

TABLE 7. - Continued.

(e) SRC (light organic liquid and recycle solvent); data from ref. 38.

Property	Text	Distillate categories					
		Light organic liquid (J-7951)	Recycle solvent (J-7950)				
Gravity, °API (specific)		---- (0.9182)	---- (1.039)				
Bolling range:							
Initial boiling point, °F		181	326				
5 %							
10 %		284	398				
20 %		325	405				
30 %		335	434				
40 %		348	454				
50 %		365	492				
60 %		375	526				
70 %		397	566				
80 %		407	595				
90 %		415	657				
95 %							
Final boiling point, °F		561	877				
Pour point, °F		65	75				
Flashpoint, °F		90	205				
Viscosity at 100°F, cS		1.463	5.88				
at 210°F, cS		0.647	1.464				
at °F							
Ash, wt%	D-482	18.	3.				
Ash: melt temperature, °F							
Heat of combustion, Btu/lb		17 275	16 715				
Carbon residue (Conradson), wt%		0.01	0.08				
Carbon remaining, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment	combined, vol%	0.03	0				
Neutrality							
Corrosion							

TABLE 1. - Continued.

(f) SRC products from Kentucky #9 coal; data from letter of May 16, 1975, to T.W. Reynolds, NASA Lewis Research Center from Robert G. Speriac, Pittsburgh & Midway Coal Mining Co.

Property	Test	Distillate categories					
		Solvent-refined coal	Wash solvent	Light oil			
Gravity, °API (specific)			---- (0.984)	---- (0.936)			
Bolling range:	D-86						
Initial boiling point, °F			383	155			
5 %			402	219			
10 %			408	280			
20 %			413	310			
30 %			417	322			
40 %			421	332			
50 %			425	342			
60 %			430	350			
70 %			436	357			
80 %			444	366			
90 %			455	380			
95 %			463	400			
Final boiling point, °F			482	402			
Pour point, °F; fusion point, °F		430					
Flashpoint, °F							
Viscosity at 77°F, cS				1.236			
at 100°F, cS			2.75	0.794			
at °F							
Ash, wt%		0.3					
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon vanadatum, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

TABLE 7. - Continued.

(g) SRC (light organic liquids and recycle solvents); data from ref. 41.

Property	Test	Distillate categories						
		Light organic liquid (76D-1291)	Recycle solvent (76D-3019)	Recycle solvent (76D-1289)	Recycle solvent (76D-1290)			
Gravity, °API (specific)		--- (0.8470)	--- (1.0318)	--- (1.0333)	--- (1.0333)			
Boiling range:								
Initial boiling point, °F		83	321	306	326			
5 %		149	361	373	367			
10 %		177	375	393	390			
20 %		213	400	409	403			
30 %		250	416	434	441			
40 %		284	443	453	470			
50 %		317	468	483	501			
60 %		339	498	510	550			
70 %		347	537	551	584			
80 %		384	586	594	667			
90 %		399	647	669	771			
95 %		420	688	724	859			
Final boiling point, °F		563	844	902	1007			
Pour point, °F								
Flashpoint, °F		18		180	182			
Viscosity at 100°F, cS			5.36	5.79	10.44			
at 210°F, cS			1.45	1.48	2.25			
at °F								
Ash, ash ₂ , ppm	D-482		10	100	100			
Ash: melt temperature, °F								
Heat of combustion, Btu/lb		18 148	16 826	16 921				
Carbon residue (Conradson), wt%			0.29	0.19	0.22			
Carbon residue bottom, wt%								
Thermal stability								
Electrical conductivity								
Water		0		0	0			
Sediment								
Neutrality								
Corrosion								

TABLE 7. - Continued.

(h) SRC (Wilsonville Process Solvent); data from ref. 41.

Property	Test	Distillate categories						
		Process solvent (76D-1289)	Hydroprocessed process solvent					
			J-8511	J-8512	J-8513			
Gravity, °API (specific)		5.3	13.0	19.5	23.4			
Bolling range:								
Initial boiling point, °F	D-2887	324	175	180	172			
5 %		375	303	216	207			
10 %		394	362	268	232			
20 %								
30 %		446	413	402	387			
40 %								
50 %		492	469	463	432			
60 %								
70 %		564	534	525	495			
80 %								
90 %		665	627	602	578			
95 %		709	681	649	610			
Final boiling point, °F		872	857	818	814			
Pour point, °F								
Flashpoint, °F		180	87	48	62			
Viscosity at 100 °F, cS		5.79	3.43	2.20	2.00			
at 210 °F, cS		1.48	1.10	0.93	0.90			
at °F								
Ash, wt%								
Ash: melt temperature, °F								
Heat of combustion, Btu/lb		16 921	17 228	18 572	18 903			
Carbon residue								
Carbon ramabottom, wt%								
Thermal stability								
Electrical conductivity								
Water								
Sediment								
Neutrality								
Corrosion								

TABLE 7 - Concluded.

(i) SRC-II from Kentucky Coal; data from ref. 52.

Property	Test	Distillate categories					
		Naphtha	Mid-Distillate	Heavy Distillate	Vacuum bottoms		
Gravity, °API (specific)		.845	0.979	1.080			
Boiling range:	D-1160						
Initial boiling point, °F							
5 °F		140	341	500	1000		
10 °F		170	390	575			
20 °F		200	400	593			
30 °F		207	418	608			
40 °F		277	421	642			
50 °F		288	423	650			
60 °F		318	439	675			
70 °F		325	443	702			
80 °F		342	460	744			
90 °F		361	470	794			
95 °F		386	497	859			
Final boiling point, °F		400	510	923			
Pour point, °F		428	532	1000			
Flashpoint, °F					370		
Viscosity at 100 °F							
cSt at °F		0.943	3.51	103			
at °F							
Ash, wt%							
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon ramabottom, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type:								
Saturates								
Olefins								
Aromatics, total								
Aromatics, polynuclear								
Luminometer number								
Analine point, °F								
H, C atom ratio								
Elemental analyses, wt%:								
C	83.43	84.66	89.19	69.40				
H	11.53	9.10	7.46	4.15				
N	0.78	0.94	1.34	1.68				
S	0.27	0.16	0.34	2.46				
O	3.99	5.14	1.67	-				
Trace metal analyses, ppm:								
V								
Ni								
Na								
K								
Mg								
Ca								
Pb								
Cu								
Fe								
Si								
Zn								
Ba								
Mn								
Mo								
W								
Ti								

TABLE 8. - FUEL DATA FROM COED PROCESS
(a) COED fuel from West Kentucky coal; data from ref. 53(a).

Property	Test	Distillate categories						
		Whole crude	Naphtha (22.4 percent)	Middle distillate (46.2 percent)	Gas oil (27.8 percent)			
Gravity, °API (specific)		23.1	44.5	20.7	12.0			
Bolling range:								
Initial boiling point, °F	Simulated	97	97	364	217			
5 %	Distillation		---	---	---			
10 %			144	434	663			
20 %			219	468	693			
30 %			230	499	712			
40 %			257	525	731			
50 %			280	555	750			
60 %			298	581	769			
70 %			325	611	790			
80 %			345	637	811			
90 %		835	367	671	835			
95 %								
Final boiling point, °F								
Pour point, °F								
Flashpoint, °F								
Viscosity at °F								
at °F								
at °F								
Ash, wt %								
Ash: melt temperature, °F								
Heat of combustion, Btu/lb								
Carbon residue								
Carbon residue bottom, wt %								
Thermal stability								
Electrical conductivity								
Water								
Sediment								
Neutrality								
Corrosion								

Hydrocarbon type:								
Saturates								
Olefins								
Aromatics, total								
Aromatics, polynuclear								
Luminometer number								
Aniline point, °F								
H/C atom ratio								
Elemental analysis, wt%:								
C	88.1	86.6	88.3	89.0				
H	11.5	13.0	11.2	10.7				
N	0.125	0.056	0.16	0.09				
S	0.013	0.0049	0.0055	0.0090				
O	0.344	0.342	0.362	0.246				
Trace metal analysis, ppm:								
V								
Ni	<0.5							
Na								
K								
Mg	<0.5							
Ca								
Pb	<0.5							
Cu	0.1							
Fe	0.6							
Cl								
Zn	<1.0							
Ba								
Mn	<0.2							
Mo	<0.1							
W								
Ti	<0.1							
Cr	<0.2							
Co	<0.1							
Sr	<0.5							
Hg	<0.01							

*Report contains detailed hydroprocessing data on CO2D fractions.

TABLE 8. - Continued.

(b) COED fuel from West Kentucky coal; data from ref. 54(b).

Property	Test	Distillate categories						
		Crude	Distillate (<205°C; 21 percent)	Distillate (205°-380°C; 54.2 percent)	Residua (>380°C; 24.2 percent)			
Gravity, °API (specific)		24.8 (.023)	40.4 (.823)	18.9 (.941)	10.1 (.999)			
Boiling range:								
Initial boiling point, °F			123	216				
5 %	Percent:	212	198	167				
10 %	12.2	302	214	415				
20 %	21.9	392	234	455				
30 %	28.3	437	250	492				
40 %	43.6	527	270	512				
50 %	54	437 at 40 mm	288	532				
60 %	63	482 at 90 mm	314	554				
70 %	73	517 at 40 mm	316	582				
80 %	82.5	572 at 40 mm	362	611				
90 %			400	646				
95 %			435	683				
Final boiling point, °F			495	706				
Pour point, °F		<5	<5	<5	80			
Flashpoint, °F								
Viscosity at 77 °F, SUS		48						
at 100 °F, SUS		43 (~5.1 cS)						
at 100 °F, cS	445		0.89	4.51				
Ash, wt%			0	0.002	0			
Ash: melt temperature, °F								
Heat of combustion, Btu/lb								
Carbon residue (Conradson)	D-189			0.0	0.36			
Carbon residue, wt%		0						
Thermal stability								
Electrical conductivity								
Water								
Sediment								
Neutrality, acid number	D-974		0.03	0.08	0.37			
Corrosion								

Hydrocarbon type:								
Saturates				25.6	23.4			
Olefins								
Aromatics, total				74.4	76.6			
Aromatics, polynuclear				32.0	51.6			
Luminometer number								
Aniline point, °F								
H/C atom ratio								
Elemental analyses, wt%:								
C								
H								
N		0.226	0.190	0.248	0.324			
S		0.08	0.05	0.04	0.01			
O								
Trace metal analyses, ppm:								
V								
Ni								
Na								
K								
Mg								
Ca								
Pb								
Cu								
Fe								
Fl								
Zn								
Ba								
Mn								
Mo								
W								
Ti								

^bMore detailed hydrocarbon analysis contained in report.

TABLE 8. - Continued.

(c) COED fuel from Utah A-seam and Illinois #6 coal; data from ref. 39.

Property	Test	Distillate categories					
		Utah A-seam	Illinois #6 seam				
Gravity, °API (specific)		10	22				
Boiling range:							
Initial boiling point, °F		280	190				
5 %							
10 %		430	273				
20 %							
30 %		530	390				
40 %							
50 %		660	518				
60 %							
70 %		780	600				
80 %							
90 %		920	684				
95 %							
Final boiling point, °F		950	746				
Pour point, °F		60	0				
Flashpoint, °F		75	60				
Viscosity at 100°F, cS		8	5				
at °F							
at °F							
Ash, wt %		<0.01	<0.01				
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue (10% bottom)			4.6				
Carbon remaining, wt %							
Thermal stability							
Electrical conductivity							
Water, wt %		0.1	0.1				
Sediment							
Neutrality							
Corrosion							

TABLE 8. - Continued.

(d) COED fuel from Illinois #6 coal (distillate cuts); data from ref. 39.

Property	Test	Distillate categories					
Gravity, °API (specific)		18.4	22.5	11.2			
Boiling range:							
Initial boiling point, °F		354	436	557			
5 %							
10 %		409	459	705			
20 %							
30 %							
40 %							
50 %							
60 %							
70 %							
80 %							
90 %		780	586	870			
95 %							
Final boiling point, °F			613				
Pour point, °F		25	-70	70			
Flashpoint, °F		160	215	400			
Viscosity at 100 °F, SUS		32.5 (8.1 cS)	39.3 (3.9 cS)				
at °F							
at °F							
Ash, wt %		0.007	0.0				
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue	D-189	0.4		1.13			
Carbon rambottom, wt %							
Thermal stability							
Electrical conductivity							
Water } Combined		0.10					
Sediment }							
Neutrality							
Corrosion							

Hydrocarbon type:								
Saturates								
Olefins								
Aromatics, total								
Aromatics, polynuclear								
Luminescence number								
Aniline point, °F								
H:C atom ratio								
Elemental analyses, wt%:								
C								
H								
N								
S		0.16	0.004	0.07				
O								
Trace metal analyses, ppm:								
V								
Ni								
Na								
K								
Mg								
Ca								
Pb								
Cu								
Fe								
Si								
Zn								
Ba								
Mn								
Mo								
W								
Ti								

TABLE 8. - Continued.

(e) COED fuel from Utah light and heavy coal; data from ref. 47.

Property	Test	Distillate categories					
		Utah light	Utah heavy				
Gravity, °API (specific)		41.9	22.5				
Boiling range:							
Initial boiling point, °F		176	<300				
5 %							
10 %		215	314				
20 %		230	416				
30 %							
40 %							
50 %		287	552				
60 %							
70 %		352	680				
80 %							
90 %		439	716				
95 %							
Final boiling point, °F		565	849				
Pour point, °F		-65	60				
Flashpoint, °F		80	120				
Viscosity at 100°F, cS		0.94	6.82				
at °F							
at °F							
Ash, wt%		<0.01	<0.01				
Ash: melt temperature, °F							
Heat of combustion, Btu/lb	Lower	18 356	18 020				
Carbon residue		0.05	1.46				
Carbon remaining, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type:								
Saturated								
Olefins								
Aromatics, total		32.	45.					
Aromatics, polynuclear		3.	14.					
Luminometer number								
Aniline point, °F		84.2	Too dark					
H/C atom ratio		1.86	1.51					
Elemental analyses, wt%:								
C								
H								
N		0.193	0.143					
S		<0.01	0.05					
O								
Trace metal analyses, ppm:								
V		<5.1	<5.4					
Ni								
Na		0.92	6.13					
K		1.81	0.38					
Mg		2.68	3.21					
Ca		<0.61	28.3					
Pb		0.74	<0.54					
Cu								
Fe								
Si								
Zn								
Ba								
Mn								
Mo								
W								
Ti								

TABLE 8, - Continued.

(f) COED fuel from Utah and West Kentucky coals; data from ref. 55.

Property	Test	Distillate categories					
		Utah T-460A	W. Kentucky T-460C				
Gravity, °API (specific)		19.0	22.3				
Boiling range:							
Initial boiling point, °F		198	148				
5 %		340	246				
10 %		412	287				
20 %		485	364				
30 %		510	420				
40 %		520	492				
50 %		635	537				
60 %		697	603				
70 %		755	657				
80 %		803	715				
90 %		860	782				
95 %		910	824				
Final boiling point, °F		950	844				
Pour point, °F		50	-15				
Flashpoint, °F		120	<70				
Viscosity at °F							
at °F							
at °F							
Ash, wt %							
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon remaining, wt %		0.03	0.37				
Thermal stability							
Electrical conductivity							
Water							
Bediment							
Neutrality							
Corrosion							

Hydrocarbon type:								
Saturates			7.7					
Olefins			27.4					
Aromatics, total			64.7					
Aromatics, polynuclear								
Luminescence number								
Aniline point, °F								
H/C atom ratio								
Elemental analysis, wt%:								
C		85.91	85.98					
H		11.97	12.13					
N		0.25	0.18					
S		0.0188	0.0271					
O		1.62	0.60					
Trace metal analysis, ppm:								
V								
Ni								
Na								
K								
Mg								
Ca								
Pb								
Cu								
Fe								
Si								
Zn								
Ba								
Mn								
Mo								
W								
Ti								

TABLE 8 - Continued.

(g) COED from Utah coal; data from ref. 48.

Property	Test	Distillate categories					
		Whole crude	light distillate	heavy distillate			
Gravity, °API (specific)		17.9	40.2	19.4			
Boiling range:	D-86						
Initial boiling point, °F			120	241			
5 %			163	407			
10 %		325	202	462			
20 %			228	466			
30 %		528	248	484			
40 %			269	506			
50 %		675	292	524			
60 %			312	552			
70 %		805	334	583			
80 %			352	613			
90 %		915	388	661			
95 %			432	690			
Final boiling point, °F			479	692			
Pour point, °F	D-97	64		30			
Flashpoint, °F	D-93			126			
Viscosity at °F							
at °F							
at °F							
Ash, wt %	D-482			0.002			
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue	D-184	2.0					
Carbon ramsbottom, wt %							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type:								
Saturates				27.8				
Olefins								
Aromatics, total				64.9				
Aromatics, polynuclear				7.1				
Luminometer number								
Acidine point, °F								
H/C atom ratio								
Elemental analyses, wt%:								
C								
H								
N	Kjeldahl	0.478	0.27	0.533				
S	0-129	0.05	0.04	0.03				
O								
Trace metal analyses, ppm:								
V								
Ni								
Na								
K								
Mg								
Ca								
Pb								
Cu								
Fe								
Si								
Zn								
Ba								
Mn								
Mo								
W								
Ti								

TABLE 8 - Concluded.

(h) COED from Western Kentucky coal; data from ref. 48.

Property	Test	Distillate categories					
		whole crude	light distillate	heavy distillate			
Gravity, °API (specific)		21.8	40.4	18.9			
Boiling range:	D-86						
Initial boiling point, °F			123	236			
5 %			198	367			
10 %		282	214	415			
20 %			234	455			
30 %		467	250	492			
40 %			270	512			
50 %		605	288	532			
60 %			314	554			
70 %		720	336	582			
80 %			362	611			
90 %		827	400	646			
95 %			435	683			
Final boiling point, °F			499	706			
Pour point, °F							
Flashpoint, °F	D-93			116			
Viscosity at 100 °F	D-445		0.89	4.51			
cSt at °F							
at °F							
Ash, wt%	D-482		0.0	0.0002			
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue	D-189	0.0		0.0			
Carbon ramsholm, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

TABLE 9. - FUEL DATA FROM GULF CATALYTIC LIQUEFACTION PROCESS

[Data from ref. 56]

Property	Test	Distillate categories					
		Full-range F1 (Western subbituminous)	Full-range F2 (Bituminous, Pittsburgh area)	Distillate D (from F1)			
Gravity, °API (specific)		7.0	10.4	14.0			
Boiling range:							
Initial boiling point, °F				266			
5 %							
10 %							
20 %							
30 %							
40 %							
50 %							
60 %							
70 %							
80 %							
90 %							
95 %							
Final boiling point, °F				688			
Pour point, °F							
Flashpoint, °F							
Viscosity at °F		In range of #4 or #5 fuel oils		In range of #2 fuel oil			
at °F							
at °F							
Ash, wt%				0.0030			
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon on bottom, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

TABLE 10. - FUEL DATA FROM EXXON DONOR SOLVENT PROCESS

(a) EDS; data from ref. 57.

Property	Test	Distillate categories						
		Heavy naphtha		Fuel oil				
		Raw liquid	Hydrotreated liquid	Raw liquid	Hydrotreated liquid			
Gravity, °API (specific)		----(0.87)	----(0.80)	----(1.08)	----(1.01)			
Boiling range:	Nominal	158 - 192	158 - 192	392 - 1000	392 - 1000			
Initial boiling point, °F								
5 %								
10 %		223	198	477	462			
20 %	15/5							
20 %	Distillation							
10 %	D-2892							
30 %		356	315	694	657			
60 %								
70 %								
80 %								
90 %		390	360	811	774			
Final boiling point, °F								
Pour point, °F								
Flashpoint, °F								
Viscosity at °F								
at °F								
at °F								
Ash, wt %								
Ash: melt temperature, °F								
Heat of combustion, Btu/lb	Higher	18 300	19 300	17 100	18 100			
Carbon residue								
Carbon remaining, wt %								
Thermal stability								
Electrical conductivity								
Water								
Sediment								
Neutrality								
Corrosion								

TABLE 10 - Concluded.

(b) EDS from Illinois coal; data from ref. 22.

Property	Test	Distillate categories					
		Distillate	Heavy Oil				
Gravity, °API (specific)		4.6	(0.1)				
Boiling range:	D-1160	400-1000	+400°F				
Initial boiling point, °F		396	403				
5%							
10%		437	441				
20%							
30%							
40%							
50%		592	690				
60%							
70%							
80%							
90%		625	1016				
95%		984					
Final boiling point, °F		1043	1043				
Pour point, °F							
Flashpoint, °F		198	204				
Viscosity at 100°F		21.01	440				
cSt at 212°F		3.09	10.04				
at 250°F			5.8				
Ash, wt%		0.027	0.03				
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon ramsbottom, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type:								
Saturated								
Olefins								
Aromatics, total								
Aromatics, polynuclear								
Luminometer number								
Aniline point, °F								
H, C atom ratio								
Elemental analyses, wt%:		85.52	86.13					
C		8.03	8.09					
H		0.55	0.81					
N		0.60	0.82					
S		2.47	2.74					
O								
Trace metal analyses, ppm:								
V								
Ni								
Na								
K								
Mg								
Ca								
Pb								
Cu								
Fe								
Bi								
Zn								
Ba								
Mn								
Mo								
W								
Tl								

TABLE 11. - FUEL DATA FROM ZINC CHLORIDE PROCESS

[Data from ref. 58]

Property	Test	Distillate categories					
		Total distillates			Run 258 Data		
		Run 24	Run 26	Run 258	18P - 392°F	392°F - 617°F	617°F - 887°F
Gravity, °API (specific)							
Boiling range:							
Initial boiling point, °F				18P	18P	392	617
5 %							
10 %							
20 %							
30 %							
40 %							
50 %							
60 %							
70 %							
80 %							
90 %							
95 %							
Final boiling point, °F				887	392	617	887
Pour point, °F							
Flashpoint, °F							
Viscosity at °F							
at °F							
at °F							
Ash, wt%							
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon ransbottom, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type:							
Saturates							
Olefins							
Aromatics, total							
Aromatics, polynuclear							
Luminometer number							
Aniline point, °F							
H/C atom ratio							
Elemental analysis, wt%:							
C	91.17	90.17	89.74	90.58	89.09	89.40	
H	8.48	8.58	8.65	8.11	9.65	8.98	
N	0.0020	0.0194	0.0023	0.0018	0.0025	0.0060	
S	0.02	0.01	0.0	0.02	0.02	0.03	
O	0.11	1.22	1.61	1.06	1.23	1.58	
Trace metal analysis, ppm:							
V							
Ni							
Na							
K							
Mg							
Ca							
Pb							
Cu							
Fe							
Si							
Zn							
Ba							
Mn							
Mo							
W							
Ti							
Cl	161.0	40.0	98.0				
Yields, wt%: C ₃ - 329° F	16.0	16.55	41.91				
329° - 687° F	18.0	20.57	21.13				
>687° F	3.14	9.60	9.60				
H ₂ O	15.69	11.85	10.94				
Gases	3.86	10.85	7.14				

TABLE 12. - FUEL DATA FROM CO-STEAM PROCESS^a

[Data from ref. 59]

Property	Test	Distillate categories										
		11th run with 12 HCOOH	11th run with no additive	11th run with aged lignite and H ₂ O								
Gravity, °API (specific)												
Bolling range:												
Initial boiling point, °F												
5 %												
10 %												
20 %												
30 %												
40 %												
50 %												
60 %												
70 %												
80 %												
90 %												
95 %												
Final boiling point, °F												
Pour point, °F												
Flashpoint, °F												
Viscosity at 140°F, cS		190	598	12800								
at 180°F, cS		46.8	110	1010								
at °F												
Ash, wt %		0.05	0.03	0.01								
Ash: melt temperature, °F												
Heat of combustion, Btu/lb	Calculated	17 056	16 886	16 906								
Carbon residue												
Carbon residuebottom, wt %												
Thermal stability												
Electrical conductivity												
Water												
Sediment												
Neutrality												
Corrosion												

Hydrocarbon type:								
Saturated								
Olefins								
Aromatics, total								
Aromatics, polynuclear								
Luminometer number								
Aniline point, °F								
H/C atom ratio								
Elemental analysis, wt%:								
C		88.6	89.8	89.5				
H		7.1	6.8	6.6				
N		1.1	1.1	1.1				
S		0.13	0.10	0.12				
O		3.0	3.2	2.6				
Trace metal analysis, ppm:								
V								
Ni								
Na								
K								
Mg								
Ca								
Flu								
Cu								
Fe								
Si								
Zn								
Ba								
Mn								
Mo								
W								
Ti								

Table 7 in reference. Operating conditions: 1 hr. at 410°C and 1000 psi; synthesis gas at 1:1 (C₁ to C₁₀), 9.13-10).

TABLE 13. - FUEL DATA FROM FLASH PYROLYSIS PROCESS

[Data from ref. 60; PDU run 120, 200 lb/hr.]

Property	Test	Distillate categories					
		F3912 (startup, 95.5% oil)	F4038 (end of run, 61.9% oil)				
Gravity, °API (specific)							
Boiling range:							
Initial boiling point, °F							
5 %		406	411				
10 %		495	540				
20 %		525	595				
30 %		556	660				
40 %		593	710				
50 %		620	745				
60 %							
70 %							
80 %							
90 %							
95 %							
Final boiling point, °F							
Pour point, °F							
Flashpoint, °F							
Viscosity at °F							
at °F							
at °F							
Ash, wt%		0.37	6.06				
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon combustion, wt%							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

TABLE 14. - FUEL DATA FROM CATALYTIC LIQUEFACTION OF PITTSBURGH SEAM BITUMINOUS AND WYOMING SUBBITUMINOUS COAL

[Data from ref. 61]

Property	Test	Distillate categories					
		Pittsburgh seam	Wyoming Big Horn				
Gravity, °API (specific)							
Boiling range:							
Initial boiling point, °F		110	110				
5 %							
10 %							
25 % 25.2X		470					
28 % 28.3X			470				
40 %							
50 %							
60 %							
70 %							
80 %							
90 %							
95 %							
Final boiling point, °F							
Pour point, °F							
Flashpoint, °F							
Viscosity at °F							
at °F							
at °F							
Ash, wt %							
Ash: melt temperature, °F							
Heat of combustion, Btu/lb							
Carbon residue							
Carbon ramabottom, wt %							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type: ^a	<470	>470	<470	>470						
Saturates	16.2	1.8	14.0	3.6						
Olefins	0.2		0.1							
Aromatics, total	10.8	36.2	14.2	58.3						
Aromatics, polynuclear		10.3		49.3						
Luminometer number										
Analyte point, °F										
H/C atom ratio										
Elemental analyses, wt%:										
C		89.05		89.18						
H		8.18		8.97						
N		0.82		0.40						
S		0.17		0.04						
O		1.47		1.03						
Trace metal analyses, ppm:										
V										
Ni										
Na										
K										
Mg										
Ca										
Pb										
Cu										
Fe										
Si										
Zn										
Ba										
Mn										
Mo										
W										
Tl										

^aMore detailed analyses of various fractions contained in report.

TABLE 15. - FUEL DATA FROM SEA COAL PROCESS

[Data from ref. 47]

Property	Test	Distillate categories					
		Sea Coal					
Gravity, °API (specific)		18.4					
Boiling range:							
Initial boiling point, °F		<100					
5 %							
10 %		<300					
20 %		318					
30 %							
40 %		460					
50 %							
60 %							
70 %		572					
80 %							
90 %		760					
95 %							
Final boiling point, °F		875					
Pour point, °F		55					
Flashpoint, °F		145					
Viscosity at 100 °F, cS		9.78					
at °F							
at °F							
Ash, wt %		0.02					
Ash: melt temperature, °F							
Heat of combustion, Btu/lb	Lower	17 782					
Carbon residue		2.59					
Carbon combustion, wt %							
Thermal stability							
Electrical conductivity							
Water							
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type:									
Saturates									
Olefins									
Aromatics, total		47.0							
Aromatics, polynuclear		12.0							
Laminometer number									
Aniline point, °F		Too dark							
H/C atom ratio		1.52							
Elemental analyses, wt%:									
C									
H									
N		0.401							
S		0.02							
O									
Trace metal analyses, ppm:									
V		<5.3							
Ni									
Na		142.0							
K		2.47							
Mg		2.76							
Ca		12.7							
Pb		<0.53							
Cu									
Fe									
Si									
Zn									
Ba									
Mn									
Mo									
W									
Ti									

TABLE 16. - SUMMARY OF LIQUID FUEL PROPERTIES

Boiling range, °F	Gravity		Elemental composition, wt %			Viscosity, cP		Heat of combustion, Btu/lb	Reference
	API	Specific	H	N	S	at 100° F	at 210° F		
H-Coal process									
180 - >944	27.6	-----	7.4	0.81	0.47	-----	-----	-----	1
≥620	1.9	-----	8.1	.77	.15	178	7.2	17 420	(a)
≥358	2.0	-----	8.0	.80	.23	272	8.8	17 415	(a)
282 - 570 (90%)	19.0	-----	10.34	.22	.16	2.47	.99	18 415	(a)
-50 - 350	44.9	-----	12.9	.047	.26	-----	-----	-----	2
217 - 500	25.9	-----	11.2	.0044	.17	-----	-----	-----	2
434 - 767	7.9	-----	10.4	.0083	.17	-----	-----	-----	2
400	-7.5	-----	7.38	1.3	.48	-----	(465 cP)	16 700	(b)
466 - >876	-16.5	-----	68.35	1.11	1.43	-----	-----	-----	3
493 - >910	-17.7	-----	6.96	1.30	.66	-----	-----	-----	3
144 - 639	19.8	-----	-----	.44	.21	2.4	-----	-----	4
144 - 397	32.3	-----	-----	.42	.13	1.08	-----	-----	-----
397 - 687	13.0	-----	-----	.44	.29	3.87	-----	-----	-----
138 - 795	17.0	-----	-----	.683	.27	6.1	-----	-----	-----
138 - 367	37.4	-----	-----	.212	.06	.96	-----	-----	-----
367 - 785	6.6	-----	-----	.071	.35	14.9	-----	-----	-----
180 - 975	6.4	-----	8.19	.81	.22	155	-----	-----	(c)
180 - 445	36.6	-----	12.41	.19	.24	-----	-----	-----	-----
372 - 680	14.0	-----	9.73	.42	.18	4.45	2.7	-----	-----
639 - 975	-2.3	-----	7.58	1.01	.22	-----	36	-----	-----
482 - >963	-----	-----	7.94	.77	.42	-----	318.3	17 411	5
>950	-----	-----	8.85	.39	.19	-----	-----	-----	5
≥950	-----	-----	8.26	1.30	.95	-----	-----	-----	5
180 - 375	-----	-----	13.6	.1	.1	-----	-----	-----	6
375 - 650	-----	-----	11.0	.1	.1	-----	-----	-----	-----
650 - 975	-----	-----	10.2	.1	.3	-----	-----	-----	-----
180 - 975	-----	-----	11.9	.1	.1	-----	-----	-----	-----
C ₄ + Liquids	15.0	-----	9.48	.68	.19	-----	-----	-----	7
C ₄ + Liquids	4.4	-----	8.43	1.05	.43	-----	-----	-----	7
C ₄ + Liquids	26.6	-----	10.54	.64	.16	-----	-----	-----	7
271 - 685	-----	-----	10.14	.38	.11	-----	-----	-----	32
270 - 942	-----	-----	9.80	.38	.13	-----	-----	-----	-----
26 - 748	-----	-----	11.76	.20	.25	-----	-----	-----	-----
20 - 548	-----	-----	11.99	.20	.26	-----	-----	-----	-----
315 - 851	-----	-----	9.43	.42	.12	-----	-----	-----	-----
81 - 582	-----	-----	11.85	.13	.09	-----	-----	-----	-----
71 - 808	-----	-----	11.27	.44	.24	-----	-----	-----	-----
275 - 890	-----	-----	8.64	.41	-----	-----	-----	-----	-----

^aLetter from G. R. Fox of General Electric Research and Development Center to Lloyd I. Shure of NASA Lewis Research Center, Feb. 18, 1977.

^bMemo for record, John S. Clark of NASA Lewis Research Center, July 19, 1977.

^cMeeting handout on H-Coal products for gas-turbine combined cycles, Paul H. Kydd of General Electric Co., Schenectady, N.Y., Jan. 9, 1976.

TABLE 16. - Continued.

Boiling range, °F	Gravity		Elemental composition, wt %			Viscosity, cP		Heat of combustion, Btu/lb	Reference
	API	Specific	H	N	S	at 100° F	at 210° F		
Symbol process									
241 - >>520	-----	-----	7.72	1.190	1.021	-----	-----	-----	5
395 - >945	-5.7	1.125	-----	-----	-----	-----	43.65	-----	3
407 - >951	-3.5	1.1055	7.59	1.46	.55	-----	34.25	-----	↓
445 - >970	-4.3	1.1124	7.42	1.31	.59	-----	36.20	-----	
463 - 950	9.5	1.0035	9.77	.377	.02	-----	-----	-----	↓
329 - >795	-6	1.081	-----	.786	.42	450	-----	-----	
329 - 405	19.7	.936	-----	.423	.20	2.27	-----	-----	↓
495 - 685	11.4	.950	-----	.724	.30	9.33	-----	-----	
655 - 988	-3.3	1.109	-----	1.137	.44	-----	-----	-----	↓
(Full range)	-----	-----	7.72	1.205	1.057	-----	-----	-----	
300 - >698	5.9	-----	-----	.79	.22	673	-----	-----	11
>695	-4.3	-----	-----	1.22	.31	-----	109.1	-----	12
509 - 650	15.9	-----	-----	.32	.14	7.23	1.85	-----	↓
650 - 698	9.4	-----	-----	.47	.12	35.3	3.91	-----	
341 - >890	-2.9	1.10	7.97	.97	.43	2509	25.6	16 891	5
<409 - >730	4.0	-----	-----	.91	.21	143.5	-----	17 245	13
SRC process									
Solid: m.p. 312	-----	-----	6.56	1.97	1.07	-----	-----	15 719	15
Solid: m.p. 357	-----	-----	6.12	1.36	.58	-----	-----	15 733	↓
Solid: m.p. 327	-----	-----	5.62	1.91	1.10	-----	-----	15 857	
Solid: m.p. 354	-----	-----	5.45	1.95	1.09	-----	-----	15 673	↓
Solid: 900 ^a	-19.3	-----	-----	2.0	.8	-----	-----	15 000	
400 - 900	5.0	-----	7.9	.9	.3	7.3	-----	17 500	16.17
100 - 400	39.0	-----	11.5	.4	.2	-----	-----	12 045	16.17
400 - >1020	-5.8	-----	6.90	1.28	.72	1900	20.45	-----	3
385 - >375	2.5	-----	-----	-----	-----	-----	-----	-----	3
433 - >1000	9.6	-----	9.76	.548	.02	-----	32.69	-----	3
131 - 561	22.6	.9192	9.99	.23	.40	1.442	1.647	17 229	5
328 - 377	4.69	1.039	7.56	.59	.32	5.33	1.434	16 715	5
383 - 482	12.3	.984	9.6	.6	.2	2.75	-----	-----	(9)
155 - 492	29.0	.934	10.1	.6	.3	.764	-----	-----	(6)
83 - 563	35.6	.947	11.33	.30	.60	-----	-----	15 158	32
321 - 844	5.64	1.0318	7.65	.59	.41	5.25	1.45	16 826	↓
306 - 902	5.43	1.0333	7.43	.62	.37	3.79	1.48	16 921	
326 - 1007	3.48	1.0333	9.78	.50	.35	10.44	1.25	-----	↓
324 - 972	5.3	-----	7.43	.62	.37	3.79	1.43	15 921	

^a Letter from Robert G. Sperhac of Pittsburgh & Midway Coal Mining Co. to Thales W. Reynolds of NASA Lewis Research Center, May 16, 1975.

TABLE 15. - Continued.

Boiling range, °F	Gravity		Elemental composition, wt %			Viscosity, cP		Heat of combustion, Btu/lb	Reference
	API	Specific	S	N	S	at 100° F	at 210° F		
SRC process (Concluded)									
175 - 857	13.0	-----	8.88	0.44	0.06	3.43	1.10	17 728	30
180 - 818	14.5	-----	10.32	.11	.01	2.20	.93	18 572	30
172 - 814	23.4	-----	10.99	.02	.01	2.00	.90	19 903	30
COED process									
97 - 935	23.1	-----	11.5	0.125	0.013	-----	-----	-----	18
97 - >367	44.5	-----	13.0	.956	.0049	-----	-----	-----	↓
364 - >671	20.7	-----	11.2	.16	.0055	-----	-----	-----	↓
217 - >235	12.0	-----	10.7	.09	.0090	-----	-----	-----	↓
212 - >800	21.8	-----	-----	.226	.08	5.1	-----	-----	19
123 - 499	40.4	-----	-----	.190	.05	.89	-----	-----	↓
236 - 706	18.9	-----	-----	.248	.04	4.51	-----	-----	↓
>716	10.1	-----	-----	.294	.01	-----	-----	-----	↓
280 - 950	20	-----	11.0	.2	.1	8	-----	-----	6
190 - 746	22	-----	10.9	.3	.1	5	-----	-----	↓
354 - >780	18.4	-----	-----	-----	.16	8.1	-----	-----	↓
436 - 613	22.5	-----	-----	-----	.004	3.9	-----	-----	↓
557 - >870	11.2	-----	-----	-----	.07	-----	-----	-----	↓
176 - 545	41.9	-----	-----	.193	<.01	.94	-----	18 356	13
<300 - 849	22.5	-----	-----	.143	.05	6.82	-----	18 020	13
198 - 950	19.0	-----	11.97	.25	.18	-----	-----	-----	20
148 - 844	22.3	-----	12.13	.0388	.0271	-----	-----	-----	20
Gulf Catalytic process									
-----	7.0	-----	8.84	0.51	0.07	-----	-----	-----	21
-----	10.4	-----	9.44	.50	-----	-----	-----	-----	↓
266 - 688	14.0	-----	9.54	.31	.04	-----	-----	-----	↓
>130	-----	-----	8.97	.40	.04	-----	-----	-----	↓
>130	-----	-----	8.18	.82	.17	-----	-----	-----	↓
Exxon Donor Solvent process									
158 - 392	31.1	0.87	10.90	0.21	0.47	-----	-----	18 300	23
158 - 392	45.4	.80	12.90	.68	.005	-----	-----	19 300	↓
392 - 1000	-.5	1.08	7.70	.86	.41	-----	-----	17 100	↓
392 - 1000	8.6	1.01	8.60	.24	.04	-----	-----	18 100	↓

TABLE 16. - Concluded.

Boiling range, °F	Gravity		Elemental composition, wt %			Viscosity, cP		Heat of combustion, Btu/lb	Reference
	API	Specific	H	N	S	at 100° F	at 210° F		
ZnCl ₂ hydrocracking process									
180 - 887	-----	-----	8.65	0.0023	0	-----	-----	-----	24 ↓
180 - 392	-----	-----	8.33	.0018	.02	-----	-----	-----	
392 - 617	-----	-----	9.65	.0025	.02	-----	-----	-----	
617 - 887	-----	-----	8.98	.0060	.03	-----	-----	-----	
C ₅ - >887	-----	-----	8.48	.0020	.02	-----	-----	-----	
C ₅ - >887	-----	-----	8.65	.0023	0	-----	-----	-----	
C ₅ - >887	-----	-----	8.58	.0194	.01	-----	-----	-----	
Co-Steam process									
-----	-----	-----	7.1	1.1	0.13	-----	-----	17 056	25
-----	-----	-----	6.8	1.1	.10	-----	-----	16 885	25
-----	-----	-----	6.6	1.1	.12	-----	-----	16 900	25
Flash Pyrolysis process									
408 - >620	-----	-----	6.15	1.13	0.56	-----	-----	-----	26
411 - >745	-----	-----	6.19	1.43	.54	-----	-----	-----	26
Sea Coal process									
<300 - 875	18.4	-----	-----	0.403	0.02	9.70	-----	17 782	13

TABLE 17. - PROPOSED SPECIFICATIONS FOR TYPICAL COAL-DERIVED FUEL^a

[Data from ERDA RFP-EF-77-R-01-2674, June 6, 1977.]

Property	Test	Distillate categories					
Gravity, °API (specific)		17 - 25					
Boiling range:							
Initial boiling point, °F							
5 %							
10 %							
20 %							
30 %							
40 %							
50 %							
60 %							
70 %							
80 %							
90 %							
95 %							
Final boiling point, °F							
Pour point, °F		20 - 30					
Flashpoint, °F		140 - 160					
Viscosity at 100 °F, cS		10 - 20					
at °F							
at °F							
Ash, wt %		0.01 - 0.07					
Ash: melt temperature, °F		1800 - 1900					
Heat of combustion, Btu/lb		17 500 - 18 500					
Carbon residue		0.03 - 1.30					
Carbon ramolition, wt %							
Thermal stability							
Electrical conductivity							
Water		<0.1					
Sediment							
Neutrality							
Corrosion							

Hydrocarbon type:									
Saturates									
Olefins									
Aromatics, total		30 - 50							
Aromatics, polynuclear									
Luminescence number									
Aniline point, °F									
H/C atom ratio		1.6 - 1.9							
Elemental analysis, wt%:									
C									
H									
N		0.1 - 0.8							
S		<0.9							
O									
Trace metal analysis, ppm:									
V		0.1 - 0.20							
Ni		0.2 - 0.3							
Na		1.3 - 2.5							
K		0.9 - 0.6							
Mg									
Ca		1 - 10							
Pb		0.1 - 2							
Cu		0.2 - 0.3							
Fe		3 - 5							
Si		0.50 - 0.60							
Zn		1 - 2							
Ba									
Mn									
Mo									
W									
Ti									

* Range of properties assumed to be after water-wash cleanup.

† Inconsistent with gravity range.

TABLE 18. - COAL DERIVED SYNGAS PROPERTY FORM

Property				
Composition, vol %:				
H ₂				
CO				
CO ₂				
H ₂ S				
NH ₃				
CH ₄				
Other hydrocarbons				
N ₂				
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu ft ³ :				
Gross				
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 19. - FUEL DATA FROM LOW-BTU GAS
(a) Low Btu coal gas; data from ref.5, p. 6

Property	Typical ranges			
Composition, vol %:				
H ₂	12 - 16			
CO	7 - 12			
CO ₂	0.5 - 1.2			
H ₂ S				
NH ₃				
CH ₄	0.5 - 1.5			
Other hydrocarbons				
N ₂	10 - 55			
COS				
Specific gravity	0.8 - 0.92			
Average molecular weight				
Heating value, Btu ft ³ :				
Gross	110 - 165			
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 19. - Continued.

(b) Typical low-Btu gas, from air-blown gasifiers; data from ref. 77

Property				
Composition, vol %:				
H ₂	17.0			
CO	28.3			
CO ₂	4.5			
H ₂ S				
NH ₃				
CH ₄	3.0			
Other hydrocarbons				
N ₂	47.2			
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu. ft ³ :				
Gross	176.0			
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 19. - Continued.

(c) Typical fixed-bed gasifier composition (raw gas out of gasifier); data from ERDA RFP-EF-77-R-01-2674, June 8, 1977

Property				
Composition, vol %:				
H ₂	19.93			
CO	12.66			
CO ₂	13.75			
H ₂ S	0.57			
NH ₃	0.23			
CH ₄	4.58			
Other hydrocarbons	0.40			
N ₂	37.63			
COS	0.06			
Specific gravity				
Average molecular weight				
Heating value, Btu ft ³ :				
Gross	163.8			
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm lb dust lb gas	~0.049			
Solids: particle size, μm	(a)			
Flammability limit ratio				
H ₂ O	10.19			

^a Less than 5 percent of solids smaller than 2 μm.

TABLE 19. - Continued.

(d) Molten-salt gasification; data from ref. 79.

Property	Raw fuel gas (p.42)	Hot-wall gasification (p.35)	Cold-wall gasification (p.35)	Study assumption (Illinois #6 coal) (p.17)
Composition, vol %:				
H ₂	13.79	13.175-14.337	12.658-13.173	12.57
CO	28.33	27.77-29.413	26.279-27.989	26.398
CO ₂	3.08	1.735-2.667	2.599-3.217	3.322
H ₂ S	0.10	0.007-0.016	0.014-0.028	0.009
NH ₃				
CH ₄	1.50	1.518-2.028	1.266-2.037	1.850
Other hydrocarbons				
N ₂	50.85	50.848-51.905	51.991-52.868	53.01
COS		0.005-0.011	0.010-0.019	0.007
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net		143.9-149.7	129.6-144.7	
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %	2.35	2.041-2.44	2.164-3.130	2.837
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 19. - Continued.
(e) Typical gaseous fuels; data from ref. 79.

Property	blast furnace gas	Producer gas (coke)	Producer gas (coal)	
Composition, vol %:				
H ₂	2.0	11.0	12.0	
CO	27.0	29.0	29.0	
CO ₂	11.0	5.0	4.0	
H ₂ S				
NH ₃				
CH ₄	---	0.5	2.6	
Other hydrocarbons	---	---	0.4	
N ₂	60.0	54.5	52.0	
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross	91.2	131.5	166.4	
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 19. - Continued.

(f) Data from ref. 80.

Property	Predicted range not yet verified by test of composition system	Range from tests		
Composition, vol%:				
H ₂	14 - 17	11.17-23.5		
CO	9 - 22	6.58-30.95		
CO ₂	5 - 11	6.91-19.26		
H ₂ S				
NH ₃				
CH ₄	3	1.49-3.66		
Other hydrocarbons				
N ₂	48 - 52	34.96-56.7		
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net	100 - 135	90-197		
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %	9	0		
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 19. - Concluded.

(g) Producer gas; data from course notes on "Synthetic Fuels from Coal," Center for Professional Advancement, July 22-24, 1974, p. 50

Property	Typical			
Composition, vol%:				
H ₂	10 - 14			
CO	26 - 32			
CO ₂	2 - 5			
H ₂ S				
NH ₃				
CH ₄	2 - 3			
Other hydrocarbons	0.1 - 4.0			
N ₂	50 - 53			
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross	158 - 170			
Net	150 - 160			
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				
Oxygen	0.1 - 0.3			

TABLE 20. - PROPERTY DATA FOR SYNTHETIC GAS FROM LURGI PROCESS

[Data from ref. 81]

Property	Montana Coal	Illinois #6	Illinois #5	Pittsburg #8
Composition, vol%:				
H ₂	40.1	38.4	39.2	39.4
CO	15.1	17.8	17.1	16.0
CO ₂	29.7	31.1	30.0	32.0
H ₂ S				
NH ₃	0.63	0.51	0.5	0.47
CH ₄	12.1	9.5	10.0	9.3
Other hydrocarbons				
N ₂		0.7	0.1	0.9
COS				
Specific gravity,				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net	307.1	298	300.5	290.4
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 21. - PROPERTY DATA FOR SYNTHETIC GAS FROM KOPPERS-TOTZEK PROCESS

[Data from ref. 81]

Property	Eastern Coal			
Composition, vol %:				
H ₂				
CO	25.17			
CO ₂	37.36			
H ₂ S	7.13			
NH ₃				
CH ₄	0.17			
Other hydrocarbons	0.08			
N ₂				
COS	0.3			
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net	286			
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 22. - PROPERTY DATA FOR SYNTHETIC GAS FROM HYGAS PROCESS

[Data from ref. 81]

Property				
Composition, vol%:				
H ₂	24.22			
CO	7.28			
CO ₂	3.59			
H ₂ S				
NH ₃	0.52			
CH ₄	13.26			
Other hydrocarbons				
N ₂	0.33			
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 23. - PROPERTY DATA FOR SYNTHETIC GAS FROM SYNTHANE PROCESS

[Data from ref. 81]

Property	Illinois #6			
Composition, vol%:				
H ₂	20			
CO	6			
CO ₂	19			
H ₂ S				
NH ₃				
CH ₄	6			
Other hydrocarbons				
N ₂	49			
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 24. - PROPERTY DATA FOR SYNTHETIC GAS FROM EXXON CATALYTIC PROCESS

[Data from ref. 66]

Property				
Composition, vol%:				
H ₂	61.4			
CO	15.3			
CO ₂	14.6			
H ₂ S	0.7			
NH ₃				
CH ₄	8.0			
Other hydrocarbons				
N ₂				
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

TABLE 25. - PROPERTY DATA FOR SYNTHETIC GAS FROM CO₂ ACCEPTOR PROCESS

[Data from ref. 68]

Property				
Composition, vol %:				
H ₂	23.1			
CO	21.9			
CO ₂	10.9			
H ₂ S	0.01			
NH ₃				
CH ₄	4.0			
Other hydrocarbons				
N ₂	40.1			
COS				
Specific gravity				
Average molecular weight				
Heating value, Btu/ft ³ :				
Gross				
Net				
Gross with CO ₂ , H ₂ S, and NH ₃ removed				
Net with CO ₂ , H ₂ S, and NH ₃ removed				
Sulfur, ppm				
Alkali metals and sulfur, ppm				
Water, vol. %				
Solids, ppm				
Solids: particle size, μm				
Flammability limit ratio				

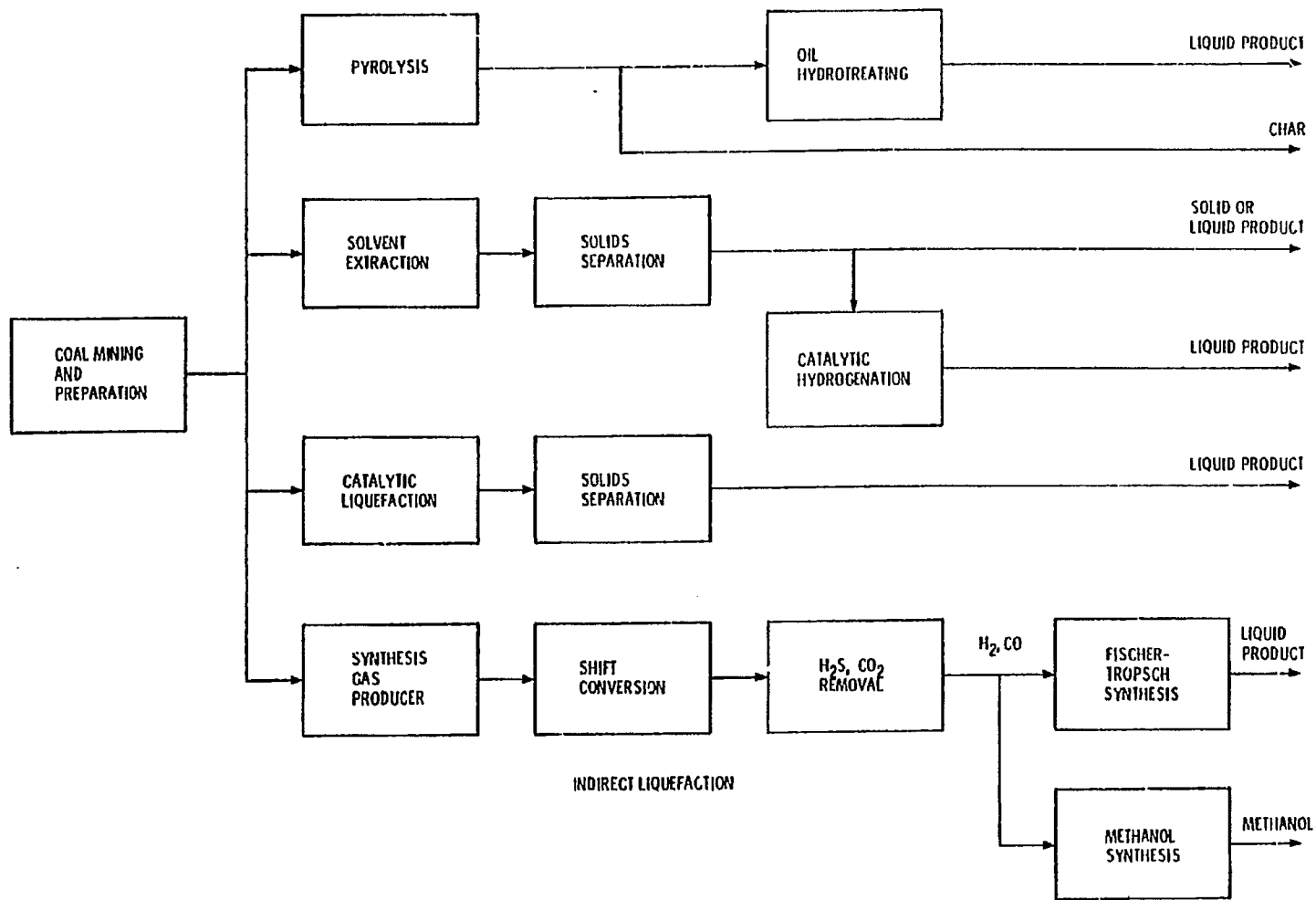


Figure 1. - Coal liquefaction routes (only major products are shown).

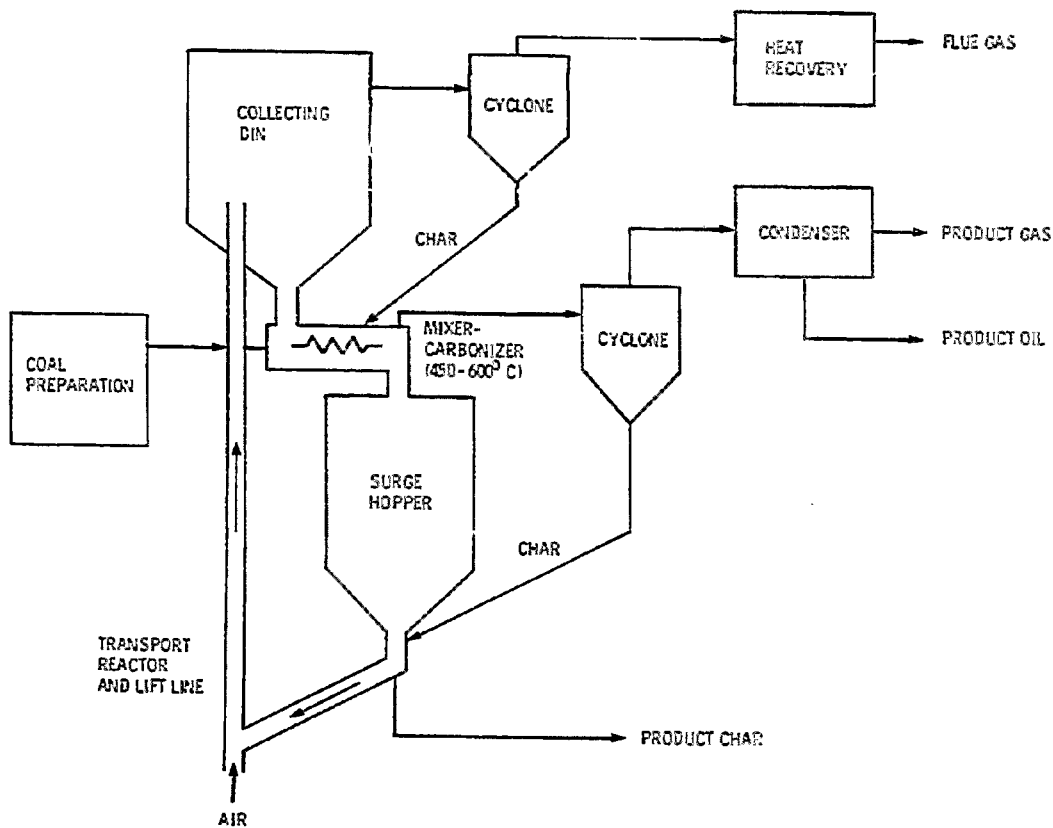


Figure 2. - Schematic of Lurgi-Ruhrgas process.

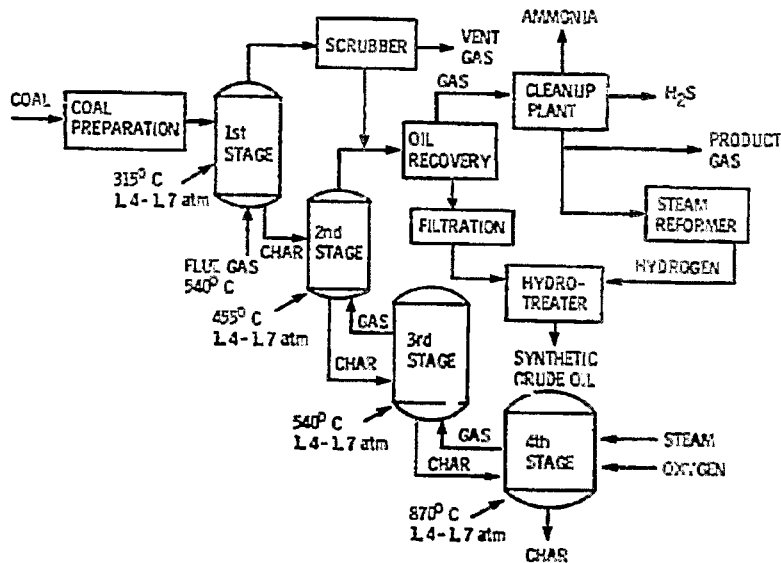


Figure 3. - Schematic of COED (FMC) process.

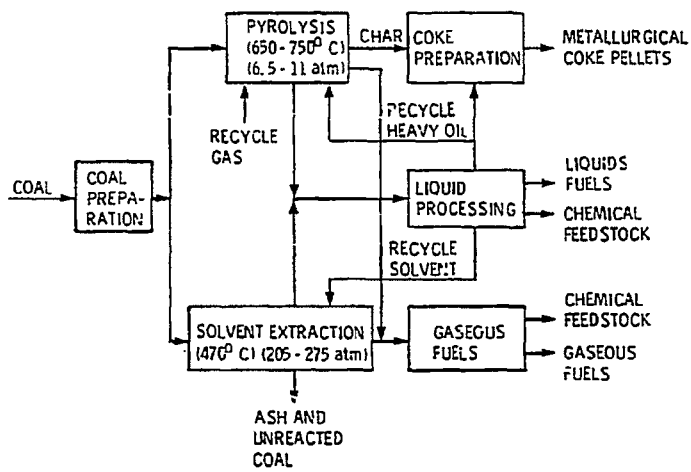


Figure 4. - Schematic of the U.S. Steel clean-coke process.

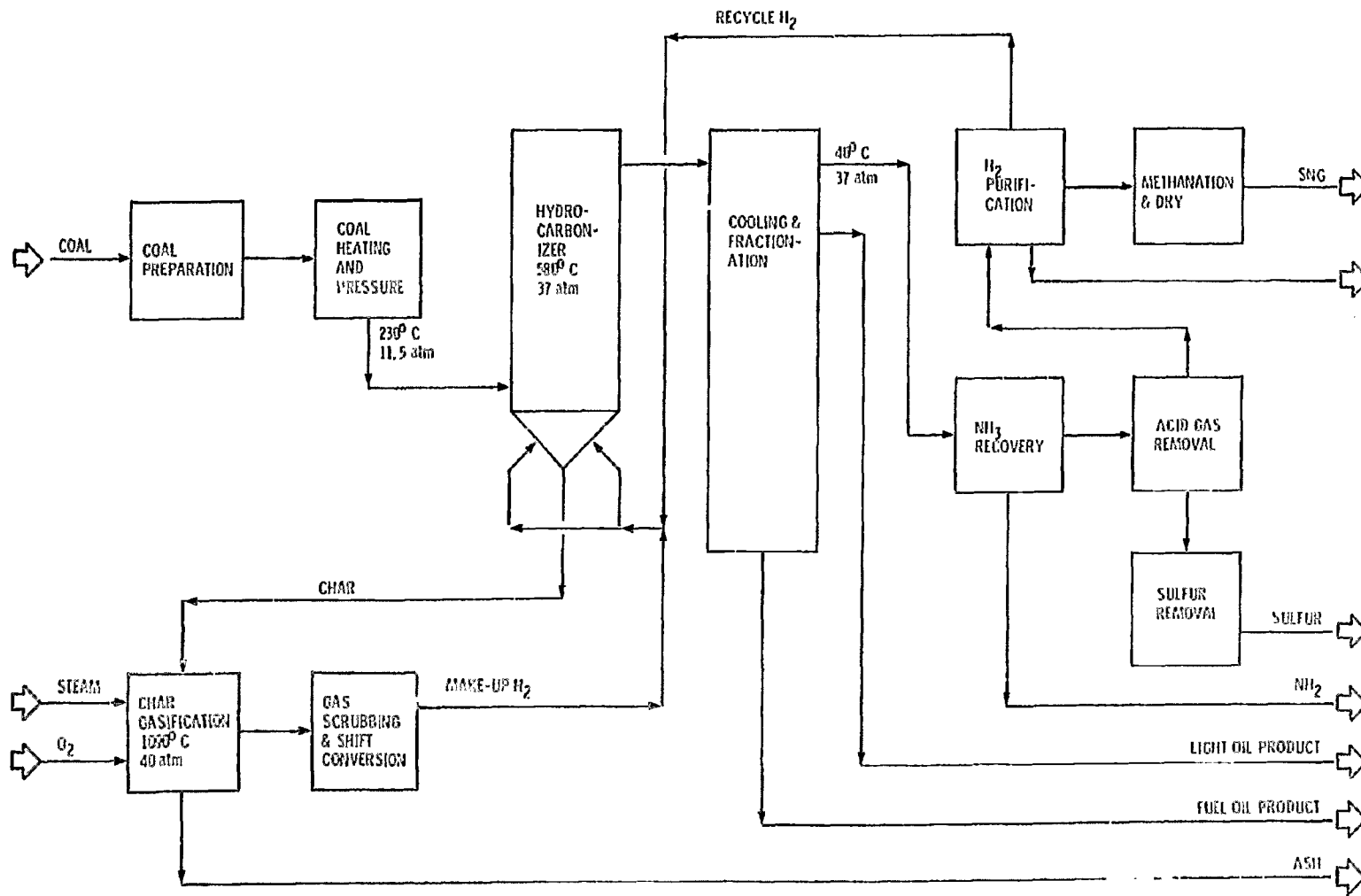


Figure 5. - Costean hydrocarbonization process.

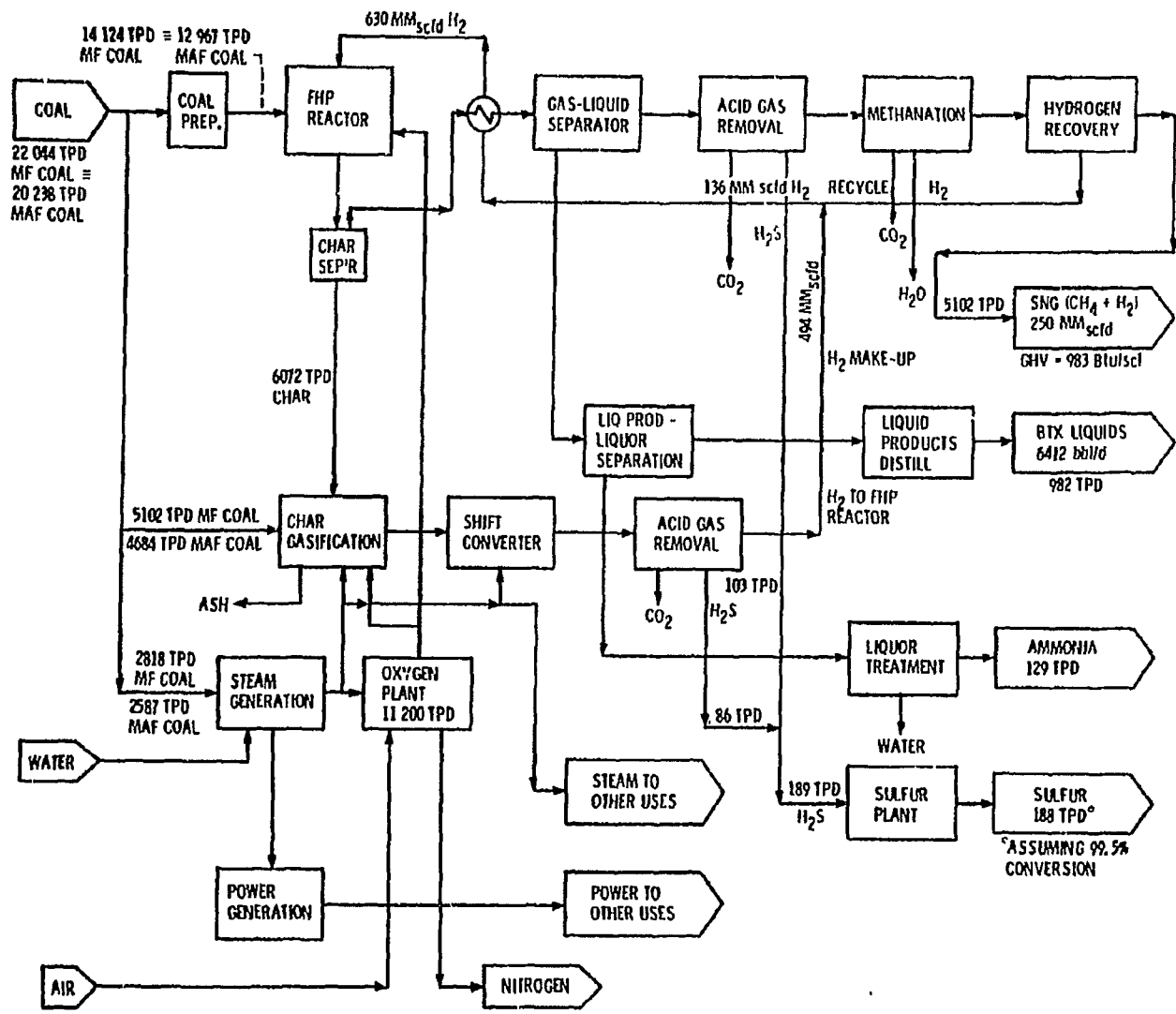


Figure 6. - Block flow diagram for the Cities Service conceptual FHP process using char gasification for hydrogen production.

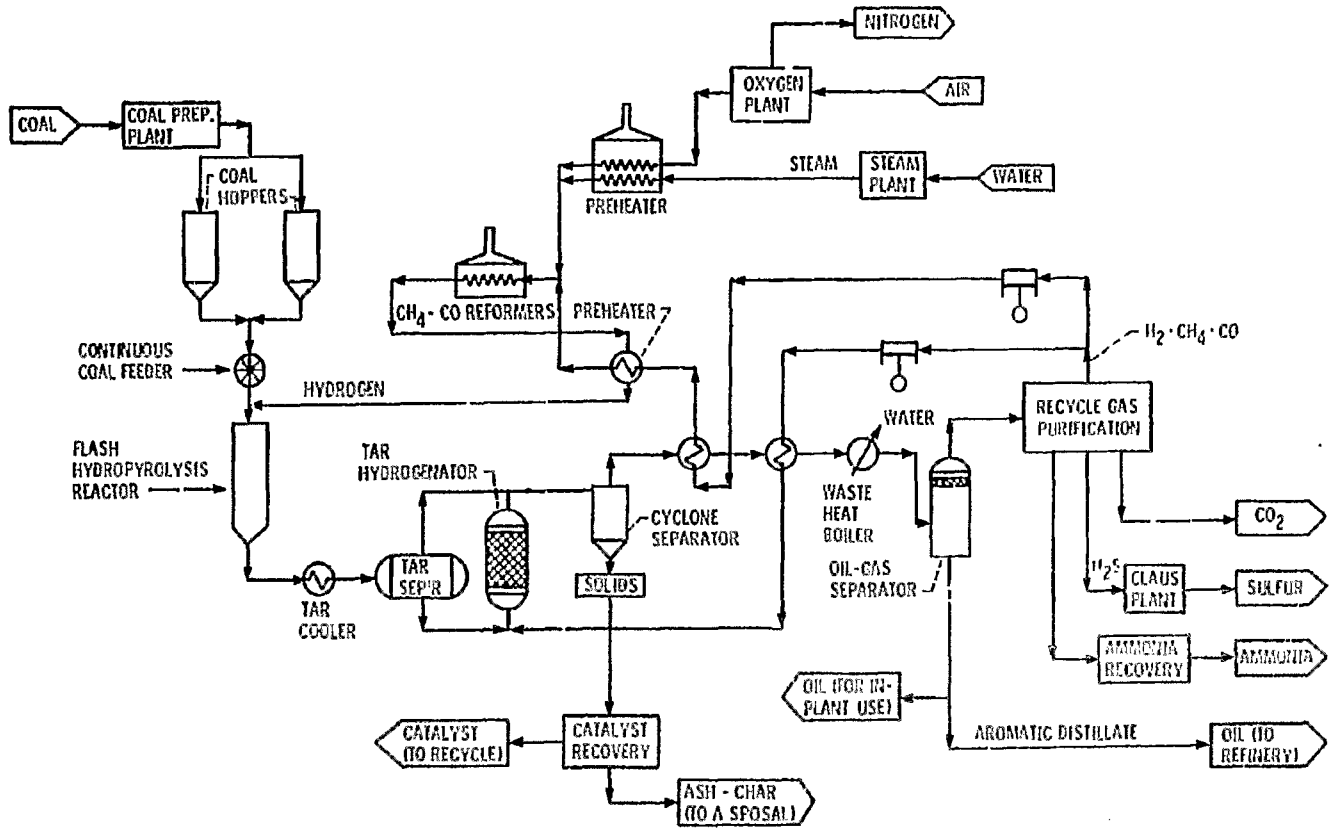


Figure 7. - Schematic flow diagram for the Schroeder-SCC FHP process.

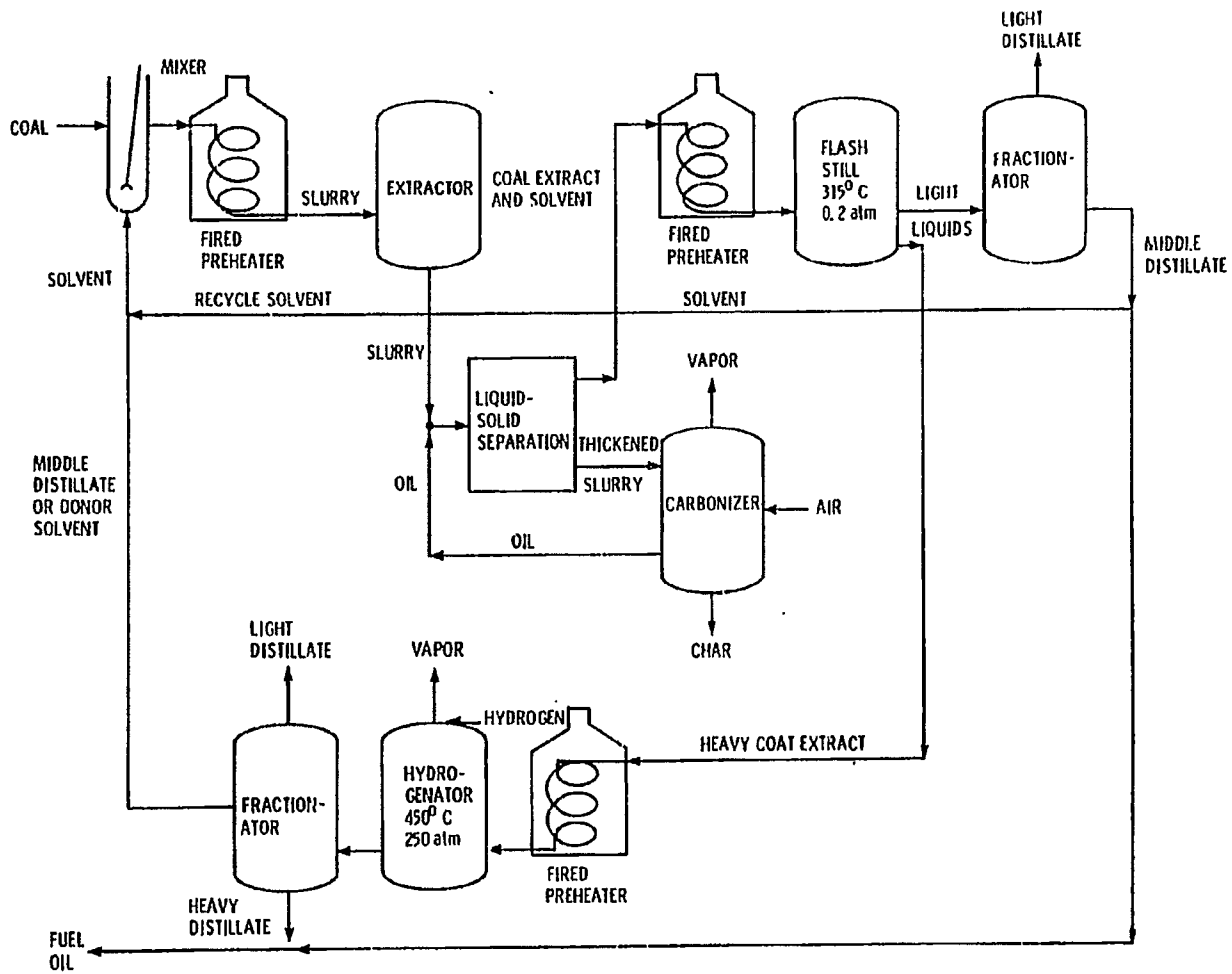


Figure 8. - Schematic of Consol synthetic fuel (CSF) process.

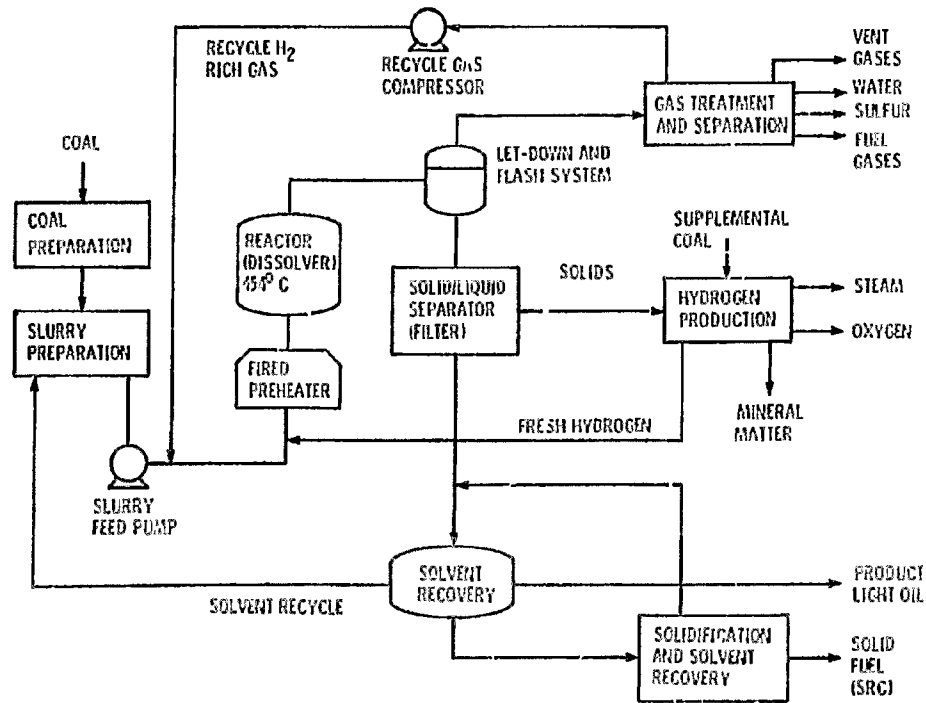


Figure 9. - Schematic of the solvent refined coal (SRC) process.

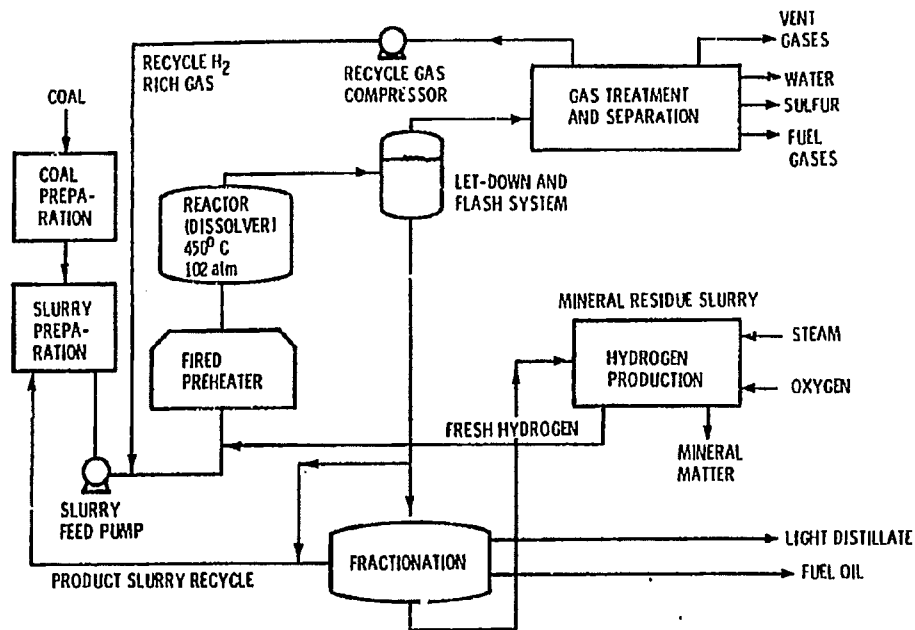


Figure 10. - Schematic of modified SRC process for distillate product.

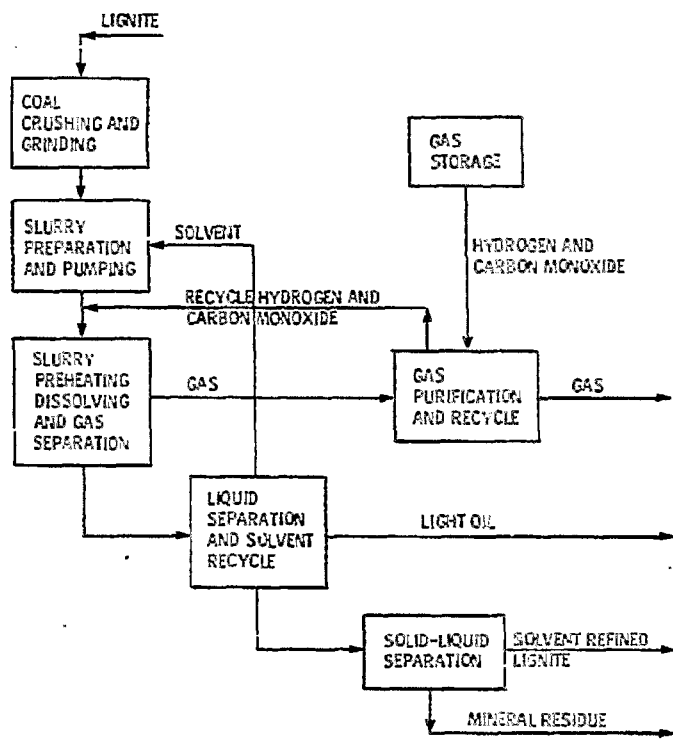


Figure 11. - Block flowsheet for solvent-refined lignite process.

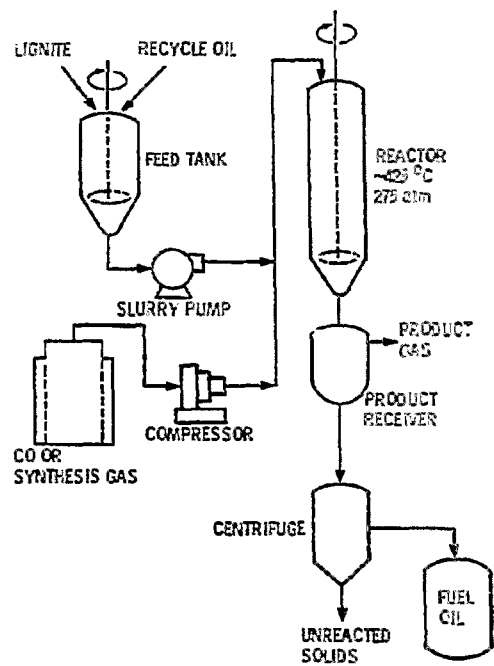


Figure 12. - Schematic of the Costeam process.

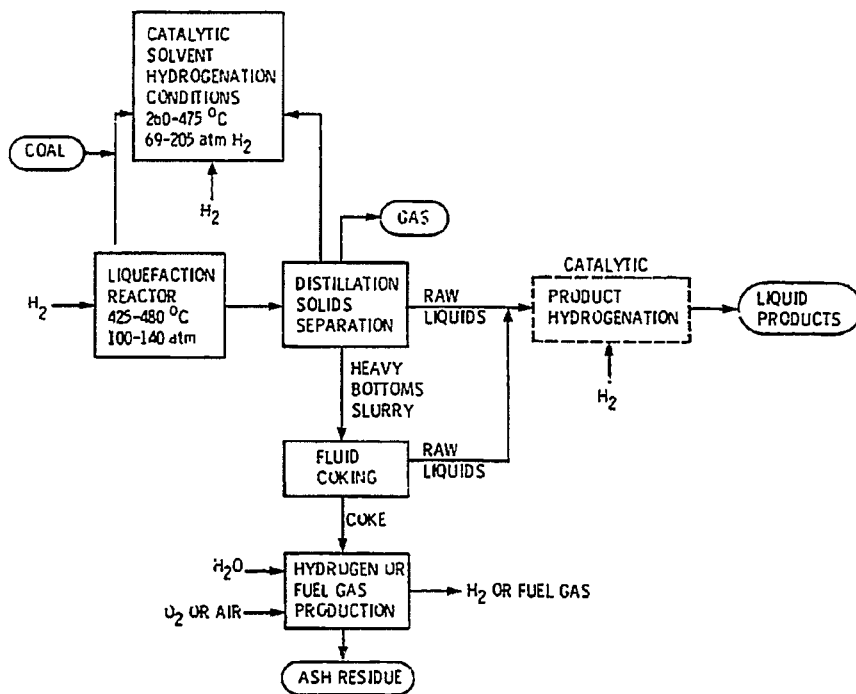


Figure 13. - Block diagram of Exxon donor solvent (EDS) process.

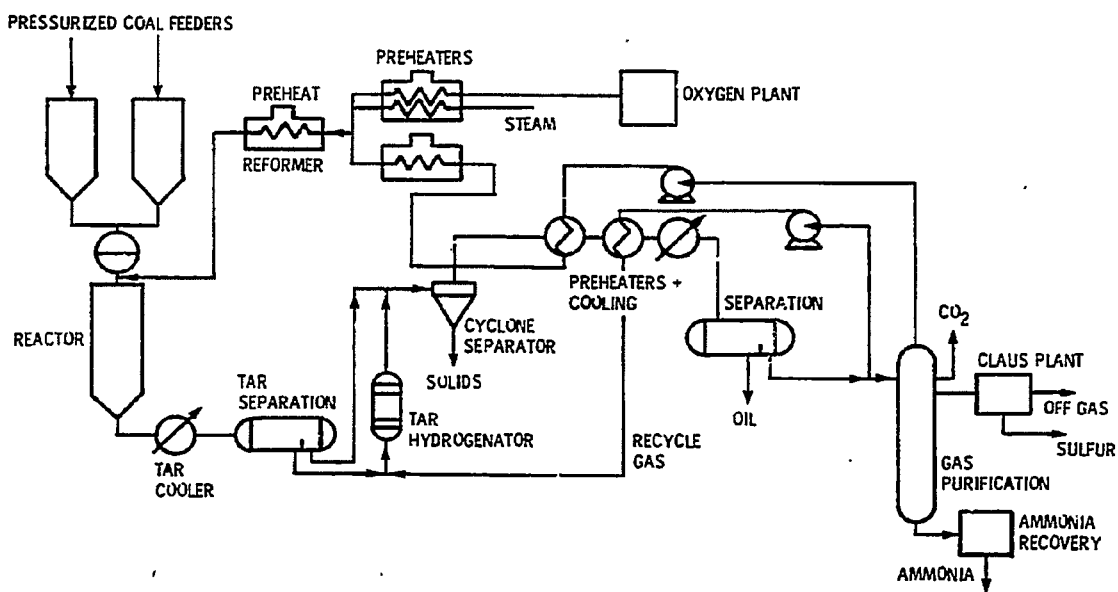


Figure 14. - Flow scheme for solid phase hydrogenation of coal to syncrude by Schroeder process.

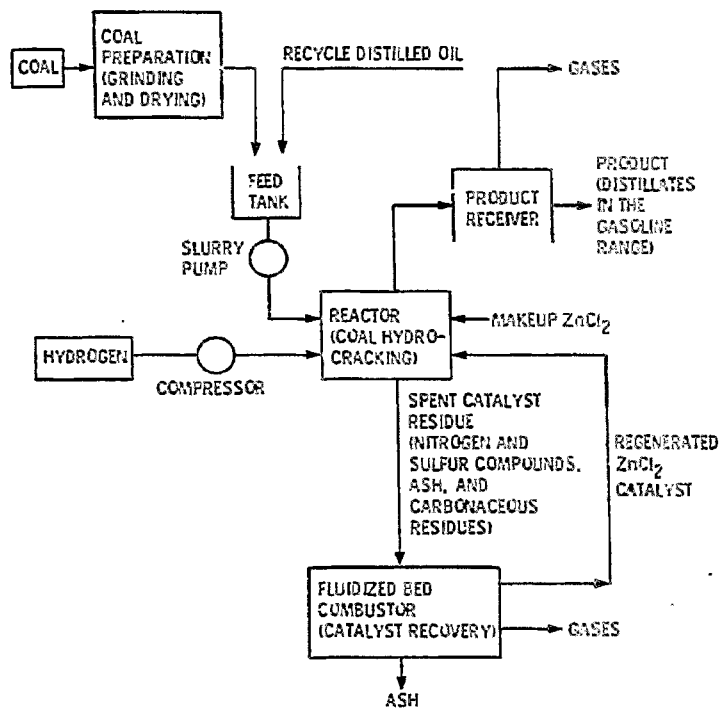


Figure 15. - Flow diagram of liquid-phase zinc chloride process being studied by Conoco.

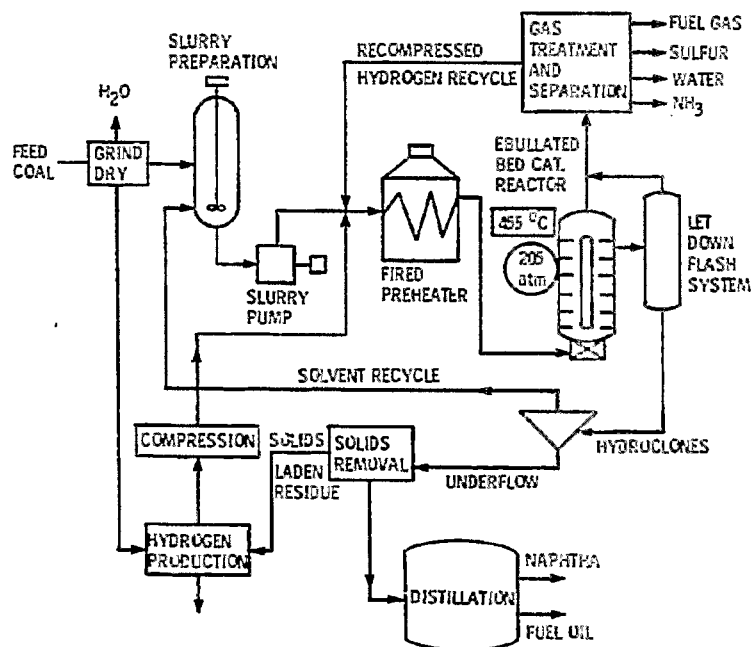


Figure 16. - Process flow scheme for H-Coal process.

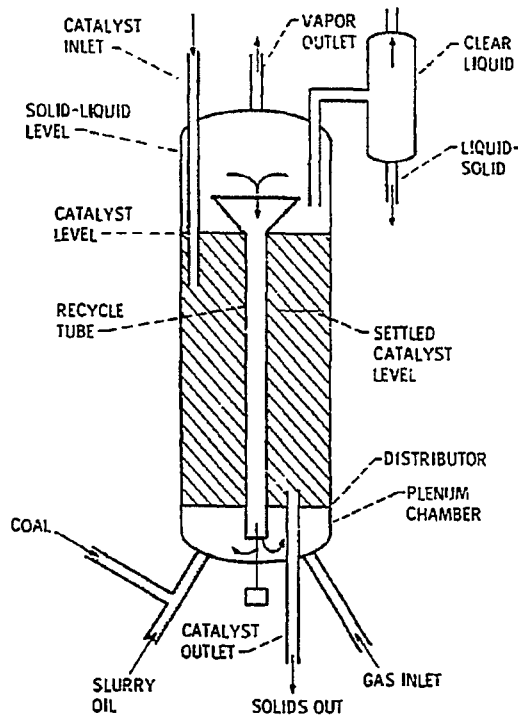


Figure 17. - Ebullating-bed reactor.

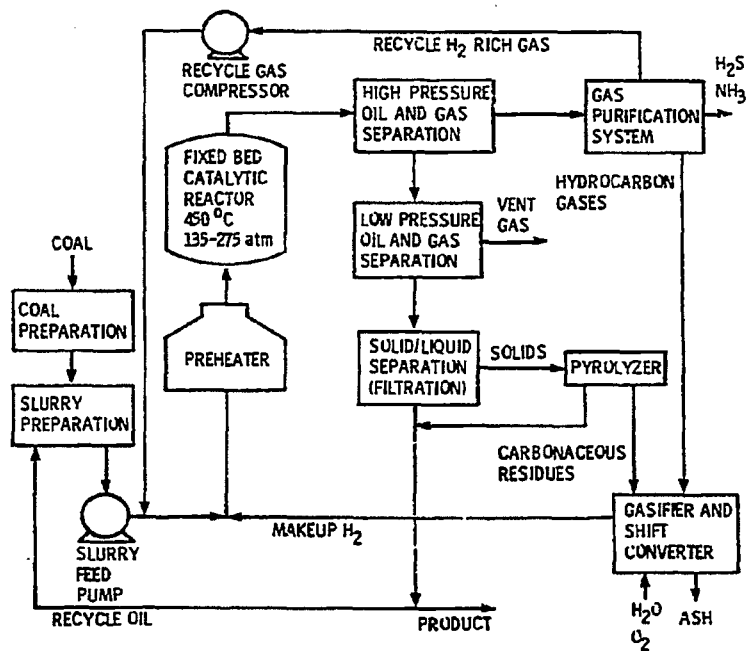


Figure 18. - Synthoil process flow scheme.

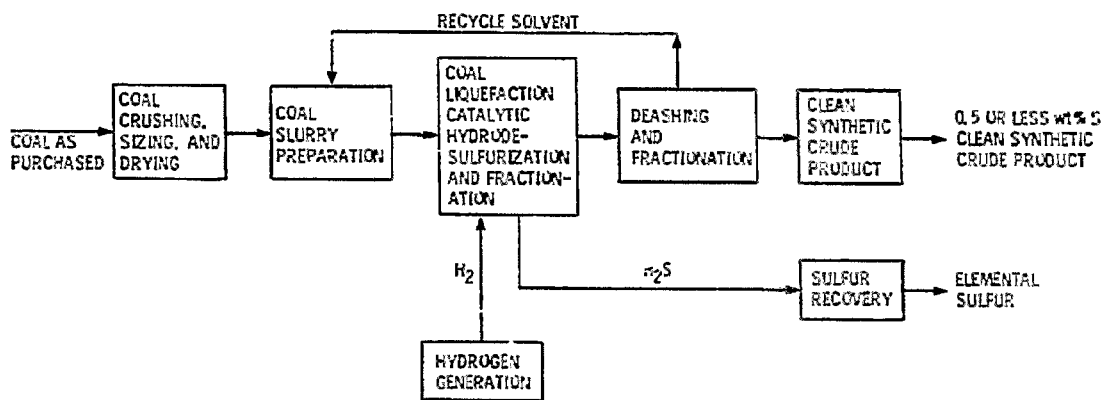


Figure 19. - Simplified flow diagram of the C-E Lummus CFPC process.

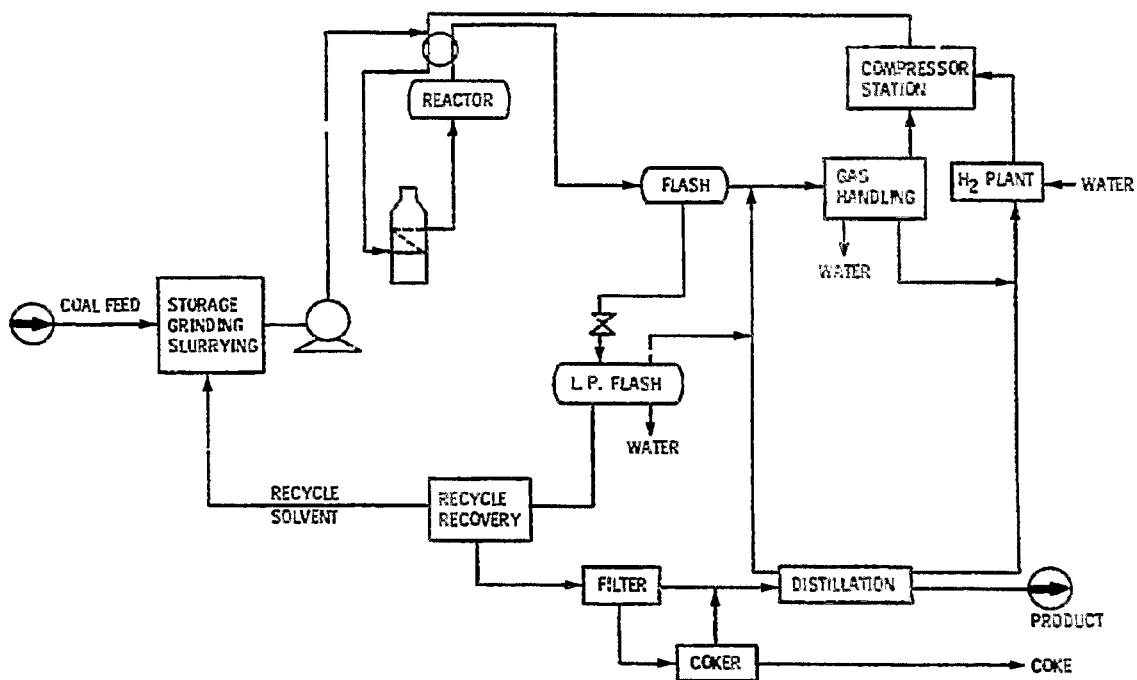


Figure 20. - Process schematic of Gulf CCL process.

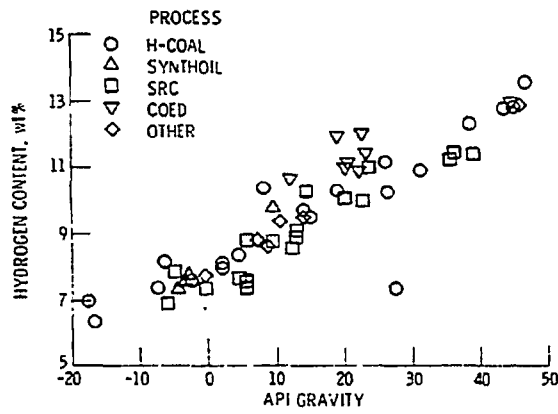


Figure 21. - Variation of hydrogen content of coal-derived fuels with API gravity.

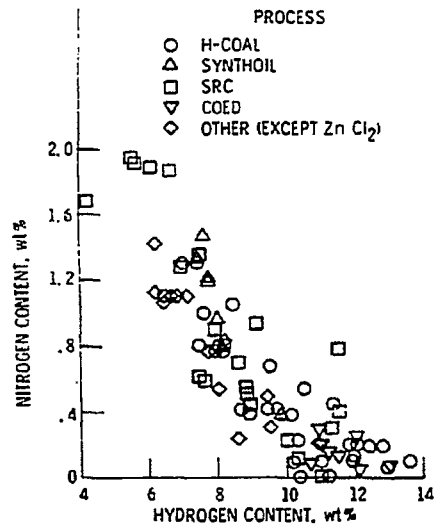


Figure 22. - Relation of fuel-bound nitrogen and hydrogen levels in coal-derived fuels.

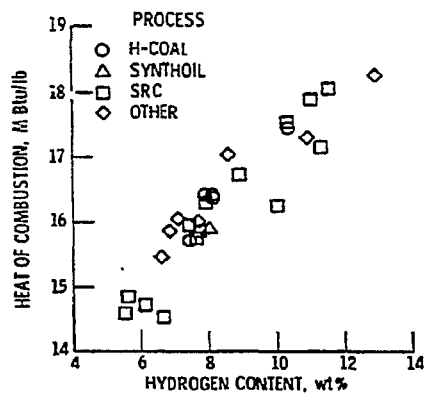


Figure 23. - Variation of heat of combustion of coal-derived fuels with hydrogen content.

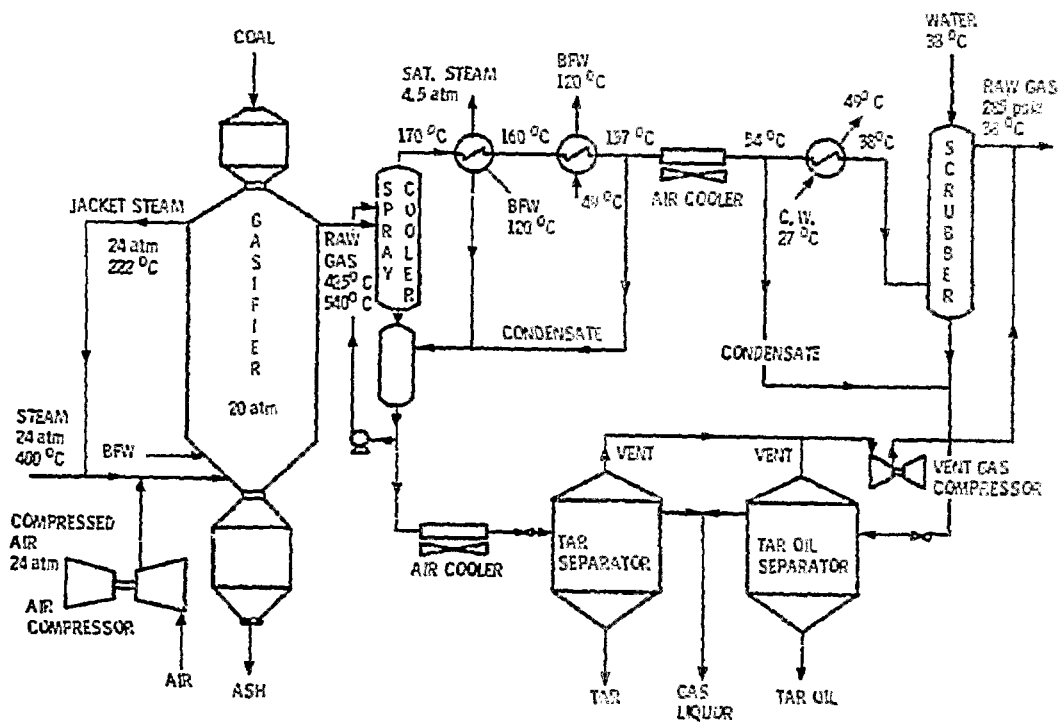


Figure 24 - Lurgi gasification configuration.

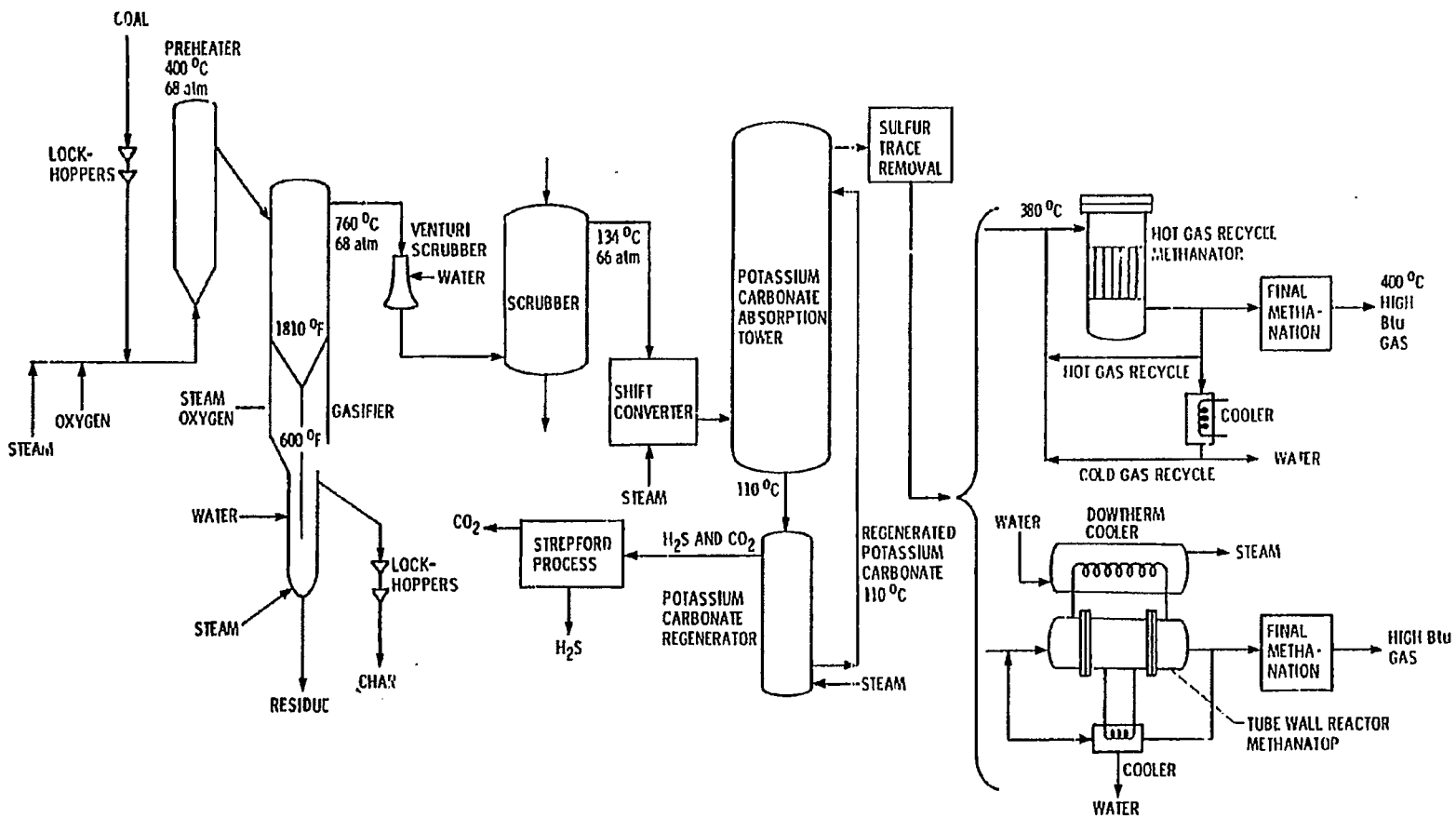


Figure 25, - Synthene process schematic.

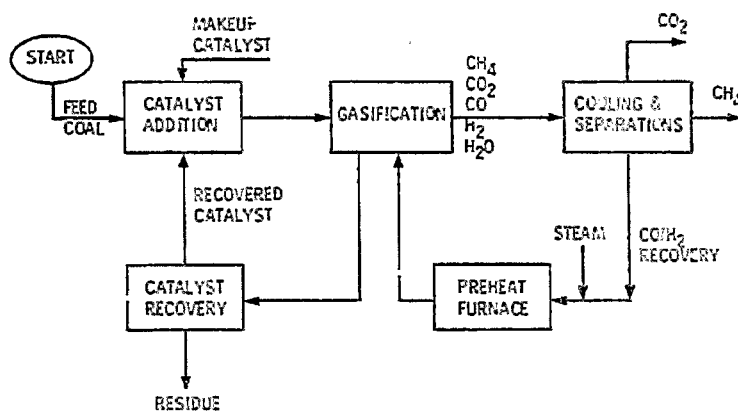


Figure 26. - Exxon catalytic gasification process.

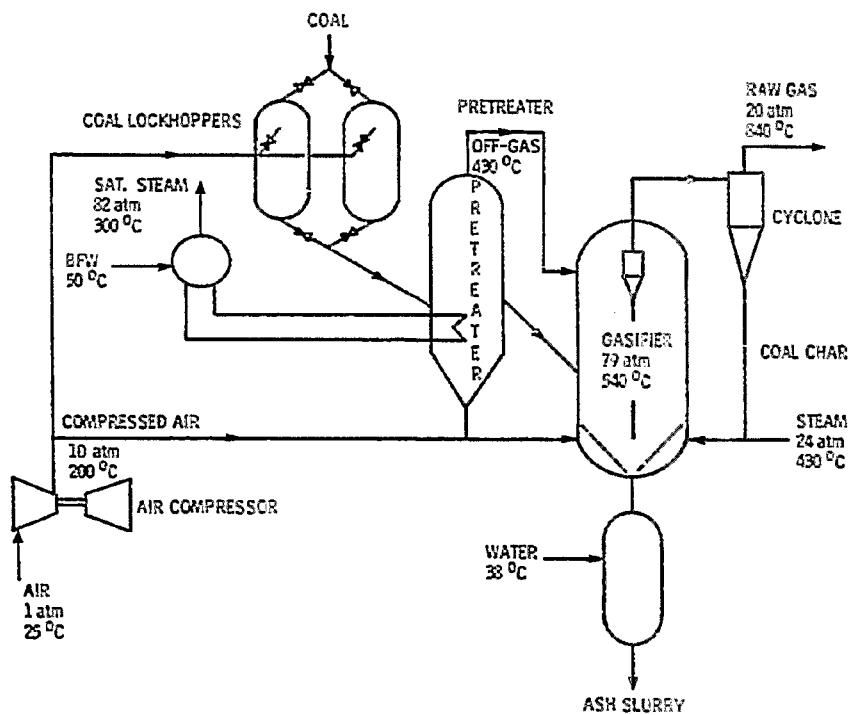


Figure 27. - IGT U-gas gasification configuration.

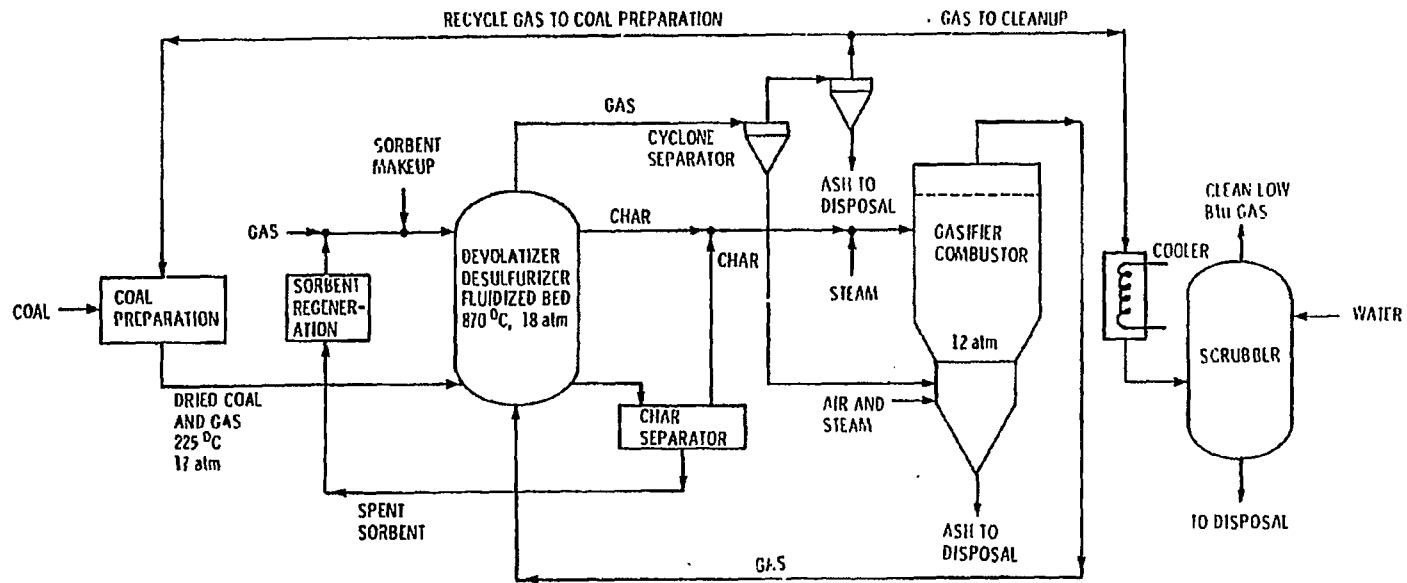


Figure 28. - Schematic of advanced coal gasification system for electric power generation (Westinghouse).

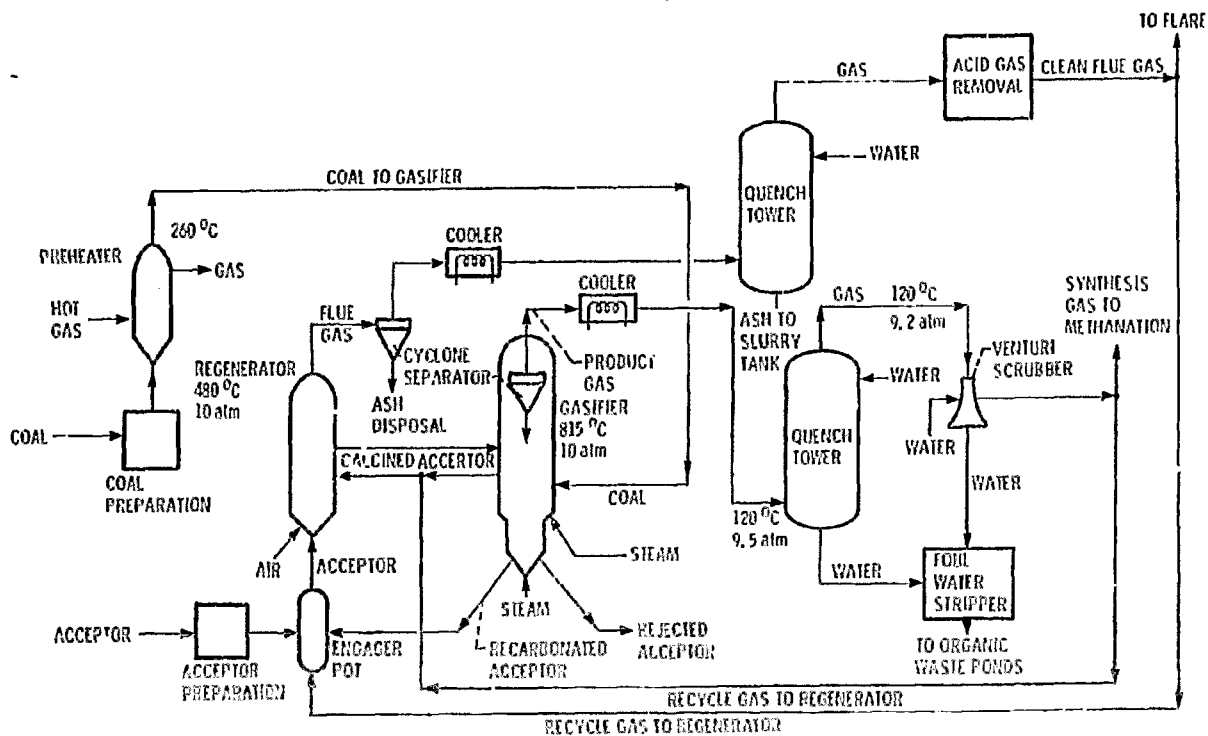


Figure 29. - Carbon dioxide acceptor process schematic.

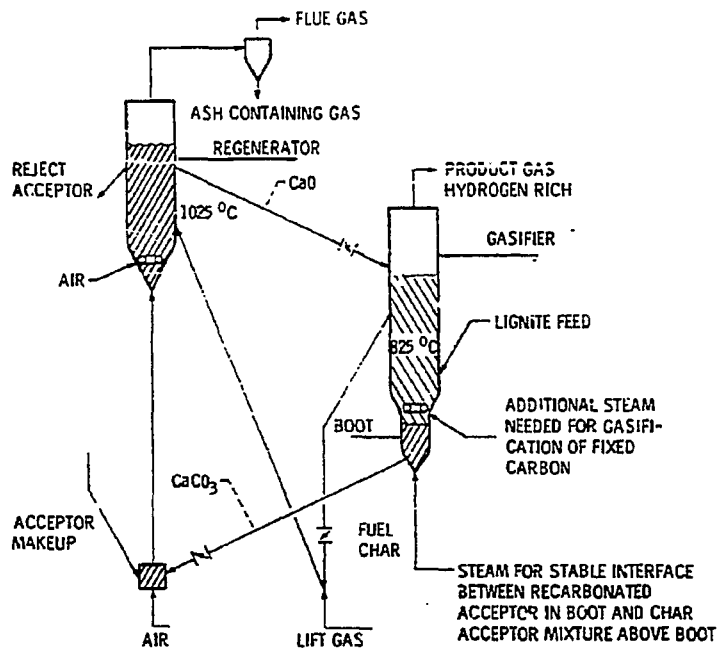


Figure 30. - Reactor for the CO₂ acceptor process.

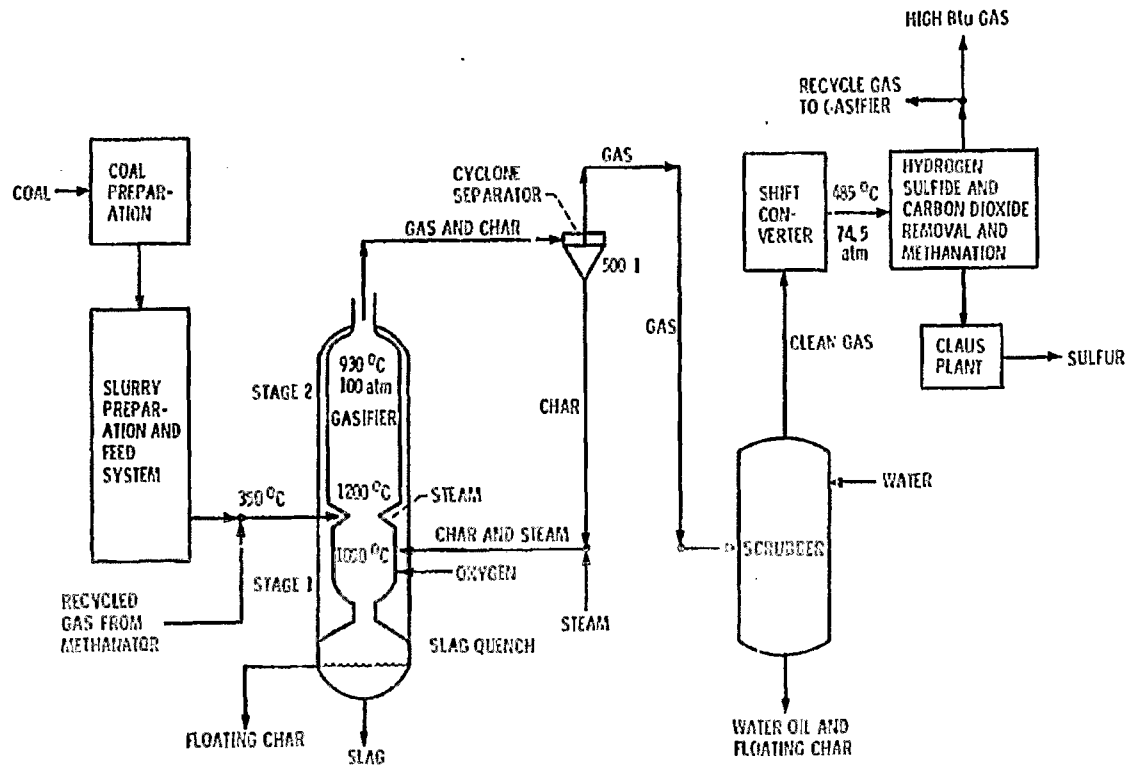
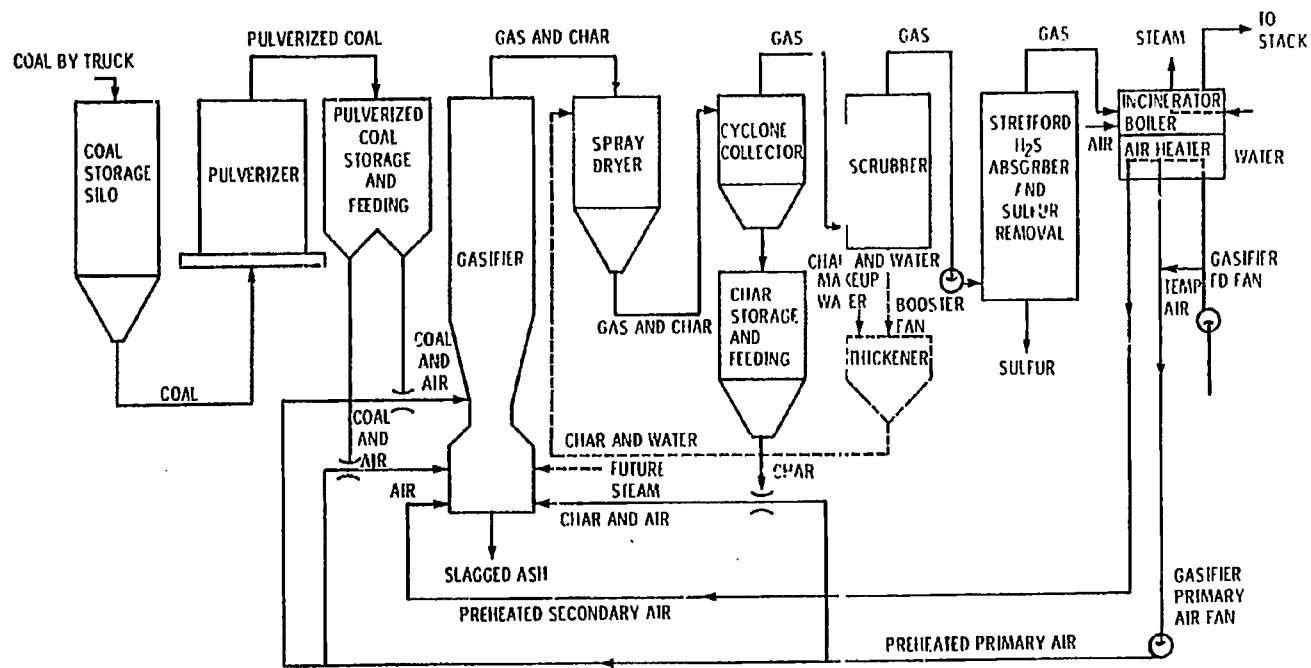
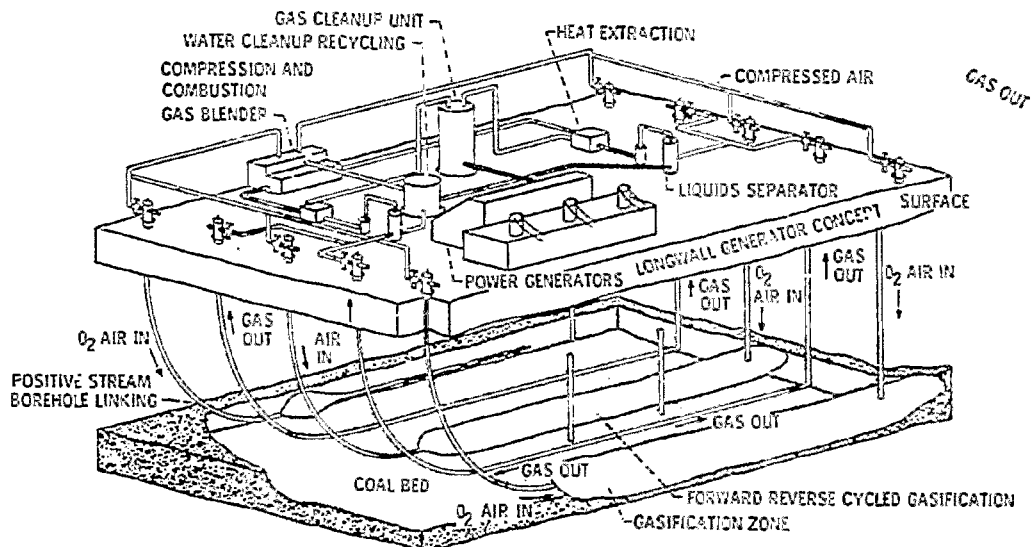


Figure 31. - B1-gas process schematic.



Figur 32 - C - E, Inc. gasification process.



UNDERGROUND GASIFICATION OF COAL FOR POWER GENERATION

Figure 33 - MERC longwall generator concept for underground coal gasification.

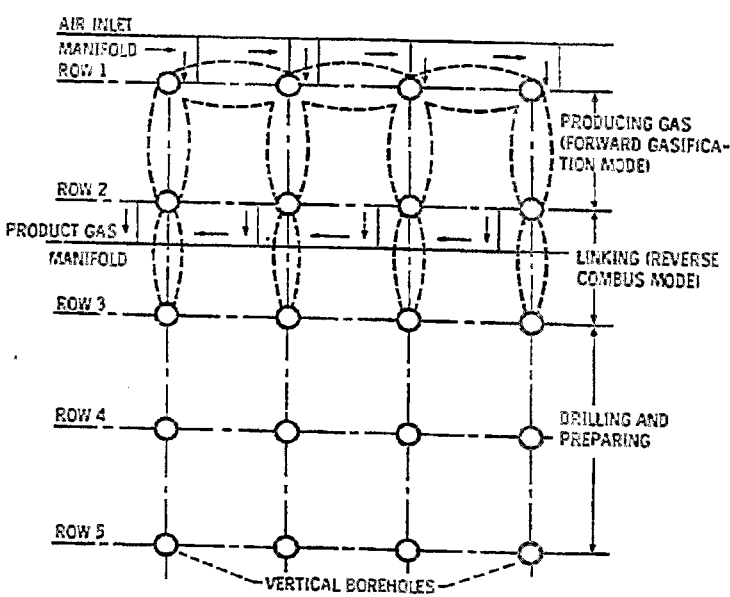


Figure 34 - Plan view of the LVW process.

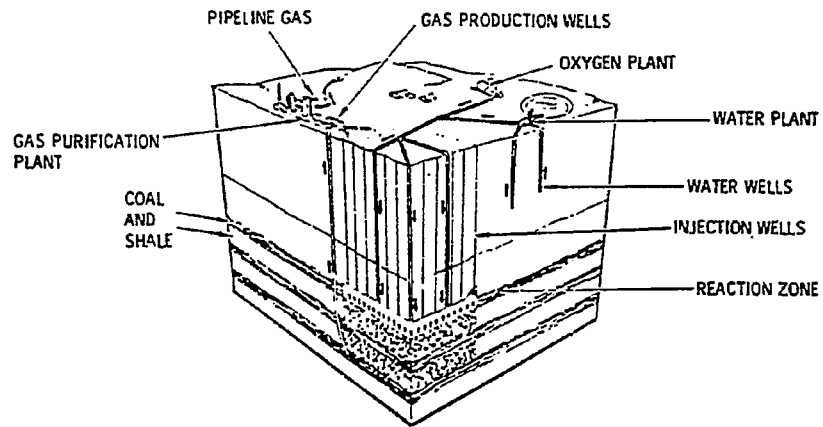


Figure 35. - Packed bed (PB) concept.

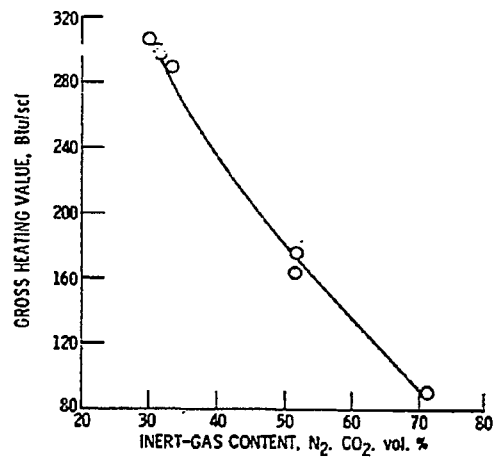


Figure 36. - Variations in gross heating value of low and medium Btu gases with inert-gas content.

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7. Author(s) Francisco Flores		8. Performing Organization Report No. E-1052	
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9. Performing Organization Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135		11. Contract or Grant No.	
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16. Abstract <p>This report is a literature survey of the properties of synfuels for ground-based turbine applications, compiled to October 1980. The four major concepts for converting coal into liquid fuels (solvent extraction, catalytic liquefaction, pyrolysis and indirect liquefaction), and the most important concepts for coal gasification (fixed bed, fluidized bed, entrained flow and underground gasification) are described. Upgrading processes for coal-derived liquid fuels are also described. Data on full range syncrudes, various distillate cuts, and upgraded products are presented for liquid fuels derived from various processes, including H-Coal, Synthoil, Solvent-Refined Coal, COED, Donor Solvent, Zinc Chloride Hydrocracking, Co-Steam, and Flash Pyrolysis. Typical composition, and property data is also presented for low and medium-BTU gases derived from the various coal gasification processes.</p>			
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