SECTION 15

EXPERIMENTAL DATA BASE FOR KEY CONVERSION PROCESSES

15.1 HYDROLIQUEFACTION

15.1.1 SRC-II CHARACTERISTICS

The SRC-II mode of operation was used for this design in preference to SRC-I because:

- It produces more gaseous products, which coincides with the Oil/Gas objectives.
- Except for SNG, the primary products are liquid at ambient temperatures.
- The sulfur content in the fuel oil product is less than 0.5 wt %.

15.1.2 DATA BASIS

The design was based primarily on five SRC-II material balance runs performed at the Tacoma Pilot Plant in August 1975, SR-1 through -5,[18] and supporting SRC-II data from a process development unit. The following procedure was used to develop the design yield structure:

- Adjust SR-3, -4, and -5 yields to 100%.
- Average the yields from SR-3, -4, -5.
- Adjust the heteroatom balance to give 15% nitrogen removal, 35% oxygen removal, and 67% sulfur removal. The heteroatom removals and reaction conditions summarized in Section 15.1.3 are consistent with the objective of producing a fuel oil product containing 0.5 wt % sulfur, maximum. (Nitrogen appears only in ammonia, sulfur in hydrogen sulfide, and oxygen in carbon dioxide and water.)
- Using the Oil/Gas base coal analysis, perform an elemental balance for the adjusted yields, based on use of the liquid elemental analyses published for SRC-I yields.[17]

The results of the above procedure are shown in Table 15-1, which gives the complete yield structure and elemental analyses of all products.

Tacoma laboratory distillation results[16] were used to construct distillation and specific gravity curves for the products; these are shown in Figures 15-1 and 15-2. All other properties of product streams were generated by standard Ralph M. Parsons Company proprietary correlations.[19]

All available data were considered in preparing the design basis. The resulting material and elemental balances are a composite projection of expected results. Based on information available, these balances are expected to conform to the yields and product distribution to be achieved with SRC-II.

Other hydroliquefaction design factors are:

- Solvent/Coal (S/C) Ratio - Solvent is defined here as the total weight of the recycle stream, including both liquids and solids.

  Initial SRC-II pilot plant tests, runs SR-1 through -5, used S/C ratios in the range of 4 to 6, which is too high. SRC-I operates satisfactorily with S/C ratios of 1.5 to 2.0. Judgment led to the selection of a design basis of S/C = 3. This judgment was later confirmed when the process developer recommended a solvent-to-coal ratio in the range of 1.5 to 2.5.[21]

  The economic implications of using an S/C ratio of 3.0 vis-a-vis 1.5 were investigated. The results indicate that use of the lower S/C should result in a fixed capital investment decrease of approximately $72.5 million, or about 6%. The operating costs and required product selling price would be reduced approximately 3 and 5%, respectively.

- Temperature; Hydrogen Partial Pressure, and Hydrogen Circulation Rate - The conditions listed in subsection 15.1.3 were selected to produce a fuel oil product with 0.5 wt % sulfur, maximum. The selection was based on data analysis and discussions with process development personnel from the Pittsburg & Midway Coal Mining Company.

15.1.3 DESIGN CONDITIONS

To summarize, the following design conditions were used:

• Solvent/coal weight ratio	3:1 (2/3 slurry, 1/3 filtrate)
• Temperature	850°F outlet of dissolver 700°F outlet of preheater
• Hydrogen partial pressure	1,900 psig (at preheater entrance)
• Hydrogen circulation rate	2 times consumption

15.2 PROCESS GASIFICATION

High-pressure steam/oxygen gasification of coal was used to produce a hydrogen-rich synthesis gas to supply hydrogen for dissolving and naphtha hydrotreating. The gasifier is an entrained, slagging, two-stage design, based on information published by Bituminous Coal Research, Inc., during the ERDA-sponsored Bi-Gas Development program.[3] This gasifier also produces a significant quantity of methane, which is recovered in the cryogenic separation unit and sent to product SNG.

Gasifier conditions were selected to convert 20% of the carbon in the feed coal to methane. Heat and material balance calculations for conditions to accomplish this in the gasifier follow closely the procedures recommended by BCR, Inc.[12] The coal feed rate to the gasifier of 10,000 TPD was determined by the overall plant hydrogen balance.

15.3 FUEL GAS GENERATION

The fuel gas required for process furnaces and power plant boilers is generated in a low-pressure, slagging, air-blown, two-stage gasifier. This gasifier was designed to operate at a pressure of 45 psia in order to move the gas through the downstream H_2S removal system and to the point of use. Calculations for this gasifier are similar to that for the process gasifier. The process utility balance determined the required coal feed rate of 5,670 TPD.

15.4 PRODUCT POST TREATMENT

Light oil produced in the SRC process is hydrotreated to produce naphtha-range material suitable for gasoline production. Hydrotreater conditions and yields were based on a previously published design for hydrotreating of coal-derived light liquids.[13,14,15] Product contains 1 ppm of sulfur and 5 ppm of nitrogen.

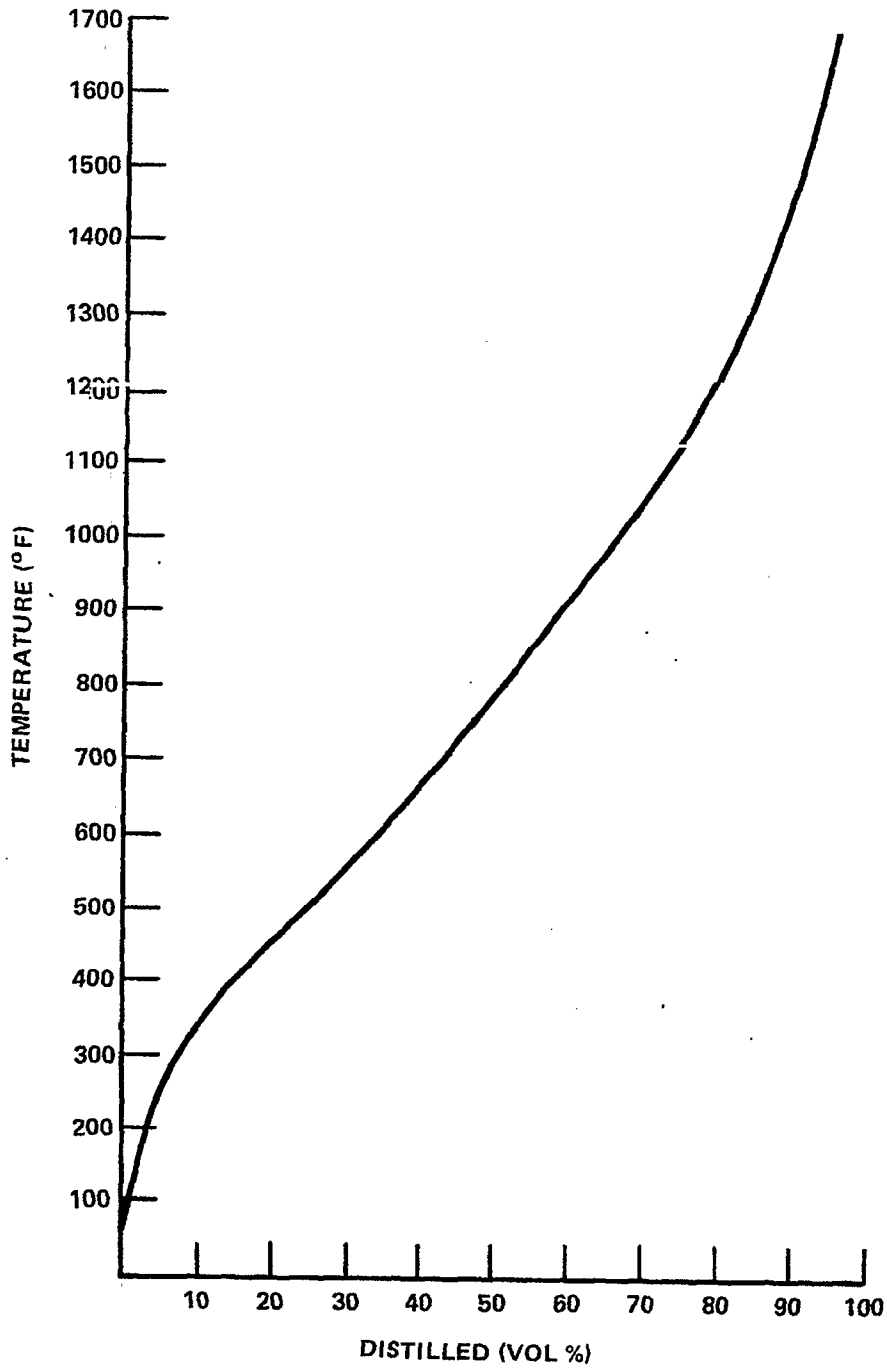

Figure 15-1 - Dissolver Product
True Boiling-Point Curve

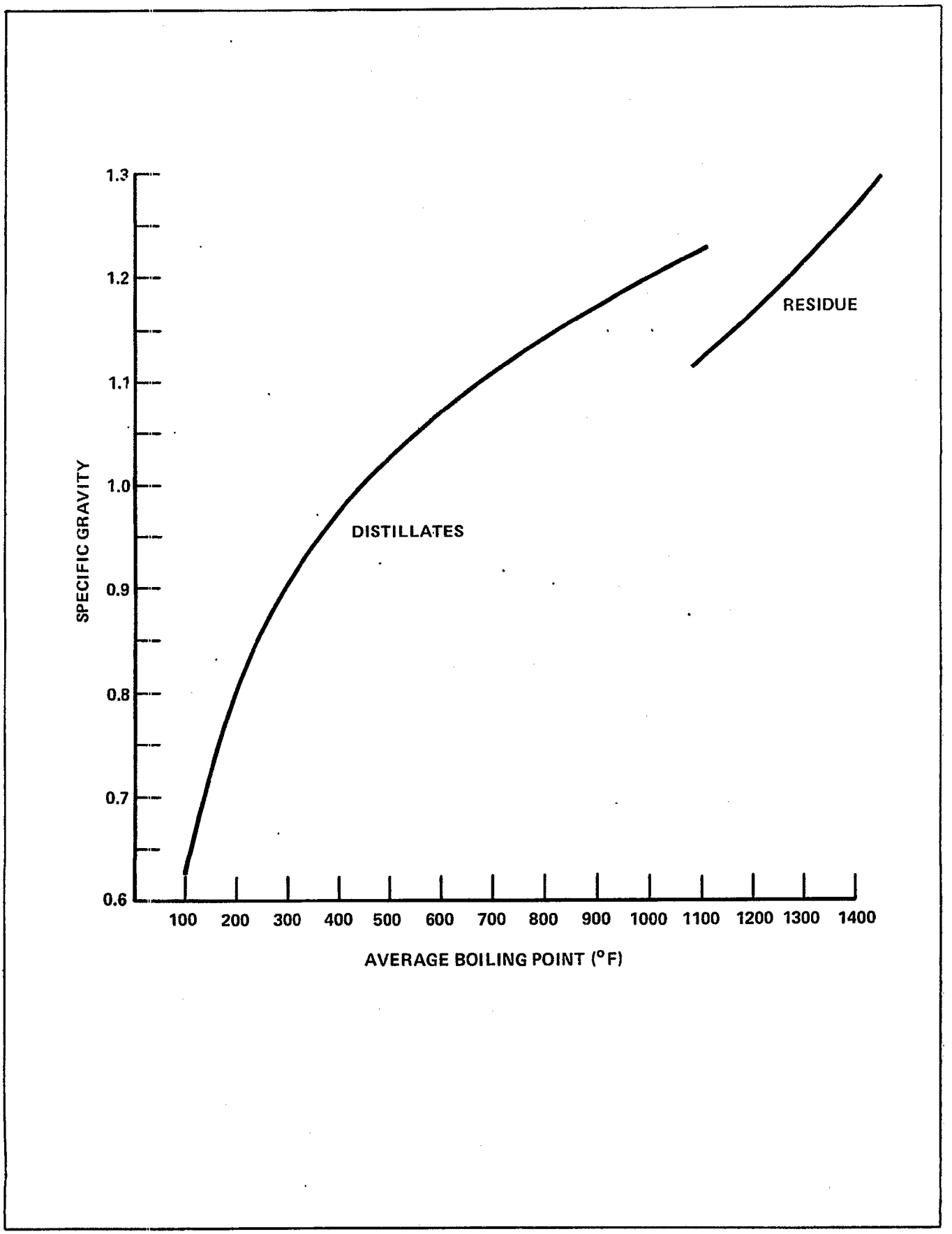

Figure 15-2 - Dissolver Product Specific Gravity vs. Boiling Point

Table 15-1 - Design Dissolver Balance

	C	H	N	S	O	Ash	Total
Input, lb							
MF Coal	69.07	4.74	1.32	3.78	8.96	12.13	100.00
H_2		4.70					4.70
Total	69.07	9.44	1.32	3.78	8.96	12.13	104.70
Output, lb							
C_1	3.52	1.18					4.70
C_2	2.34	0.59					2.93
C_3	3.17	0.70					3.87
C_4	1.56	0.32					1.88
CO_2	0.29				0.77		1.06
H_2S		0.16		2.49			2.65
NH_3		0.04	0.20				0.24
H_2O		0.30			2.37		2.67
Light oil	5.13	0.93	0.02	0.02	0.40		6.50
Wash solvent	5.99	0.80	0.05	0.02	0.48		7.34
Process solvent	12.72	1.40	0.17	0.05	0.91		15.25
	31.82	2.72	0.59	0.16	1.41		36.70
Mineral residue	2.53	0.30	0.29	1.04	2.62	12.13	18.91
Total	69.07	9.44	1.32	3.78	8.96	12.13	104.70

Table 15-1 (Contd)

Compositions						
	MF Coal	Light Oil IBP-400°F	Wash Solvent 400 to 500°F	Process Solvent 500 to 950°F	SRC 950°F+	Mineral Residue
C	69.07	78.92	81.61	83.41	86.70	13.38
H	4.74	14.31	10.90	9.18	7.41	1.59
N	1.32	0.31	0.68	1.11	1.61	1.53
S	3.78	0.31	0.27	0.33	0.44	5.50
O	8.96	6.15	6.54	5.97	3.84	13.86
Ash	12.13	—	—	—	—	64.14
	100.00	100.00	100.00	100.00	100.00	100.00
HHV, Btu/lb	12,444	19,890	18,134	17,376	16,926	2,080
Heat of Reaction - 209.7 Btu/lb MF coal (exothermic).						

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