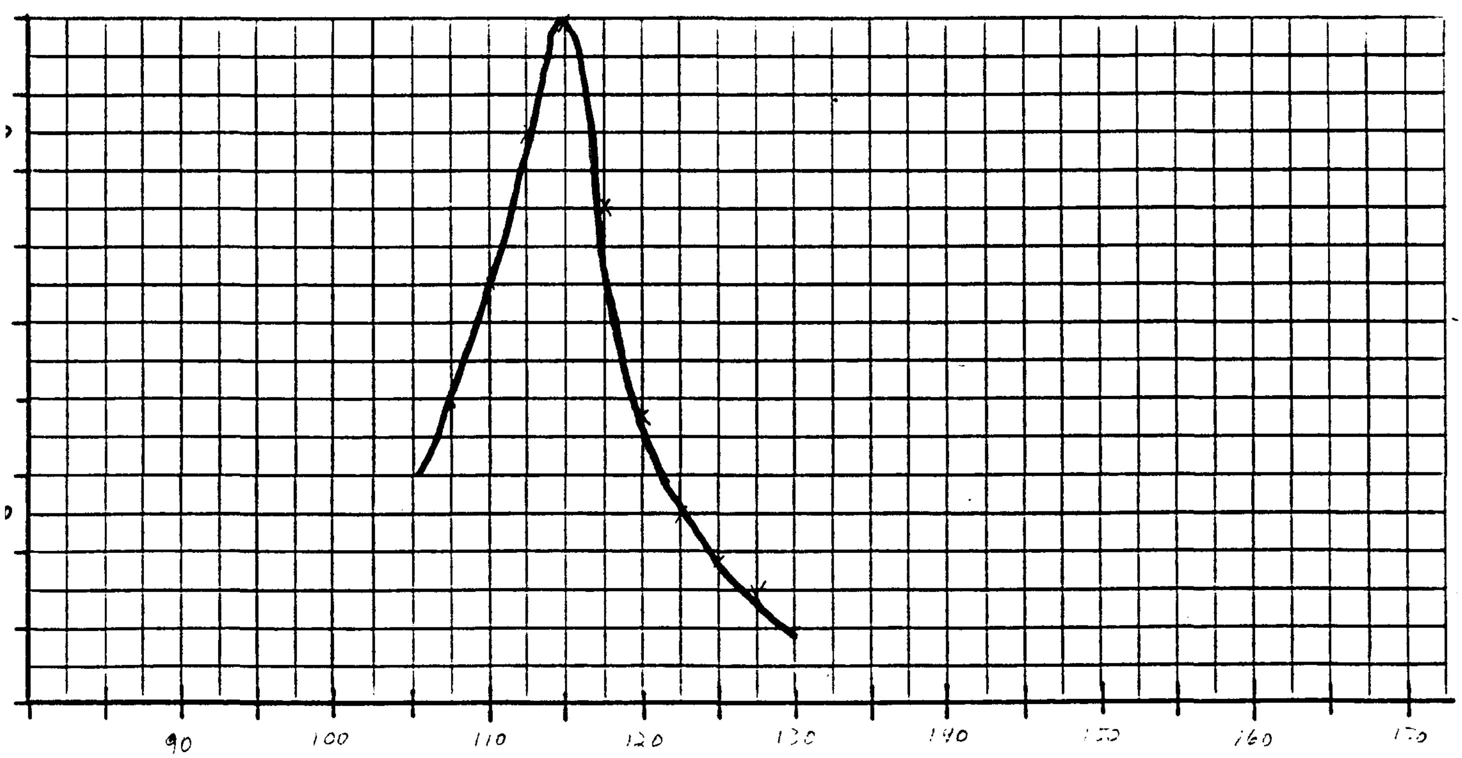
QUANTITY DIRECT OPERATING COSTS
SUBJECT SUBJECT D (GREEN



QUANTITY Direct operating costs

SUBJECT Subject E (Brown)

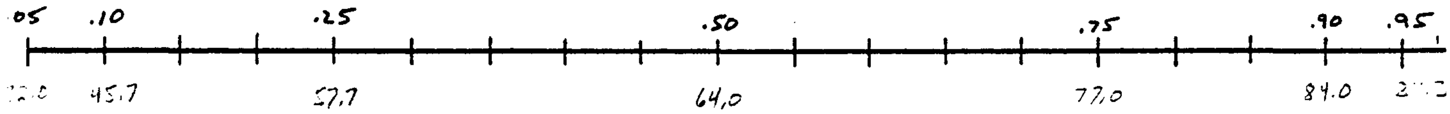


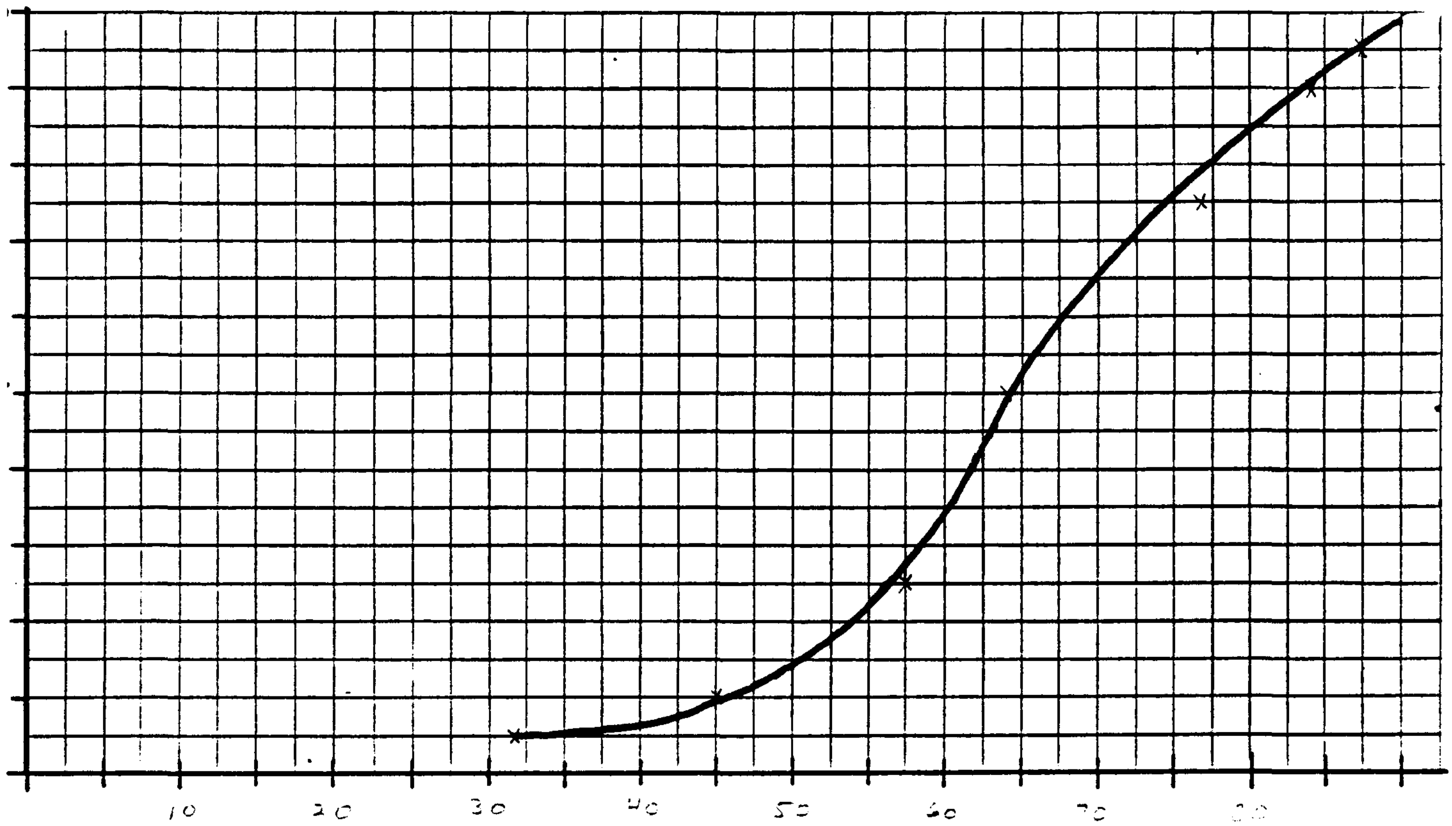


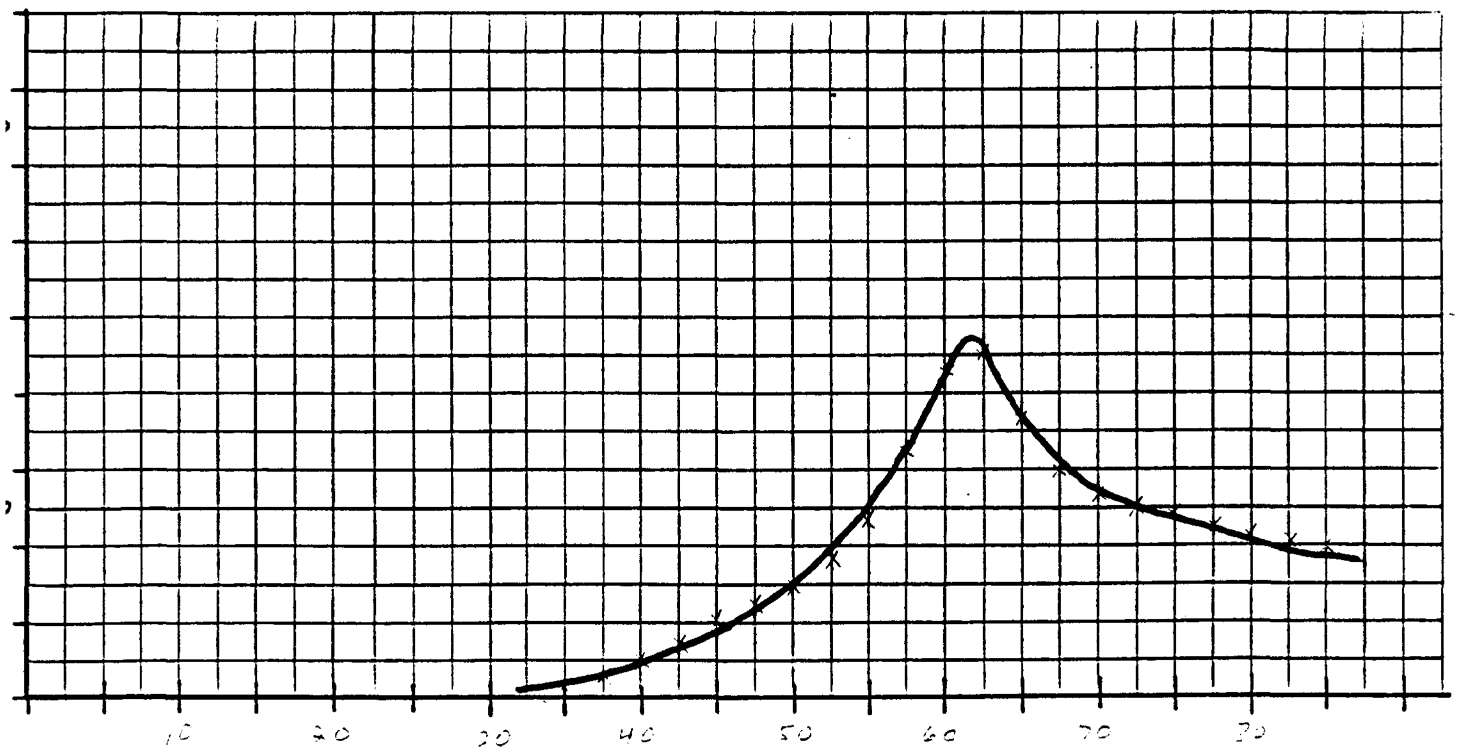
APPENDIX C

QUANTITY % OPERATING TIME (YEAR 1)

SUBJECT COMBINED

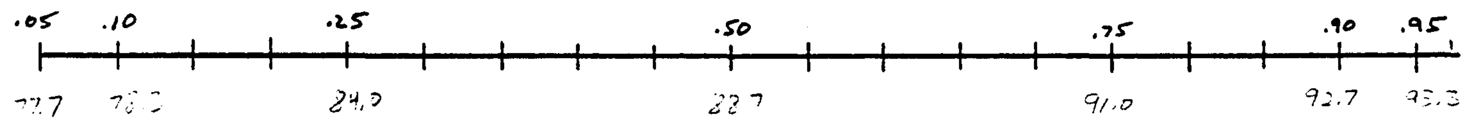


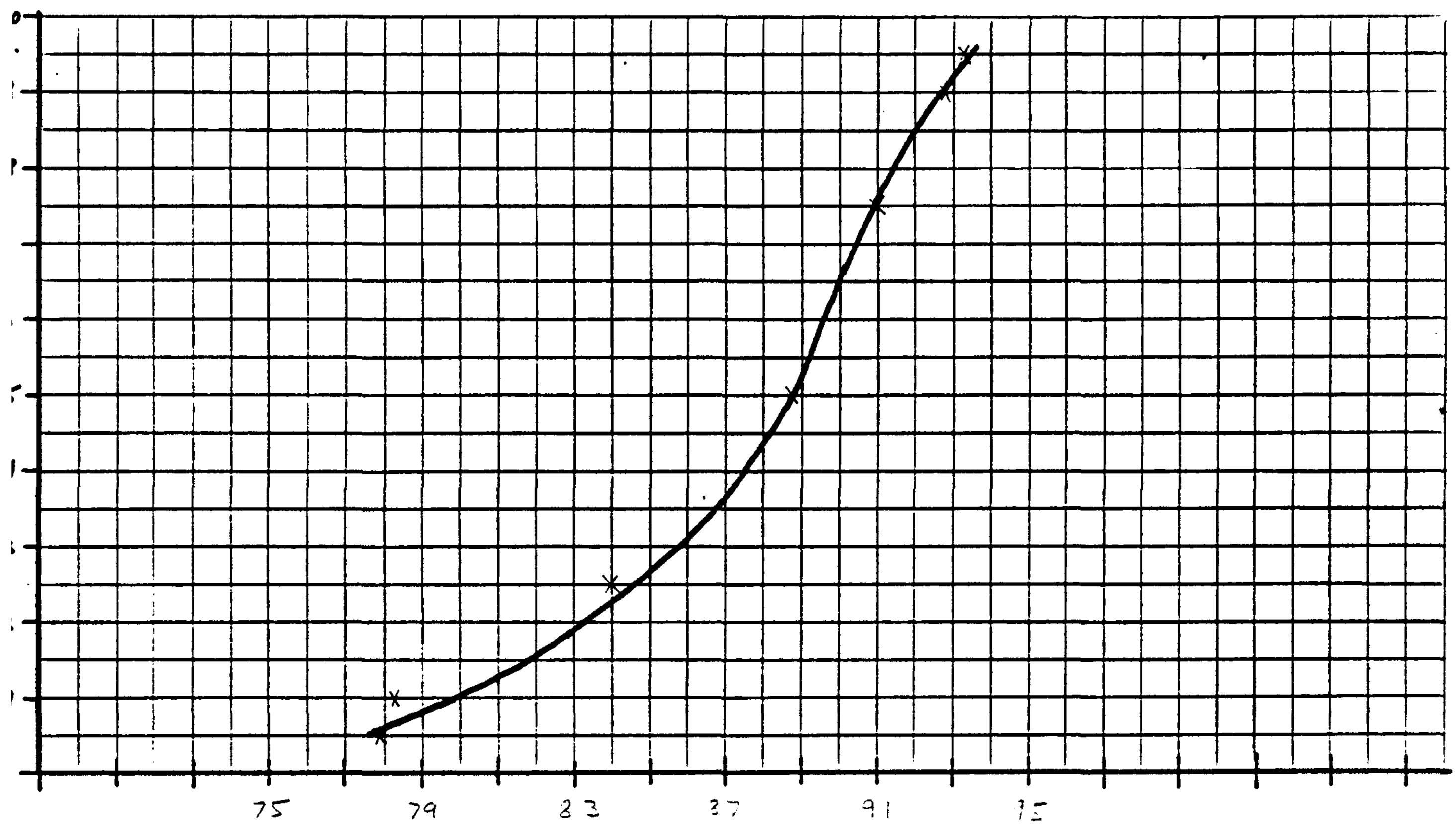


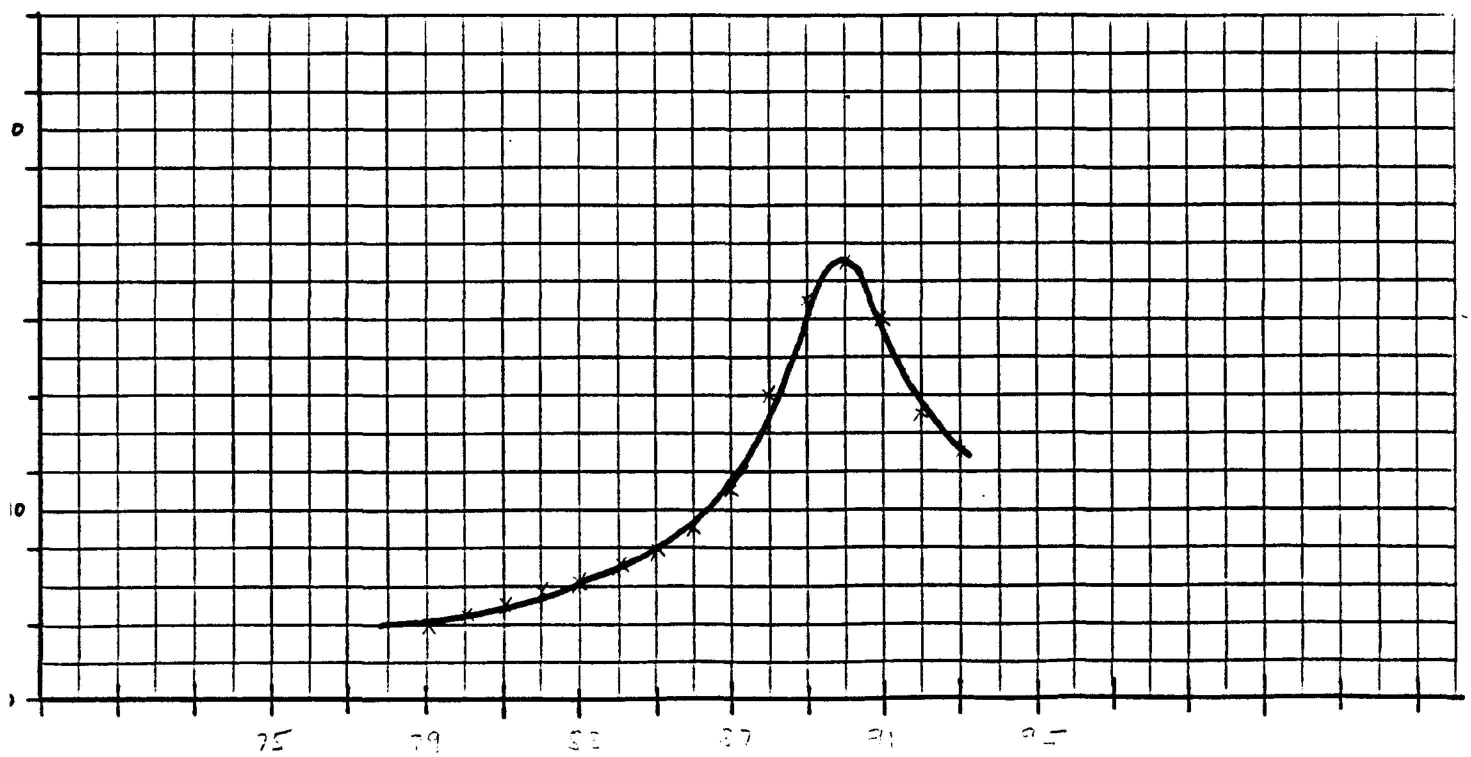


QUANTITY % OPERATING TIME (YEAR N)

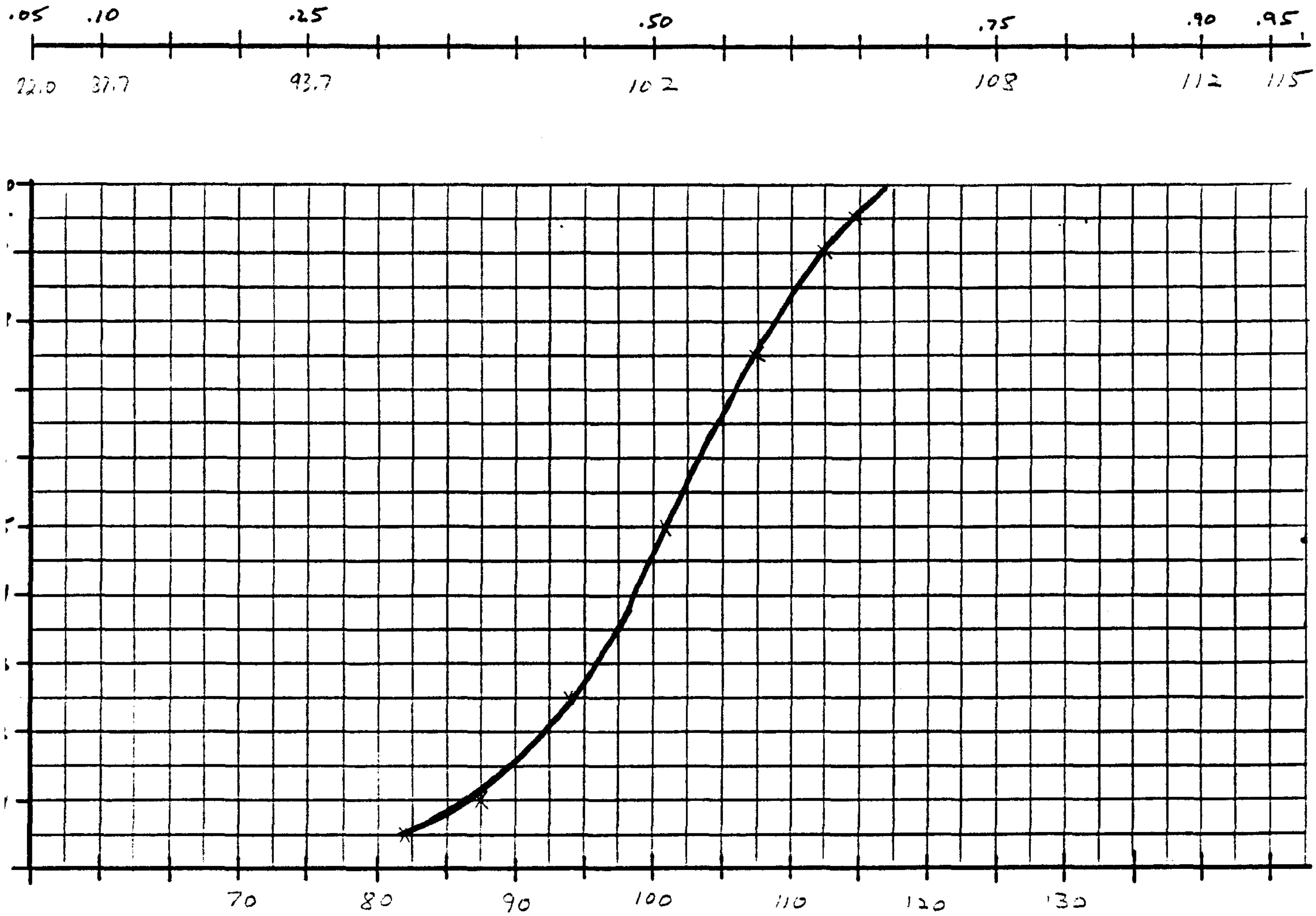
SUBJECT COMBINED

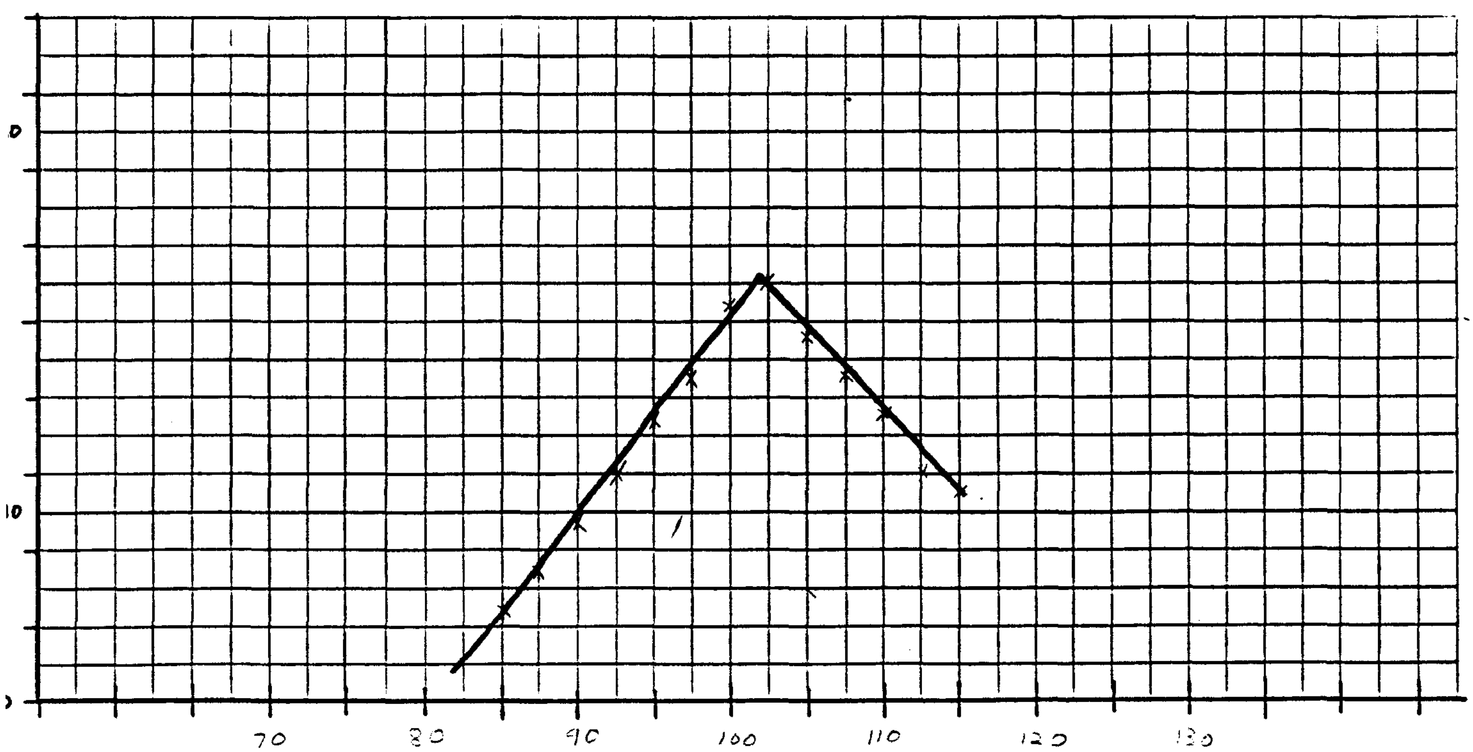






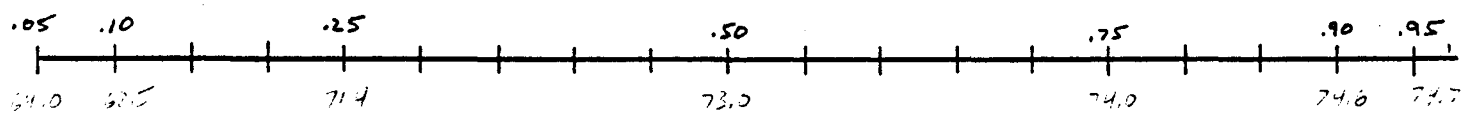
QUANTITY % DESIGN CAPACITY
SUBJECT COMBINED

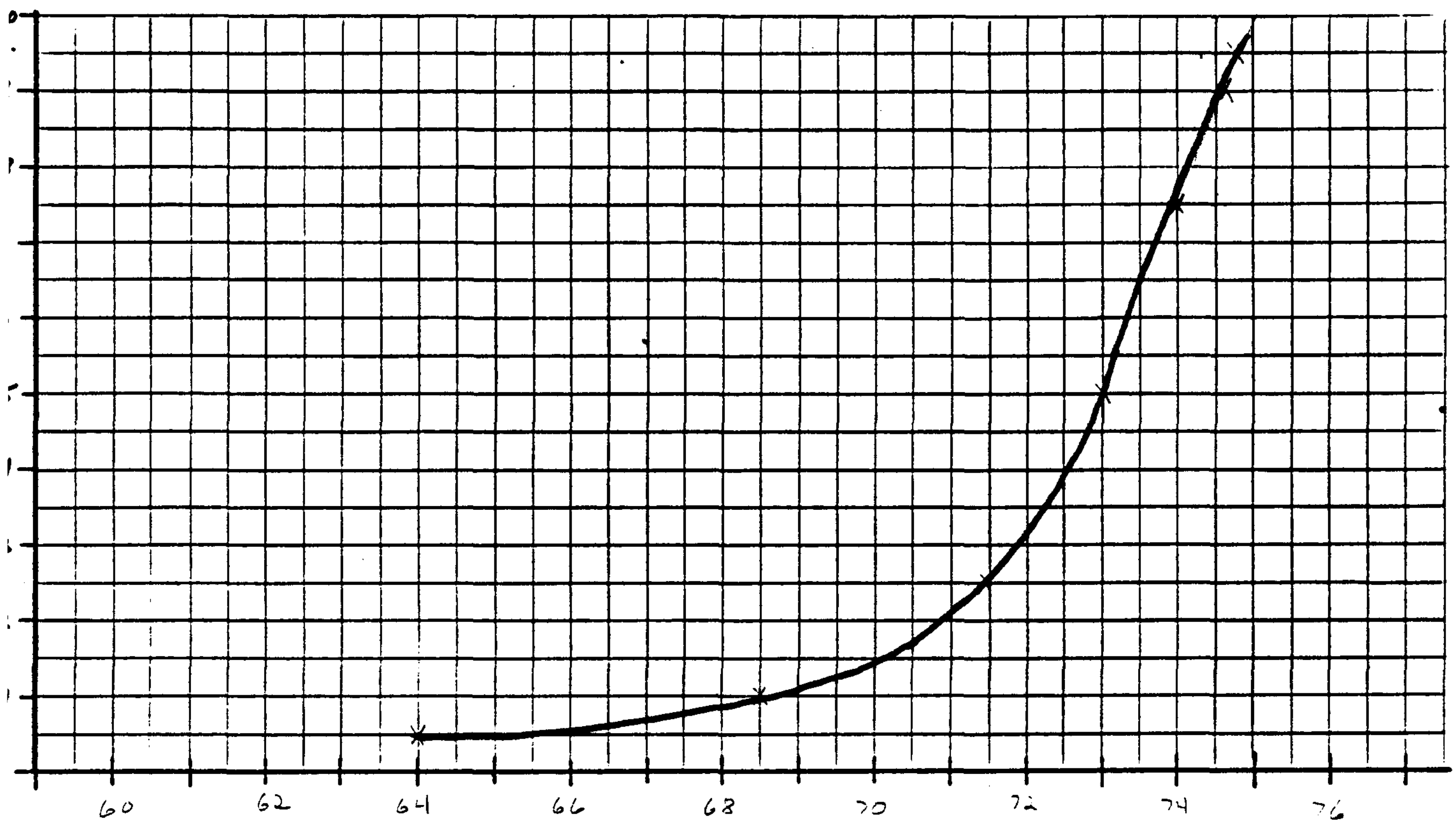


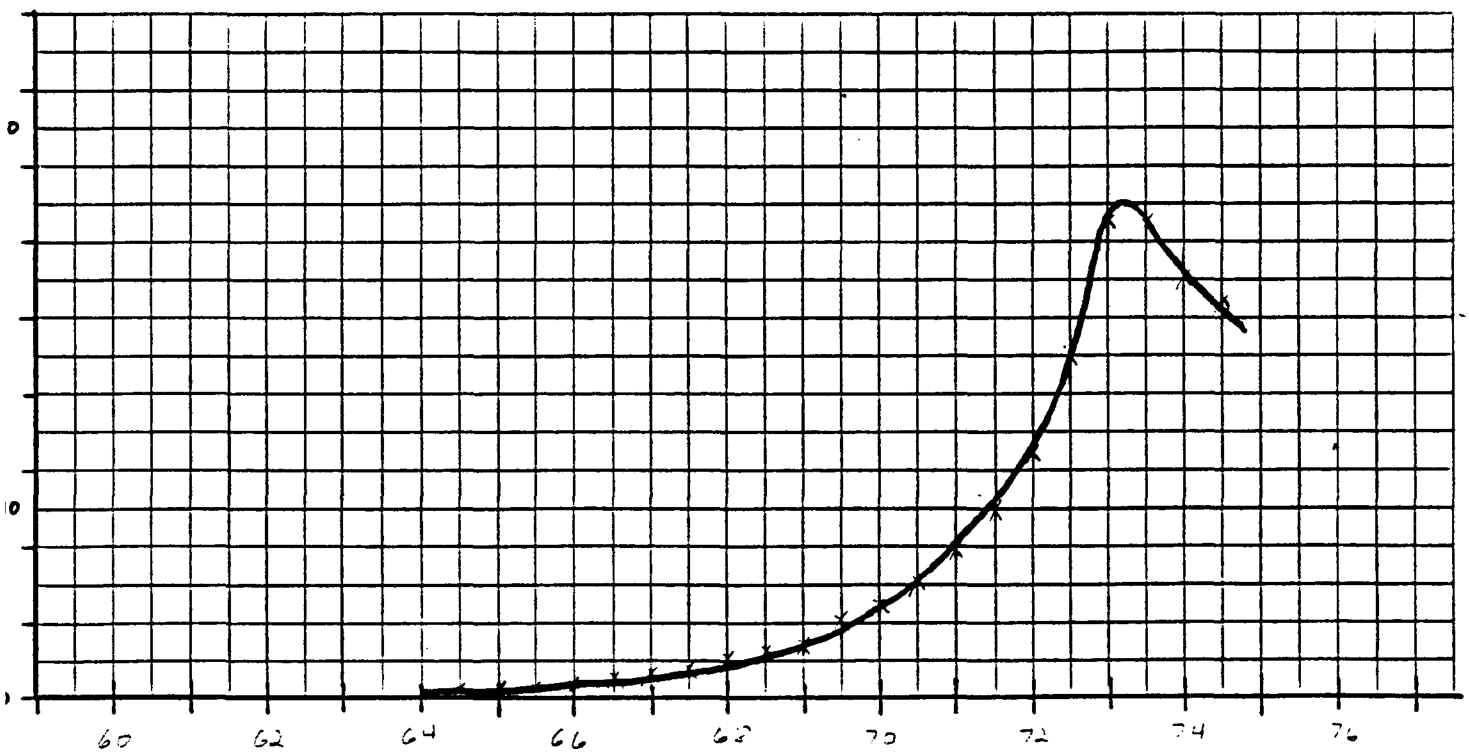


QUANTITY THERMAL EFFICIENCY %

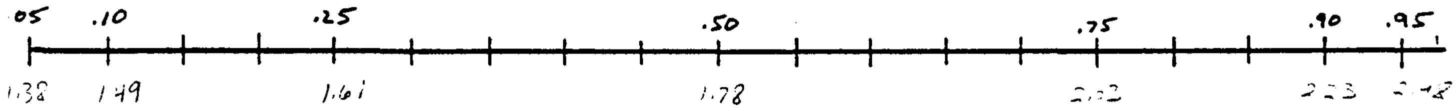
SUBJECT COMBINED

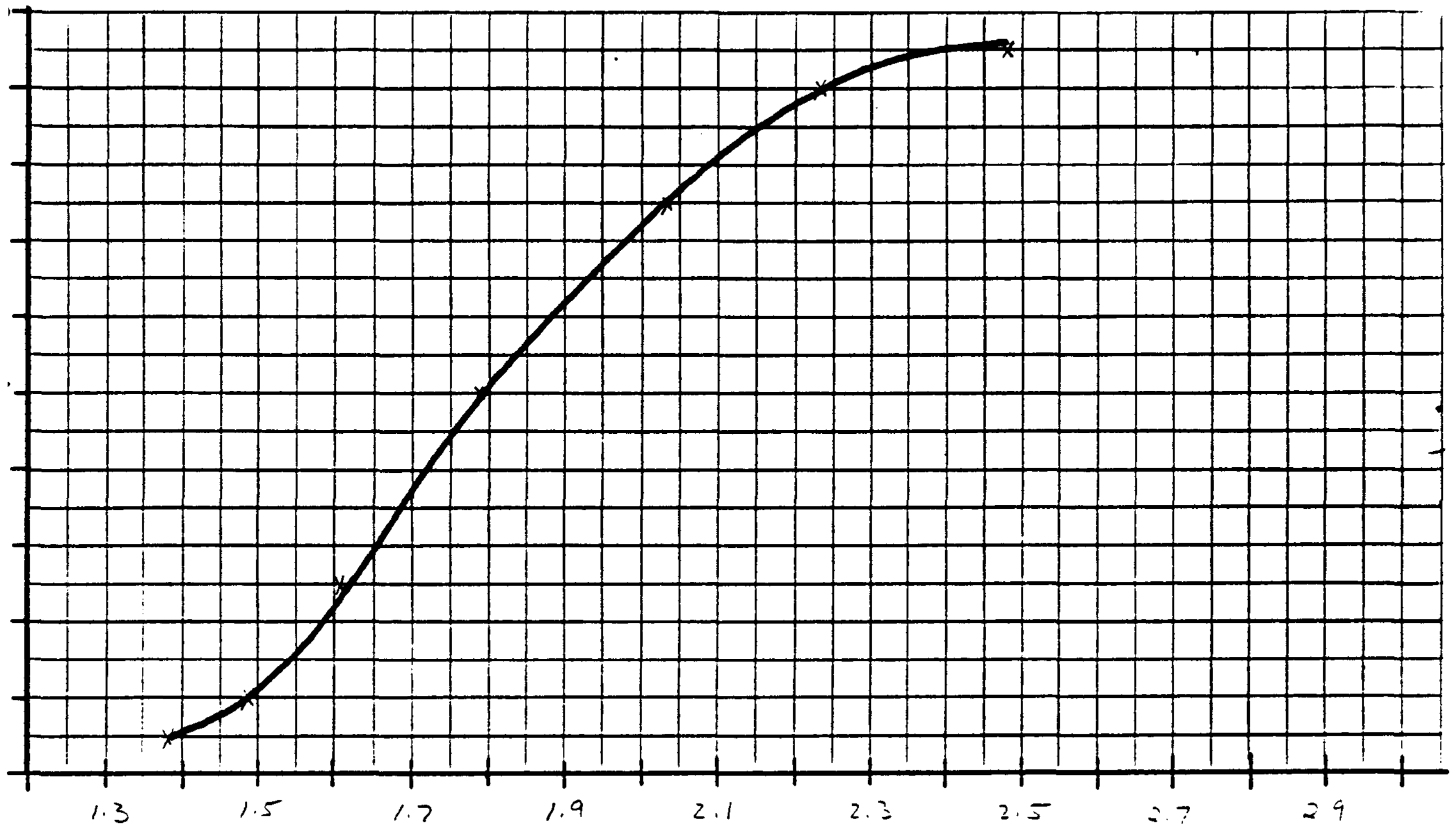


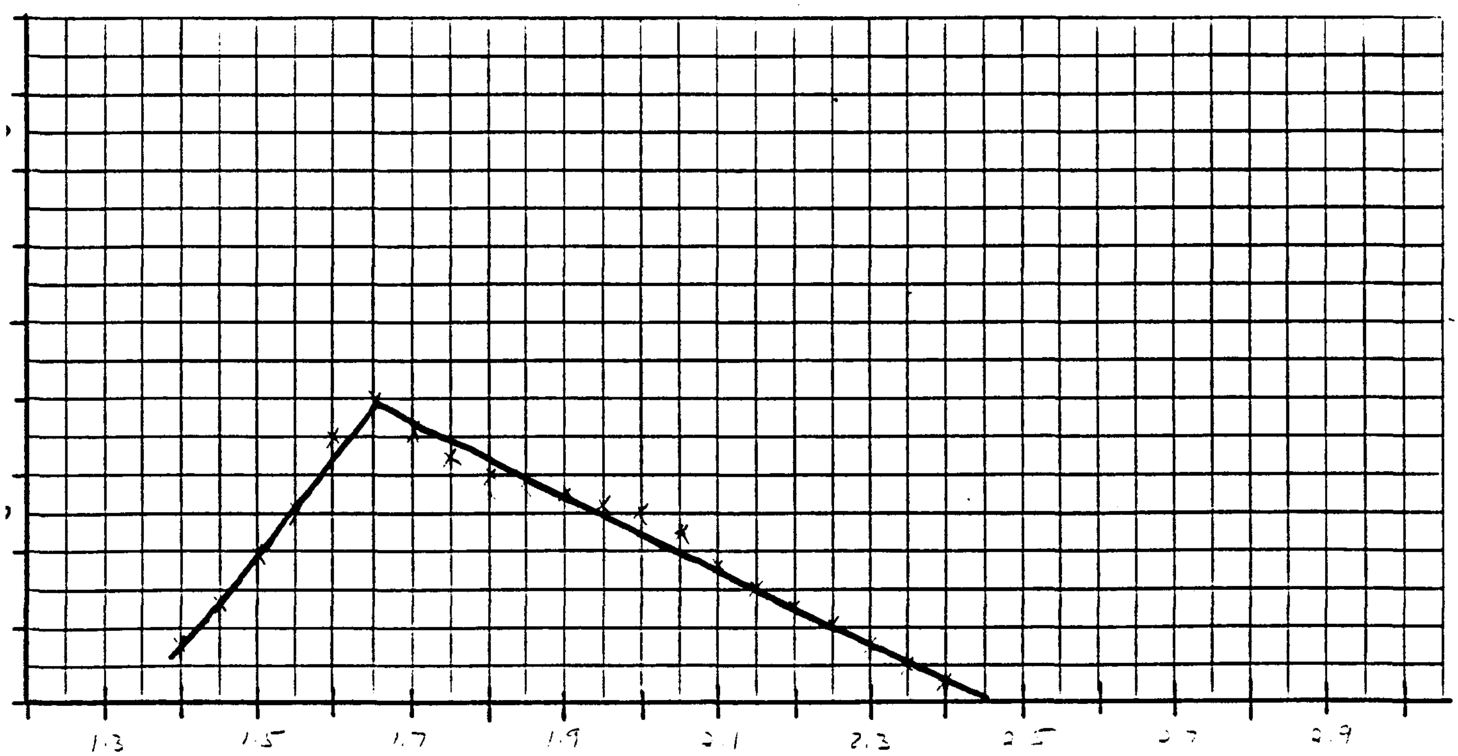




QUANTITY CAPITAL COSTS
SUBJECT COMBINED

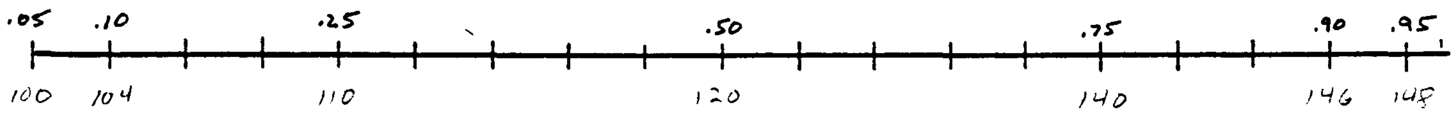


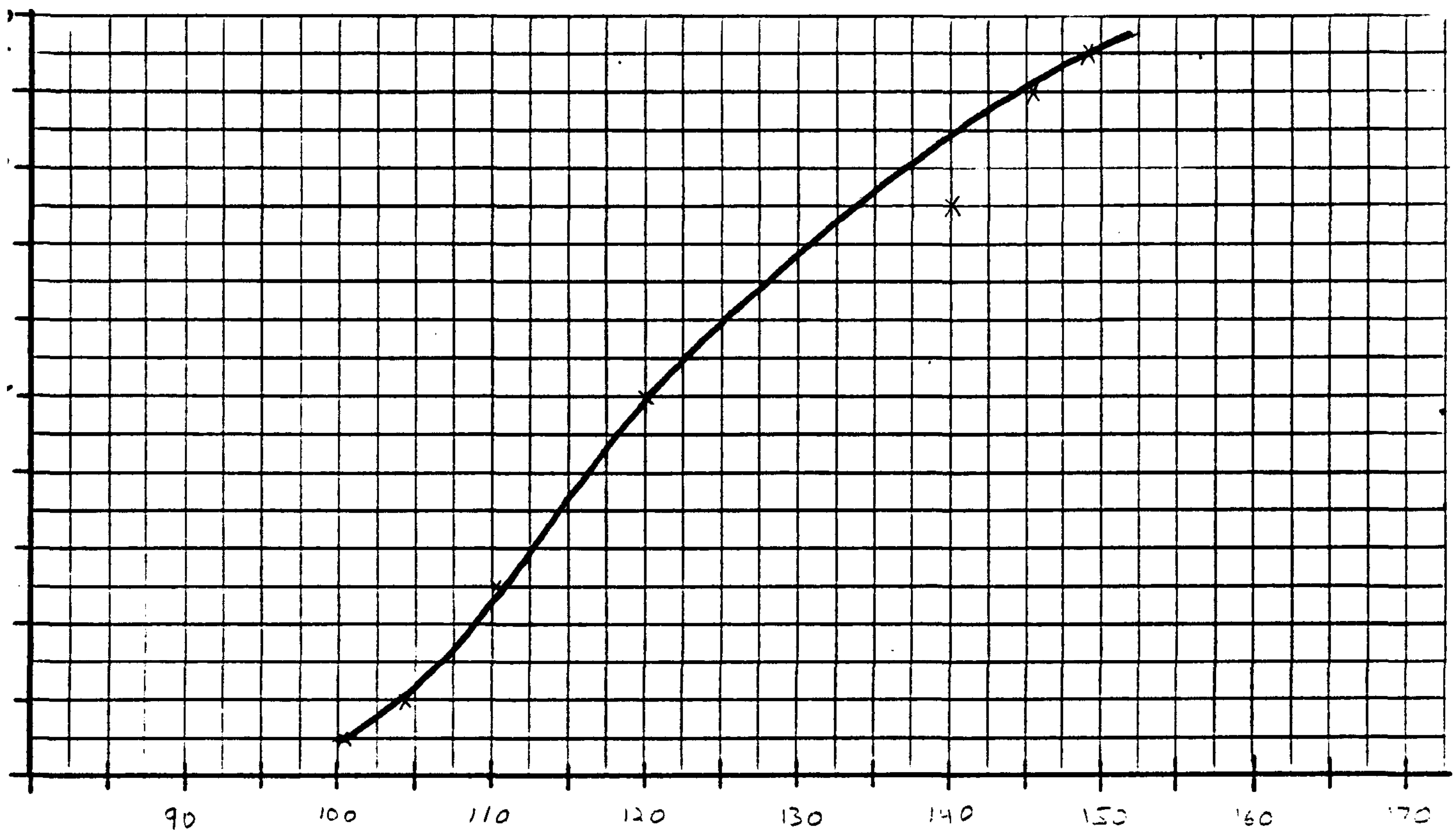


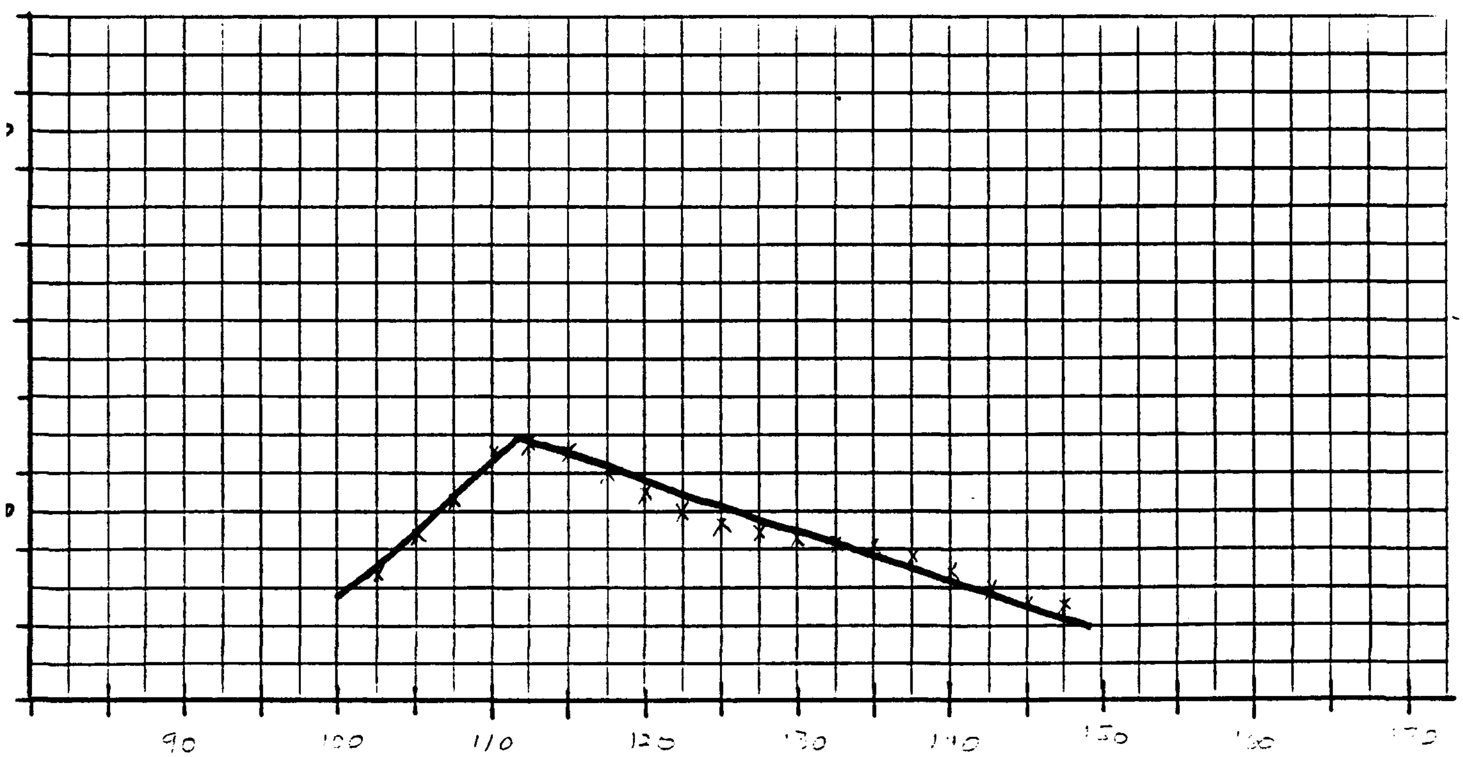


QUANTITY DIRECT OPERATING COSTS

SUBJECT COMBINED







APPENDIX A

ECONOMIC ASSESSMENT: CASE REQUIREMENTS

BASE CASE ASSUMPTIONS

1. Capacity: 30,000 short tons, moisture-free coal/calendar day (30,000 x 365 = 10,950,000 tons per year)

2. On-stream time: 328.5 days/year

3. Project life: 25 years

4. Plant life: 20 years (first operating year at 50% capacity, then 19 years at 90% capacity)

5. Capital costs in 4th quarter CY-1978 dollars plus 6% per annum escalation until year of expenditure

*6. Coal cost: $1.15/MMBTU delivered for washed coal (4th quarter CY-1978 dollars)

*7. Annual repairs and replacements: 2% of original depreciable investment

8. State and local taxes and insurance as percent of gross capital investment in service: 1.5%

9. Operating cost escalation including insurance and ad valorem taxes: 6% per annum

10. Land cost: $3,000 per acre (4th quarter CY-1978 dollars), recovered at the end of the project at original value

11. Working capital recovered at the end of the project

12. Plant and equipment scrap value: zero

*13. Debt/equity ratio: 25/75

14. Interest rate on debt: 9%

15. Debt financing: uniform principal payments commencing in the first year of operations

*16. Earnings on equity investment: 15%

17. Federal, state and local income tax rate: 50%

18. Operating loss offset against other income of parent company

*19. Depreciation: Double-declining balance switching to straight line. Placed in service date at start of first operating year. Thirteen-year life for depreciation.

*20. Investment tax credit: 10% in year expended

* Varied in sensitivity analysis

TABLE 1

FORMAT FOR PRESENTATION OF RESULTS
EARNINGS STATEMENT
(Step B Solution: All Costs in Current Year Dollars)

	1983	1984	1985	1986	1987	1988	1990	1991	1992	2007
1. Unit Sales 10^9 BTU										
2. Unit Price $/MMBTU										
Earnings Statement $MM										
3. Revenue										
4. Coal Costs										
5. Other Operating Costs										
6. By-product Sales Credit										
7. Gross Margin										
8. Depreciation										
9. Interest										
10. Ins., Ad Valorem Taxes										
11. Earnings Before Taxes										
12. Federal Income Tax										
13. Earnings After Taxes										
14. Change in Working Capital[1]										
15. Depreciation										
16. Capital Investment										
17. New Debt										
18. Net Cash Flow to Equity										
19. Cumulative Net Cash Flow to Equity										
20. Remaining Outstanding Debt										

[1] Working capital established last day of construction period and financed at debt-equity ratio.

SENSITIVITY ANALYSIS (16 Cases in Addition to Base Case)

1. Sensitivity matrix for debt/equity ratio and discounted cash flow return on equity

D/E	Return on Equity		
0/100	12	15	18
25/75	12	15*	18
50/50	12	15	18
65/35	12	15	18

* Base Case

2. Other sensitivities around Base Case

- Investment tax credit: 10% as in Base Case plus additional 10% on qualifying expenditures under the Energy Act of 1978

- Coal Costs: $.90/MMBTU, $1.40/MMBTU

- Depreciation period: 5 years

- Repairs and replacements: 4% of original depreciable investment

SUPPORTING DATA REQUIRED FOR BASE CASE

ANNUAL PLANT INVESTMENT COSTS

1. Cost of Engineering - the following component breakdown is desired if available:

   a. Design
   b. Engineering related to construction

2. Land - the following component breakdown is desired if available:

   a. Site acquisition
   b. Site preparation

3. Off-Site Utilities

4. Plant Acquisition Cost - the following component breakdown is desired if available:

   a. Materials
   b. Major Equipment
   c. Labor
   d. Installation
   e. Erection

*5. G&A to Plant Commissioning

6. Contingency

* Excludes "Expensable Costs During Construction" defined in Attachment II

ANNUAL OPERATING COSTS

Annual costs data for each of the items identified below should be provided for the Base Case for the 25-year project life.

*1. Capital expenditures

2. Coal

*3. Annual wages (including provision for 10% replacement for holidays, vacations, and sick leave)

*4. Fringe benefits

5. Plant overhead (including expenseable costs incurred during construction)

6. Allocated G&A expenses (including expenseable costs incurred during construction)

*7. Chemicals and catalysts (initial charge will be capitalized, annual replenishment will be expensed)

8. Insurance and taxes

*9. Repairs and replacements

10. Credits for by-product and co-product sales

11. Investment tax credit

12. Additional tax credit under the Energy Act of 1978 (For Sensitivity Case)

13. Electricity (at 3¢/kWh, 4th quarter CY-1978 dollars) and Other (specify what is included)

* Including 20% contingency

ANNUAL OPERATING COSTS (Cont.)

14. Backup data required to determine total working capital requirements by year:

    a. Total annual payroll costs to determine cash requirements

    b. Accounts receivable

    c. Accounts payable:

        1. coal component
        2. catalyst, chemicals, and materials and supplies other than coal

    d. Finished goods inventory:

        1. coal component
        2. other

    e. Raw material inventory

        1. coal component
        2. catalyst, chemicals, other

    f. Work in process inventory

        1. coal component
        2. other

    g. Spare parts inventory

ATTACHMENT II

ECONOMIC ASSESSMENT: GROUNDRULES

PLANT INVESTMENT COSTS

- Five-year construction period, CY-1983 - CY-1987
- Costs based on 4th quarter CY-1978 dollars escalated at 6% per annum to year of expenditure
- Annual capital expenditure pattern, in constant dollars for the five-year construction period: 5%, 10%, 30%, 40%, 15%

LABOR COSTS, OVERHEAD, G&A, IDLE TIME, CONTINGENCIES

1. Wage Rates:

Based upon the Survey of Current Business for November 1978, Volume 58, No. 11, page S-16, the average hourly earnings for production for non-supervisory workers in the petroleum and coal products industries for October 1978 was $8.77/hour for operating labor, $13.68 for skilled construction labor, and $10.33 for common construction labor. Assuming a mix of 2/3 skilled construction labor to 1/3 common construction labor, the average maintenance labor rate would be $12.56. The annual wages to be used are as follows:

	Operating Labor	Maintenance Labor
Wage rate/hour[1]	$8.77	$12.56
Hours/year	2080	2080
Annual wages	$18,242	$26,125

[1] Includes holiday and vacation pay.

2. Fringe Benefits:

A rate of 30% of annual salaries and wages is to be used for fringe benefits. Included are the costs of medical, dental and life insurance, workman's compensation and payroll taxes. Holiday and vacation pay is excluded because it is included in the annual wages.

3. Plant Overhead and Allocated G&A Expenses:

General and administrative expenses have been broken into two categories - those for work performed on the plant site and those that would be allocated from the parent company for services rendered by the corporate office. All services for which there would be a sufficient workload would be staffed at the plant site. Only specialized services that are more efficiently performed at the corporate office level would be performed for the project by the parent company. The resulting breakdown is as follows:

<u>Plant Overhead</u>

Plant Manager
Administrative Services
Purchasing
Materials Control
Human Resources
Safety and Security
Health Protection
Public Relations
Plant Supervisors (Shift Supervisors included with Operating Personnel)
Technical Operations Personnel
Maintenance Technical Personnel and Craft Supervisors

<u>Allocated G&A Expenses</u>

Legal
Corporate Control and Accounting
Annual Internal Auditing
Treasury and Insurance Support
Corporate Human Resource Management
Corporate Tax Management

A rate of 77.3% of operating and maintenance labor (exclusive of fringe benefits) has been determined for plant overhead. A rate of 10% of operations and maintenance labor (exclusive of fringe benefits) has been determined for allocated G&A expenses.

4. Provision for Idle Time:

Allowance must be made in the estimating of the operating and maintenance labor manning for extra personnel required for replacements during holidays, vacations, and sick leave. An allocation of 10%

to the basic operating and maintenance labor manning is to be added to cover idle time. This provision will not be applied to overhead personnel or to supervision included in plant overhead.

5. Contingency Allowance:

A 20% contingency allowance is to be applied to capital and direct operating costs to reflect uncertainty about process costs due to lack of detailed engineering in Phase Zero. No contingency will be applied to plant overhead and allocated G&A expenses since these can be determined with reasonable accuracy from similarly sized refining operations.

6. Example:

Example of Application of Assumptions
Regarding Wages, Fringe Benefits, Plant Overhead
Allocated G&A and Contingency

	Operating Labor	Maintenance Labor
Wage Rate/Hour	$8.77	$12.56
Hours/Year	2080	2080
Annual Wages	$18,242	$26,125

Example:

Basic manning without provision for nonproductive time	100 man/years	100 man/years
Manning provision for replacements during holidays, vacations, and sick leave @ 10%	10 man/years	10 man/years
	110 man/years	110 man/years

Cost Summary
Wages, Fringe Benefits, Plant Overhead,
Allocated G&A and Contingency

	Operating Labor	Maintenance Labor
Annual Wages (including provision for 10% replacement for holiday, vacation, and sick leave)	$2,006,620	$2,873,750
Fringe Benefits @ 30%	601,986	862,125
Plant Overhead @ 77.3%	1,551,117	2,221,409
Allocated G&A @ 10%	200,662	287,375
Total Operating and Maintenance, Labor, Fringe Benefits, and Overhead Costs before Contingency	$4,360,385	$6,244,659
Contingency @ 20% Operating and Maintenance Labor and Fringe Benefits	521,721	747,175
Total Operating and Maintenance, Labor, Fringe Benefits, Plant Overhead, Allocated G&A and Contingency	$4,882,106	$6,991,834

Other Direct Costs

Other Direct Costs	xxxx
Contingency @ 20% of Other Direct Costs (exclusive of Coal Costs)	xxx
Total Other Direct Costs including Contingency @ 20% of Other Direct Costs (exclusive of Coal Costs)	xxxx

BY-PRODUCT PRICES

The following by-product prices (4th quarter CY-1978) are to be used in the economic assessment:

Crude sulfur, 99.5% minimum purity, carload lots, FOB plant	$50 per short ton
Ammonia, anhydrous, fertilizer, wholesale, delivered East Coast	$120 per short ton
Tar acid oil, 15-18%, tank car lots, FOB plant	$1.02 per gallon

EXPENSEABLE COSTS DURING CONSTRUCTION

Normal plant overhead and allocated G&A expenses should be written off for income tax purposes as incurred. While construction-related expenditures must be capitalized, pre-start-up expenses such as training of operating personnel, departmental expenses that would normally be part of plant overhead (such as those for accounting, personnel administration, engineering not related to construction, etc.), and any other expenses that would be incurred in the normal course of business, may all be expensed currently since it is assumed that the parent company has been engaged in the SRC business prior to undertaking this project.

A recommended schedule for the buildup of plant overhead and allocated G&A expenses (in constant dollars) during construction is shown below:

(1) Construction Years	(2) % of Normal Plant Overhead and G&A Incurred
-4	4%
-3	5%
-2	9%
-1	30%
0	91%

PLANT START-UP COSTS

Plant start-up costs in 1988 are assumed to be 4/9 of the 1989 operating costs (exclusive of the cost of coal). Since it was assumed plant production in 1988 will be only 5/9 of a normal year's output, the remaining 4/9 of operating costs are assumed to be costs incurred in solving start-up problems.

WORKING CAPITAL

Working capital will be established on the last day of the construction period with inventory components (indicated with *) based on fourth quarter CY-1987 dollars and the remaining three components based on fourth quarter CY-1988 dollars. The working capital established at this time will remain constant throughout the twenty-year operating period and will be recovered at the end of plant life. Working capital will not be escalated in the Step "B" solution (page 8). Working capital components are:

Cash..............................	1/12 of year's payroll
Accounts receivable...............	1/12 of year's revenue
Accounts payable..................	1/12 of year's a/c expenses
*Finished goods....................	10/365 of year's production
*Catalyst and chemicals............	1/12 of year's requirements
*Raw materials	1/12 of year's requirements
*Work in process...................	As required
*Spare parts inventory.............	3% of gross capital equipment

*Assume LIFO accounting for these inventories

The contributions from each component above will be based on the requirements to support operations at the assumed steady-state production level of 90% of design capacity. The contribution from receivables will be based on the constant dollar (CY-1988 dollars) SRC price solved for in Step "A" (page 7) of the price calculation, and the sales volume at 90% design capacity. There will also be a contribution to receivables based on one month of revenues from by-product and co-product sales, at the annual steady-state rate, priced in 1988 dollars.

Working capital will be financed from debt and equity in the ratio specified for the case. The total investment in working capital will be recovered at the end of the project.

FINANCING CONVENTIONS

Financing cost of construction: borrow the specified percentage of the net cash flow for construction, interest payments, pre-start-up expenses, investment tax credits, and income tax credits.

Interest Calculation

The following is a formula for calculating interest during the five-year construction period. It includes a term for pre-start-up expenses.

$$\text{Interest} = \frac{Debt_{N-1}i + \frac{C_N Di}{2} + \frac{E_N(1-TR)}{2}Di}{1 - \frac{(1-TR)Di}{2}}$$

Where,

$Debt_{N-1}$ = Sum of all previously issued debt through year N-1
i = Interest rate on debt (0.09)
D = Debt fraction
TR = Income Tax Rate (.50)
C_N = Capital Investment in Year N
E_N = Expenses-not-capitalized in Year N

When escalation rates are applied, all costs will be escalated to the end of year expended. During the five-year construction period annual capital expenditures, although fully escalated to year-end price levels will be assumed to be uniformly distributed throughout the year for the purpose of calculating annual interest costs (mid-year convention). For discounting purposes, all net cash flows will be assumed to occur at year-end (year-end convention).

During the 20-year operating period, all cash flows will be assumed to occur at year-end.

Method of Determining Price

The method for determining the annual price of product ($/MMBTU) from the SRC plants will consist of two steps:

A. The net cash flow to equity during the construction period in current year dollars will be determined in accordance with the conventions and financing assumptions outlined above. Operating Costs for CY-1988 through CY-2007 will be determined in constant 4th quarter CY-1988 dollars, and a solution for a constant product price over the 20-year operating life will be determined. This solution will generate a set of net cash flows to equity.

B. To determine the annual product price in current year dollars for CY-1988 through CY-2007, the annual operating costs (including coal and state and local taxes and insurance) will be escalated to current dollars and the product price will be increased to a level which will maintain the same annual before tax earnings, debt issuance, and net cash flow to equity over the 25-year project life as was obtained in the solution to step "A" above.

PRESENTATION OF RESULTS

The Step "B" solution for the Base Case is to be tabulated in the format shown in Table 1 for the 25-year project life. This format is identical to Table 4, Attachment I, of Mr. John F. Pearson's letter of February 12, 1979, with the exception that line 19 has been changed to show "Cumulative Net Cash Flow to Equity," and line 20 has been retitled "Remaining Outstanding Debt." For each of the sensitivity cases the unit cost of the SRC product in the Step B solution will be tabulated over the twenty-year operating life of the plant.