Section 3

BASIS FOR DESIGN

GENERAL

EPRI provided SWEC with process designs, yields, and material balance data for the Hydrocarbon Research Institute (HRI) H-Coal liquefaction process for both Illinois No. 6 and Wyodak coal feeds. These data were used to develop complete overall material balances and process designs for the H-Coal plant using Illinois coal, Case HE, and for the H-Coal process using Wyodak coal, Case HW. Yield data for the H-Coal processes are presented in Table 3-1.

The Coal-to-Methanol design, Case CM, using Illinois coal, combines a front end Texaco coal gasification process with a Lurgi methanol synthesis unit. The coal gasification design was furnished by the Texaco Development Corporation. The Lurgi methanol synthesis design was developed by SWEC using in-house data. The gas composition from the Texaco coal gasification process and the makeup gas composition to the Lurgi methanol synthesis process are presented in Table 3-2.

Process designs for the H-Coal liquefaction process and for coal-to-methanol are based on the coal feedstock compositions presented in Table 3-3. It is assumed that the coal is mined, washed, and delivered to the plant site by others. For the Illinois No. 6 coal cases, the coal is delivered by rail. For the Wyodak coal case, the coal is delivered by belt conveyor from the mine.

The naphtha fraction, hydrotreated and catalytically reformed, is marketed as a quality motor fuel. The 350/650°F distillate is hydrotreated to yield a marketable turbine fuel product. The 650°F+ distillate fuel oil product is marketed without further treatment.

Ethane and lighter hydrocarbons are used as fuel for the process and for electric power generation. Propane and butane are recovered as LPG product in the H-Coal Illinois case, but are used for hydrogen production and fuel in the Wyodak case.

Product cost includes by-product credit for sulfur, ammonia, and export electric power. Phenol, recovered in water treating, is marketed without credit.

Gasification of vacuum bottom residue by the Texaco oil gasification process is the primary source of process hydrogen for the direct coal liquefaction cases. The gasification process is supplied with oxygen of 99.7 to 99.9 percent purity.

All compressors, pumps, and other mechanical equipment are provided with electric drivers. All electricity is generated onsite. For the H-Coal cases, electricity is generated by a combined cycle gas turbine power generation system using plant fuel gas and by-product steam. For the Coal-to-Methanol case, by-product steam is superheated and drives turbo-generators to provide the electrical requirements.

The use of cooling water is minimized by air cooling where feasible.

The designs provide for zero discharge of liquid effluent. All gaseous emissions are treated to meet environmental standards. Solid wastes are transported to a solid waste disposal area.

PLANT CAPACITY

For the H-Coal liquefaction cases, using Illinois No. 6 or Wyodak coal, the nominal plant design capacity is 50,000 bbl/sd fuel oil equivalent (FOE) of liquid distillate products. (An FOE barrel = 5.85×10^6 Btu, HHV.) For the coal-to-methanol case, the design capacity is 15,000 short tons per stream day of methanol fuel product containing 98.29 weight percent methanol, which is equivalent to 52,209 FOE bbl/sd.

PLANT SITE

Eastern coal cases are sited in southern Illinois and western coal cases are sited in Wyoming. Site conditions are presented in Table 3-4.

ADDITIONAL DESIGN CRITERIA

The plant design is based on a 90 percent capacity factor. A consistent equipment sparing policy is used for all cases.

The direct coal liquefaction cases are designed to produce the following products:

CASE HE ILLINOIS COAL	CASE HW WYODAK COAL
C_3 LPG C_4 LPG	(C_3 and C_4 are internally consumed)
C_5/350°F Light Naphtha-(Reformate Gasoline Blend)	C_5/350°F Light Naphtha-(Reformate Gasoline Blend)
350/650°F Distillate-(Turbine Fuel)	350/650°F Distillate-(Turbine Fuel)
650°F + Distillate-(Fuel Oil)	650°F + Distillate-(Fuel Oil)

Table 3-1

YIELD STRUCTURE FOR THE H-COAL LIQUEFACTION PROCESS

Component	Yields, lb/100 lb Dry Coal	
	Illinois No. 6 Coal	Wyodak Coal
CO	0.16	0.44
H_2S	2.64	0.87
NH_3	1.08	0.75
H_2O	6.65	17.13
CO_2	0.37	2.46
C_1	3.70	5.24
C_2^-	0.15	0.23
C_2	3.39	3.17
C_3^-	0.06	0.00
C_3	3.33	3.50
C_4	2.42	2.19
IBP-100°F	1.72	2.34
100-200°F	3.23	4.60
200-300°F	4.43	7.00
300-400°F	6.89	7.80
400-500°F	9.38	8.51
500-600°F	8.92	4.14
600-700°F	4.71	2.42
700-800°F	1.57	2.12
800-900°F	1.88	2.58
900-975°F	1.92	2.50
Residuum	19.00	11.46
Unconverted Coal	5.78	7.09
Ash	11.51	7.73[a]
TOTAL	104.89	106.27
Hydrogen Consumed	4.89	6.27
	100.00	100.00

[a] In this analysis, HRI reports sulfate in the ash as ash.

Table 3-2

SYNTHESIS GAS COMPOSITIONS
COAL TO METHANOL PROCESS

	Synthesis Gas - mol %[a]	
Component	Raw Synthesis Gas	Synthesis Make-up Gas
CO	45.79	27.94
H_2	33.91	67.05
CO_2	17.52	3.11
CH_4	0.34	0.41
$A+N_2$	1.25	1.49
H_2S	1.11	--
COS	0.08	--
TOTAL	100.00	100.00

[a] Illinois No. 6 Coal feed, dry gas basis

Table 3-3

COAL ANALYSIS

	Illinois No. 6	Wyodak
Ultimate Analysis wt %		
Carbon	69.76	66.58
Hydrogen	4.91	4.93
Nitrogen	1.47	1.05
Sulfur	3.47	1.14
Oxygen	8.88	19.22
Ash	11.51	7.08
	100.00	100.00
Water-wt %	12.0	30.0
HHV (MF) Btu/lb	12,669.5	11,420.6

Table 3-4

SITE CONDITIONS

Location		Illinois	Wyoming
Elevation	feet	500	4500
Atmospheric pressure	psia	14.4	12.4
Summer dry bulb	°F	88	85
Summer wet bulb	°F	75	65
Winter dry bulb	°F	12	-15
Cooling water			
in	°F	85	75
out (max.)	°F	120	120
Air cooling			
air out (max.)	°F	125	122
Process water in	°F	70	70
Demineralized water in	°F	70	70