DE82012040

DOE/RA/20221--T1 Vol. 2

DE82 012040

Supplemental Studies

for

Anthracite

Coal Gasification

to

Produce

Fuels and Chemicals

NEPGAS PROJECT

VOLUME II

Prepared for FG01-79RA20221

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VOLUME II

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INTRODUCTION

In the initial stages of the Conceptual Project Study, the Babcox-Wilcox gasifier was selected for the NEPGAS Project. As indicated in Ebasco's Report, Babcox-Wilcox merged with Koppers-Totzek to form the KBW Gasification System. During the course of the study the plans of the new organization were still in the formation stages. As finally evolved the KBW Gasification System policy is to offer two gasification systems both operated at slightly above atmospheric pressure. The systems being the KBW Jacket Cooled System, which is similar in design to the Koppers-Totzek System, and the KBW Tubular Cooled Gasifier.

These developments and the need to assure that the gasifier selected be compatible to the technical and commercial conditions expected to exist during the time frame in which the plant will be built, requires a reevaluation of the technologies initially covered in the Conceptual Project Study. In addition to the gasifiers initially covered this review included and evaluated three gasification systems that have evolved during the course of the study. The technologies include:

- Westinghouse
- Saarberg/Otto
- KGN/PVC

APPROACH, RATIONALE AND CRITERIA FOR CANDIDATE SELECTION

Approach

The information presented on which to base candidate selection has been obtained from the following sources:

- In-house knowledge developed as a result of client gasification projects and internal studies.
- Supplemental data from available literature.
- Preliminary gasification information obtained from vendor's gasifier technology.
- In-house computer simulation models of gasifier technology.

Rationale and Criteria

The coal gasification systems selected as candidates must be able to gasify anthracite coal and culm to produce a raw synthesis gas suitable, through downstream processing, to be used as a feedstock in the production of chemcial and fuel grade methanol. Therefore, it is of prime importance that the gasifier system selected is judged compatiable with this coal. Demonstration of this compatability by operating expereince, although not essential to selection, is a definite asset. While the plant design will be based on the use of anthracite coal, it would be to the projects advantage to use a gasifier with a flexible feedstock requirement. This would broaden the potential sources of coal and the negotiating position of the NEPGAS Project.

Several coal gasifier processes exist which are commercially proven on nondomestic coals (e.g., Lurgi, Koppers-Totzek). A number of systems have been demonstrated in pilot plants and prototype units of semi-commercial scale (e.g., Texaco, Shell-Koppers, British Gas Council Slagging Lurgi, Saarberg-Otto, Westinghouse, and others). Still more systems are in a development. pilot plant, or demonstration plant state.

The coal gasification processes that are generally perceived to be ready for commercial design and operation are listed below and have been reviewed:

- -Lurgi Dry Ash/Slagger
- -KGN
- -Westinghouse
- -KBW Water Jacket/Tubular
- -Koppers-Totzek
- -Saarberg/Otto
- -Shell-Koppers
- -Texaco

A screening methodology was established to determine those processes that, on the basis of the available information, have applicability to the NEPGAS Coal Gasification Project. A summary of the assessments are presented in this report.

As a preliminary survey, a general tabulation was prepared entitled Gasifier Systems Review (Exhibit II-1A), which summarizes the following information for each gasification system:

- -Type
- -Pressure Range
- -Gasifier Operating Temperature
- -Applicability to Coal Type
- -Coal Preparation
- -Coal Feed Method
- -Ash Handling

The operating characteristics for each gasifier system, with particular reference to anthracite coal, are illustrated in Exhibit II-2A, entitled Gasifier Process Characteristics Review. Presented in this tabulation are such parameters as:

- -Oxygen and steam requirements
- -Coal requirements
- -Synthesis gas composition
- -Cold Gas Efficiencies
- -Heating value of raw synthesis gas
- -Type of steam produced
- -Carbon Conversion
- -Number of gasifiers

These findings were developed using an in-house computer simulation model in conjunction with preliminary vendor supplied data. This information should be considered directional in nature and would require coal characterization tests to validate the results. However, we believe it to be sufficiently accurate to be used in a screening evaluation.

The operating characteristics are based on producing a synthesis gas containing 22,300 pound moles of CO and H_2 per hour exit the gasifier equivalent to the quantity of CO and H_2 required to produce 2,500 TPD of methanol as developed in the NEPGAS Conceputal Project Study. The anthracite coal used as feed has the same properties as the case for the NEPGAS Conceputal Project Study.

ULTIMATE ANALYSIS

	Weight Percent
C	58.06
H_2	1.80
N_2	0.66
O_2	1.22
S	0.71
Ash	27.55
Moisture	10.00
	100.00
Higher Heating Value, Dry Coal	10549 Btu/lb
Softening Temperature	2750-2850°F
Fluid Temperature	2900-3000°F

Downstream processing of the synthesis gas exit the gasifier to meet the methanol feedstock requirements, such as CO Shifting and Purification, were not quantitatively evaluated for each gasification system. These processing requirements were evaluated qualitatively in terms of the relative amount of CO Shifting based on the H_2/CO ratio exit the gasifier and by-product formation such as tars, oils and other hydrocarbons which necessiate more extensive gas purification.

Also, developed is a brief process description and a general overview of the commercial status and availability for each system.

Based on all the information generated above, a summary is presented listing the positive and negative aspects of each system, entitled, Gasifier Evaluation Guide, (Exhibit II-3B), which was used as an aid in the final selection and recommendations for the gasifiers best suited for the NEPGAS Project.

Although the ecomonics of each gasifier plays a vital role in final selection of the system, this aspect has been treated in a qualitative manner. Systems requiring added capital and/or added operating costs for operations such as gas purification to remove by-product hydrocarbons, added shifting to produce methanol synthesis gas, or large waste heat boilers to improve the overall thermal efficiency have been judged less favorable.

EXHIBIT II - IA

GASIFIER SYSTEMS REVIEW

	WESTINGHOUSE	TEXACO	SHELL-KOPPERS	KT/KBW	SAARBERG/OTTO	LURGI DRY ASH	LURGI SLAGGER	KGN
Type	Fluidized bed Dry Ash	Entrained Slagging	Entrained slagging	Entrained Slagging	Entrained slagging	Fixed Bed	Fixed Bed	Fixed Bed Dry Ash
Pressure Range, psia	225-600	15-1200	450	15	350-400	350-450	350-450	300-500
Gasifier Operating Temperature, °F	1550-1900	2300-2600	2300-3200	2400-3200	2700-3200	1500-2100	2000-2800	1500-2100
Applicability to Coal Type	Have tested and been successful with coal ranging from coke to lignites anthracites have not been tested.	All types Not suitable for coals with a high chemically bound moisture content. Coals with high fluid temperatures may cause problems.	All types Moisture content up to 30%.	All types Requires pretreatment drying to a moisture content of 1-3%.	Major efforts have been directed toward hard coals. Moisture content less than 2% hard coals, 12% lignites.	All types Lignites and bituminous coals may require pretreatment or gasifier modification.	Major testing has been done on subbituminous and lignite coals.	Have tested and been successful with hard coa where major effort is directed.
Coal Preparation	Readily utilizes fines and coal/char feedstocks 3/16"x0".	55%-67% solids slurry, coal crushed to less than 14 mesh.	Pulverized to dust having a grain size about 45 to 60 microns.	Pulverized/dried 70% must be less than 200 mesh.	Crushed/dried to a grain size less than 3MM·70% less than 0.2MM.	Graded coal 5/8"-14/8" one stage screening for each stage of crushing to eliminate fines.	Graded coal 5/8" 14/8", currently testing for fines limitations.	Graded coal similar to Lurgi & coal briquettes weighing approximately 40 grams each.
Coal Feed Method	Pneumatically transported from lockhoppers to gasify using recycle product gas.	Pumped preheated slurry.	Pressurized coal cyclones and bunkers using nitrogen.	Screw feeders equipped with mixing heads for oxygen injection.	Pneumatically to storage, carried from coal locks by recycle product gas to four feed pipes.	Pneumatically conveyed to storage and fed to the gasifier through pressurized lockhoppers.		
Ash Handling	Ash agglomerates discharged from gasifier through lockhoppers	Water quenching of molten slag discharged intermittently from an ash lock sluice.	Molten ash is quenched in water both equipped with a pulverizer.	Water quenching of molten slag.	Slag overflows through a tap hole quenched in water bath.	Through a grate in bottom of gasifier	Molten slag falls to bottom of gasifier, water quench removed via slag lock hopper.	Through a grate in bottc of gasifier into ash lockhoppers.

EXHIBIT II - 2A

GASIFIER PROCESS CHARACTERISTICS REVIEW

	LURGI DRY ASH	LURGI SLAGGER	KGN (5)	KBW WATER JACKET	KBW TUBULAR	KOPPERS TOTZEK	SHELL KOPPERS	SAARBERG OTTO (4)	TEXACO	WESTINGHOUSE
Pressure, psia	350	450	450	15	15	15	450	500	900	450
Dry Coal Feed, TPD	5042	4415	4645	4633	4397	4405	4030	4290	4707	3915
Steam Injection, lbs/lb dry coal	1.70	0.50	2.43	0.30	0.3	0.30	0.12	0.065	-	1.2
Oxygen Feed/Dry coal, lb/lb	0.425	0.280	.51	0.725	.709	0.711	.766	0.835	0.920	0.730
Moisture content in coal to gasifier, Wt.%	10.0	10.0	10.0	1.0	1.0	2.0	2.0	2.0	38.5	10.0
Gasifiers Required	10	7	8	14	5	12	8	3	4	8
Raw Synthesis Gas Composition (Mole Percent)										
CO	13.569	47.425	20.00	51.421	52.438	52.758	71.050	76.7	34.624	28.819
H_2	23.069	30.450	47.85	25.982	27.977	26.943	22.745	18.7	23.489	23.403
CO_2	15.487	5.010	26.65	11.786	11.294	10.497	3.43	3.4	19.362	11.590
H_2O	43.648	9.127	-	9.872	7.368	8.887	1.820	-	21.775	35.557
CH_4	3.452	6.423	4.18	0.107	0.106	0.105	0.071	0.20	.084	0.153
$Ar + N_2$	0.170	0.283	1.00	0.502	0.491	0.488	0.538	0.70	.414	0.289
$H_2S + COS$	0.170	0.489	0.329	0.320	0.326	0.323	0.348	0.30	.252	0.189
1) $C_nH_m + NH_3$	0.436	0.794	-	-	-	-	-	-	-	-
Total Flow, mol/hr	60865.5	28635.7	32856.6	28810.4	27731.2	27979.6	23775.4	23375.3	38373.2	42702.0
2) Total by-product formation, lbs/hr	28298	16115	-	-	-	-	-	-	-	-
H_2/CO Ratio	1.700	0.6421	2.393	0.5053	.5335	0.5107	.3201	0.2438	0.678	0.8121
Cold Gas Efficiency, HHV, %	83/93 (3)	91/93 (3)	80.0	87.0	72.0	71.0	77.0	74.0	68.0	80.0
Overall Carbon Conversion, %	98.0	98.0	98.00	88.0	90	90.0	98.5	99.95	99.0	98.0
HHV Dry Product Gas, Btu/SCF	283	360.0	262.0	278.0	282	283	308.0	308.0	240.0	265.0
Type of Steam Produced, psia	30-100	30-100	30-100	30-1100	600-850	900-1400	1000-1500	500-900	1000-1500	800-1000

(1) C_nH_m includes C_2H_4, C_2H_6
(2) Includes tar, oils, phenols, naphtha, fatty acids
(3) Exclude/Include by-products produced.
(4) Information received from Saarberg/Otto was on a dry basis
(5) Information presented based on a similar anthractie coal on a dry basis for crude gas composition.

GASIFIER EVALUATION GUIDE

Entrained Beds	Positive Features	Negative Features
Koppers-Totzek KBW Jacket Cooled/Tubular	1. Applicable to wide variety of coals. 2. Commercially proven technology. 3. No tars, phenols or higher boiling hydrocarbons produced. 4. Can handle coal fines. 5. Simple design, operation at atmospheric pressure gives high reliability. 6. Low methane content in crude synthesis gas.	1. Low pressure operation - will require large product gas compression for high pressure methanol synthesis. 2. Low product gas through-put. 3. Pretreatment drying of coal required. 4. High oxygen requirement. 5. Elaborqte waste heat boiler system.
Texaco	1. High pressure operation. 2. Availability of pilot plant facilities for coal testing. 3. High pressure steam generated in gas cooling mode. 4. Can handle coal fines	1. High oxygen requirements. 2. Not suitable for an ash with a high fluid temperature. 3. Slurry feed system not suitable for coals with a high chemically bound moisture content.
Shell-Koppers	1. High pressure operation. 2. Low steam consumption. 3. High cold gas efficiency and overall carbon conversion. 4. Versability of coal feedstock. 5. Product gas free from higher boiling hydrocarbons. 6. Product gas virtually free of methane. 7. Can handle coal fines.	1. Low H_2/CO ratio. 2. Relatively high oxygen consumption. 3. Possible refractory problems operating with a coal with a high fluid temperature.
Saarberg/Otto	1. Applicable to a wide variety of coals with major efforts directed for use with hard coals. 2. Product gas free from higher boiling hydrocarbons. 3. High pressure operation. 4. Low steam consumption. 5. Suitable for coals having ash contents up to 40 percent irrespective of caking properties. 6. High cold gas efficiency and overall carbon conversion. 7. Low methane content in product gas.	1. High oxygen requirement. 2. Extensive testing needed to hot gas clean-up. 3. Continuous feeding of dust like coal into a system under pressure. 4. Operation in slagging mode with coals having a high fluid temperature may cause problems with refractory linings.

GASIFIER EVALUATION GUIDE

Fixed Bed

KGN

Positive Features

1. High pressure operation.
2. High H_2/CO ratio, which is favorable for methanol production.
3. Low oxygen consumption.
4. Crude synthesis gqs free of higher boiling hydrocarbons such as tars and oils.
5. Licensor can supply coal briquetting process resulting in the ability of the gasifier handling coal fines.
6. High Cold Gas Efficiency.
7. Does not require large waste heat boilers for efficient plant operation.

Negative Features

1. High steam consumption required.
2. Technology not proven on a large scale.
3. High methane content in synthesis gas.
4. Low through-put for low reactive coals.
5. Higher product temperature than Lurgi's.

GASIFIER EVALUATION GUIDE

	Positive Features	Negative Features
Fluidized Beds		
Westinghouse	1. High pressure operation. 2. Applicable to a wide variety of coals. 3. Lower product gas temperatures than entrained beds systems. 4. High cold gas efficiency and overall carbon conversion. 5. Licensor will supply complete gasification system. 6. Product gas free from higher boiling hydrocarbons. 7. Low methane content in product gas.	1. Technology not proven on large scale unit. 2. High steam requirements to keep ash below fluid temperature. 3. Elaborate gas clean up system for removal of unreacted fines and entrained ash.
Fixed Bed		
Lurgi Dry Ash	1. High H_2/CO ratio which is favorable for methanol production. 2. High pressure operation. 3. Low oxygen consumption. 4. High cold gas efficiency. 5. Proven gasification technology. 6. Coal drying accomplished within the gasification unit. 7. Applicable to a wide variety of coals. 8. Does not require large waste heat boilers for effluent plant operation. 9. Licensor can supply complete gasification and downstream processing units.	1. High methane content, lessens suitability of synthesis gas for a methanol feedstock. 2. Crude synthesis gas contains tars, oils and other hydrocarbons which require extensive gas purification. 3. High steam consumption required to keep ash below fluid temperature. 4. Requires frequent routine maintenance. 5. Low through-put for low reactive coal such as anthracite. 6. Cannot handle coal fines, which requires more coal screening.
Lurgi Slagger	1. High cold gas efficiency. 2. Lower steam and oxygen consumption then Lurgi Dry Ash. 3. Applicable to a wide variety of coals. 4. Potential for utilizing coal fines by injection through tuyeres. 5. High pressure operation. 6. Greater through-put than Lurgi Dry Ash per unit bed area. 7. Technology based on commercially proven Lurgi Dry Ash. 8. Does not require large waste heat boilers for efficient plant operation.	1. High methane content. 2. Lower H_2/CO ratio than Lurgi Dry Ash, which requires a greater amount of CO Shifting. 3. Crude synthesis gas contains tars, oils and other hydrocarbons. 4. Technology not proven on a large scale. 5. Requires frequent routine maintenance. 6. Requires addition of a flux to reduce fluid temperature of the ash to be in slagging mode.

DESCRIPTION OF RESULTS

The evaluations presented should be considered screening type evaluations and the recommendations made as preliminary. While a number of trade offs were made, only major factors were considered, and the recommendations are based gasifier performance information supplied by the various process developers and in-house heat and material balances and judgement.

The information illustrated and referred to, should be considered directional and would require coal characterization tests and process development unit testing to validate the results.

Based on previous experience with developing technologies, the tendency exists for the vendors to be overly optimistic or conservative concerning their respective technologies. Therefore, the reader should note that when reference is made to such operating parameters as cold gas efficiencies and carbon conversion or the quantities of coal, steam and oxygen required that these values represent a best estimate based on calculations.

Owing to the numerous factors considered in the analysis of each gasifier technology, from both a technical and commercial development effort, the evaluation has been divided into two categories. The gasification systems were judged, and recommendations made in terms of the technical operating characteristics as illustrated in Exhibit II-2A, and the vendors efforts towards commercialization for use with an anthracite coal.

Based on the criteria stated, it is Ebasco's judgement that the gasification systems most suitable for the NEPGAS Project requirements are:

- Westinghouse
- Saarberg/Otto
- KGN

Ebasco therefore, recommends that the above gasification technologies be further evaluated using a in-depth analysis as can be obtained from coal characterization analyses and bench scale testing.

An analysis of each gasification technology being reviewed is presented in the next section entitled "Gasifier Evaluations and Recommendations."

Table 1 presents a comparison of the design parameters for the gasifiers considered as the most suitable alternates for the NEPGAS Project by this study, and the Babcock Wilcox (B/W) gasifier used as the base technology in the NEPGAS Conceptual Project Study.

The coal requirements, the main raw material stream to the potential alternate gasifier ranges from 88 to 105% of the base case requirements. The oxygen consumption for all the alternate gasifiers is lower.

The gas composition produced, varies from the base case to the degree that the mechanics of the gasification operation varies. For the Saarberg/Otto Gasifier (S/O), both the composition and the quantity of gas processed downstream of the gasifier may be considered as identical. The reasons for the similarity being that the S/O and the B/W gasifiers are both dry feed, water wall entrained slagging type gasifiers. The difference in the quantity and composition of the Westinghouse and the KGN gasifier product gases is due to the degree to which the CO is shifted to H_2 in the gasifier. In the proposed application, the production of methanol, the product gases require shifting. Thus, the downstream shifting requirements will be reduced by the degree of shifting which takes place in the gasifier.

The Westinghouse, the Saarberg/Otto and the KGN gasifiers all are capable of operating at higher pressures than the originally proposed B/W Gasifier. In general, studies for the production of methanol from coal, show that there is an overall economic advantage to operate at gasification pressure at the reported expected operating pressures of the 400-500 psi when producing methanol.

While the use of a Westinghouse, Saarberg/Otto and a KGN will effect the details of the conceptual design, the proposed process scheme will remain unaltered. The degree of modification required, will be determined by the gasifier that is finally selected.

TABLE 1

COMPARISON OF GASIFIER DESIGN PARAMETERS

	NEPGAS Basic Study	Westinghouse	Saarberg/Otto	KGI
Gasifier Feed Requirements				
Coal	4,432	3,915	4,290	4,64[illegible]
Oxygen	3,866	2,860	3,580	2,368
Gasifier Product (Mole %)				
Composition (Dry)				
CO	72.60	44.72	76.7	20.[illegible]
H_2	17.68	36.32	18.7	47.8[illegible]
CO_2	5.67	17.98	3.4	26.[illegible]
CH_4	-	0.24	0.2	4.1[illegible]
H_2S + COS	0.36	0.29	0.3	0.3[illegible]
Inerts	3.69	0.45	0.7	1.0[illegible]
Flow MPH (Dry)	24,678	27,518	23,375	32,8[illegible]
Pressure	200	400 (1)	500 (1)	450

(1) Pressure used in gasifier study based on reported expected operating range.

From the standpoint of operational requirements it is expected that a gasifier change-out will not increase the raw material and operations costs of the project. This study indicates that these may be a reduction, however, an indepth study on the selected gasifier will be required to fully define the improvements.

While the study did develop capital requirements a number of generalized conclusions can be made.

- o From the previous discussion, the coal oxygen and process related facilities required to produce methanol synthesis gas are expected to either remain the same or decrease. This represents approximately 45% of the original estimated capital investment.

- o The product, maintenance, and service related facilities can be assumed to remain the same as they are in essence independent of the gasifier selected. This represents 21% of the original estimated capital investment.

- o The gasification section represents 18% of the original estimated capital investment.

- o Support related facilities represent 16% of the original estimated capital investment.

These values have been tabulated in table II.

From the above, it appears reasonable to assume that approximately 80% of the original estimated investment would remain uneffected if the B/W gasifier were to be substituted by the Westinghouse, Saarberg/Otto or the KGN Gasifier.

Generalized studies have placed the cost of the gasifier or approximately 15-30% of the total investment cost. The directional effect of the increase in methanol product cost can be estimated from the sensitivity studies made in the NEPGAS Conceptual Study for various gasifier costs (percent of total plant costs). Table III tabulates the expected methanol costs as a function of gasifier and total plant cost.

TABLE II

CAPITAL INVESTMENT ESTIMATE

	($ x 1000)	%
Coal, Oxygen and Process Related Facilities	201,490	45
Product, Service and Maintenance Related Facilities	92,680	21
Support Facilities	73,700	16
Gasifier	82,130	18
Total	450,000	

TABLE III

PROJECTED METHANOL COSTS

Costs in Million Dollars			Gasifier As Percent of Plant	Methanol Costs. $/MM BTU
Gasifier	Balance of Plant	Total Plant Cost		
90	360	450	20%	12.6
120	360	480	25%	12.8
154	360	514	30%	13.9
205	360	565	36%	14.8

TABLE 5-2

EDRC - NEPGAS
CAPITAL INVESTMENT ESTIMATE
(4th Quarter '79 Pricing Level)

Description		($ x 1000)	
CO Shift		21,000	(1)
Air Separation		60,980	(1)
Coal Gasification		82,130	(4)
Raw Gas Compression		5,630	(1)
Acid Gas Removal		73,240	(1)
Methanol (Compression, Distillation, Synthesis)		65,810	(2)
Sulfur Recovery		5,650	(1)
	Sub-Total	314,440	
Coal Handling		34,990	(1)
Raw Water		13,950	(3)
Cooling Water		30,600	(3)
Treated Water/Boiler Feedwater		18,000	(3)
Start-up Boiler		1,690	(3)
Waste Treatment		8,330	(3)
Ash Disposal		1,130	(3)
On-Site Railroad Service		4,140	(2)
Storage (Methanol & Fuel Oil)		2,250	(2)
Maintenance		3,600	(2)
General Plant		16,880	(2)
	Sub-Total	135,560	
	Total	450,000	

(1) Coal Oxygen & Process Related

(2) Product, Service and Maintenance Related

(3) Support Facilities

(4) Gasifier

Gasifier Evaluations and Recommendations

Entrained Beds

KT/KBW

One of the main features of the Koppers-Totzek gasification process is it that it is a commercially proven technology. Although positive consideration was given for its commercial status, our calculations show that the KT/KBW jacket cooled systems require the largest number of gasifiers to produce the required quantity of CO and H_2 needed for the production of 2500 TPD of methanol. This is attributed to the low pressure operation of the system. Along with the low through-put per gasifier, use of the KT/KBW system would require a large product gas compressor before downstream processing of the product gas for the methanol synthesis. Further, the overall carbon conversion and cold gas efficienies are expected to be relatively low as compared to the alternate technologies (See Exhibit II-2A).

For these reasons the KT/KBW jacket cooled systems have been judged not compatiable for the NEPGAS Project.

The KBW tubular cooled gasifier as illustrated in exhibit has similar operating characteristics as the KT/KBW gasifiers such as low pressure operation, low overall carbon conversion and cold gas efficiencies with similar product gas compositions. Although, use of the KBW tubular cooled system would reduce the coal requirements and increase gasifier through-put the disadvantages associated with a low pressure operation and the low carbon conversion and cold gas efficiency make it incompatible for the NEPGAS Project.

Additionally, as stated in the section entitled History, Commercial Status and Availability the KBW tubular cooled gasifier does not have a process devleopment unit to test a representative sample of the anthracite coal considered.

Texaco

To date commercial potential application has been limited to coals with slagging temperatures with an upper range of 2400-2600°F. Temperatures required to slag anthracite coal are beyond the present limitations of the gasifier, refractory wear being excessive at these temperatures.

Potential use of the Texaco system would require an improved refractory system or the addition of a water wall to maintain the refractory at reasonable temperatures.

Alternately, the gasification temperature may be reduced by the addition of a fluxing agent or running in a dry ash mode. Information specific to the design coal is not presently available to evaluate either mode of operation.

While projected operating conditions have been estimated and are given in Exhibit II-2A for the Texaco unit operating is a slagging mode, the Texaco gasifier in its present state of development is not considered as a compatitable gasifier for the NEPGAS Project. The Texaco data presented in Exhibit II-2A, are to be considered the potential projected operating conditions with anthracite assuming the improved refractory system and would require extensive testing and engineering studies to verify.

Shell-Koppers

The Shell-Koppers gasification process has been judged as a viable technology for the NEPGAS Project.

The basis for its recommendations is the suitability of the crude synthesis gas for a feedstock in methanol production. The product gas is virtually free of methane and does not contain any higher boiling by-products requiring extensive gas purification. There is less compression for the methanol synthesis processing section, because of the high pressure operation of the gasifier.

Also, the Shell-Koppers gasifier has a low coal requirement and produces high pressure steam which would improve the effective overall thermal efficiency.

However, discussions with Shell-Koppers indicated that further commercial development efforts of the NEPGAS Project must be addressed before application of their technology can be considered.

Saarberg/Otto

The Saarberg/Otto gasification process, as illustrated in exhibit II-2A, would require the fewest number of gasifiers to produce the desired quantiy of CO and H_2 for use as a methanol feedstock. Further, the Saarberg/Otto gasifier has a high cold gas efficiency and overall carbon conversion with low process steam requirements. While the Saarberg/Otto product gas has a low H_2/CO ratio, it is felt that the relative amount of CO Shifting to provide the required H_2/CO ratio for methanol synthesis will not add considerable costs to the process on an overall basis.

Also, the commercial development efforts of the Saarberg/Otto gasifier have been directed for use with hard coals similar to anthracite which is a definite asset in terms of actual operating experience with this type of coal.

Based on the technical and commercial development efforts the Saarberg/Otto has been judged as a favorable gasifier for the NEPGAS Project.

Fixed Beds Lurgi Dry Ash Slagger

Positive consideration was given both the Lurgi gasification technologies for their high cold gas efficiencies, low oxygen requirements and relatively high H_2/CO ratio which would require less CO Shifting than the alternate technologies.

Although the Lurgi Dry Ash does not have these positive operating characteristics it has the largest coal requirement and a high steam consumption to keep the ash below the fluid temperature. Also, the Lurgi Dry Ash requires extensive gas purification to eliminate the by-products produced. Therefore, the Lurgi Dry Ash has been judged not compatible for the NEPGAS Project requirements.

For the required quantity of CO and H_2 the Lurgi Slagger requires less coal, has lower steam and oxygen requirements and fewer gasifiers when compared with the Lurgi Dry Ash. Similar to the Lurgi Dry Ash, the Slagger requires extensive gas purification.

Calculations indicate a considerable improvement over the Dry Ash operations and although the Lurgi Slagger would require coal characterization tests to validate the results illustrated in exhibit II-2A, it has been judged as a possible alternative for use in the NEPGAS Project.

KGN

The KGN gasification process as illustrated in exhibit II-2A, has a high cold gas efficiency and the highest H_2/CO ratio, when compared to the alternative being reviewed.

This high H_2/CO ratio would result in a reduction in the relative costs associated with the CO Shift processing section needed to meet feedstock requirements for the methanol synthesis.

The main advantage of the fixed bed KGN gasifier is that the synthesis gas is free from the higher boiling hydrocarbons such as naphtha, tars, and oils when compared to the Lurgi units. The ability of a fixed bed system to produce a synthesis gas free from higher boiling hycrocarbons eliminates the gas purification section required to recover these by-products. Further, the gasifier operates at high pressure which is favorable in terms of product gas compression required in the methanol synthesis section.

The unfavorable features are the high coal requirements and steam consumption inherent in a fixed bed, dry ash gasifier.

To assure the total use of the proposed feedstock of anthracite coal and culm it would be advantageous that the gasifiers selected have the ability to handle coal fines. This requirement has normally eliminated consideration of fixed bed gasification systems for their inability to utilize a finely graded coal. However, KGN/PVC GmbH has demonstrated, through the use of a coal biquetting process their ability to successfully gasify coal fines. Further, their developmental efforts have been directed, by order of the Ministry of Economics of North-Rhine, towards utilizing the West Germany resource of hard coals.

It is Ebasco's judgment, because of the experience with hard coals similar to anthracite, ability to gasify coal fines and favorable process operating characteristics, that the KGN gasifiers advantages outweight it disadvantages and would be a suitable gasification system for the NEPGAS Project.

Fluidized Bed

Westinghouse

One of the design criteria for the Westinghouse gasification system has been that the gasifier be able to handle a wide variety of coal feedstocks. Over the years laboratory and pilot scale tests have demonstrated that coals ranging from low grade lignites through high grade bituminous coals can be gasified efficiencly and produce a high quality low or medium Btu gas. Westinghouse, however, has not yet evaluated anthracite coal as a gasifier feedstock. As such, the design of a system based upon anthracite coal would be outside of Westinghouse's current experience spectrum.

Westinghouse, however, believes that its process can successfully gasify an anthracite feedstock based upon the successful use of coke and coke breezes during several pilot plant tests. This experience may be directly applicable, however, due to differences in coke characteristics, some laboratory tests will be required to allow the undertaking of a reliable conceputal design which can then proceed to a detailed design.

Therefore, Westinghouse has proposed that a series of coal characterization tests be undertaken to better define the gasifier's projected operability when using anthracite. These tests performed primarily at the Waltz Mills R&D Center will address outstanding questions. Primary among these questions is the impact of a low reactivity feedstock with high ash fusiblility temperatures upon gasifier operating conditions, product rates, and overall system efficiency. These laboratory tests which include chemical analysis, and a proprietary analysis procedure for determining reactivity characteristics will require about 50 pounds of representative sample. It is important that the sample be collected according to standardized sampling procedures and that a chronology of the sample beginning at the time of mining be provided.

Westinghouse has advised that the coal characterization tests and engineering analysis to provide sufficient information to allow a decision to be made to proceed to a preliminary engineering design for a specific project would cost approximately $15,000.

To determine the comparative merits of the Westinghouse System Ebasco made a preliminary heat and material balance of the system based on available literature data. The results of the analysis are given in Exhibit II-2A.

Based on this analysis the Westinghouse gasification system has a relatively high cold gas efficiency and overall carbon conversion producing a synthesis gas suitable for methanol production. The Westinghouse gasifier also has the lowest coal consumption requirement and would not require pretreatment drying of the coal.

The Westinghouse gasification system for both its process operating characteristics and commercial devleopment efforts would be a favorable gasifier for the NEPGAS Project.

HISTORY, COMMERCIAL STATUS AND AVAILABILITY

Currently the only gasification processes under review that are, commercially proven, on-stream technologies are the Koppers-Totzek and Lurgi Dry Ash units. The remaining systems (except the KBW) do have process development units which are operating and testing the broad spectrum of coals ranging from anthracites to lignites. These test will serve in obtaining process data, maximum plant through-puts and conversion efficiences for the different coals. The knowledge gained will serve as the basis for design, construction and operation of commercial scale gasification plants as energy and raw material suppliers.

Presented is a brief summary of each technologies achievements, and its efforts towards commercial readiness of their perspective gasification systems.

ENTRAINED BED SYSTEMS - KOPPERS-TOTZEK

The Koppers-Totzek gasification process was first introduced in the United States in 1948 at the Bureau of Mines Coal-To-Oil Demonstration Plant at Louisiana, Missouri. Since that time it has had a reputation as the only current commercially proven, entrained-type gasification process. It is used in some 13 plants throughout Europe, Asia and Africa. There are no gasification plants in the U.S. Feeds ranging from coke, oven gas, residium, lignites and bitumious coals have been and are being gasified to produce a feedstock predominantly for ammonia.

TEXACO

Texaco's process for coal gasification is an outgrowth of its partial oxidation of heavy petroleum fractions to produce hydrogen.

Texaco operates a process development unit in Montebello, California, which is rated at 15 TPD of coal fed, operating at 40 atmospheres and temperatures above the ash slagging point.

Two other Texaco units are also in operation, Ruhrkohle of West Germany started up a 150 TPD plant in 1978 which is now testing various coal feedstocks and slurry concentrations and Tennessee Valley Authority is operating a unit rated at 200 TPD of coal which came on stream in October 1980. The Tennessee Eastman Project, of disclosed capacity is in the stage of equipment construction and erection. Also, Southern California Edison has in the design stage a 1000 TPD unit which is scheduled to come on stream in 1984.

SAARBERG/OTTO

The first pilot-plant Rummel/Otto single-shaft gasifier was installed by Union Krafstaff at Wesseling, West Germany, in 1950 , producing a medium Btu synthesis gas using oxygen as the gasification agent feeding 250 TPD of coal. In 1960, Dr Otto designed an improved version of the single-shaft gasifier installed at Wesseling which operated for 18 months. In 1964, the entire coal gasification plant was shut down in favor of steam-naphtha reformers for SNG production.

The most recent development of the Saarberg/Otto gasifier is a 250 TPD development unit which came on stream in December, 1979. The major funding for this project (70 percent) was undertaken by the German governments Ministry of Research and Technology with Otto and Company in a joint-venture with Saarberg Werke providing the remaining 30 percent.

SHELL-KOPPERS

The Shell-Koppers gasifier is an offshoot of the Koppers-Totzek unit which utilizes a high temperature and pressure operation. Shell has been using its experience with high pressure oil gasification to design and develop a system that combines the advantages of entrained-bed gasification and high pressure operation, enabling a wide variety of coals to be converted to a low methane content gas.

A Shell-Koppers unit began operation in 1976 in Amsterdam feeding 6 ton per day of coal which in turn led to a 150 TPD unit developed by Krupp-Koppers at the Hamburg refinery of Deutsche Shell A.G. near Hamburg,the plant is fully owned by Shell A.G. The Plant started producing a synthesis gas in November 1978 and achieved over 250 hours of operation by mid 1979.

Shell also plans to build a 2000 metric-ton per day demonstration plant, due for completion by 1985. It would produce synthesis gas only, although, there are plans to process this into methanol from 1986 onward. Plans also call for a second-phase expansion of 5000 MT/D capacity by 1992, rising to 17,000 MT/D by 1998. Total investment is estimated at $1.7 billion.

Also, Shell Netherlands expects to start construction of a 1000 TPD coal gasification plant by late-81 in Holland.

KBW - WATER JACKET/TUBULAR

The KBW gasification unit is culimination of technologies and experience developed by Koppers-Totzek and Babcox-Wilcox.

Although the units are based on the technologies of Kopper-Totzek and Babcox-Wilcox, they have not build a demonstration unit for either the water jacketed or tubular cooled systems. The water jacketed system is essentially a replica of the Koppers-Totzek gasification unit and KBW feels that they do not have to build a demonstration unit because the technology is already proven. As for the tubular cooled system the gasifier is similar in design to the Babcox-Wilcox gasifi which they also feel does not need a demonstration unit to prove the technology. This unit will operate at conditions similar to the Dupont demonstration unit described in the Conceptual Study.

KBW, offers and guarantees both systems for commercial scale operations, operated at atmospheric pressure, and will build, but not guaranqee units operated at higher pressure.

FIXED BED SYSTEMS - LURGI SLAGGER

The Lurig Slagger is the result of the joining together of the British Gas Corporation and Lurgi Company technology. Since 1974, the British Gas Corporation, under the sponsorship of fifteen U.S. companies, has been testing the process at Westfield, Scotland. The pilot plant at Westfield has gasified over 50,000 tons of coal. The U.S. coals tested include Pittsburg 8 and Ohio 9 which are strongly caking and high swelling coals having moisture and ash contents in the range of 1.4-14.7 and 11.5-20.8 weight %, respectively. These tests have shown no appreciable performance differces between weakly caking and strongly caking high volatile bitminious coals.

There are two projects in the design stages utilizing the Lurgi Slagger technology

LURGI SLAGGER (CONTINUED)

The Conoco Coal Development Company expects to have complete engineering design my mid-1981 of a 3800 TPD unit and British Gas Corporation plans to begin operation of a 600-800 TPD unit by 1982. The Conoco project is also uncertain because of funding.

LURGI DRY BOTTOM

The Lurgi dry bottom is the best known commercially proven gasification process. The first work dates back to 1936 and since 1961 it has operated on a large scale at several locations to produce, town gas, synthesis gas and low Btu gas, using sub ituminous, lignite and anthracite coals.

The most recent concept being test is the Lurgi Ruhr-100, which incorpoates the following two improvements:

- o Operates at 100 atmospheres versus 35 atmosphers for the Lurgi/Mark IV, presumably inabiling it to increase gasifier through-put.
- o A second gas stream containing none of the tars is withdrawn from the middle of the bed, reducing the problem of tar removal from the primary gas stream.

The project started up in September 1979 with initial operation of 75-170 TPD of coal feed and a pressure of 25-40 atm, work is being done by Ruhr-Gas in Dorsten, West Germany.

The other projects in the demonstration stage are a 1700 TPD unit, operated by KDV-Plant in Lumen, West Germany where changes are being made to improve efficiency. Satisfactory operation has been achieved. A 14,000 TPD plant using lignite coal is being planned by Great Plains Gasification Associates, Mercer County, North Dakota which has recently received a loan guarantee from Synfuels Corp.

KGN

The Kohlegas Nordrhein GmbH (KGN) pilot plant was built in six months between September 1978 and February 1979, and was thereafter taken into operation. During this period, minor difficulties in connection with the coal locker, the recycling tube for the low-temperature carbonization gas, and the driving mechanism of the grate, have been experienced. These difficulties have, however, been overcome.

Since October, 1979, the plant has been operating successfully and according to plan. Test runs since March, 1979 total approximately 5000 hours of operations and include two uninterrupted periods of 1000 hours duration. These demonstrated that a tarfree gas can be produced from coal in the KNG gasifier.

During test periods so far, more than 3000 metric tons of coal have been gasified.

FLUIDIZED BED - WESTINGHOUSE

Westinhouse has been engaged in the development of the pressurized fluidized bed unit since 1972 which has resulted in a single-stage air or oxygen-blown process.

Beginning in 1975, the Energy Research and Development Administration and the Coal Research Institute with the Department of Energy have directed the program toward the development of a medium Btu, oxygen-blown process.

WESTINGHOUSE (CONTINUED)

Currently, work is being carried out in a 15 ton per day process development unit (PDU) at Waltz Mill, Pennsylvania, which has over 7,000 hours of operation. Based on the pilot plant operation and design evaluations available. The process has been considered for commercial plant design by the following firms.

- NASA/Lewis Research Center
- Gulf States Utilities
- Fluor Engineers and Constructors, Inc.
- Westinghouse Lamp Division Plant
- Gas Research Institute

A feasibility study for a Coal-to-Methanol Project has been recommended for funding and the Department of Energy is planning to award a contract to Westinghouse Electric Corp. The Keystone Methanol Project would use Pennsylvania coal to produce methanol at a site in Cabmria-Somerset County using Westinghouse pressurized fluidized bed technology. The feasibility study is planned for twelve months. Long range plans anticipated a 10,500 bbl/day prototype plant on stream by 1985, with the potential for increasing capacity to 100,000 bbl/day.

Further, The South African Coal, Oil & Gas Corp (Sasol) and Westinghouse Electric have agreed to build a commercial scale 1,200-t/d coal gasification system at the Sasol-II coal-based synthetic fuels complex in Secunda, South Africa, by 1983, the South African Consulant General said

Under the agreement, Westinghouse will supply and install a U.S.-built demonstration gasifier using the pressurized, fluidized-bed system it has developed over the last 11 years.

Process Descriptions

For the gasification processes under review, is a brief summary describing the coal preparation, gasifier feeding, gasification, and waste heat recovery units utilized in each particular system is presented. The process descriptions while not directed to a specific coal, serve to give a general overview of the difference methods used for synthesis gas production.

The Koppers-Totzek and both the KBW gasifiers (tubular and water jacket) are presented together owing to the many similarities between the systems.

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Westinghouse

Process Description

The Westinghouse gasification process is a high pressure, dry ash, fluidized bed reactor which utilizes steam and oxygen or air as the gasification media.

Coal Handling and Gasifier Feeding

The fresh, unpretreated coal is ground to a 3/16 by 0-inch size or smaller and conveyed by bucket elevator to the coal lockhoppers, which provides feed control through rotary feeders. Load cells monitor the feed rate by providing a continous measure of lockhopper inventory. Recycled product gas is used to transport the coal as well as char-fines recycled from the collection cyclone downstream of the gasifier. The coal is then fed to the gasifier along its center line, where it is combusted in a stream of oxygen and stream through a central feed tube.

Gasification and Heat Recovery

Referring to exhibits II-1B and II-2B, sized coal and recycled fines from the downstream cyclone are transported by recycled product gas and fed to the gasifier combustion chamber along with a stream of oxygen and steam. The oxygen and steam react with the coal and char to form hydrogen and carbon monoxide. As the bed of char circulates through the jet, the carbon in the char is consumed by combustion and gasification, leaving particles that are rich in ash. The ash-rich particles contain mineral compounds and eutectics that melt at temperatures of 1000 to 2000^{o}F. These liquid phases within the char particles extrude through the pores to the surface of the char, where they stick to other liquid droplets on adjacent particles. Ash agglomerates form that are larger and denser then the particles of char in the bed. The agglomerates defluidize, migrate to the annulus around the feed tube and are continously removed by a rotary feeder to the lockhoppers. Recylced product gas or steam is used to partially fluidize the ash and cool it as it is withdrawn.

The raw product gas, containing methane, hydrogen, carbon monoxide, carbon dioxide, gaseous impurities, exits the reactor at approximately 1800°F. A refractory-lined cyclone is used to remove char particles from the raw gas before it is quench-cooled in a quench scrubber that also removes most of the remaing paritculate matter. The char fires collected in the cyclone are pneumatically transported to lockhoppers from which they are reinjected into the gasifier along with the fresh coal. All of the fines collected and recycled are consumed by the combustion, gasification and agglomeration processes within the reactor.

EXHIBIT II - 1B

WESTINGHOUSE GASIFIER

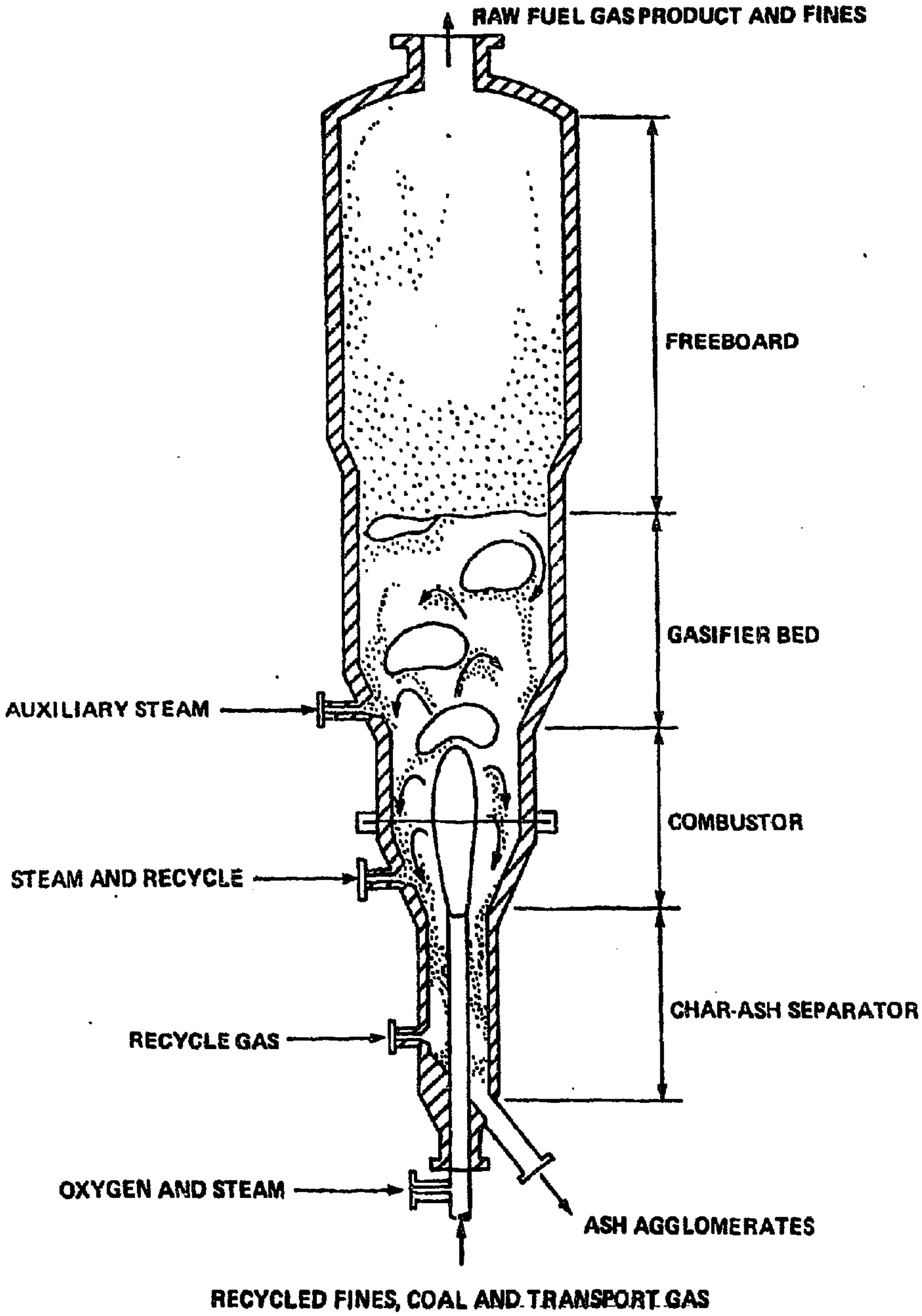

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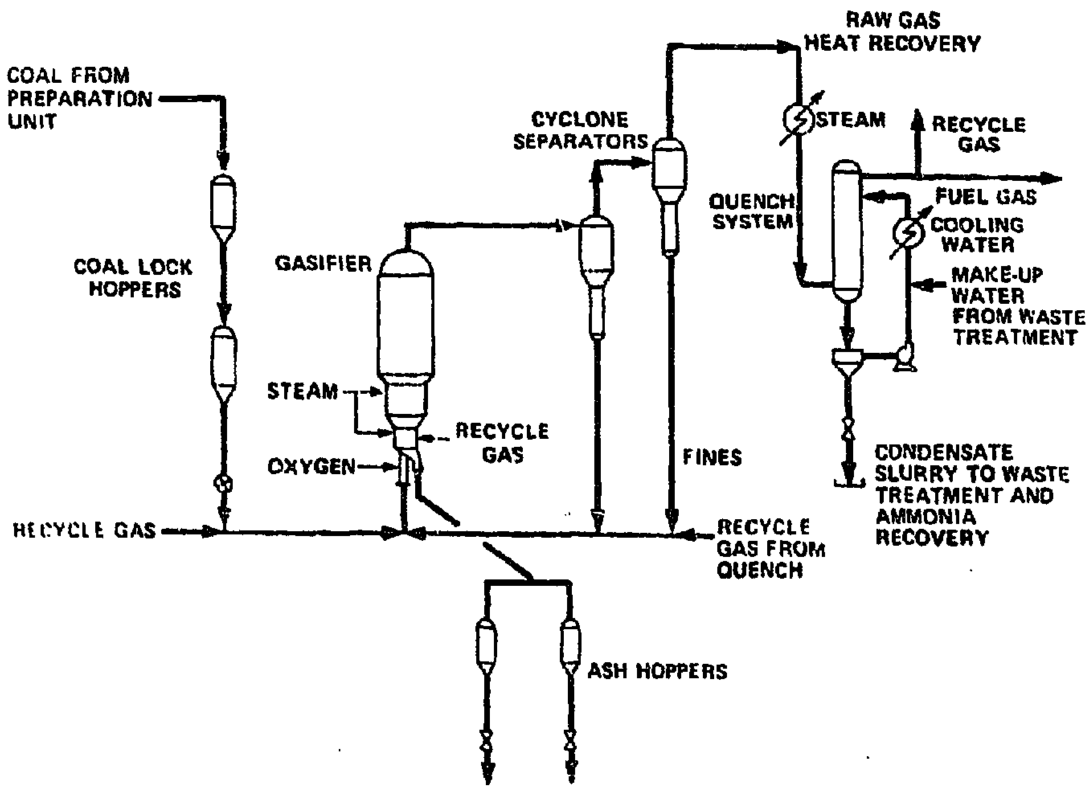
EXHIBIT II - 2B

WESTINGHOUSE PROCESS SCHEMATIC



Lurgi Dry Ash

Process Description

Lurgi pressure gasification of coal is an autothermic, counter current, fixed bed, dry ash process which utilizes mixtures of steam and oxygen, steam and air, or steam and oxygen enriched air as the gasifying medium.

Coal Preparation and Gasifier Feeding

The crushed coal with fines eliminated through screening is conveyed to the coal bunker which is an atmospheric pressure vessel that normally contains approximately a 3 hour supply of coal. Coal then passes to the coal lock chamber through the coal distributor and into the gasifier. Under full load operation, coal supply in the lock is equivalent to about 15 minutes of operation. The lock operation, is therefore, cyclic at this interval. The coal lock is normally pressurized with downstream gases but can also be operated with an inert gas such as nitrogen or a low value by-product gas such as carbon dioxide. The coal distributor is a hydraulically or mechanically operated rotary device through which coal is introduced into the reactor to achieve an even distribution of coal across the reactor cross-section. To accomodate caking coal, blades are mounted on the distributor which rotates within the fuel bed. These blades not only agitage the bed, thereby preventing agglomeration or breaking up agglomerates, but also work to constantly move char from below upwards into the caking zone. The mixing of this recycled char with the caking coal reduces its caking tendency through dilution or leaning.

Gasification and Heat Recovery

Referring to figure II-2B and starting at the bottom of the reactor, the gasification process proceeds as follows. Oxygen required for combustion, and steam for gasification, enter the gasifier through slots in the rotary grate and flow upward through the ash bed. The ash bed helps to distribute the mixture evenly over the entire cross section of the gasifier. The oxygen is completely consumed in a narrow combustion zone above the ash bed where it reacts with the carbon contained in the downward moving char. Upon leaving the combustion zone, the gas is typically at a temperature of about 2200°F. As gasification progresses, sensible heat supplies the required reaction heat and gas temperature falls to the final reaction temperature where the gasification rates become negligible. This temperature depends on the reactivity of the coal and varies between 1200°F for lignite and 1560°F f coke.

Gases leaving the gasification zone are still at relatively high temperatures (1350-1700°F). A significant portion of the sensible heat of the gas is recovered in carbonizing, drying, and preheating the coal as it moves downward in the gasification zone. The gas outlet temperature from the reactor is, therefore, relatively low. It varies between 570°F for a lignite with a high moisture content and 1200°F for coals with a low reactivity and low moisture content.

Starting at the bottom of the reactor, the coal is subjected to the following processing steps. Incoming ambient temperature coal is preheated and dryed by effluent gases. As the coal gravitates downward and its temperature rises, most of the volatile components are stripped from it and eventually recovered as by-products. Then, beginning at a temperature of 1100 to 1380°F, devolatization is accomplished by gasification of the resulting

char. The interaction between devolatization and gasification is a determining factor for the kinetics of the gasification process as a whole. The minimum residence time of a coal grain for good performance of the reactions at the desired temperature level of 1290 to 1650^{o}F is about ½ to 1 hour. Unreacted carbon is finally burned from the ash in the combustion zone and a nearly carbon free dry ash is discharged by the rotary grate referring to exhibits II-4B and II-5B.
The raw gas leaving the reactor is then scrubbed to remove dust and the heavier liquid hydrocarbons produced in the gasifier. Hot gases exiting the gasifier are washed with a circulating stream of impure water referred to as gas liquor. This cools the gas and removes the dust and most of the tar. The temperature exiting the scrubber is such that the saturated gas and gas liquior leaving the scrubber transfers the heat from the raw gas to the waste heat boiler, water of saturation is condensed, resulting in a net production of liquor. This liquor, containing dust and condensed tar and oil, is continously discharged to the gas liquior separation area for recovery of by-products.

EXHIBIT II - 3B

THE LURGI DRY ASH GASIFIER

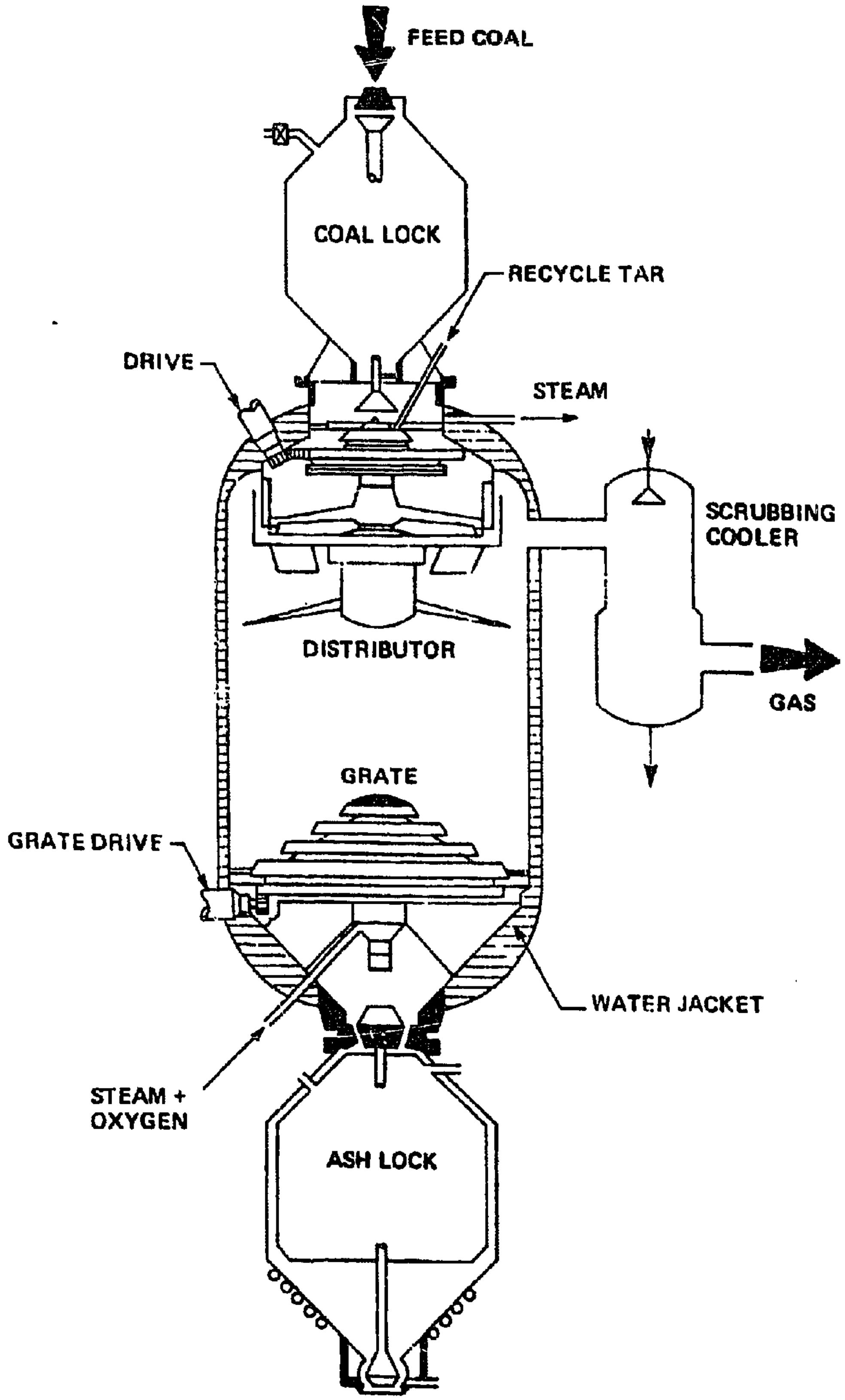


EXHIBIT II - 4B

LURGI COAL GASIFICATION AND RAW GAS SCRUBBING

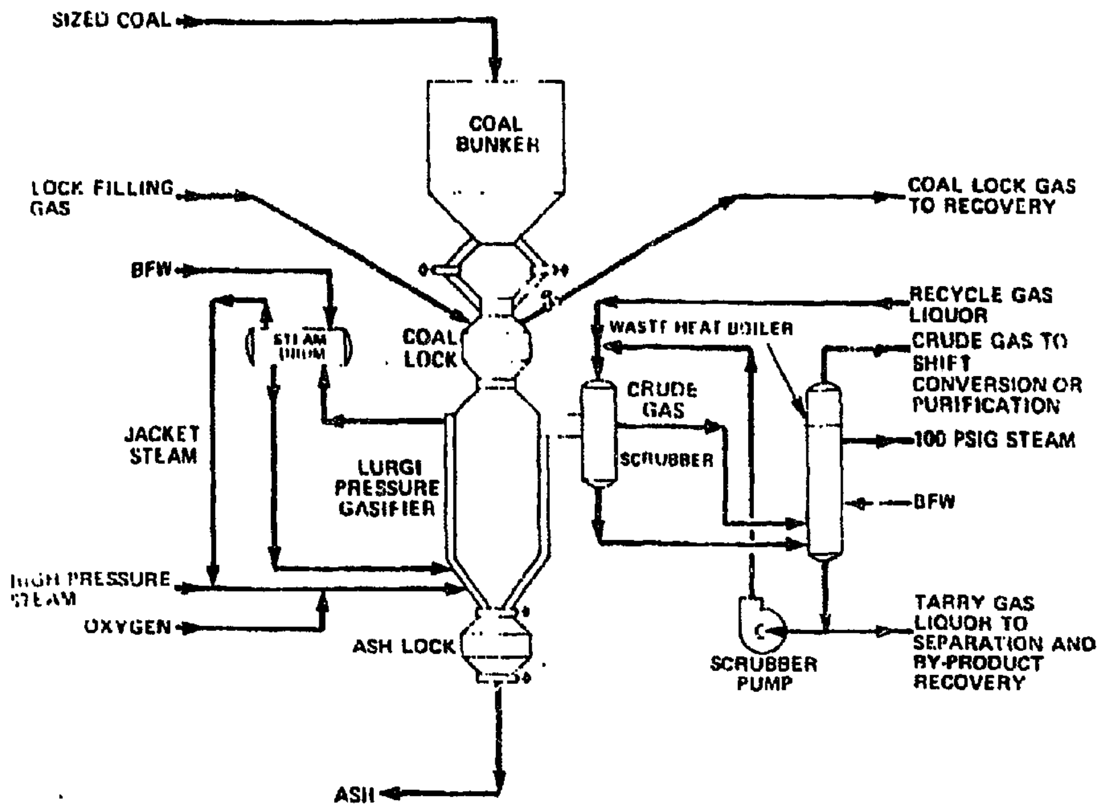


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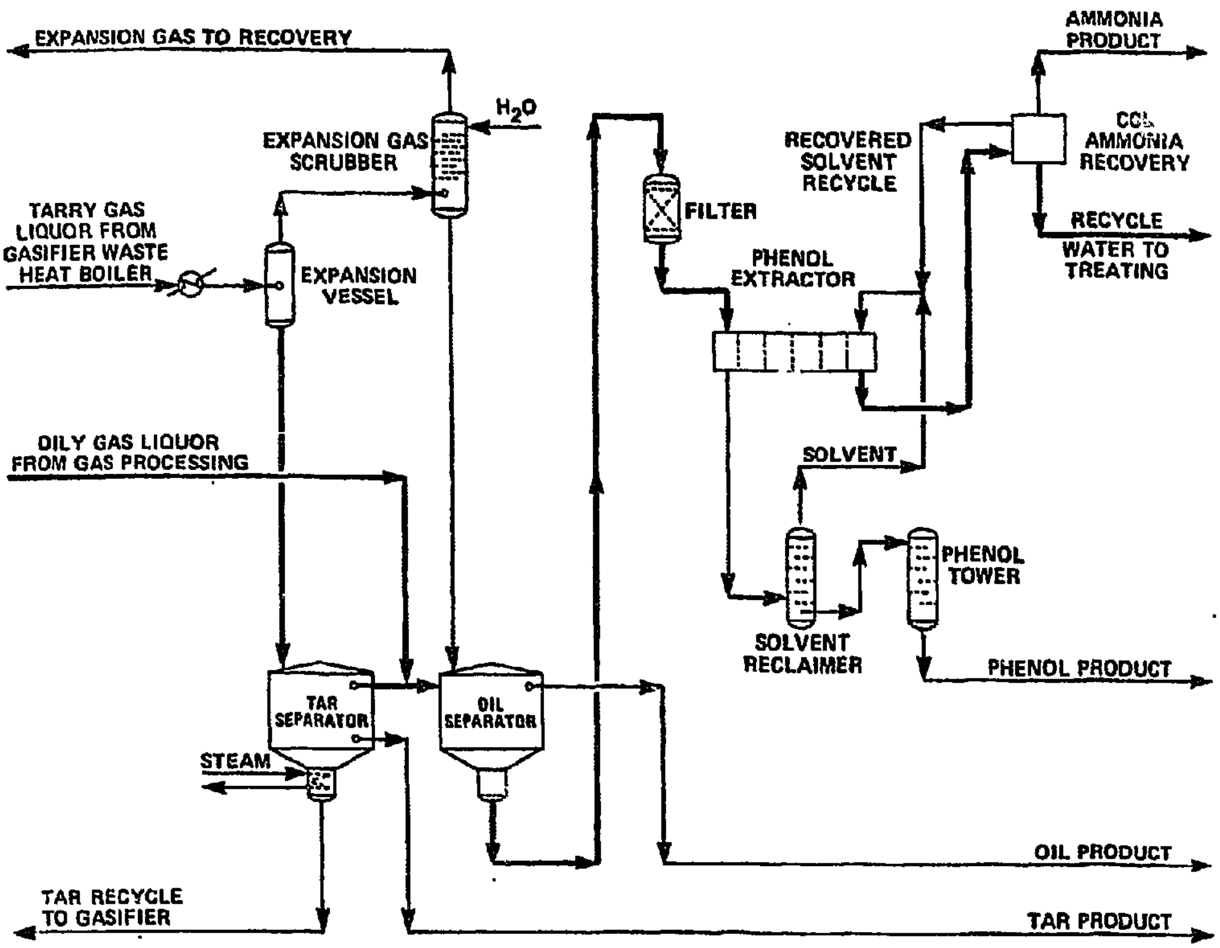
EXHIBIT II - 5B

LURGI GAS LIQUOR PROCESSING AND BY-PRODUCT RECOVERY



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British Gas/Lurgi Slagger

Process Description

The British Gas Slugger is a high pressure, fixed bed, gravitional flow process which utilizes steam and oxygen as the gasification agents.

Coal Preparation and Gasifier Feeding

The crushed, coal is fed from bunkers to the coal lock chamber at the top of the gasifier similar to the Lurgi Dry Ash. The coal leaving the hopper enters a storage volume at the top of the gasifier from which it is delivered by a rotary distributor. This distributor ensures that the coal level in the gasification portion of the gasifier remains constant. Attached to the distributor and rotating with it is a stirrer which breaks up any agglomerates formed in the carbonization zone when using caking coals.

Gasification and Heat Recovery

Referring to Exhibit II-6B, high pressure steam and oxygen pass through flow controls and are blended together and fed to the base of the gasification section through tuyeres entering into the combustion area, where the oxygen is consumed. The gaseous products pass up through the bed with further endothermic gasification reactions occuring until the carbonization region is reached.

The gas leaves from the top of the carbonization zone and pass to the quench chamber where they are cooled by aqueous condensate which is recirculated from the primary gas cooler with make-up from the liquor condensing in the quench cooler and primary gas cooler pass to the liquor separation section. The tar and oils formed can either be recycled and injected through the tuyeres and gasified or can be sold as a by-product. The gas purification section is similar to that illustrated for the Lurgi Dry Ash, Exhibits II-4B and II-5B.

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Referring to Exhibit II-7B, the slag at the base of the gasification section collects in the hearth from which it is discharged through a slag tap hole into the slag quench chamber through which warm water is circulated. .

EXHIBIT II - 6B

THE SLAGGING GASIFIER

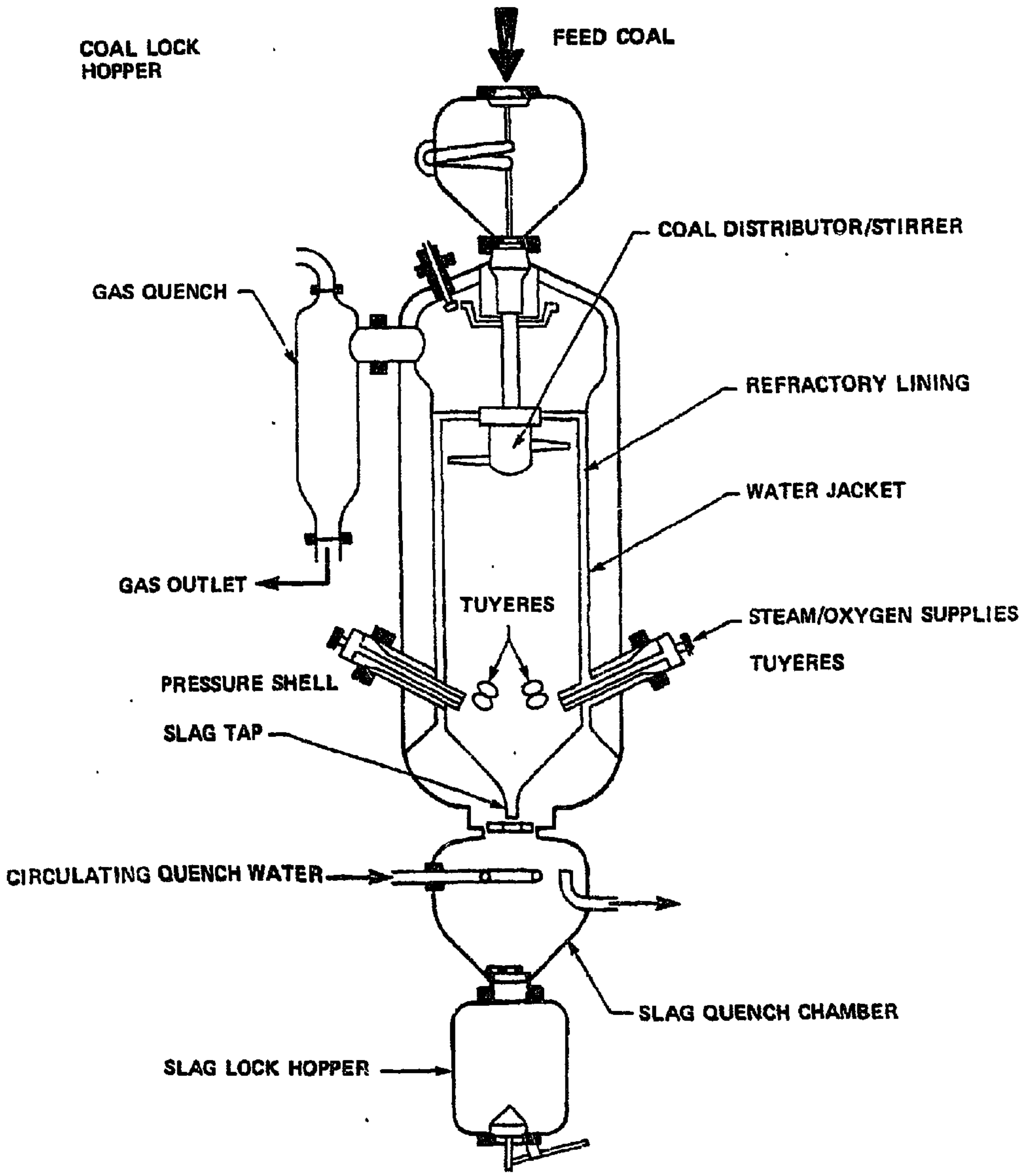
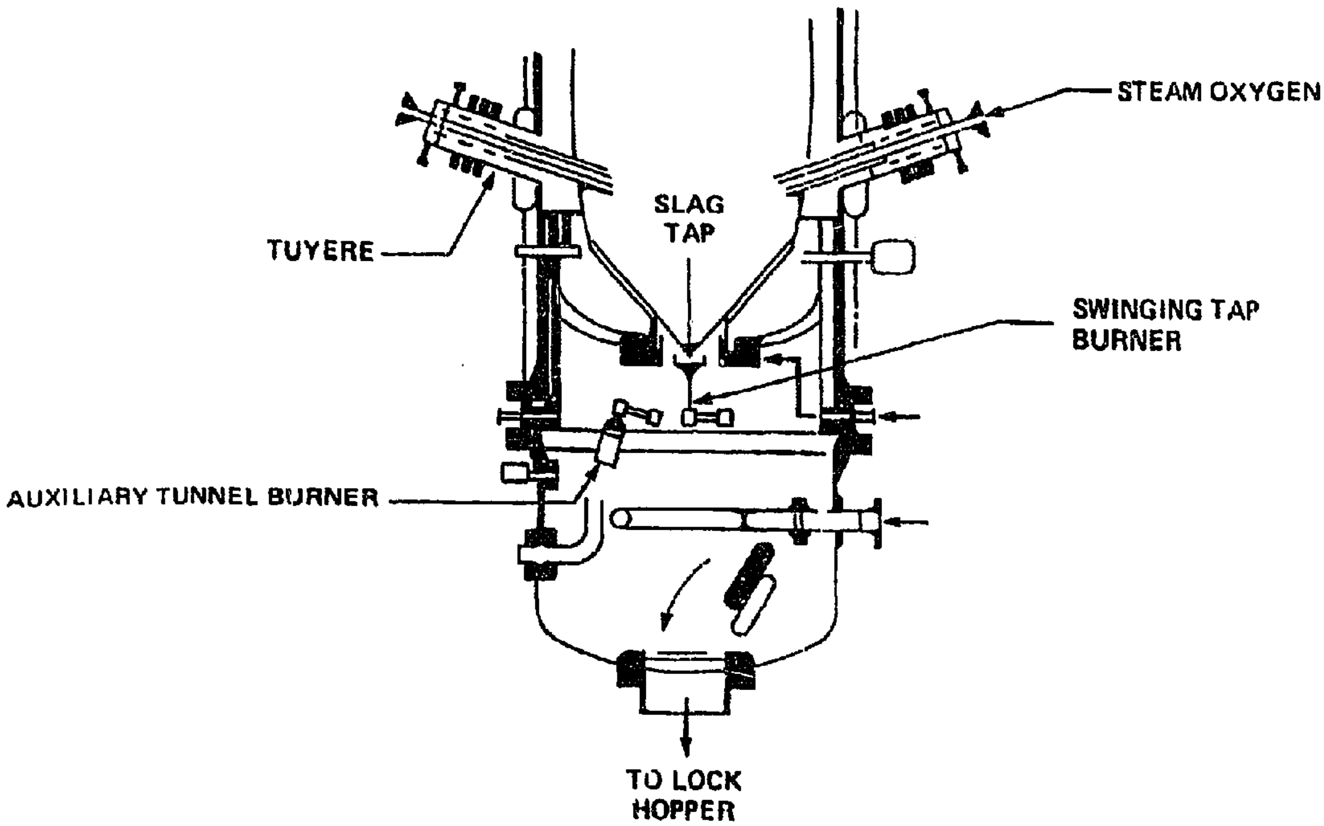


EXHIBIT II - 7B

BG LURGI-SLAGGING GASIFIER SLAG REMOVAL



KGN Continuous Synthesis Gas Process

Process Description

The KNG gasification process is a fixed bed, countercurrent flow high pressure, dry ash unit which utilizes steam and oxygen or air as the gasification media.

Coal Handling and Gasifier Feeding

The coal handling and gasifier feeding system is similar to that described in the process description for the Lurgi Dry Ash. The main difference between the two systems is that PVC GmbH has a coal briquetting process which has been used extensively for anthracite coal fines. A flow diagram of the process is shown in exhibit II-8B, the feature of the process is that wet coal is used, without being predried or preheated. The coal is then appropriately sized and, after preparation of the briquetting mixture, consisting of the components coal, coal sludge, binders and additives, it is shaped into briquettes, the briquettes are subsequently dried and either sent to intermediate store or directly to the gasifier feeding system.

Gasification and Heat Recovery

Referring to exhibit II-9B, the gasification reactor of the demonstration plant consists of a cylindrical steel shell its widest diameter in the gasification zone being 9.5 feet and overall height being about 45 feet. The inside is lined with refractory material and the gasification zone is cooled by a water jacket. The reactor consists of the following parts:

- coal locks
- distillation chamber
- gasification section
- recycling of carbonization gas
- ash removal via rotating grate
- ash lock

In the distillation chamber, the feed coal (lump coal or compacts) is dried, devolatilized and coked. The necessary heat is obtained by sucking-up part of the generated hot product gas by means of the steam injection pump which is located at the top of the gasifier. Owing to the recycling of the carbonization gas, these gases (product gas and volatiles from the coal) are carried under the rotating grate; they are mixed with the remaining process steam and oxygen, then through the ash layer on the grate they are passed into the hot gasification zone where they are cracked into CO and H_2. The generated product is therefore, free of all hydrocarbons such as tars, oils, phenols, etc.

The grate, which is operated from outside, is protected by a layer of ash to prevent overheating. This layer also has the effect of evenly distributing the gasification media over the cross section.

Referring to exhibit II-10B, for the interrelationships in the waste heat recovery section, the crude gas exit the gasifier containing dust particles are removed in hot cyclones at a temperature of about 800°C and then this crude gas is cooled down indirectly to about 280°C. During this process, part of the steam required for the generation of gas is produced. In the next stage, the synthesis gas is further dedusted in a Venture-scrubber. It is then available with residual dust contents of 20mg/m^3 and at a temperature of 200°C for further treatment.

EXHIBIT II - 8B

KGN BRIQUETTING PROCESS

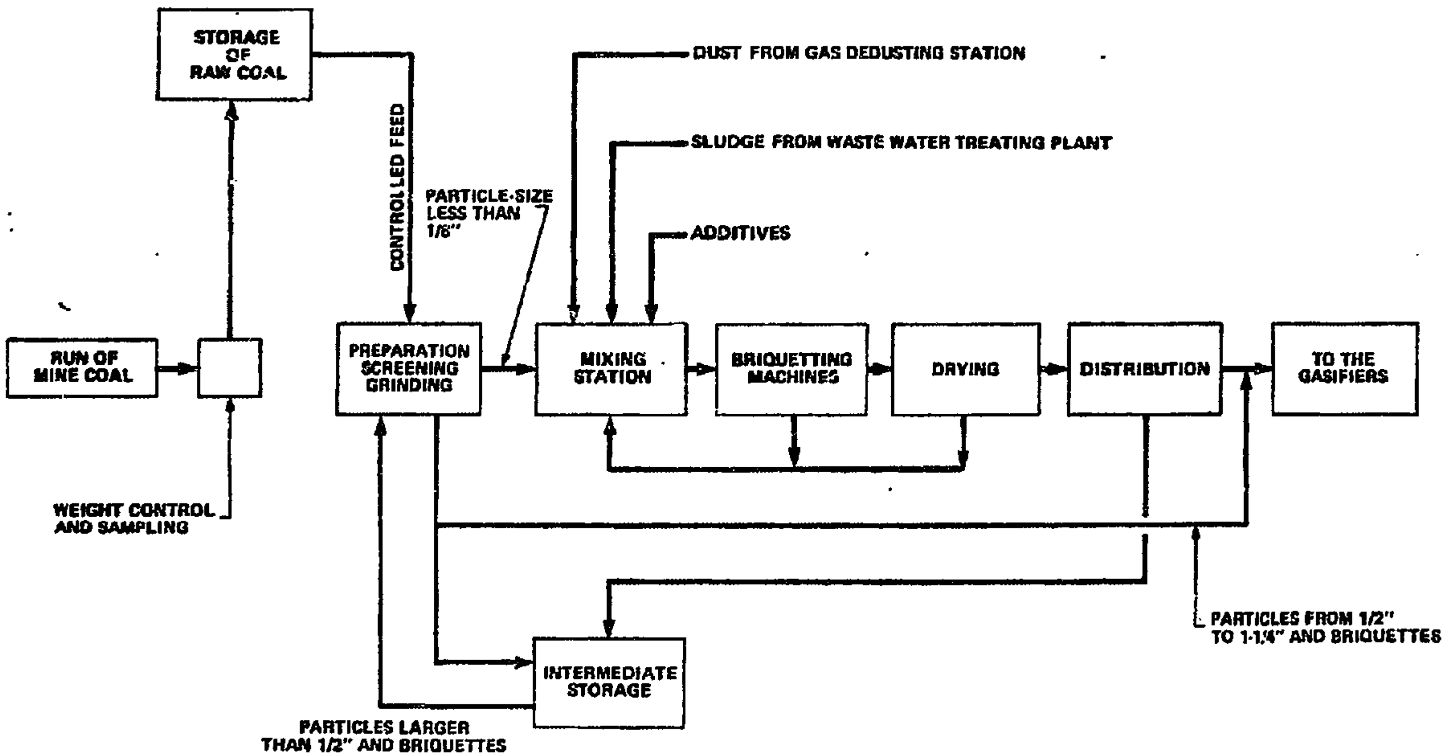


EXHIBIT II - 9B

KGN FIXED BED GASIFIER

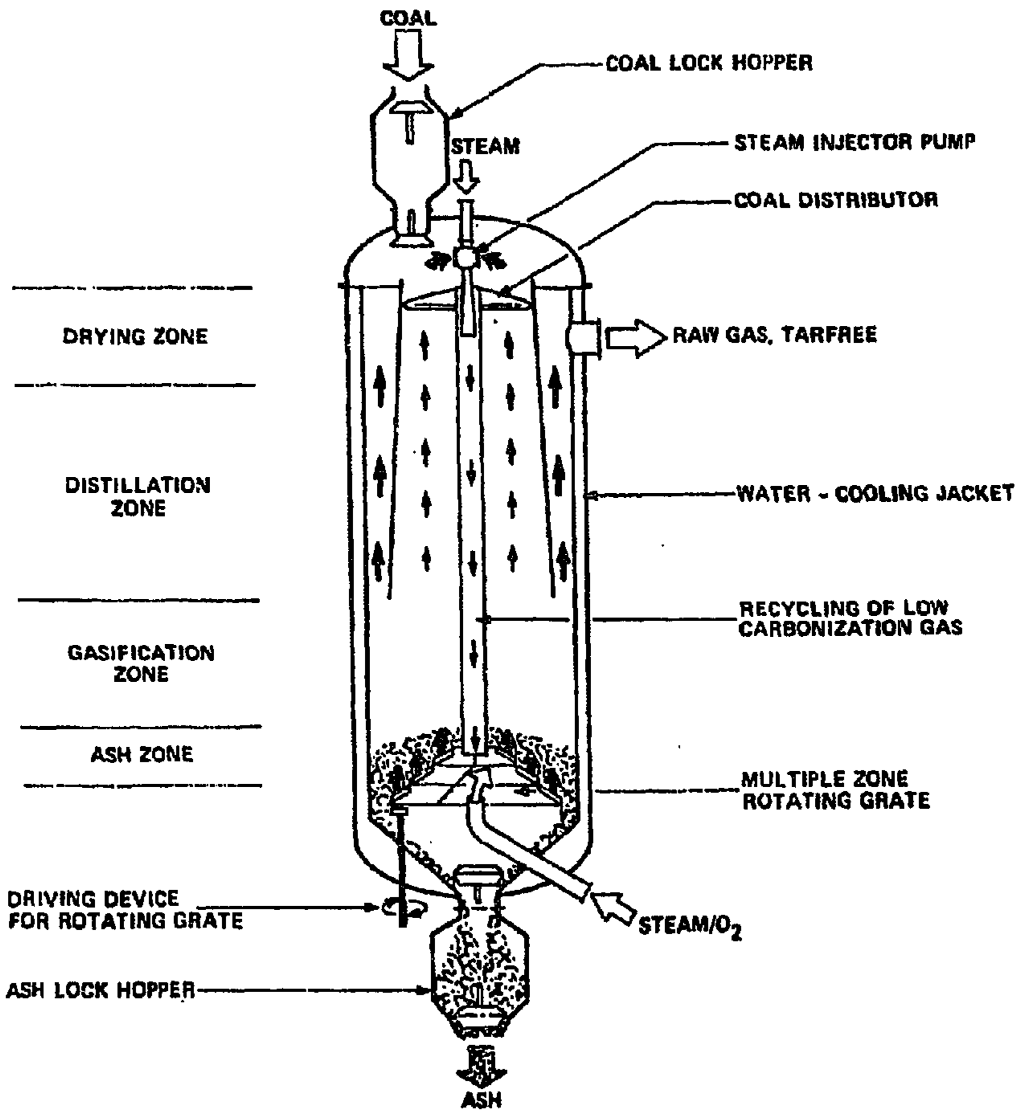
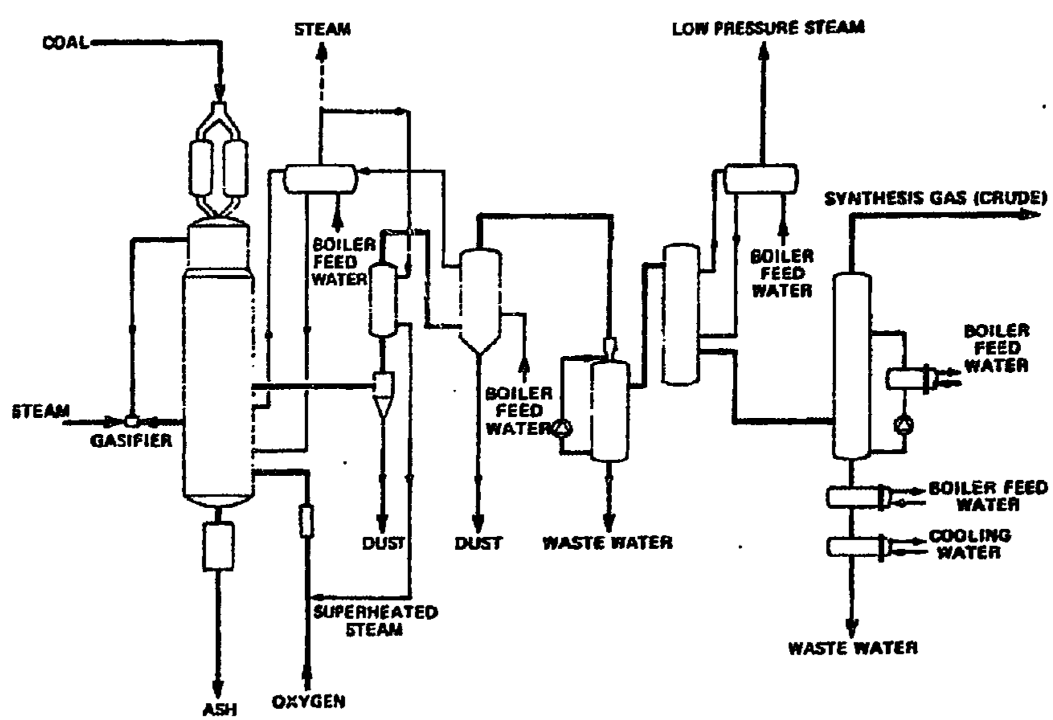


EXHIBIT II - 10B

KGN PROCESS FLOW SCHEMATIC



Texaco

Process Description

The Texaco gasification process is a high pressure, entrained flow, slagging unit which utilizes oxygen and steam as the gasification agents.

Coal Preparation and Gasifier Feeding

The Texaco unit utilizes a coal slurry feed as the charge to the gasifier. The coal preparation system is comprised of coal silos, gravimetric feeders, grinding mills, mill slurry tanks and pumps, vibrating screening, first stage slurry tanks and pumps, and other auxillary facilities to assure the production of a coal slurry feed with the design concentration and particle size distribution. Slurry concentration is usually 55-65 percent solids.

Coal at 1-¼"x0" size is reclaimed from the slurry preparation silo to the gravimetric feeder. It is mixed with the slurry containing water and oversized particles separated by the vibrating screens. The slurry thus formed is discharged into the grinding mill. The grinding mill is a horizontal, cyclindrical, size reduction device that tumbles the material through grinding rods to effect the required size reduction.

When the coal slurry is up to specification it is transferred to the run tank by circulation pumps. The slurry is then charged to the gasifier through a Texaco proprietary burner by charging pumps.

To reduce oxygen consumption the coal slurry is preheated before it is charged to the refractory-lined reactor.

Gasification and Heat Recovery

See the Process Block Diagram Exhibits II-11B and II-12B, for the counter-relationship between the plant subsystems, and for plant effluent streams

The gasifier consists of a steel shell pressure vessel of cylindrical configuration and with a semi-hemispherical heat and bottom. The top section of the gasifier is lined with a special refraction material designed to withstand the reducing atmosphere. The coal slurry is charged into the gasifier with oxygen and is atomized and entrained in the gas flow. The reaction is complete in approximately 10 seconds rising the temperature to about 2300-2600°F to produce a gas consisting mainly of CO, H_2, CO_2. Most of the sulfur in the coal is converted to H_2S_2 the balance being COS. Nitrogen and argon from the oxygen feed appear in the gas together with most of the nitrogen from the coal. The gas contains a small amount of methane and is essentially free of combined oxygen. The unconverted carbon and all of the ash exit the gasifier in the form of slag.

The gas products exit the reactor and can be cooled by either one of the following methods:

1. Gas-cooler/High Pressure-Boiler Mode Exhibit II-13B
   In the gas cooler mode, the gas goes through the radiant heat boiler and the waste heat boiler to generate heat pressure steam. The gas is further cooled in the BFW heater before entering the scrubber for carbon soot particulates removal.

2. Water-Quench/Low Pressure Boiler Mode Exhibit II-14B

   In the water quench mode, the raw gas and slag are quenched in the quench chamber below the gasifier. The raw gas then goes through a venture scrubber and scrubber separator to remove any entrained slag particles.

In both modes, the slag removal systems are identical. Solifified slag is collected in a slag lock hopper which serves also as a pressure barrier. The slag is periodically discharged to a slag sump and removed by scraper conveyer to the disposal area.

EXHIBIT I - 11B

TEXACO COAL GASIFICATION PROCESS
Gas Cooler Mode

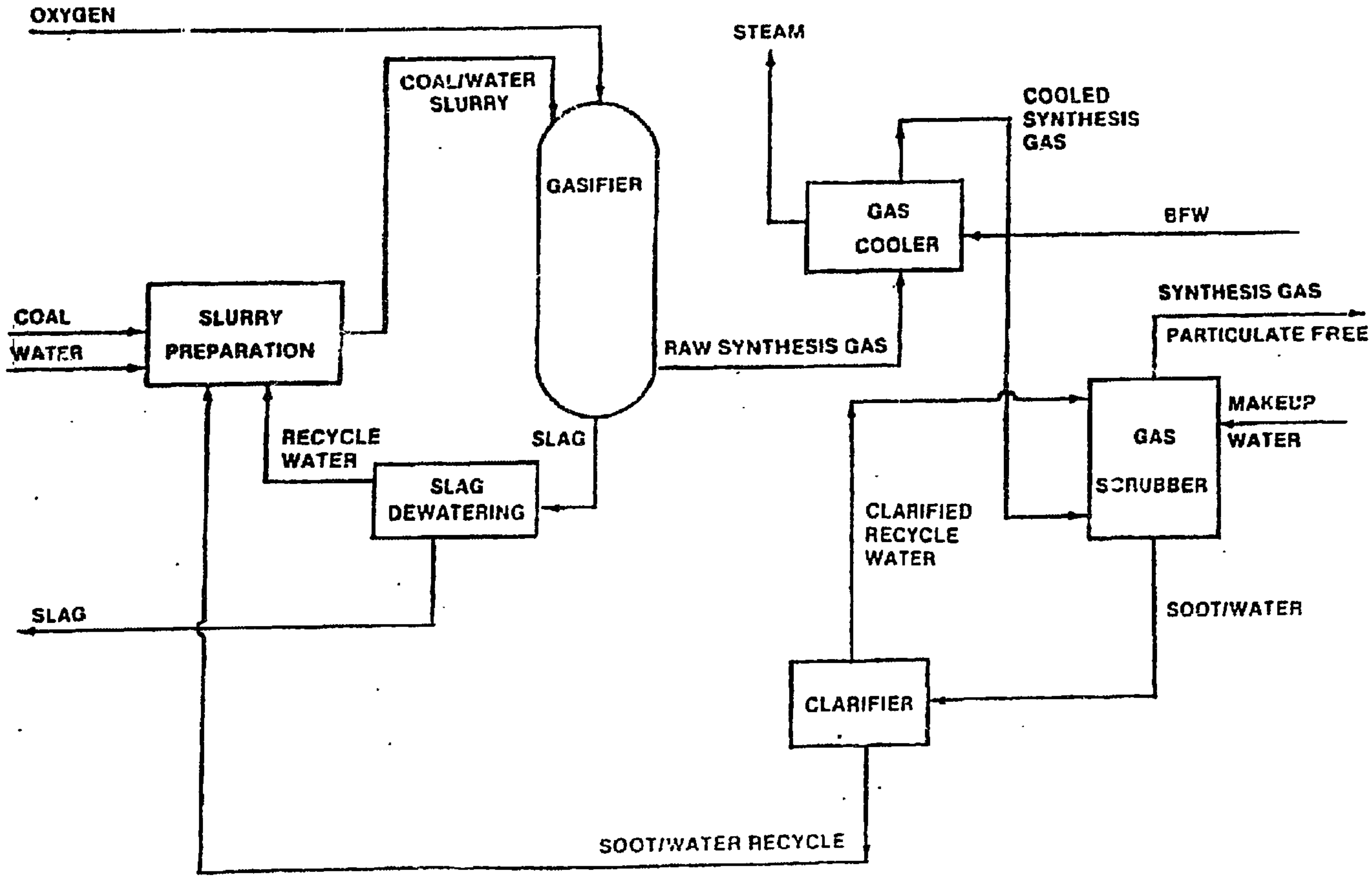


EXHIBIT I - 12B

TEXACO COAL GASIFICATION PROCESS

Direct Quench Mode

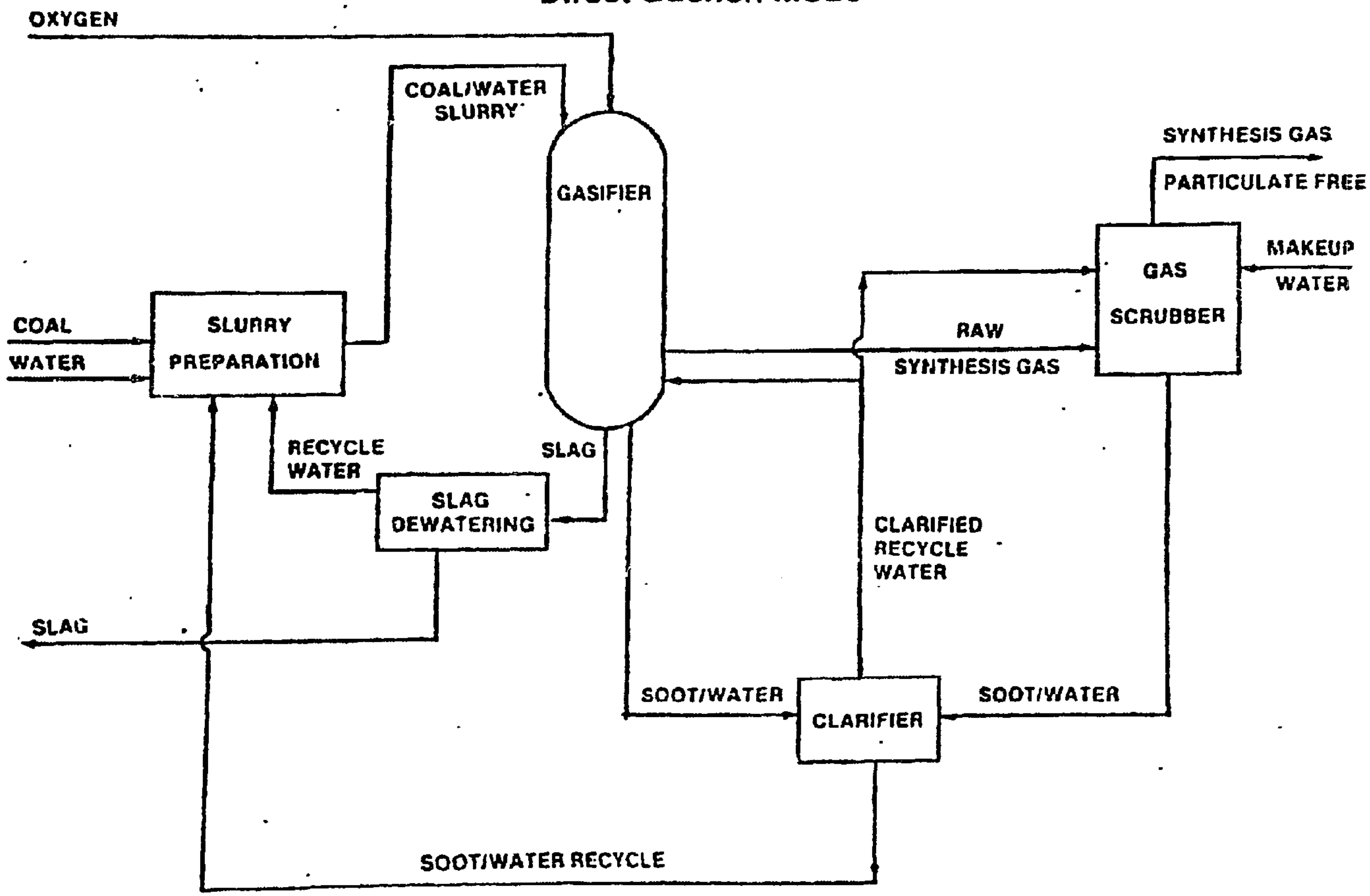


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EXHIBIT II - 13B

RADIANT SECTION OF TEXACO GASIFIER
(Gas Cooler Mode)

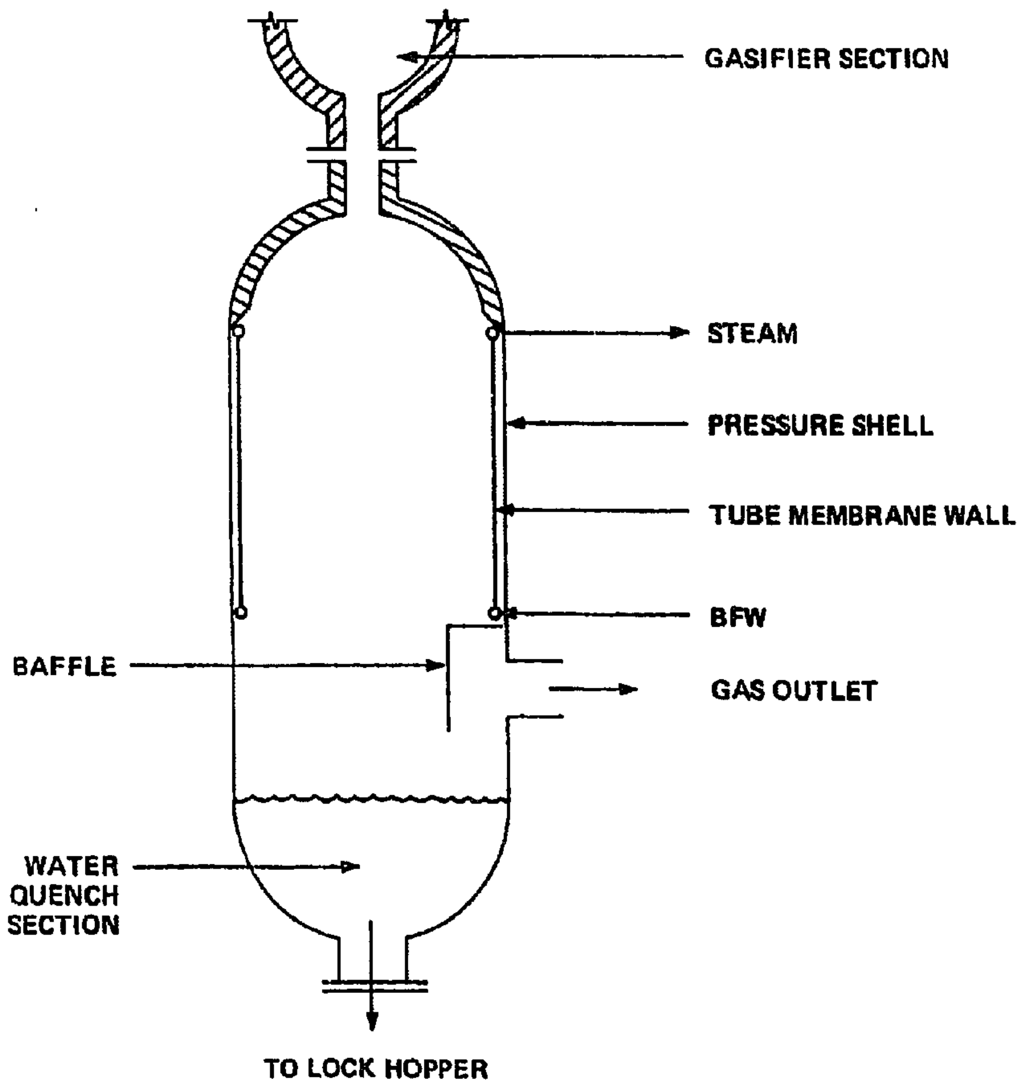
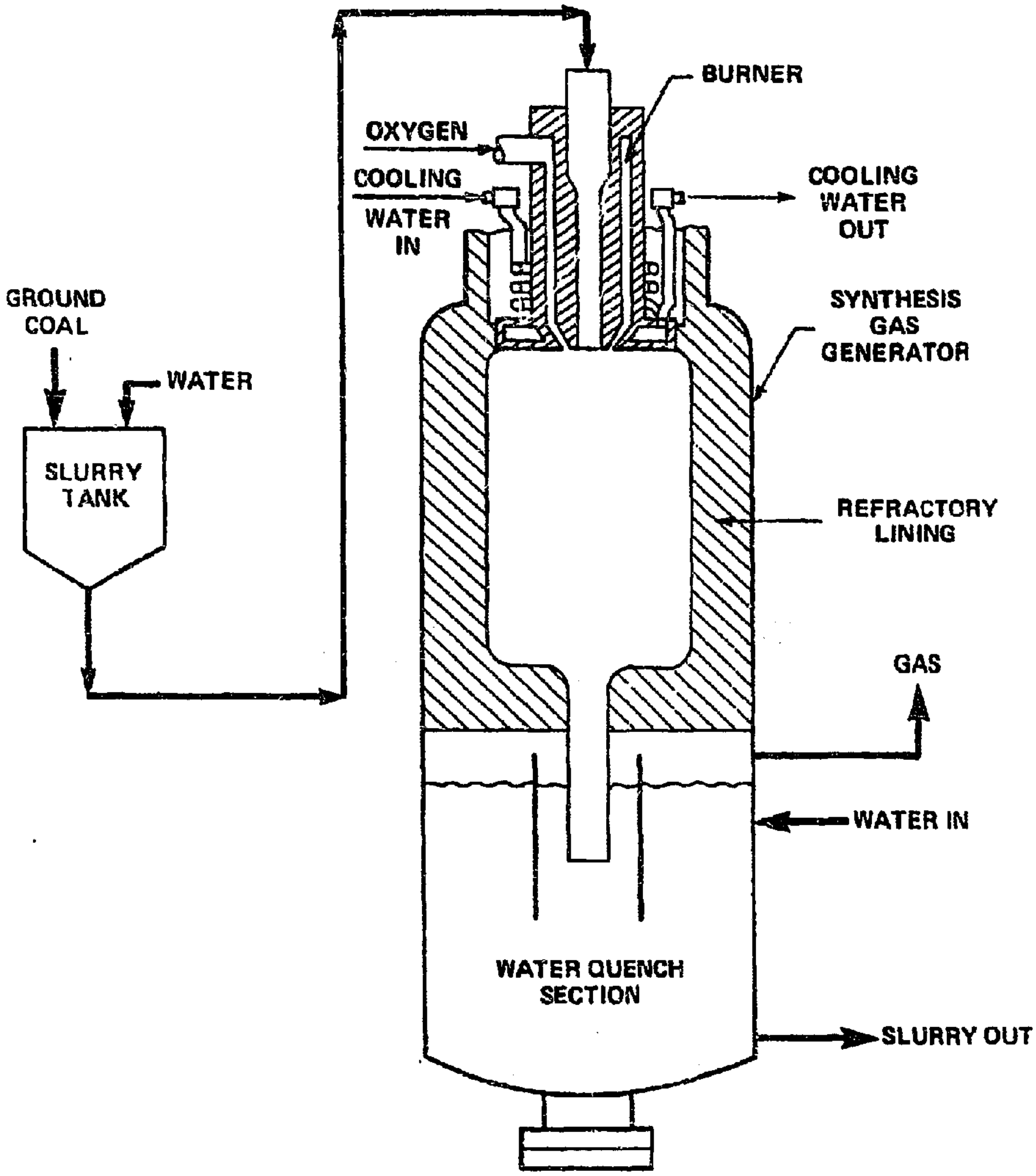


EXHIBIT II - 14B

THE TEXACO COAL GASIFIER QUENCH MODE



Shell-Koppers

The Shell-Koppers gasification process is an entrained bed, high pressure, slagging unit which utilizes steam and oxygen as the gasification media.

Coal Preparation and Gasifier Feeding

Coal is normally crushed and ground to size, where 90 percent is less than 90 microns and dried to approximately 1 to 8 percent moisture content. The dried coal dust is pneumatically conveyed to pressureless cyclone bin to the feed bin, whichis under pressure, usually using nitrogen. From the feed bin, the dust is fed into the reactor chamber cocurrently with oxygen and a relatively small amount of steam.

Gasification and Heat Recovery

As schematically shown in exhibit II-15B, the dried coal is dust fed into the reaction chamber through diametrically opposed diffusion guns and reacts with the gasification media in a flame-like reaction. Flame temperatures can be as high as 1800-2000^{o}C but reactor outlet temperatures will not normally exceed 1400-1500^{o}C.

The reactor is an empty pressure vessel whose wall temperatures are controlled by water cooled tubes in which medium pressure steam is generated. The tubular wall is protected by a thin refractory lining.

As the gasification reactions proceed producing a crude synthesis gas some of the ash is entrained in the product gas. As the product gas approaches the reactor outlet a quench zone is provided to solidify any of the ash particles before entering the waste heat boilers.

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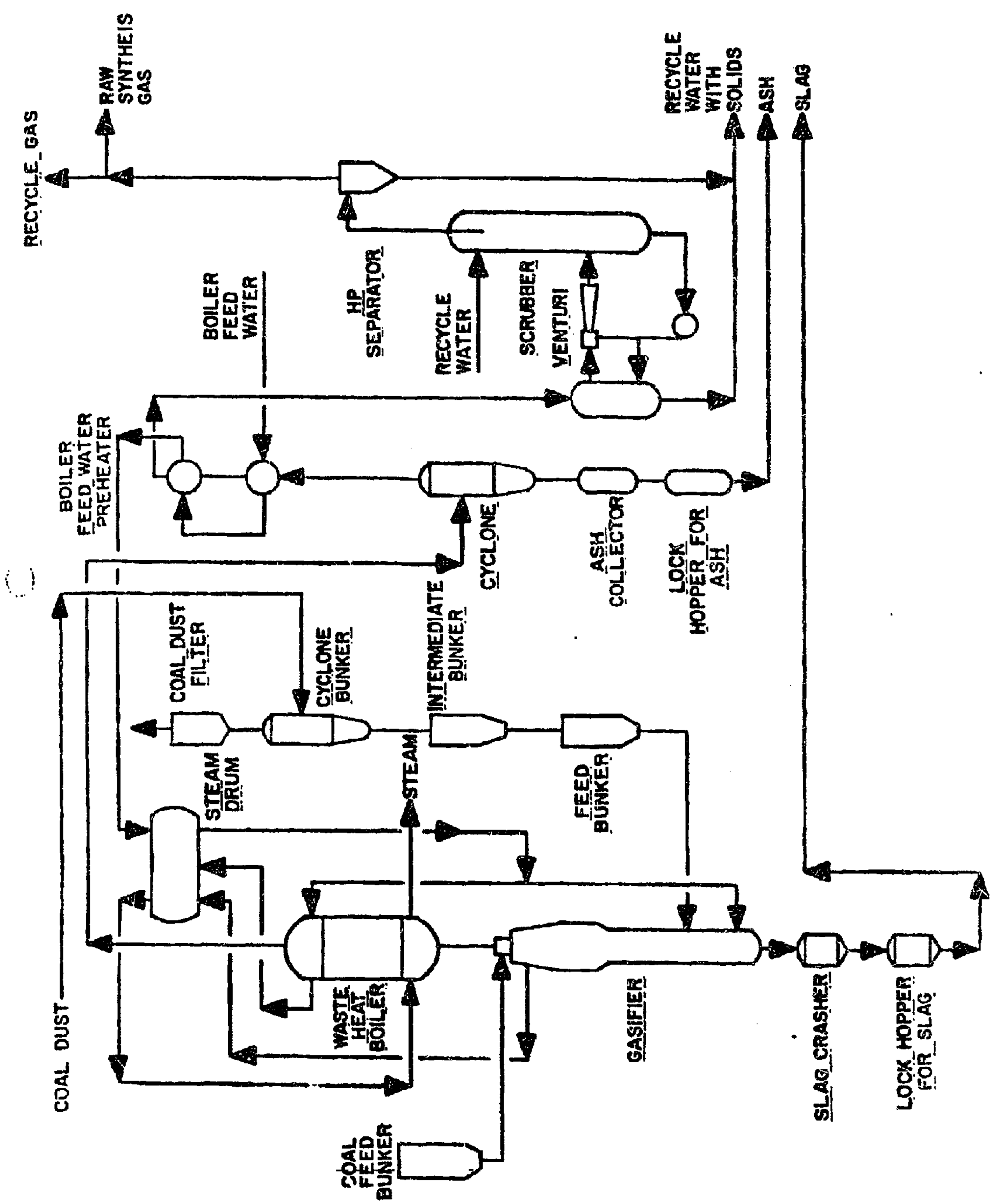
The raw synthesis gas is quenched with either cold recycle gas or a water spray in a narrow zone immediately above the gasification zone. About 90 percent of the particulate matter is precipitated out of the raw gas before entering the waste heat boiler. The gas leaving the at about $320^{o}F$ and is to a proprietary system of cyclones and scrubbers designed to reduce the particulate content to less than $1mb/Nm^{3}$. The system also recovers a large proportion sensible heat by which the gas is cooled to approximately $40^{o}C$.

The molten ash formed in the reactor settles to the bottom of the bed and is collected in a cooling water bath equipped with a crusher to pulverize the quenched slag.

EXHIBIT II - 15B

SHELL-KOPPERS GASIFICATION SYSTEM



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Saarberg-Otto

Process Description

The Saarberg-Otto gasification process is an entrained bed, high pressure, slagging unit which utilizes steam and oxygen, or oxygen enriched mixtures as the gasification agents.

Coal Preparation and Gasifier Feeding

See Process Block Diagram Exhibit II-16B and II-17B for the interrelationships between plant subsystems and gasifier configuration.

Coal is introduced into the grinding and drying facilities where it is pulverized to a grain size of less than 3MM (.01 inches) and dried to a moisture content of approximately two percent. It is then transferred to the storage bin. From the storage bin which is at atmosphere pressure and under nitrogen, the coal dust is passed via a lock hopper to the pressurized feed tank. The coal feeding system continuously supplies the four feed pipes to the gasifier with the required quantity of coal dust. Recycled product gas is used as a carrier.

Gasification and Heat Recovery

The feedstock and gasification media are injected into the gasifier through a system of nozzles directed tangentially towards the surface of the molten slag. The feedstock reacts with the gasification medium at temperatures between 1650 and 2400°C. The oxygen or mixture of oxygen and air, is preheated by saturated steam from the waste heat system. Superheated steam from the high pressure system serves as process steam.

The primary gasification and the post gasification zone in the gasifier chamber are protected on the inside by water cooled finned tubes. The cooling zone of the gasifier is refractory lined. Surplus slag flows through a central tap hole in the bottom of the gasifier, is granulated in a water tank beneath the gasifier and then discharged through the lock hopper. The ascending gas stream is cooled in the refractory lined zone by cold recycle gas to a temperature of 800 to 900°C in order to solidify the entrained slag particles.

From the gasifier, the raw gas passes to the cyclone, where the majority of the entrained solids are removed. The heat of the raw gas is used in the waste heat boiler to generate high pressure superheated steam. The gas then passes through a high temperature fibrous filter where most of the dust, which is still present in the gas chiefly in the form of finer particles, is removed. The particular matter (char and slag) separated in the cyclone, waste heat boiler, and the fibrous filter is then recylced in order to gasify any remaining unconverted carbon. The raw gas is cooled in the spray cooler to 40°C.

The cooling water of the spray cooler is circulated via a heat exchanger. Part of this water is blown down and treated in a conventional waste water system.

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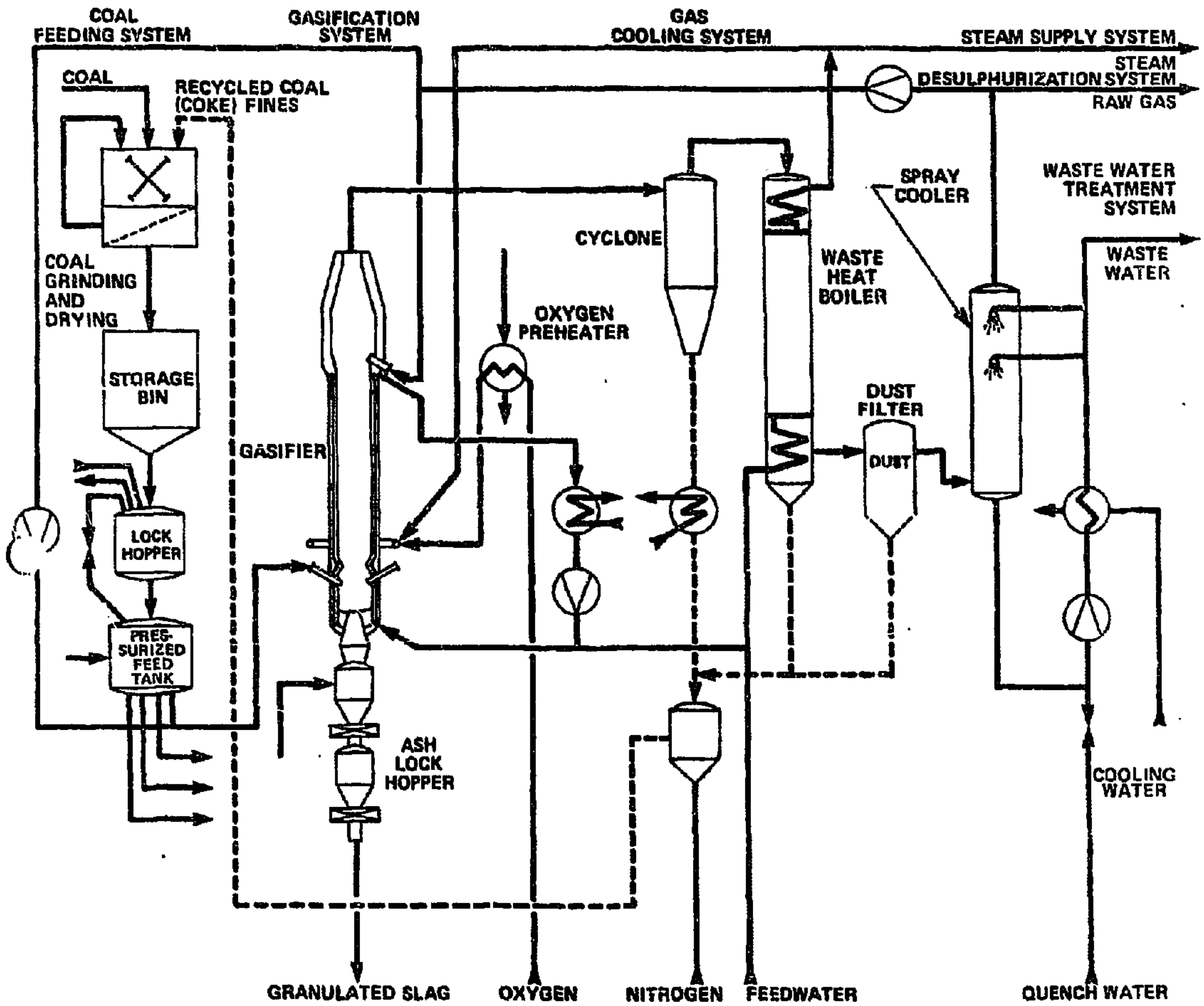
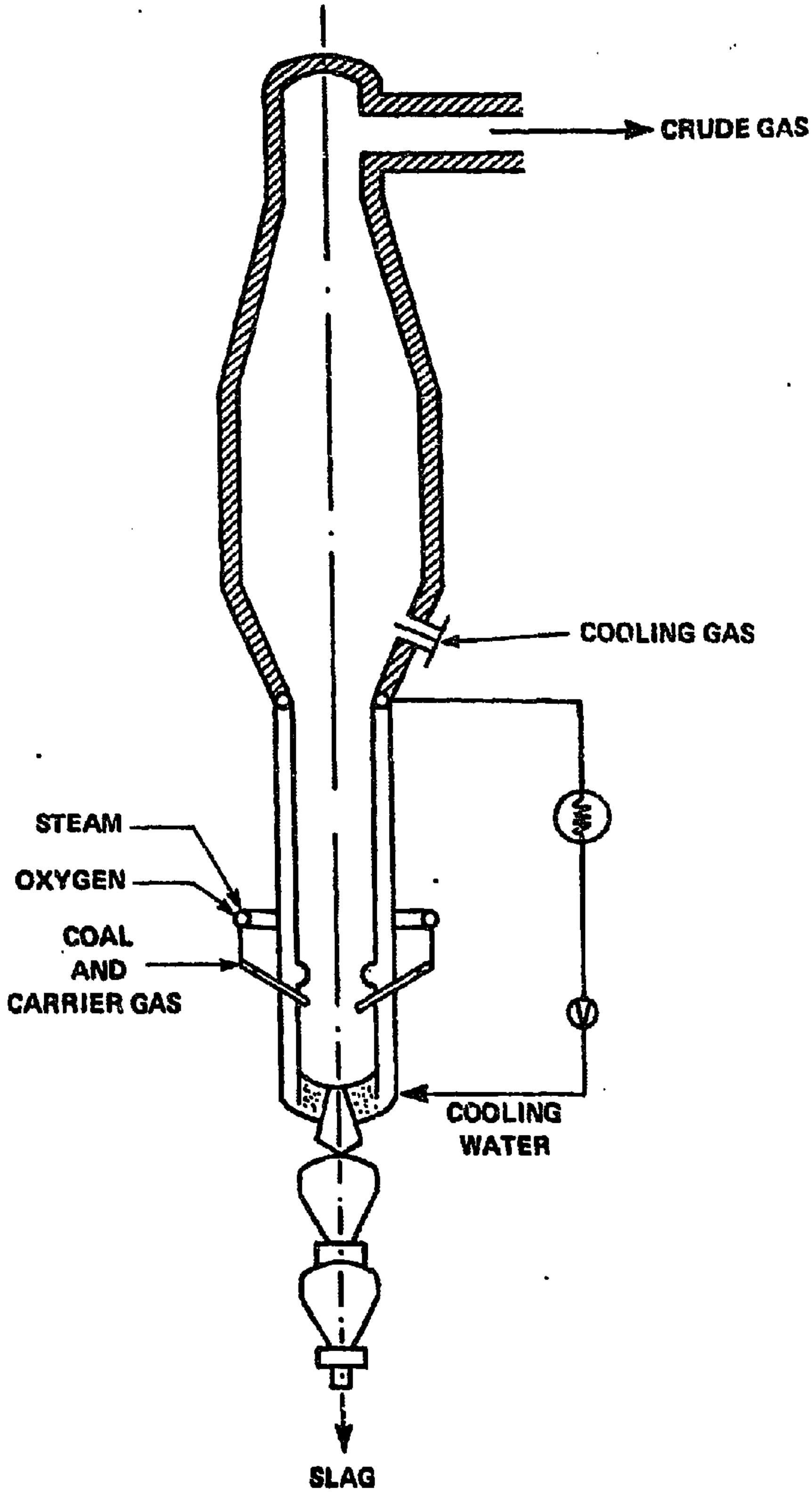
EXHIBIT II - 16B

SAARBERG/OTTO PROCESS FLOW DIAGRAM



SAARBERG - OTTO GASIFIER



Process Description/Koppers Totzek

Coal Preparation and Gasifier Feeding

The coal is dried to between 2 and 8 percent moisture and pulverized to 70 to 90 percent through 200 mesh. Roller-or-ball-type wind swept pulverizing mills are used; and choice depends on capacity. Pulverizers are designed to use up to 600°F combustion gases for the drying medium so that the coal particle temperature never exceeds 180°F. At this temperature there is no devolatilization or chemical reaction of the coal particles, and as a result the evaporated coal moisture, after particle removal, can be discharged as vapor to the atmosphere. The pulverized coal is conveyed with nitrogen from storage to the gasifier service bins. In the pulverization system and thereafter, the finely divided coal particles are kept under an inert atmosphere to eliminate explosion hazards. Controls regulate the intermittent feeding of coal from the service bins to the feed bins, which are connected to two variable-speed coal screw feeders. The pulverized coal is continously discharged from each screw into a mixing nozzle where it is entrained in a stream of oxygen and low pressure steam. The mixture is then delivered through a transfer pipe to the burner head of the gasifier. Moderate temperature and high burner velocity in the burner pipe prevent the reaction of the coal and the oxygen prior to entry into the gasification zone.

Gasification and Heat Recovery

A two headed gasifier, capable of gasifying over 400 tons of coal per day is shown in exhibit II-18B. The oxygen steam, and coal react at a slight positive pressure in the refractory-lined-steel-shell gasifier. Coal, oxygen, and steam are brought together in opposing burner heads spaced 180°

apart. Four headed gasifiers, capable of gasifying over 800 tons of coal per day, employ burner heads 90^{o} apart. These larger units resemble intersecting ellipsoids having a major axis of 13 feet. The gasifier is lined with a monolithic refractory lining. The average life of the lining is normally 2 to 3 years.

Gasification of the coal is almost complete and instantaneous. Carbon conversion is a function of the reactivity is the coal. Exothermic reactions produce a flame temperature of approximately 3500^{o}F. Endothermic reactions, occuring in the gasifier between carbon and steam and radiation to refractory walls, reduce the flame temperature from 3500^{o}F to an equilibrium temperature of 2700^{o}F. Low pressure process steam is produced in the gasifier jacket from the heat passing through the refractory lining.

Ash in the coal feed is liquified at the high reaction temperature. Approximately 50 to 70 percent of the molten slag drops out of the gasifier into a slag quench tank and is recovered for disposal as a granular solid. The remainder of the slag and most of the unreacted carbon are entrained in the gas exiting the gasifier. Water sprays located at the gasifier outlet quench the gas to drop the temperature below the ash fusion temperature to prevent slag particles from adhering to the tubes of the waste heat boiler mounted atop the gasifier.

Referring to exhibits II-19B and II-20B raw gas from the gasifier passes through the waste heat where high pressure steam is produced. After leaving the waste heat boiler the gas at 350^{o}F is cleaned and cooled in a water scrubber system. The system consists of a washer cooler for removing the largest particles followed by disintegrators where more than 99 percent of the remaining particles are removed. The gas then passes into a separator and into a low-pressure fan. A precipitator is used only when gas is processed in catalytic units for chemical production.

The KBW tubular cooled system utilizes the equivalent coal preparation, gasifier feeding, waste heat recovery and slag removal units as presented for Koppers-Totzek and KBW jacket cooled systems.

The gasifier differs in physical shape and method of cooling as the gasification reactions are taking place. The gasifier is rectangular in shape and uses a water tube membrane wall, which generates 600 psig steam. A cross section of the gasifier and a process flow schematic are illustrated in exhibits II-21B and II-22B, respectively.

EXHIBIT II - 18B

KOPPERS-TOTZEK GASIFIER TYPICAL CROSS SECTION

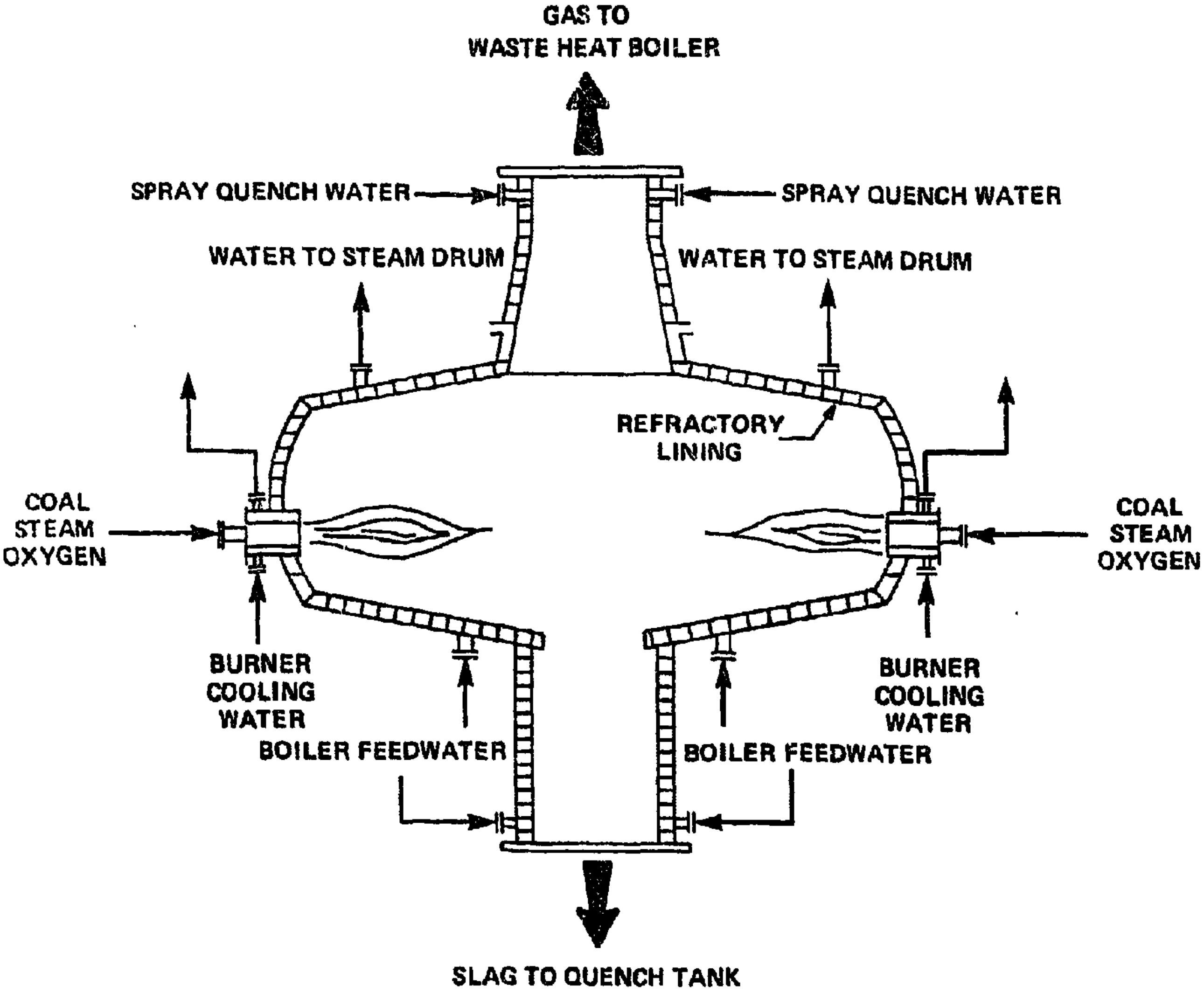


EXHIBIT II - 19B

KT & KBW JACKET COOLED GASIFIER

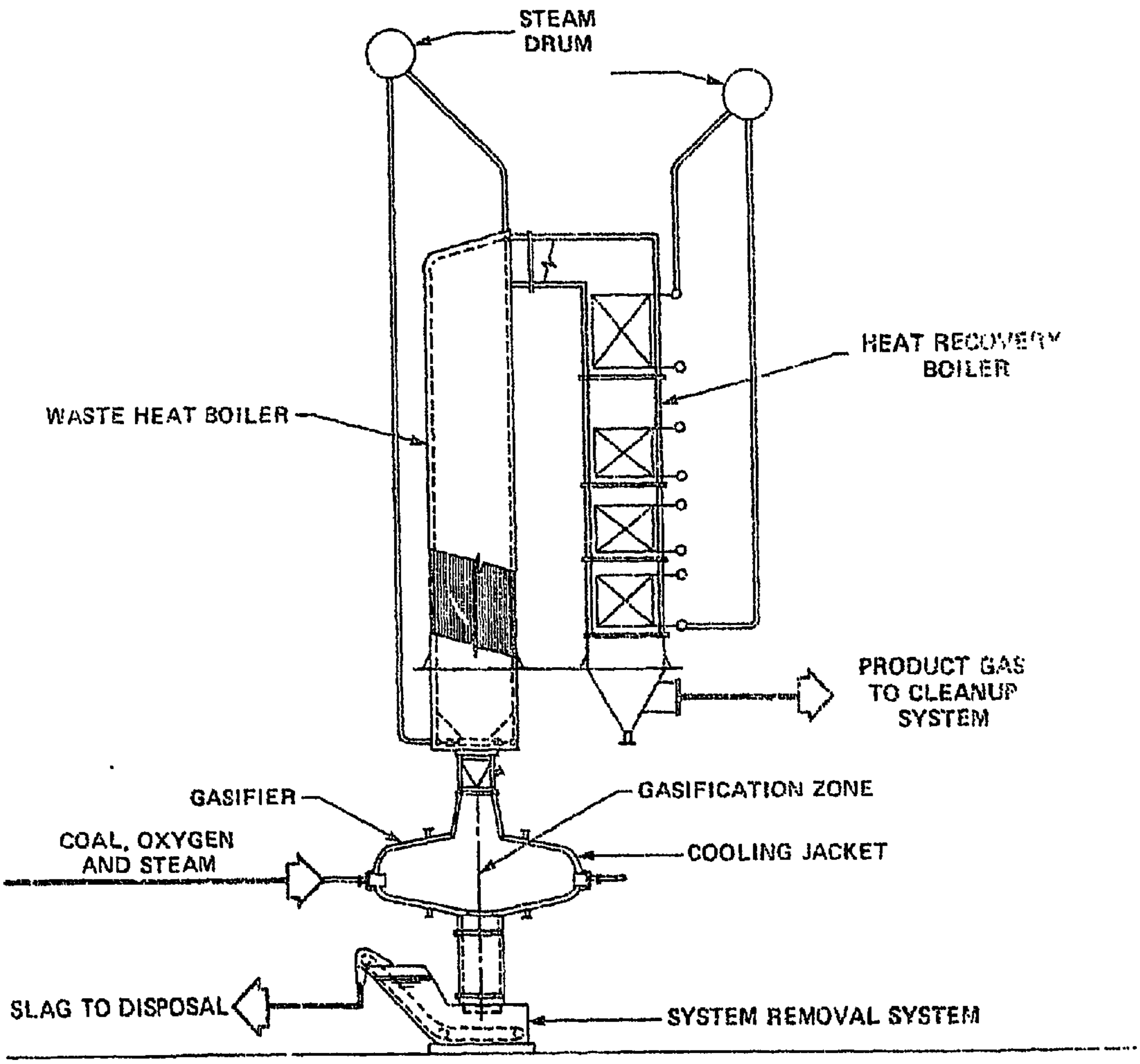


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EXHIBIT II - 20B

KOPPERS-TOTZEK GASIFICATION

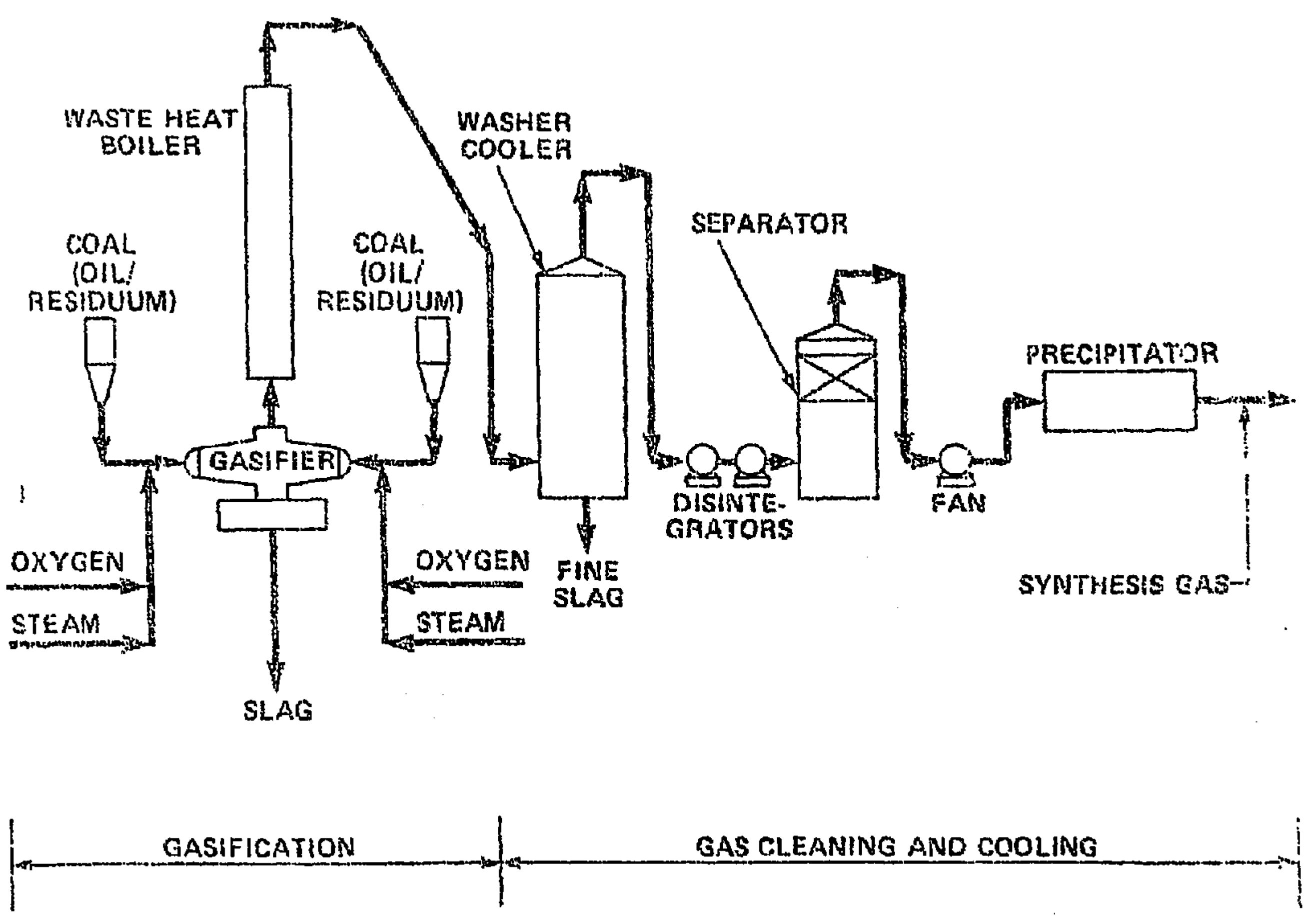

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EXHIBIT II - 21B

KBW TUBE COOLED GASIFIER

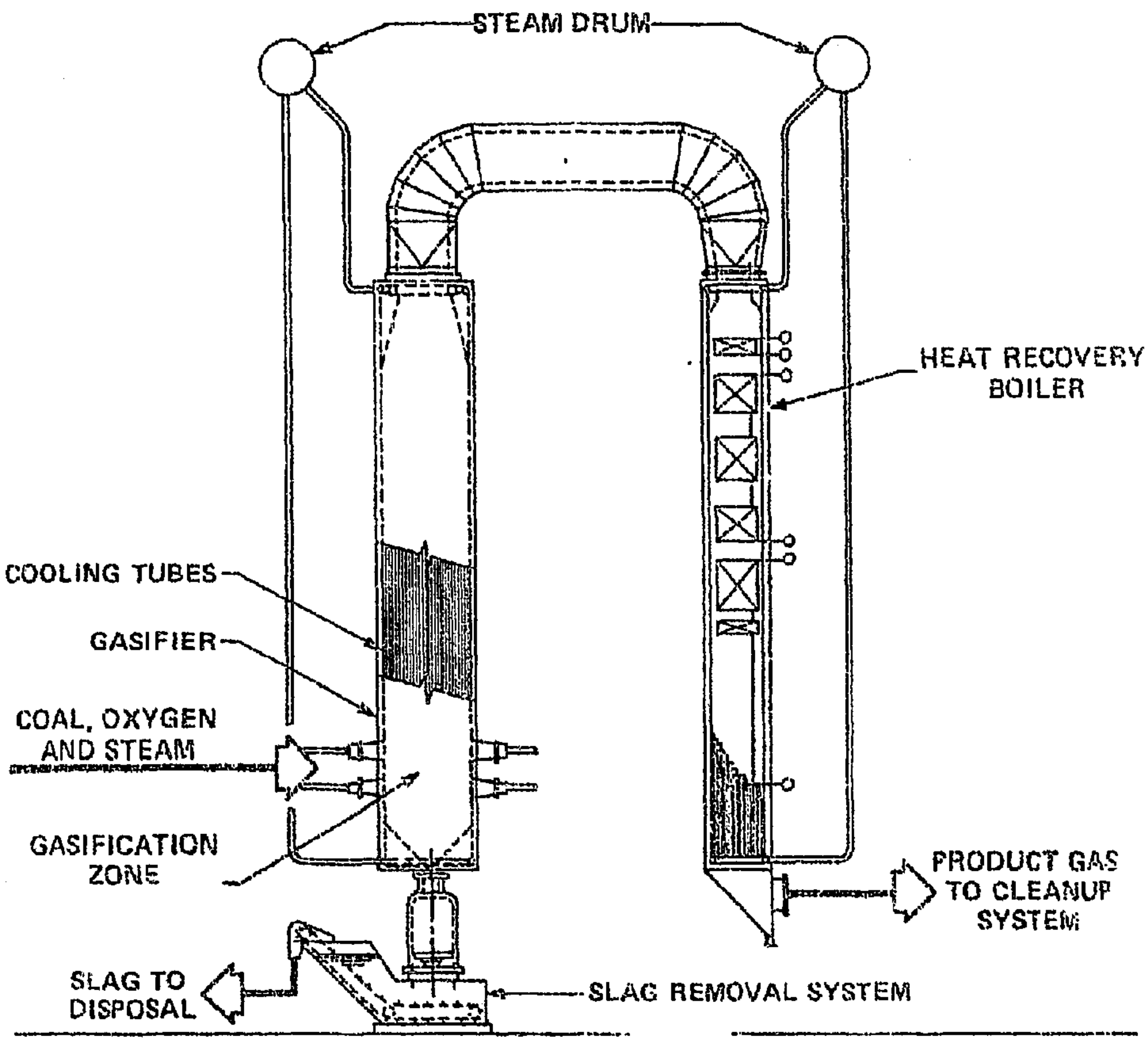

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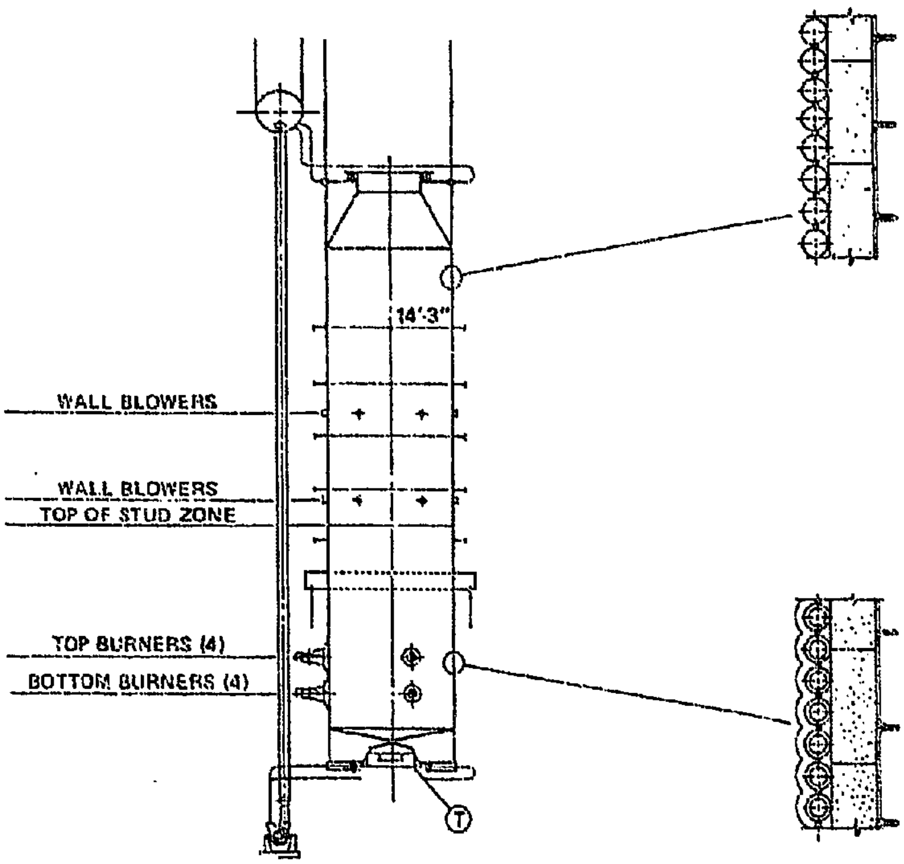
EXHIBIT II - 22B

KBW TUBE COOLED GASIFIER



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NEPGAS CONTINUATION STUDY

SUPPLEMENTAL TASK II

TECHNICAL DOCUMENT

PREPARED FOR
ENERGY DEVELOPMENT AND RESOURCE CORP.
NANTICOKE, PENNSYLVANIA
BY
EBASCO SERVICES INCORPORATED
AUGUST 24, 1981

INTRODUCTION

This technical support document has been developed to establish a technical support plan and the staged data development requirements to assure the applicability of the technology to be used in the NEPGAS Project.

The principle areas to be addressed in this document are site, coal and process engineering considerations, technological, support for the gasification system including testing to ensure that solids from gasifier can be disposed of in an environmentally acceptable manner. In addition an execution plan has been developed.

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I SITE CONSIDERATIONS

INTRODUCTION

A carefully designed site confirmation process for the NEPGAS Syn Fuels Plant and its auxiliary facilities will minimize environmental and social impacts while allowing the program to proceed in a timely and economic fashion.

In the conceptual design study, and initial screen of the potential sites in the northern and middle coal fields identified Hazelton as the prime potential candidate site for the plant. A subsequent environmental survey assessing the feasibility of the site for further study and program continuation, confirmed the initial findings.

The site characteristics significantly effect the engineering and environmental design of the complex. The discussion which follows assumes that the commercial consideration of making the site available to the project have been completed and addresses the site data which must be available to proceed with the design phase of the project. While the conceptual report gives the major site parameters, a checklist of the site data required for design is given in Exhibit I-1.

I-1 Topography and Site Conditions

While maps, geology reports, soil bearing studies, subsurface conditions information and seismic zone reports are informative as to site conditions the "lay of the land" is best obtained from walking the property and getting a first-hand look.

Subsurface conditions such as previous mining activity, rock escavation requirements should be carefully examined as they can add considerably to the cost of construction. Complete data in an area specifics must be on hand before final design is begun to avoid duplication of design efforts. In general, the state of Pennsylvania, except for the extreme northwest corner, is considered as (zone one) limited seismic risk. However, local faults and seismic conditions must be established.

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I-2 Climate

The proposed site will require weather protection for major mechanical equipment such as compressors, coal grinding machines, etc.

Design climate conditions must be established for HVAC requirements and the process operations. Other examples of climatic considerations in design include snow loads affects on structural design, and average rainfall dictates storm-sewer capacities. Wind direction and velocity dictate design of buildings, tanks, towers, and stacks.

Specific weather history for a location is available from the U.S. National Weather Service.

I-3 Utilities

As discussed in the site evaluation report, Hazelton was selected because of its proximity to culm, the availability to areas with sound soil conditions for construction of heavy equipment as well as suitable land for slag disposal.

Power

After the site selection has been finalized, a conference should be arranged with the appropriate electric utilities to present the requirements for the proposed plant. The utilities should be furnished with:

- Preferred point of delivy of electric service.
- Plant load, preferably maximum demand in kilo-volt-amperes (kVA).
- Required service voltage.
- Preferred utility-supply arrangement.
- Construction and start-up schedule.
- Description of special equipment in the system, such as unusually large motors.
- Anticipated power factor.

Based on this information, the utilities should be able to provide electric rates, and to comment on their ability to meet requirements.

Water

The environmental assessment report discusses in detail the potential water sources.

- o Susquehanna River,
- o Lehigh River,
- o Mine drainage overflows and,
- o Groundwater

The Susquehanna River appears the most likely candidate source with groundwater as a supplemental source. Withdrawal and consumption of water from the Susquehanna River must be in compliance with the following SRBC regulation:

"Compensation in an amount equal to the project's total consumptive use shall be required when the stream flow at the point of taking equals or is anticipated to equal the 7-day 10 year low flow plus the project's total consumptive use and dedicated augmentation."

Regulations allow compensation to be accomplished by either of the following:

- o Construction or aquisition of storage facilities;
- o Use of currently owned facilities; or,
- o Purchase of water from a water company.

As the method of compensation was not addressed in the conceptual study, it should be resolved early on in the next phase.

I-4 Government Regulations

In addition to government regulations controlling environmental aspects of the design, state and local codes governing boilers, buildings, structures, storage tanks, electrical installations, fire protection, and pressure vessels must be considered.

A typical list of codes and specifications for plant equipment is presented in Exhibit I-2.

The plant equipment shall be furnished in accordance with the listed codes and specifications as applicable. These codes and specifications set forth a minimum requirement which may be exceeded where specific conditions govern or where superior or more economical designs or materials are available and have been applied successfully to plant operations.

I-5 Environmental

The legal process of implementing and enforcing environmental laws play a vital role in the timely and economic design, construction, and operation of a synthetic fuel complex.

Factors to be closely examined include air pollution wastewater disposal and the handling and disposal of both solid waste and hazardous waste all of which are subject to a bewildering variety of regulations promulgated by federal, state, regional and, local bodies.

For large and sometimes controversial projects such as a synthetic fuel plant. The licensing process can be complex and time consuming. The Environmental/Licensing Review task III of this expanded workscope addresses the environment question and licensing requirements.

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EXHIBIT I-1

SITE DATA CHECKLIST

SITE DESCRIPTION

Map showing roads, railroads, etc.

Geodetic survey map of area

Overall plant map

Large-scale map of jobsite

Contour map of jobsite

General description of area

Publications by state and local governments, regional industrial-development groups, chambers of commerce, etc., regarding site and area

CLIMATE

Maximum temperature and month (no. days)

Minimum temperature and month (no. days)

Maximum wet-bulb temperature and duration

Average temperature--warmest and coldest months

Rainfall maximum, in./h, in./24 h

Snowfall maximum, in./h, in./24 h, and accumulation

Wind--prevailing direction, minimum and maximum velocity

Likelihood of hurricanes or tornadoes

Effect of climate on work habits

Outdoor working days/yr normally lost due to inclement weather

Seasonal conditions: duration of rainy season and snows; length of time that ground is frozen, muddy, dry; ice, sand, dust; temperature inversions, etc.

Historical local weather bureau records

GEOLOGY AND CONDITION OF SITE

Elevation above sea level; nearby bodies of water of any significance

Nature of soil and underlying rock strata, depth of overburden, normal frost penetration

Elevations of groundwater table, high and low levels and, if temporary, for what duration

Natural drainage of site

Site clearing and leveling requirements

Availability, type and quality of: fill material, fine aggregate and coarse aggregate

SITE DATA CHECKLIST (CONT'D)

Soil-bearing data

Earthquake history--severity and frequency, earthquake factor

Previous mining activity

Seismic-zone number

Geological publications relating to any of the foregoing

TRANSPORTATION AND COMMUNICATION

Description of access roads to site capacity, width and limitations of bridges; overhead obstruction clearances; requirements for road transportation permits, and where these can be obtained

Railroads serving jobsite--distance and access to nearest spur; clearances to build jobsite

Distance and access to river

Availability of all transport facilities (truck, deepwater and rail), and basis for contracting

Nearest airports, airlines serving them, and types of service available

Telephone, cable, telex and mail services

Publications about transport facilities by: national, state and local governments; transportation or trade associations, chambers of commerce

GOVERNMENTAL REGULATIONS

State and local codes governing boilers, buildings, structures, pressure vessels, plumbing, sanitary facilites, storage tanks, electrical installations, fire protection, pressure vessels, safety and labor

Special state and local regulations regarding protection of groundwater

Environmental agencies to be satisfied; Environmental Protection Agency (EPA), State Department of Environmental Resources, etc.

State and local inspection agencies

State and local permits required to do work

State, local and other publications regarding regulations, permits, inspections, etc.

SITE DATA CHECKLIST (CONT'D)

UTILITIES AND FUELS

Cooling-water source, availability, supply pressure, return pressure, return destination, cost (rate), temperature, fouling properties, chemical analysis, supply-line size, return-temperature limitations, and other regulations on use

Process-water source, availability, pressure, temperature, cost (rate), chemical analysis, supply-line size

Portable-water source, availability, pressure, cost (rate), chemical analysis, supply-line size

Fuel-gas source, pressure, low and high heat values, chemical composition, cost, supply-line size

Fuel-oil source, availability, cost

Coal source, availability, quality, size, cost

Electricity source, characteristics, frequency and duration of interruptions, causes of interruptions, rates, limitations

WASTE DISPOSAL

Liquid-waste disposal destinations, quality and quantity limitations, and state and local (or drainage basin commission) ordinances, laws, etc., governing disposal of liquid wastes

Solid-waste disposal--state or local restrictions on quality, quantity, method and location, trash-handling-service availability

Waste-gas disposal--state or local regulations on air pollution, climatic conditions affecting dispersion, use of flares

CONSTRUCTION AND OPERATING LABOR

Availability of construction labor locally and regionally (by craft) and general construction-labor conditions

Amount of other construction in area for next two year

Construction-labor rates

Construction-labor unions

Local labor-market conditions for permanent operating labor availability, skills, competition for personnel, etc.

Likely union representation

Prevailing local rates for similar labor

Publications by U.S. Bureau of Labor Statistics, state or local governments, chambers of commerce, labor union, etc., on area labor topics

EXHIBIT I-2

TYPICAL CODES AND SPECIFICATIONS

AGA - AMERICAN GAS ASSOCIATION

AGMA - AMERICAN GEAR MANUFACTURERS ASSOCIATION

AISC - AMERICAN INSTITUTE OF STEEL CONSTRUCTION

ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE

API - AMERICAN PETROLEUM INSTITUTE

ASA - AMERICAN STANDARD ASSOCIATION

ASME - AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ASNT - AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING

ASTM - AMERICAN SOCIETY FOR TESTING AND MATERIALS

AWS - AMERICAN WELDING SOCIETY

AWWA - AMERICAN WATER WORKS ASSOCIATION

HEI - HEAT EXCHANGE INSTITUTE

HI - HYDRAULIC INSTITUTE

ICEA - INSULATED CABLE ENGINEERS ASSOCIATON

IEEE - INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS

ISA - INSTRUMENT SOCIETY OF AMERICA

MIL - MILITARY SPECIFICATIONS

NAFM - NATIONAL ASSOCIATION OF FAN MANUFACTURERS

NB - NATIONAL BOARD OF BOILER AND PRESSURE VENDOR INSPECTORS

NEMA - NATIONAL ELECTRICAL MANUFACTURES ASSOCIATION

NFBA - NATIONAL FIRE PROTECTION ASSOCIATION

OSHA - FEDERAL OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION STANDARDS

SSPC - STEEL STRUCTURES PAINTING COUNCIL

TEMA - TUBULAR EQUIPMENT MANUFACTURES ASSOCIATION

UBC - UNIFORM BUILDING CODE OF THE INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS

UL - UNDERWRITERS LABORATORS

II - Coal

Coal

The complex heterogenous nature of coal and the state-of-the art of coal gasification systems require that testing be undertaken to confirm that design considerations address the relevant coal and systems properties.

The following tests and/or data are recommended before initiation of the plant design and engineering. Data or test results available from previous work can be used to initiate design. However, a critical review should be made to ensure that information used is applicable to the design requirements.

Extensive grinding tests have been made on some of the candidate coals. This data should be reviewed, and applicable data should be used to expedite initial phase of plant design and engineering.

II-1 Survey of Coal Source

A survey of the potential coal sources should be undertaken to establish the project candidate coals. The results of the survey will provide comparative information on the coal characteristics, availability, quantity, transportation requirements and economics of each coal source. An analysis of this data together with the data developed from Coal Characterization Tests should be used to establish the coal design parameters for the project.

II-2 Coal Characterization Tests

A reliable source of data on the physical and chemical characteristics of the coal is essential to the project design. The results of the following analyses will characterize the gasification parameters for the selected coal.

- Sampling of Coal

  Although the coal consumed in a gasification plant may be measured in thousands of tons per day, the samples used for laboratory analysis are measured in grams. It is therefore important and difficult to obtain representative samples of coal.

  ASTM Standard D 492 now in use was developed, adopted in 1948, and reapproved in 1958. In this standard, which is less laborious than the original, allowances are made for the probable ash content of the coal, permitting the use of smaller gross samples for the coals of lower ash content.

  Standard D 492 also sets procedures for reducing gross samples and for obtaining samples for standard and special moisture determinations. Two additional pertinent publications by the ASTM are: Symposium on Bulk Sampling (STP 242, 1958) and Symposium on Coal Sampling (STP 162, 1955). A new method has also been adopted in 1968 covering the mechanical sampling of coal, D 2234.

  Careful coal sampling is of prime importance since any data resulting from subsequent analyses are only as representative as the sample provided.

- Coal Analysis

  The conceptual project study for the gasification of anthracite coal has been based on a composite of the range of coal in the region.

  For the design of the plant the proximate and ultimate analysis, of the design coal must be established. The scope of each analysis is indicated in the following exhibit.

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COAL ANALYSES ON AS-RECEIVED BASIS

Proximate Analysis	Weight %	Ultimate Analysis	Weight %
Moisture		Moisture	
Ash		Carbon	
Volatile Matter		Hydrogen	
Fixed Carbon		Nitrogen	
		Chlorine	
		Sulfur	
		Ash	
		Oxygen (diff)	

The standard Laboratory procedures for making these analyses where formerly listed under ASTM D271. These methods were discounted in 1975 and were replaced by ASTM Method D3176 and ASTM D3172 for the proximate and ultimate analyses, respectively.

Also included in the coal analysis would be the gross calorific value or higher heating value. The gross calorific value is the heat produced by combustion of a unit quantity of solid fuel, at constant volume, in an oxygen bomb caloricmeter under specific conditions. The preferred procedure for measuring the gross calorific value is ASTM Method D2015, which also covers methods for determining the net or lower calorific value.

The ultimate analysis and heating values determined in the coal analysis are important for calculating accurate material and thermal balances of the gasifier.

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o Free Swelling Index:

This index (the FSI) is a measure of the volume increase that a coal undergoes when it is heated without physical restraints under standard conditions. The FSI provides a general indication of the plastic behavior of coal during combustion or gasification.

The standard emprical test method, ASTM D720 involves heating a 1 gram sample of coal in special equipment under specified conditions. A coke button is produced, the profile of which is then compared with a series of standard profiles. Readings are reported as the FSI, on a numerical scale of 1 through 9, in steps of one-half.

o Grindability

Common indicators of this property relate the amount of work needed to pulverize a given coal to that needed to pulverize certain standard coals. Grindability is determined by a specific test procedure, ASTM D409, which employs a Hardgrove grindability machine.

The Hardgrove grindability index is derived by comparing the weight of a test sampler passing through a 200 mesh screen with that of the fines produced from standardized reference coals, using a standard calibration chart.

o Ash Fusibility

The preferred procedure for measuimg ash fusion temperatures is outlined in ASTM D1857. Earlier procedures used only a reducing atmosphere for such determinations, whereas the standard presently adopted employs both reducing and oxidizing atmospheres.

Instead of measuring loosely defined softening and fluid - critical points, the new procedures specify the following types of data:

- Initial Deformation Temperature
- Softening Temperature
- Hemispherical Temperature
- Fluid Temperature

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Along with the ash fusibility characteristics an analysis of the major components of the coal ash should be determined. The procedure used for a rapid and inexpensive analysis is ASTM Method D2795.

Knowing the major components of the ash and ash fusionability temperatures an analysis can be made to determine the T250 point. The T250 point is the temperature at which the viscosity of the slag is 250 poise. Analysis has shown, that it has been feasible to remove molten ash at or below the T250 point, reasonabily easily and reliably.

<u>Coal Grinding Reveiw</u>

All the coal gasification technolcgies under investigation require a certain amount of coal preparation, including the reduction of the coal feedstock to a proper size range of particles. This need to produce the appropriately sized particles has raised several process questions.

1. What type of crusher or grinder is best or satisfactory to take a given feed size and type of coal to a desired product size? Frequently, a desired product is smaller than some size but with as few fines as possible, or the fraction in some size range has to be as high as possible.

2. How big does the machine have to be for a given throughput rate?
3. How much electrical energy (or its equivalent) is required per ton of product?
4. How does the size distribution vary with change in throughput rate and is a control scheme necessary or desirable?
5. Can the size distribution be readily varied if desired?
6. What is the optimum way of operating a machine in a given system?

While the final resolution to these questions may require grinding tests, the costs and time required to conduct these tests can be reduced considerably by the judice use of existing information. The coal preparation study program is planned as three subtasks:

- o State of the Art Search
- o Mathematical Modeling
- o Testing

State-of-the-Art Search

The State-of-the-Art Search is targeted to examine existing coal size reduction technology by examining the capacity, power draw, and output spectrum of commercially available coal size reduction equipment.

The study will include:

1. Currently used equipment.
2. Results of a brief literature survey.
3. Manufacturers information.

The initial effort will be directed towards obtaining manufacturers information. As a result of the survey a guide listing size reduction equipment manufacturers, the output spectrum (top size and size slate of product), maximum top size of feed, volume rate of units, and driving power required will be prepared.

This survey will select the candidate technically to which Mathematical Modeling will be applied.

Mathematical Modeling

Study programs, such as the DOE coal grinding studies, have improved methods of modeling coal grinding. The model views the grinding process as a rate process. With the proper kinetic model it is possible to predict a grinding circuit performance.

In addition, alternate configuration and control performance can be simulated.

The equations of comminution are coupled with material balance equations, time of grind expressions and classification models to simulate the operation of a grinding circuit.

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The Matematical Model methodology can then be applied to the candidate grinding system selected from the State-of-the-Art-Search to determine guides for expected performance and the near optional conditions to be used in the next stage of testing.

Grinding Test

The parameters to be used in the design of the grinding system will be verified in grinding tests.

A research and testing facility located at Danville Penn operated by Kennedy Van Saun Corporation (KVS) was established by DOC as a coal test center.

Commercial testing facilities are operated by Babcock & Wilcox.

The need to proceed to the final testing stage depends on the data available in the literature and the critical need for a specific product slate for good gasification.

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III - GASIFICATION TESTS

Constant updating and system improvement is a feature of the present state-of-the art in gasification. While a number of plants of comparable capacity have proceeded to various levels of planning a design, there are no coal gasifications units in the United States on the scale of the proposed installation. Information developed to date from Process Development Units (PDU), Demonstration and Semi-Commercial Plants leads to the conclusion that the design and operation of a coal gasification based fuel grade methanol complex is not expected to present any insurmountable technical problems.

It recommended that for the gasifier system selected, tests be conducted on the candidate coal. Such tests will serve to confirm the parameters to be used in the design. The following items must be confirmed through testing.

- o Steam to carbon ratio
- o Oxygen to carbon ratio
- o Coal feed system
- o Gasifier capacity
- o Gasifier heat and material balances
- o Slag removing requirements
- o Trace component material balance

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ESTIMATE OF OPERATION

Based on data developed in the Coal Characterization Tests an estimate of the operating conditions for the gasification section should be developed by the selected gasification vendor. This estimate, based on extrapolation of existing data such as reaction kinetics, equilibrium factors used in conjunction with computer simulations will serve to confirm the oxygen plant size, the steam system design and its associated equipment, the number of gasifiers required developed in preliminary evaluation given in Task I Report.

If the representative coal is outside the experience spectrum of the vendors gasification technology bench scale tests should be made to establish the relevant parameters as discussed above.

While the estimate of operation is an engineering estimate of the proposed conditions it will also target the conditions to be tested in the PDU.

SHORT GASIFICATION RUNS

The objective of preliminary PDU test runs is to confirm the operability of the coal gasification process at the design pressure with the selected coals, to refine the estimate of preferred operating conditions, product gas yields and composition, to obtain and analyze samples of slag and fines and to establish the basis for a sustained run with the selected coal. Maximum projected gasifier throughput will be determined and unexpected operating problems will be identified.

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A test will consist of several short pilot plant runs, each conducted at a different gasifier temperature, utilizing a single set of gasifier parameters.

EXTENDED GASIFICATION RUN

The extended run shall be designed to simulate the plant operation and collect data which reflects the operating conditions of the plant. Approximately 200-300 tons of coal should be gasified during the extended run. The following tests should be included in the extended test run.

- Corrosion Test

  Test coupons should be inserted for corrosion at strategic points in the pilot plant to collect data. The results of the test will provide valuable insights for the selection of materials that are compatible with the type of coal used.

- Recyle Test

  This test using recycle solids should be designed to confirm the gasification parameters and the feasibility of operations with ash and carbon recycle.

- Blowdown Water

  Criteria used in the estimate of operations to determine blowdown rate based on total dissolved solids and/or chloride concentration level should be confirmed. This data will finalize the water management program within the gasification system. Blowdown water data including an analysis of trace components will provide the information necessary to determine and confirm the environmental impact of wastewater treatment requirements.

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- <u>Slag Discharge Simulation</u>

  The slag discharge system of the pilot plant should simulate the operation of the proposed plant and/or provide data which can be used to design a slag discharge system. Slag discharge data will improve the operability and economics of the slag handling system.

- <u>Trace Component Analysis</u>

  A trace component analysis is important from several points of view. If there are trace components present in the raw gas that are peculiar to the candidate coal, they could cause problems either in downstream processing units or the waste water treating system. Trace components which leave in the product gases may cause catalyst poisoning. Trace components which are removed during the washing step of particulate removal may lead to unforeseen problems in the waste water treatment system. Finally, trace components present in the slag or ash could lead to uncertainty in the solid waste disposal system.

- <u>Heat Recovery & Particulate Removal</u>

  Every effort should be made to include a simulation of Heat Recovery and Particulate Removal in the PDU.

  Questions to be addressed in this area should include materials of construction, potential fouling and plugging of boilers and methods for extending waste heat boiler on stream time such as soot blowers.

The potential for downstream equipment fouling due to the presence of particulate in the product gas must also be addressed.

The scale and costs of PDU operations may limit the applicability of the data collected in this area. This specifics of the available equipment of the PDU may dictate that heat recovery and particulate removal tests be postponed to the Demonstration Scale Tests, as tests at this stage may not simulate final equipment design.

TESTS FROM DEMONSTRATION UNITS

Process development units have gasification capacities on the order of 15 to 50 T/D. The gasifier for the proposed installation will gasify from 1000 to 2500 T/D. Thus, the question of scale up remains.

Consideration should be given to obtaining data from large demonstration units. This data will be used to eliminate the unquantifiable scale up risk factor and provide data which cannot be obtained from PDU tests.

SLAG LEACHABILITY TESTS

The environmental impact of the disposal of the slag/ash requires that tests be conducted to develop and assess design parameters to be used in solids waste disposal system.

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NEPGAS CONTINUATION STUDY

SUPPLEMENTAL TASK III

ENVIRONMENTAL ASSESSMENT REPORT

LICENSING REVIEW

HAZELTON SITE

PREPARED FOR
ENERGY DEVELOPMENT AND RESOURCE CORP.
NANTICOKE, PENNSYLVANIA
BY
EBASCO SERVICES INCORPORATED

JULY 15, 1981

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I. INTRODUCTION

A. PURPOSE

The purpose of this study is to assess on a preliminary basis the feasibility of the Hazle Township shale pit site as the location for a commercial gasification facility producing marketable methanol. A previous site in northeastern Pennsylvania, the Nanticoke Industrial Park, was initially considered as the potential site but was found inadequate due to limited plant area and undesirable subsidence characteristics resulting from previous mining activities. Subsequently an evaluation of alternate candidate sites was undertaken to determine a more suitable site. From this evaluation the shale pits site was given the prime consideration. This study serves to assess the feasibility of the shale pit site for further study and program continuation.

B. SCOPE

In order to accomplish the above objective, Envirosphere has performed environmental investigations relevant to the following areas:

- Air Quality;
- Water and Solid Waste;
- Land Use/Socioeconomics
- Ecology; and
- Regulatory Requirements.

For each of the above areas, the following tasks were undertaken:

1) Establishment of site characteristics on a qualitative basis from available literature and field level reconnaissance;

2) Analysis of potential interactions between the coal gasification facility and the existing environment;

3) Identification of the potential changes to the environment resulting from plant construction and operation; and,

4) Determination of implications of potential changes as they might relate to the prevention of plant siting in Hazle Township (Fatal Flaw Assessment).

In executing the above tasks, Envirosphere has with Ebasco engineering input, provided a process description including estimates of air, water and solid waste emissions. The results of these investigations are presented below.

II SITE DESCRIPTION

A. LOCATION

The proposed gasification facility is located in Hazle Township, Luzerne County, 2.7 kilometers ENE of the City of Hazelton and 32 kilometers south of Wilkes Barre. Wilkes-Barre is the county seat and largest city in Luzerne County.

The site, known as the shale pit site, is a 170 acre, rectangular shaped parcel situated on top of a ridge between the villages of Oakdale and Stockton on Stockton Mountain Road. The parcel is a largely wooded site except for the western portion of the site which has been mined for shale. The site is bound on all sides by strip mining areas except for isolated housing developments west and east of the site. The gasification facility and surrounding ara is illustrated on the site plan, Figure 1.

B. DISCIPLINARY CHARACTERIZATION OF SITE

1. Air Quality

In general, Pennsylvania climate is defined as humid continental type. Annual temperature average for the Hazelton area is 8.6°C (47.5°F). Summers are generally warm with the July mean daily maximum temperatures of 26.7°C (80°F). High temperatures of 32.7°C (90°F) or above occur on the average of 3 days per year with the highest temperature recorded being 36.7°C (98°F). Thunderstorms average 30 per year and account for a large part of the summer precipitation.

Winters are normally cold with an average mean temperature for December, January and February of -3.2°C (26.3°F). Freezing temperatures occur or the average of 150 days per year and the coldest temperature recorded is -31°C (-24°F). Measurable snow generally occurs between late November and mid-March with the greatest amount generated from coastal storms. Precipitation is fairly evenly distributed throughout any given year with an average of 48.2 inches.

Climatic information for the proposed facility was extracted from Climatic Summaries published by NOAA. Although data is not available for Hazelton, information from Freeland, Pa is considered to be representative of the proposed site location due to its proximity 3 km (5 miles) and altitude 623 m (1900 ft) (Hazelton site is approximately 1700').

The discussion of ambient air quality is based upon ambient air quality data collected by the Pennsylvania Bureau of Air Quality Control[(2)] in and around the Hazelton area. The station at Hazelton, operating since 1979, monitors only Total Suspended Particulates (TSP). Data collected at this site has shown no violations of the primary or secondary National Ambient Air Quality Standards (NAAQS) through June, 1980, with the highest and second highest values recorded being 137 ug/m^3 and 131 ug/m^3, respectively. Sulfur dioxide (SO_2) data is recorded in Palmerton, 12.6 km (21 miles) ESE of Hazleton. The annual mean 40 ug/m^3 (0.015 ppm), the highest 24 hour average 218 ug/m^3 (0.084 ppm) and the highest one hour average 907.4 ug/m^3 (0.349 ppm) are all well below the NAAQS. There were no contraventions of the NO_2 NAAQS annual mean of 100 ug/m^3 (0.050 ppm) reported in Pennsylvania. NO_2 is not monitored at Hazelton. Four stations collecting NO_2 in the surrounding area have annual means that range from 38-68 ug/m^3 (0.019-0.034 ppm). Based on these figures and the statewide summary for the years 1974-1979, a reasonable estimate of the background concentration of NO_2 at Hazelton would be 56 ug/m^3 (0.028 ppm), well below NAAQS of 100 ug/m^3 (0.050 ppm). Carbon Monoxide (CO) levels are generally low throughout Pennsylvania with the statewide annual mean averaging 1.4 mg/m^3 (1.3 ppm) from 1974 to 1979. Vehicular emissions are the major source of CO and are a problem only in high traffic density areas. No contraventions of the primary 1 hour standard of 40 mg/m^3 (35 ppm) and the primary 8-hour standard of 10 mg/m^3 (9 ppm) have been reported throughout the state. Based on data collected from surrounding stations, a conservative estimate of the annual mean, 8 hour and 1 hour background CO concentrations is 2.2 mg/m^3, (2.0 ppm) 8.3 mg/m^3 (7.5 ppm) and 16.7 mg/m^3 (15 ppm), respectively.

Pennsylvania has been designated as non-attainment for ozone. Monitoring data for ozone and non-methane hydrocarbons (precursors in the formation of ozone) supports the non-attainment designation. There is no ozone monitor at Hazelton although stations at Palmerton and Wilkes-barre reported concentrations above the .120 ppm standard. Approximately 79% of the stations collecting data in Pennsylvania reported contraventions of the standard while all stations reported 3 hr means (6-9 am) well above the NAAQS of 0.24 ppm. Of the ozone monitoring stations in Pennsylvania, 18.7% had levels between 1.0-2.0 ppm, 37.5% between 2.0-3.0 ppm and the remaining 43.8% exceeded 3.0 ppm.

Five non-attainment areas, as designated by the State of Pennsylvania, are located within 50 miles of the proposed facility. These areas and the pollutants that currently exceed standards are:

- Entire State of Pennsylvania - Ozone
- Allentown/Bethlehem - Easton Air Basin - total suspended particulates
- Reading Air Basin - total suspended particulates
- Scranton/Wilkes-barre Air Basin - total suspended particulates
- Portions of Northumberland County - sulfur dioxide

A recent conversation with the Pennsylvania State Department of Environmental Resources has confirmed these air quality designations promulgated in the February 12, 1980 issue of the Federal Register. The proposed facility is located at least 20 miles from the nearest non-attainment area (other than ozone). It is situated in a Volatile Organic Compound (VOC) emission offset county and subject to the state's emission offset policy.

There are no Class I areas (national parks, wilderness or recreational areas) located within 80 km (50 miles) of the site or in the State of Pennsylvania. The entire state is designated as Class II, which allows for moderate economic growth. Brigintine, N J Dolly Sods and Otter Creek, W Va are the nearest Class I areas. However, when one assesses the distance (at least 206 km) from the proposed facility, pollutant specific impacts on these Class I areas are expected to be inconsequential.

In a recent phone conversation[3], with EPA Region III it was learned that there are only two PSD sources located within 50 miles of Hazelton. One source, anthracite combustion boiler, is located in the City of Wilkes-barre, approximately 33.6 km (21 miles) north of Hazelton. The second source, a grain unloading platform, is located in Allentown, approximately 55 km (35 miles) southeast of the proposed plant site. Both sources are located in non-attainment areas for TSP. However, neither emission rates nor stack parameters are available for these sites at this time.

Personal communication with Rick Havens of the Pennsylvania Department of Environmental Resources (DER) has indicated little change in emissions and/or background ambient air quality over the last several years. Based on this information it appears that ambient air quality standards and not PSD increments will be the primary factor limiting ground level impacts from the proposed facility.

2. Water

The dividing line between the Susquehanna River and Delaware River Basins runs through the city of Hazleton. The proposed site is located east and south of the line, in the Delaware River Basin. Based on USGS flood-prone area information, it has been determined that the plant site, including adjacently located mined areas are not located in the 100-year floodplain. The nearest 100-year floodplain areas are one mile north of the site near Black Creek and approximately one mile southeast near the Hazle and Dreck Creeks.

At the present time, it has been estimated that total average plant water requirements for four (4) 2500 tons/day methanol generating units would be 27,000 gpm with approximately 50 percent being consumed.

Four potential water supply sources for satisfying plant water requirements were considered:

- Susquehanna River;
- Lehigh River;
- Mine drainage overflows (tributaries to the Susquehanna and Lehigh Rivers); and,
- Groundwater.

The Delaware River was not considered as a potential water source since the shortest distance between the site and the river is approximately 40 to 45 miles. This compares with distances of approximately 10 and 15 miles for the Lehigh and Susquehanna Rivers, respectively.

The four water supply sources considered for the coal gasification plant at Hazleton are discussed below in more detail.

a. Susquehanna River

Withdrawal of water from the Susquehanna River for plant makeup would most probably be in the stretch of the river between Danville and Wilkes-Barre. Considering an estimated plant water withdrawal and consumption of 27,000 gpm (60 cfs) and 13,500 gpm (30 cfs), respectively, the Susquehanna River Basin Commission (SRBC) believes that there is adequate river flow available to meet plant requirements. The 7-day low flow with a one in 10 year occurrence period (Q7-10) in the Susquehanna River at Wilkes-Barre is approximately 359,000 gpm (800 cfs) with the historical low flow being 224,000 gpm (500 cfs). However, withdrawal and consumption of water from the Susquehanna River must be in compliance with the following SRBC regulation:

- "Compensation in an amount equal to the project's total consumptive use shall be required when the stream flow at the point of taking equals or is anticipated to equal the 7-day 10 year low flow plus the project's total consumptive use and dedicated augmentation."

Compensation could be accomplished by either of the following:

- Construction or aquisition of storage facilities;
- Use of currently owned facilities; or,
- Purchase of water from a water purveyor.

Therefore during periods when the river flow at Wilkes-Barre was determined to be 800 cfs or lower the proposed coal gasification plant would be required to have a net consumptive use of zero. This could be accomplished by the use of a reservoir serving plant water needs or compensating the river with a flow of 30 cfs.

Water quality of the Susquehanna River is presented in Table 1 based on monitoring results at the river station near Hunlock Creek.

Assuming that 15,500 gpm would be discharged to the river from the plant this discharge would have to be in compliance with specific Pennsylvania water quality standards. Specific criteria for the stretch of the Susquehanna River near the Hazleton site are presented in Table 2. Compliance with these criteria would be determined using a mass balance for the Q7-10 river flow. The maximum allowable mixing zone in the river would be on a case-by-case basis.

b. Lehigh River

Withdrawal and consumption of water from the Lehigh River is under the jurisdiction of the Delaware River Basin Commission (DRBC). From USGS data it is concluded that Lehigh River flows near Hazleton are significantly lower than those found in the Susquehanna River (eg, the 7-day low flow in the Lehigh River near White Haven is approximately 40 cfs). DRBC restrictions on water consumption along the Lehigh River are geared towards insuring adequate flow for river users downstream and preventing sea water intrusion in the Delaware River. Conversations with the DRBC indicate that for consumption of water near Hazleton compensation could probably be required to insure minimum river flows at a downstream location on the Lehigh River and at Trenton on the Delaware River. Compensation could be accomplished by release of flows to the Lehigh River from a water storage facility.

It is expected that water withdrawal and consumption from the Lehigh River when compared to similar use of the Susquehanna River would require larger water storage requirements for the proposed project due to:

- The considerably lower flows occurring in the Lehigh River; and,

- Periods of low flow conditions in the Lehigh River and in the Delaware River at Trenton that would require compensation from the project could potentially occur more frequently than the comparable 7-day low flow period in the Susquehanna River.

Lehigh River water quality at the Walnutport Station is summarized in Table 3.

The stretch of the Lehigh River near Hazleton is classified as a cold water fish habitat and a high quality water requiring special water quality protection. According to the Pennsylvania Department of Environmental Resources treatment requirements for discharges to the Lehigh River would potentially require tertiary treatment.

c. Mine Overflows

Mine drainage with characteristic low pH, and high iron and total dissolved solids concentrations occur in the vicinity of the site due to the presence of abandoned and active surface and deep mines. The potential for using mine drainage as makeup to the coal gasification plant was investigated in this study on a preliminary basis. Precedence exists for utilizing mine drainage as a water supply source. In 1972, the state of Pennsylvania proposed a plan to the City of Hazleton for using mine drainage from the Jeddo Tunnel as a water supply source. The plan fell through because Hazleton could not afford the operating costs of approximately $1 million a year.

Seven (7) mine drainage discharges points were identified in the Eastern Middle Field where the proposed site is located and are presented in Table 4. Of the seven mine drainage discharge points identified in Table 4 the two largest flows occur at Jeddo Tunnel and Beaver Meadows. The total flow and water quality information for these two drainage flows are presented in Tables 5 and 6. As shown, these flows are characterized by low pH and relatively high concentrations of sulfates, iron, manganese and dissolved solids. At the present time the Beaver Meadows flow is neutralized with lime before it drains to the Lehigh River. Plans to treat the Jeddo tunnel drainage have not been implemented due to the lack of monetary funds. While Table 6 presents an average Jeddo Tunnel flow of 27,000 gpm, more comprehensive data of Jeddo Tunnel flows occurring from 1930 to 1960 shows that the average flow is closer to 17,000 gpm. Using this lower average, the total combined average flow of the Jeddo and Beaver Meadows Tunnels is approximately 29,400 gpm which is still greater than assumed plant water requirements.

When compared to the alternative of using either Lehigh or Susquehanna river water directly as makeup, the use of mine drainage would result in higher plant water treatment requirements ie, pH neutralization, iron removal and dissolved solids removal. In addition, the higher concentrations of sulfates in the mine drainage could potentially cause scaling problems in closed water systems such as the main cooling water system without additional treatment.

d. Groundwater

The Hazleton area is located over a secondary aquifer with yields in the range of 100 to 200 gpm. At the present time groundwater is used by the city of Hazleton as a water supply source. Groundwater wells operated by the city of Hazloton in the vicinity of the site are located at Ebervale and at Lattimer.

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The wells at Ebervale consist of two artesian wells. Total yield from the wells is approximately 225 gpm. The water is of excellent quality as shown on Table 7. Groundwater yields at the Lattimer wells are in the range of 75-100 gpm. Water quality is lower than that found at Ebervale as shown on Table 8.

An artesian well exists on the site but is currently not being used. From visual observations the flow from the well is estimated at 50-100 gpm. This well could potentially satisfy potable water requirements at the plant.

In summary, while groundwater quality is high, groundwater yields in the area are limited. Potential use of groundwater for the plant should be limited to makeup to potable water systems and other low water demand systems which have high water quality requirements.

e. Comparative Evaluation of Water Supply Sources

Of the four potential water supply sources investigated, the Susquehanna River appears to be the most desirable. While water quality of the Lehigh River is comparable to that found in the Susquehanna River, withdrawal from the former is less desirable due to potentially higher compensation requirements, monetary charges for water withdrawal and consumption from the Lehigh River and higher treatment requirements for plant wastewater effluents to the river. The use of mine drainage would result in higher water storage requirements since minimum flows recorded are below plant water demands. In addition, the poor quality of the mine drainage would result in higher plant water treatment costs. Finally, available groundwater supplies near the site cannot supply plant water requirements but are limited to small water use systems.

3. Solid Wastes

As presented previously total solid wastes generated from the plant (4 units) are estimated at approximately 5600 tons/day, consisting primarily of gasifier slag, ash and evaporator residue. Over a 30-year life, total volume of solid wastes is estimated at 28,800 ac-ft. Assuming an average storage depth of 40 feet, approximately 720 acres would be required for solid waste disposal. The solid wastes could be disposed of in strip mines as part of reclamation efforts. Lining and surface water runoff control facilities would be provided as necessary to protect surface and groundwaters. With respect to water quality, it is expected that such reclamation would improve the quality of mine drainage flows to the Susquehanna and Lehigh Rivers.

4. Land/Use Socioeconomic

a. Land Use

Land use in Luzerne County has been classified by the Luzerne County Planning Commission. The largest category of land use in Luzerne County is open space which includes agricultural, wooded, vacant, inactive coal areas and state game lands. Open space in Luzerne County totals 491,989 acres or 85 percent of the land area. Open space in Hazle Township and Hazleton is substantial although less than Luzerne county. Open space in

Hazle Township totals 72 percent; open space in Hazelton totals 47 percent (see Table 9). Open space is expected to remain the largest category of land use in the future (Luzerne County Planning Commission, 1976).

The shale pit site and the area surrounding the site are classified as open space. Active mining areas are located north and south of the site. Residential developments are located west of the site and on the eastern edge of the site. West of the site a new subdivision is being developed on Forest Hill Drive where fifty lots have been subdivided and 15 houses have been built or are under construction. On the eastern edge of the site an older housing development is located. A total of 15 houses are located in this development as well as a 10 acre private recreation area.

These residential areas are zoned R-2 (two-family and apartment residence district). The site and the remaining area around the site are zoned M-1 (Mining District).

b. Population and Housing

The population in Hazelton, as well as Luzerne County has declined in the last two decades (see table below). The 1980 estimated population for Hazelton is 26,678, a decrease of 16.7 percent since 1960. The 1980 estimated population for Luzerne County is 328,086, a decrease of 5.4 percent since 1960. Population growth did occur in Hazle township, increasing 1584 (21.2 percent) people between 1960 and 1980. (U.S. Bureau of Census, 1960, 1970, 1980).

Population Change 1960-1980

	1960	1970	1960-1970 % Change	1980	1970-1980 % Change
Luzerne County	346,972	341,956	-1.4%	328,086	-4.1%
Hazleton	32,056	30,426	-5.1%	26,678	-12.3%
Hazle Twp.	7,478	7,619	1.8%	9,062	18.9%

Even though population has been decreasing in Luzerne County and Hazelton the number of housing units has been increasing. Housing units increased 17.7 percent in Luzerne County between 1970 and 1980 while in Hazelton housing units increased 6.3 percent. The increase can be explained by a reduction in household size. Persons per household in Luzerne County decreased from 3.0 people to 2.67 between 1970 and 1960. Persons per household in Hazelton decreased from 2.88 to 2.53 between 1970 and 1980. (U.S. Bureau of Census, 1970, 1980).

c. Employment

The majority of the people in Luzerne County are employed in the manufacturing sector of the economy. In 1979, 39 percent of the workers were employed in the manufacturing sector, although this percentage has been declining. In 1975 the manufacturing sector accounted for 43 percent. The construction sector is a small sector but has been steadily increasing from 6.5 percent in 1975 to 7.7 percent in 1979. The mining sector accounts for less than 1% of employment in Luzerne County, (Pa. Department of Labor and Industry, 1975-79). Employment by sector is illustrated in Table 10.

The unemployment rate in Luzerne County in January 1980 was 11.0 percent. Historically the unemployment rate in Luzerne County and northeastern Pennsylvania has been higher than Pennsylvania or the U.S. The unemployment rate for northeastern Pennsylvania during this same time period was 10.5 percent; while the unemployment rate for Pennsylvania was 7.8 percent and the U.S. 6.8 percent. (Economic Development Council of Northeastern Pa., 1979). The unemployment rates for the last ten years are displayed in Table 11.

d. Transportation

Access to the greater Hazelton area is provided by Interstate 81, Interstate 80, and State Route 309. I-80 is an east/west highway providing access to points in New Jersey and western Pennsylvania. I-81 is a north/south highway providing access to points in New York and all points south. State Route 309 provides direct access to downtown Hazelton. Access to the site is provided by Stockton Mountain Road from State Route 93 or State Route 940 or by Diamond Avenue extension from downtown Hazelton.

Rail service is provided by Conrail on tracks located south of the site. These tracks travel east-west through Hazelton.

e. Tax Revenues

Industrial and mining properties are assessed at 20% of market value. Millage rates in Luzerne County total 124.2 and include county, township, institutional, and school district taxes.

5. Aquatic Ecology

Because no streams occur on the Shale Pit Site and no primary water source has been identified, specific aquatic ecology studies have not been conducted. The only aquatic habitat on the site is a small pond, approximately fifteen (15) feet in diameter, formed by blocking a seepage area near the southern site boundary. All surface runoff from the site appears to be intermittent with all flows from the western two-thirds of the site draining to a mine tunnel.

Four potential sources of mine drainage water; Jeddo, Owl Hole, Beaver Mountain, and Buck Mountain Tunnels, were examined. Jeddo Tunnel, the largest of the four outflows, appeared to be heavily contaminated with low pH and high particulate load. This outflow enters Little Nescopeck Creek and so severely degrades it that the fishery resource is eliminated from that stream until it enters the main stem, Nescopeck Creek, about six (6) miles downstream. The Jeddo Tunnel is slated for installation of a water treatment (acid neutralization) facility. However, State funds are currently lacking and no estimate of a possible time schedule for cleanup could be elicited from State officials.

Neutralization facilities have been installed at both Buck Mountain and Beaver Meadow. However, the Beaver Meadow facility, a pumped water trickling filter, is currently inoperative, probably due to lack of funding. Consequently, the Buck Mountain outflow is the only one of the four examined which is currently being treated. Owl Hole Tunnel had only a small flow when examined and appeared to be less heavily contaminated than any of the other mine discharges.

Because of their past or present levels of pollution and/or relatively small size, it is doubtful that any of the mine discharges support significant fisheries. No rare, threatened or endangered species are known to occur on the site or in the water sources currently proposed for the facility.

6. Terrestrial Ecology

a. Soils

The majority of the soils on the Shale Pit site are stony, sandy loams belonging to the Dekalb, Buchanan and Pocono Series (Figure 2). Portions of the site in the western side have been striped for shale and subsequently partially refilled with rubble and trash. The site abutts a strip mine to the south and the southern boundary shows evidence of past mining activity. For example, a mine tunnel approximately forty yards from the road on the south boundary apparently receives most of the runoff from the western two thirds of the site. Some coal measures of sufficient size to warrant stripping reportedly (T Conner pers comm) still occur along the southern side of the site. The extent and exact location of these reserves was not determined.

Because of their stony, shallow nature, the soil types on the site have moderate to severe constraints on many types of engineering and construction uses and range from only fair to very poor in their potential wildlife habitat capabilities. In addition, a major portion of the site (Figure 3) has slopes exceeding fifteen (15) percent.

b. Vegetation

All vegetational communities on the Shale Pit site show evidences of past perturbations due to stripping, logging and/or burning. The predominant habitat type on the site was scrubby, dry slope forest (Figure 4) comprised of gray birch, scrub oak, bracken fern, dryland blueberry and other xeric and fire tolerant species (Table 12). A small protion of this community type showed evidence of recent fire and all of it had probably been exposed to wildfires in the past. Coppice growth American Chestnut saplings were an interesting and fairly common component of the forests on the site, but because of chestnut blight, rarely reached sufficient size to bear fruit.

The dry slope forest grades into a more mesic woodland dominated by white, chestnut and red oak and red maple with a shrub understory of these species and common witch-haze (Table 12). This community has been disturbed by logging, mining and nearly residential development and appeared to be relatively young with few trees more than forty to fifty years of age. This forest type, which covered over twenty (20) percent of the study area, is the most productive wildlife habitat present.

A considerable portion of the site is comprised of disturbed, make or strip-mined land (Figure 4). Although these areas may support a wide variety of Plants (Table 12), the majority are weedy species, many of them introduced aliens. All are species highly tolerant of disturbance. Gray birch was particularly common and on portions of the adjacent unreclaimed mine spoils was virtually the only vegetation present.

No floodplain, wetland or unique habitats were found on the site. All habitats observed are common and widespread in this region of Pennsylvania. No rare, threatened or endangered plants were found and none appear likely to occur. Poa-grass, Pas paludigenoi, a species listed by Wiegman (1979) as having a restricted or endemic distribution in Pennsylvania, has been recorded from Luzerne County, but is unlikely to occur on site since its preferred habitat is bogs.

c. Wildlife

Although no wildlife studies were conducted, some six (6) species of mammals, forty three (43) species of birds, and three (3) species of reptiles and amphibians were recorded on the site. Game species recorded on the site included white-tailed deer, gray squirrel, and ruffed grouse.

The dry slope forest and mesic woodland constitute the best wildlife habitats on the site. Both habitats are widespread in the region and have been perturbated on site by fire and/or lumbering. No endangered or threatened animals were recorded and due to lack of suitable habitat, none are likely to occur.

III. PROJECT DESCRIPTION

A. PLOT PLAN

The plot plan, Figure 5, illustrates the process configuration showing the plant units, the coal storage and handling, the cooling towers, the administration and parking area, railroad yard, disposal areas, flare and product storage.

The gasification facility will require a land area of approximately 170 acres (Energy Development & Resource Corporation, 1980). The largest land area would be utilized for waste disposal. The preliminry land requirements for the facility are presented below:

Process plant area - 30 acres

Coal storage and handling - 12 acres

Cooling tower area - 3.6 acres

Administration and parking area - 2.6 acres

Railroad yard and truck unloading area - 45 acres

Disposal area and waste storage - 66 acres

Flare - 3 acres

Product storage - 5.5 acres

B. PROCESS DESCRIPTION

The design basis for NEPGAS is the gasification of approximately 5000 TPD of anthracite coal and culm to produce nominally 72.5 billion BTU per day of raw synthesis gas. The raw synthesis gas is to be used in the production of 2500 TPD chemical and fuel grade methanol.

A simplified overall process outline for the NEPGAS Coal to Methanol Program is illustrated in Figure 6, NEPGAS Process Flow Diagram.

As presently envisioned, the plant is comprised of various processing steps, including:

- Coal Preparation - coal is prepared to the required size distribution;

- Coal Gasification - coal is reacted with oxygen, which is provided by the Air Separation System, to produce raw synthesis gas, releasing heat which is recovered as steam;

- Heat Recovery and Particulate Removal - raw synthesis gas is cooled, producing steam, and the residual particulate removed from the gas stream;

- Carbon Monoxide (CO) Shift - CO is converted to hydrogen by the water shift reaction in the presence of a catalyst to produce the required ratio of hydrogen to carbon monoxide;

- <u>Acid Gas Removal</u> - hydrogen sulfide (H_2S) and carbon dioxide (CO_2) are selectively removed to produce synthesis gas with the required carbon oxide level;

- <u>Methanol Synthesis</u> - synthesis gas is converted to crude methanol;

- <u>Purification</u> - crude methanol is purified by distillation as required by produce specifications;

- <u>Sulfur Recovery</u> - sulfur in the sour gases from the acid gas removal system is converted to elemental sulfur via the Claus reaction;

- <u>Tail Gas Treating System</u> - sulfur in tail gases from the Sulfur Recovery System is reduced to an environmentally acceptable level before the gases are released to the atmosphere.

The complex for the gasification of 5000 T/D anthracite coal and culm will consist of one process train. The process train will consist of a number of modules for each process system. The capacity of a process train is limited by the maximum throughput of a major process component or module of the train.

Based on information developed in the Preliminary Conceptual Study for the Nanticoke site, the capacity limit for the process train was set by the methanol synthesis system. The largest single methanol module presently in operation is limited to 2500 T/D.

As presently envisioned, the configuration of the main line process systems of the nominal 5000 T/D coal gasification/2500 T/D Methanol, Methanol Fuel Plant is illustrated in Figure 7. The train consists of a number of modules when the production requirements are beyond the range of the maximum practical equipment size.

C. PLANT EMISSIONS

1. Liquid

Average wastewater flow from the four 2500 ton methanol units is estimated at 13,500 gpm. This flow would consist of cooling tower blowdown, neutralized demineralizer regeneration wastes, filter backwash, floor drainage treatment effluent, and sanitary waste treatment effluent.

Gasifier blowdown would be treated in an evaporator system with the distillate reused within the gasifier and evaporator residue disposed of in an onsite lined pit. Therefore, there would be no discharge to receiving streams from the plant gasification units.

The remainder of the waste water flows would be directed to a central wastewater treatment facility. Effluent quality would be in compliance with Federal effluent limitations and specific Pennsylvania water quality standards.

2. Solids

Estimated quantities of solid wastes from methanol production are presented in Table 13.

The primary solid waste is slag resulting from the gasification of coal. While the physical and chemical properties of the slag are dependent on the coal utilized and the gasification process utilized it is expected that the slag would contain oxides of silicon, iron, aluminum and calcium. Specific gravity of slag range from 2.6 to 2.8. Bulk density of the gasifier slag is approximately 100 pounds per cu ft.

Evaporator residue would result from the treatment of gasifier blowdown, with solids constituents consisting of chloride, sulfate, cyanate, formate of calcium, magnesium and potassium. For a plant life of 30 years, total volume of evaporator residue is estimated at approximately 75 ac-ft.

Water pretreatment sludge would result from the screening and clarification of plant makeup water and could consist of debris, silts, clay etc. Chromium removal sludge would result from the treatment of cooling tower blowdown.

3. Air

Air emissions estimated for a 2500 Ton/Day methanol unit are presented in Table 14. A dust suppression would be employed to control fugitive particulate emissions to 125 tons per year.

IV. ENVIRONMENTAL CHANGES/IMPLICATIONS

A. AIR QUALITY

One major potential impact of a coal gasification facility is that of atmospheric emissions on the local and regional air quality. Sources of emissions from a typical coal conversion plant are:

1. coal storage and handling system
2. coal gasification system, and
3. methanol synthesis systems

The annual emissions generated by a typical coal gasification facility have been calculated based on the consumption of 5,000 tons per day of anthracite coal and culm, and the production of 72.5 tons per day of raw synthesis gas. The pollutants if emitted uncontrolled would amount in tons per year (tpy) to:

1.	particulates	1,254 tpy
2.	carbon monoxide	611 tpy
3.	hydrocarbons	219 tpy
4.	nitrogen oxides	35 tpy
5.	sulfur dioxide	23 tpy

A dust suppression system (90% efficiency) will be employed to control fugitive particulate emissions and reduce emissions to 125 tpy.

Estimated emissions of carbon monoxide (CO), hydrocarbons (HC) and total suspended particulates (TSP) for the proposed facility exceed 100 tons per day (tpy) and will increase ambient concentrations of these pollutants in the site area. The extent to which these pollutants impact any sensitive areas near the site area can only be ascertained via air quality modeling which is beyond this scope of work. According to PSD regulations the plant will be considered a major source for these pollutants listed above. Emissions estimates of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) are below the DeMinimus value of 40 tpy established by the EPA and any impact of these emissions will most likely be negligible. The proposed facility will be subject to the state's emission offset policy for volatile organic compounds (VOC) due to the high levels of hydrocarbon emissions and the non-attainment designation of the entire state for ozone.

Although modeling was not conducted, we anticipate that since the state is designated non-attainment for ozone emissions from the facility will impact upon designated non-attainment areas and may have the potential to impact (ie, any increase greater than Class I increment levels-annual geometric mean of 5 ug/m^3) several non-attainment areas for TSP since they are close by. Air quality modeling of facility emissions will define the controls necessary for operation. Air quality modeling of facility emissions will produce a clearer definition of the impacts on the areas mentioned above and will define the controls necessary for operation.

B. WATER SUPPLY AND WATER QUALITY

The environmental changes/implications to the water supply include the following:

1) Approximately 14,000 gpm would be consumed from water supplies in the area. It is noted that required compensation would result in zero plant water consumption during low flow conditions;

2) Assuming that groundwater use is limited to potable needs, it is expected that minimum impact would result on local groundwater sources;

3) Plant discharges would be in compliance with Federal effluent limitations and specific Pennsylvania water quality criteria, therefore minimum change to existing water quality is expected.

4) Use of mine drainage flows as plant makeup would have the beneficial effect of improving the quality of tributary flows to the Susquehanna and Lehigh Rivers.

5) Appropriate lining and surface runoff control facilities would be provided for solid waste disposal areas to prevent groundwater and surface water contamination.

6) Reclamation of the strip mines using gasifier slag would improve the existing water quality of mine seepage and runoff flows.

C. SOLID WASTES

The proposed gasification facility would have the following implications for solid waste disposal.

1) The disposal of slag in mines in the area would have the beneficial impact of providing fill material for mine reclamation.

2) The utilization of culm material as a fuel for the plant would reduce existing culm banks and have a beneficial impact on the environment consisting of improved area aesthetics and minimizing pollution of surface and groundwater sources.

D. LAND USE/SOCIOECONOMICS

1. Land Use

The proposed site will require a land area of approximately 170 acres. This area includes the plant area and the waste disposal areas for operation of the plant for five years. The proposed site is currently vacant with the majority of the site being wooded. Although the site is vacant it is zoned for mining and its future use is intended for industrial purposes. Construction of the plant will prempt any future mining activities on the site although mining activities will increase in the area as a result of the construction of the plant.

The area surrounding the plant is a mixture of wooded areas, strip mined areas, and residential areas. These areas are zoned for mining use except for the residential areas. The plant is compatible with existing mining areas and the proposed future use of the vacant wooded areas. However the plant is incompatible with the existing residential areas. The nearest residential area is located adjacent to the proposed site separated only by Stockton Mountain Road. Fifteen houses are currently under construction with an additional thirty five planned. These houses are being constructed in a R-2 zone which permits residential development. This R-2 zone is bounded on the north, south and east by a M-1 zone, a mining district. The construction of the plant will have a severe impact on this residential development.

The site is not located on or adjacent to a state or national park, recreation area or historic landmark. The Pennsylvania Historical and Museum Commission indicates that the proposed site has a low to moderate probability for historic or prehistoric site location. The Commission recommends a field survey of the site emphasizing those areas which are flat and near water or extinct stream beds (Pennsylvania Historical and Museum Commission)

2. Aesthetics

The proposed site is located on a ridge with varying elevation from 1580 to 1850 feet which is the highest elevation in the general area. The plant will be visible from the adjacent ridges and valleys at the following points:

- The entrance to Stockton Mountain Road from Route 940, north of the site.

- Housing in the village of Oakdale, north of the site.

- Housing in the new subdivision on Forest Hill Drive, west of the proposed site.

- Housing in the village of Stockton, south of the site

The most prominent aesthetic impact will be on the housing development on Forest Hill Drive, west of the site.

3. Employment

The coal gasification facility will result in increased employment from both construction and operation of the facility. The proposed facility will increase employment in the manufacturing, construction, and mining sectors. The manufacturing sector is the largest sector in Luzerne County although a declining sector. The facility will increase employment in this sector by 260 employees as well as stimulate spin-off industries.

The greatest implication of construction of the facility will be the impact on the unemployment rate in Luzerne County. The unemployment rate in Luzerne County in January 1980 was 11%, substantially higher than the rate in Pennsylvania and the U.S.

The work force expected to be employed at the facility is 260. An increase of 260 jobs in the manufacturing sector at an average weekly salary of $192.24 (Economic Indicators of N.E. Pa., 1979) will increase weekly earned income in Luzerne County $49,982.

4. Population and Housing

The construction of the coal gasification facility is not expected to have any impact on the housing supply or the population base. Construction workers and the operational staff of the facility are expected to be supplied by the local labor force. The high rate of unemployment in Luzerne County will provide an ample supply of construction workers and operational staff without an influx of outside labor.

The housing supply is not expected to be affected by construction of the facility. Since the labor supply will be local, additional housing will not be needed. In addition, the estimated housing vacancy rate in 1980 was 7.3%, with 9489 units vacant in Luzerne County.

5. Transportation

The coal gasification facility will have an impact on rail, truck, and automobile traffic. The shale pit site is serviced by Conrail, approximately 1/4 mile south of the site. The facility will require considerable rail traffic to the site. The Conrail tracks travel through downtown Hazelton, crossing at grade, Broad Street and Church Street. This rail traffic will impact traffic patterns and result in traffic slow-downs in downtown Hazelton.

The facility will also require considerable truck traffic. Access to the site is on Stockton Mountain Road from either State Route 93 or State Route 940 or from Diamond Avenue extension, east of Hazelton. All access points will require truck traffic to travel through residential areas impacting these residential structures.

Auto traffic will be increased due to the construction of the plant. Employees alone will create 520 additional trips daily as well as visitors to the plant. This auto traffic will travel the same roadways as the truck traffic and create the same impacts.

6. Tax Revenues

The estimated cost of construction of the plant is $450,000,000 (1979 $ estimate). Based on an assessed value of 20% of market value, and a millage rate of 124.2, tax revenues to the county, township, and school district would total $11,178,00 annually.

E. ECOLOGY

The proposed site does not contain any rare, threatened or endangered plants and none are likely to occur. This site is not in the floodplain and there are no wetlands or unique habitats on the site. No endangered or threatened animals were recorded and due to a lack of suitable habitat none are likely to occur. Due to the disturbed nature of the site the gasification facility will not cause any major changes to the site.

V. RECOMMENDATIONS

A. LICENSING REQUIREMENTS

The following is a tentative list of the Federal, state, and local environmental requirements applicable to the licensing of a coal gasification facility. Table 15 presents a possible schedule for the satisfaction of these requirements.

1. FEDERAL

a. Resource Conservation and Recovery Act (RCRA)(42 USC 6901 et seq)

The coal gasification facility may be subject to the requirements of RCRA pertaining to generators or transporters of hazardous waste. This could result from the production of hazardous waste streams, as well as from the presence of hazardous substances on soil removed from the construction site. Accordingly, the facility would have to notify EPA of its activity prior to its commencement (as required by RCRA 3010) and to comply with requirements for marking, packaging, etc. developed by EPA in its hazardous waste management regulations (45 FR 33063-33285, May 19, 1980). Note that a generator has the responsibility, according to EPA regulations, to analyze its own wastes to determine whether or not they are hazardous.

The facility may also be required to obtain a RCRA permit if its activities include the conduct of treatment, storage, or disposal of hazardous wastes. Such a permit will be issued by EPA or by a state with an EPA-approved program.

b. Clean Air Act (CAA)(42 USC 7401 et seq)

As the proposed site is located in an area which has been designated attainment for purposes of the CAA, the facility will have to obtain a Prevention of Significant Deterioration (PSD) permit from EPA prior to the commencement of construction. To obtain a PSD permit, the facility must demonstrate that it will comply with National Ambient Air Quality Standards (NAAQS)(CAA 7410), PSD increments for sulfur oxides and particulate matter as calculated by the State Implementation Plan (SIP) for that area, the New Source Performance Standards (NSPS)(CAA 7411) and the National Emission Standards for Hazardous Air Pollutants (NESHAPS)(CAA 7412). It must also demonstrate that it will apply Best Available Control Technology (BACT) for all CAA-regulated pollutants, monitor to determine compliance with the NAAQS and the PSD increments, analyze the climate, meteorology, terrain, soil, vegetation, visibility, and the growth impacts associated with the source, conduct air modeling and other monitoring as necessary.

c. Clean Water Act (CWA)(33 USC 1251 et seq)

If any disposition of dredged or fill material into a navigable waterway is expected in conjunction with this project, the facility must obtain a permit for such discharge from the Army Corps of Engineers. It is applied for on the same form as the Section 10 permit (discussed in (d.) below.)

d. Rivers and Harbors Act (RHA)(33 USC 401 et seq)

In order to construct any pier, wharf, or other structure in a navigable waterway, or to excavate, fill, or alter or modify the course of a waterway, a permit must be obtained from the Army Corps of Engineers. Such a permit is required for the construction of water intake structures, discharge structures, and loading/unloading facilities on waterways. It is applied for on the same form as the Section 404 permit (discussed in (c.) above).

e. National Environmental Policy Act (NEPA)(42 USC 4321 et seq)

NEPA requires the preparation of an Environmental Impact Statement (EIS) by any Federal agency which is performing a major action which will significantly affect the environment. The issuance of either a Section 10 or a Section 404 permit by the Corps of Engineers qualifies as a major action which must be evaluated to determine whether the permitted activity will significantly affect the environment. The results of this evaluation will be published in the environmental assessment. If significant effects will occur, the preparation of a full EIS will be required.

f. Susquehanna River Basin Commission

This Commission will review any major project which affects water quality in the Susquehanna River Basin and is especially concerned with withdrawal of water from rivers, streams, etc.

g. National Historic Preservation Act (16 USC 461-470t)

Section 106 requires any Federal agency which issues permits for structures which would affect a place significant in American history, architecture, archeology or culture, to assess those effects prior to permit issuance. This evaluation is generally conducted in conjunction with the environmental review process pursuant to NEPA and in the Army Corps of Engineer's review prior to issuance of any Corps permits.

h. Wild and Scenic Rivers Act (16 USC 1271 et seq)

If the site is located on a river which has been designated wild or scenic, construction may be prohibited or severely restricted. This is also considered in NEPA and Army Corps of Engineer's permit reviews.

i. <u>Endangered Species Act (16 USCC 1531 et seq)</u>

Section 7 requires Federal agencies which issue permits to insure that permitted activities will not jeopardize the existence of a listed threatened or endangered species, or result in the destruction of its critical habitat. This could affect the issuance of a federal permit for this project.

j. <u>Fish and Wildlife Coordination Act (16 USC 661 et seq)</u>

This Act requires that any federal agency issuing a permit or license consult with the U S Fish and Wildlife Service if the proposal would modify a water body. This requirement could affect the NEPGAS project in that it will discharge pollutants into a water body, with possible modifications resulting.

2. <u>STATE</u>

a. <u>Clean Streams Law (35 Pa Code 691.1 et seq)</u>

Authority for the issuance of permits for the discharge of wastewater into waterways which was originally given to the EPA in Section 402 of the CWA has been delegated by EPA to the Commonwealth of Pennsylvania. The NEPGAS facility will be required to obtain such a permit for the liquid effluent which it will discharge into the receiving stream. The permit will be issued containing restrictions on discharge as required to meet applicable effluent and water quality based limitations.

Although Pennsylvania does not usually require permits for construction activities, including sedimentation ponds, the applicant may be required to submit an erosion control plan. If the earth-moving activities during construction affect more than 25 acres of land, a separate permit for such activities may be necessary.

Pennsylvania does not limit that amount of water which may be withdrawn from its waterways for industrial purposes. Intake structures must reflect the best technology available for minimizing adverse environmental impact, however, in order for an NPDES permit to be issued for a facility in Pennsylvania.

b. Obstructions Statute (32 Pa Code 591)

Should the project require the construction of a culvert or the rechannelization of a stream, as in the construction of the water intake structures, a special permit must be obtained pursuant to this statute.

c. Solid Waste Management Act (35 Pa Code 29)

This Act requires use of land for solid waste processing or disposal to be permitted by the Department of Environmental Resources. Transportation, disposal, or processing of garbage, refuse, and other discarded materials, including solid and liquid wastes, from industrial activities without a permit is prohibited.

d. Air Pollution Control Act (35 Pa Code 23)

Construction, installation, and modification of any stationary air contamination source must be permitted. Construction cannot commence prior to permit issuance.

e. Other Areas

Fish and wildlife, historic preservation, floodplain and wetland protection will all be evaluated by the Department of Environmental Resources in the course of its review of the above-mentioned permit applications.

3. LOCAL

Coordination with the Luzerne County Commission (which is routinely conducted by the Department of Environmental Resources in any permit review procedures) will assure satisfaction of any local requirements.

B. ADDITIONAL STUDIES

The following studies and investigations are recommend if the program continues. These studies are directed toward more carefully defining the enviromental characteristics of the site.

1. Study to identify underground pools in the vicinity including location, water storage capacity, water quality, etc.

2. Study to develop more extensive flow and water quality information associated with the Jeddo and Beaver Meadows Tunnels.

3. Treatability studies to develop water treatment design criteria for use of mine drainage as plant makeup.

REFERENCES

Economic Indicators of Northeastern Pennsylvania, 1959-1978, Economic Development Council of Northeastern Pennsylvania, June 1979.

Energy Development and Resource Corporation, Anthracite Coal (Culm) Gasification Plant, Interim Report, March 17, 1980.

Luzerne County Planning Commission, Land Use Plan, Year 2000, June 1976

Pennsylvania Department of Labor and Industry, "Employment and Wages of Workers Covered by the Pa. Unemployment Compensation Law, 1975-1979".

Pennsylvania Historical and Museum Commission, Personal Communication with Joel I. Klein, Envirosphere Company.

U.S. Bureau of Census, Department of Commerce, 1960, 1970, 1980.

TABLE 1

SUSQUEHANNA RIVER

WATER QUALITY

(HUNLOCK CREEK)*

PARAMETER	VALUES		
	MEAN	MAXIMUM	MINIMUM
TURBIDITY (Ftu)	8.7	25.0	2.5
COLOR (Pt-Co Units)	27.8	90.0	5.0
CONDUCTIVITY (MHO/CM)	358.2	610.0	155.0
DISSOLVED OXYGEN (MG/L)	9.5	13.0	2.8
pH	6.8	7.7	0.7
TOTAL ALKALINITY ($CaCO_3$, MG/L)	47.1	83.0	10.0
TOTAL DISSOLVED SOLIDS (MG/L)	174.0	254.0	126.0
TOTAL SUSPENDED SOLIDS (MG/L)	42.8	320.0	5.0
CALCIUM (MG/L)	27.4	32.8	21.6
MAGNESIUM (MG/L)	5.4	7.7	1.4
CLORIDE (MG/L)	15.0	90.0	0.0
SULFATE (MG/L)	110.0	430.0	11.0
ARSENIC (MG/L)	10.0	10.0	10.0
CADMIUM (UG/L)	3.0	3.0	3.0
CHROMIUM (UG/L)	10.0	10.0	10.0
COPPER (UG/L)	10.0	10.0	10.0
IRON (UG/L)	3454.3	14,000.0	200.0
LEAD (UG/L)	50.0	50.0	50.0
MANGANESE (UG/L)	1027.1	5500.0	0.0
NICKEL (UG/L)	15.0	20.0	10.0
ZINC (UG/L)	10.0	10.0	10.0
ALUMINUM (UG/L)	120.0	120.0	120.0
MERCURY (UG/L)	2.0	2.0	2.0

*Based on EPA Storet Data.

TABLE 2

PENNSYLVANIA WATER QUALITY STANDARDS

SPECIFIC CRITERIA

Susquehanna River - North Branch

(Lackawanna River to West Branch)

Parameter	Criteria
Aluminum	Not to exceed 0.1 of the 96-hour LC50 for representative important species
Alkalinity	Equal or greater than 20 mg/1 as $CaCO_3$ or where receiving waters are less, no further reduction in the alkalinity of receiving water.
Aresenic	Not to exceed 0.05 mg/1
Fecal Coliform	Not to exceed 200 per 100 ml (May 1 - Sept. 30) 2000 per 100 ml (other times)
Chromium	Not to exceed 0.05 mg/1 (hexavalent)
Copper	Not to exceed 0.1 of the 96-hour LC50 for representative important species.
Cyanide	Not to exceed 0.005 mg/1 (free HCN+CN-)
Dissolved Oxygen	Minimum daily avg - 5.0 mg/1 No value less than 4.0 mg/1
Fluoride	Not to exceed 2.0 mg/1

TABLE 2 (Cont'd)

PENNSYLVANIA WATER QUALITY STANDARDS

SPECIFIC CRITERIA

Susquehanna River - North Branch

(Lackawanna River to West Branch)

Parameter	Criteria
Iron	Not to exceed 1.5 mg/l total iron 0.3 mg/l dissolved iron
Lead	Not to exceed the lesser of 0.05 mg/l or 0.01 of the 96-hour LC50 for representative important species
Manganese	Not to exceed 1.0 mg/l.
Nickel	Not to exceed 0.01 of the 96-hour LC50 for representative important species
Nitrite plus Nitrate	Not to exceed 10 mg/l as nitrogen
pH	Not less than 6.0 and not more than 9.0
Phenolics	Not to exceed 0.005 mg/l
Temperature	No rise when ambient temp is 87°F. Not more than 5°F rise above ambient until stream temperature reaches 27°F. Not to change more than 2°F during any one-hr period

TABLE 2 (Cont'd)

PENNSYLVANIA WATER QUALITY STANDARDS

SPECIFIC CRITERIA

Susquehanna River - North Branch

(Lackawanna River to West Branch)

Parameter	Criteria
Total Dissolved Solids	Not more than 500 mg/l as a monthly average value; not more than 750 mg/l at any time.
Zinc	Not to exceed 0.01 of the 96-hour LC50 for representative important species.

Note

The accepted design stream flow, to which the above criteria shall apply, is the actual or estimated lowest seven-consecutive-day average that occurs once in ten years (ie, Q7-10 flow).

TABLE 3

LEHIGH RIVER WATER QUALITY

(WALNUTPORT STATION)*

PARAMETER	VALUES		
	MEAN	MAXIMUM	MINIMUM
TURBIDITY (FTU)	8.1	70.0	1.0
COLOR (PT-CO Units)	9.4	50.0	0.0
CONDUCTIVITY ($25^{o}C$, MHO/CM)	122.9	500.0	70.0
DISSOLVED OXYGEN (MG/L)	10.6	14.2	5.7
pH	6.8	8.9	5.6
TOTAL ALKALINITY (MG/L $CACO_3$)	18.1	210.0	0.8
TOTAL DISSOLVED SOLIDS (MG/L)	88.3	184.0	16.0
TOTAL SUSPENDED SOLIDS (MG/L)	18.2	120.0	0.0
CALCIUM (MG/L)	8.9	18.4	4.8
MAGNESIUM (MG/L)	2.8	8.3	0.0
CHLORIDE (MG/L)	8.3	20.0	0.0
SULFATES (MG/L)	29.4	175.0	8.0
ARSENIC (DISS., MG/L)	10.0	10.0	10.0
CADMIUM (UG/L)	5.3	10.0	3.0
CHROMIUM (UG/L)	10.6	29.0	0.0
COPPER (UG/L)	19.6	100.0	0.0
IRON (UG/L)	462.5	4900.0	0.0
LEAD (UG/L)	50.0	50.0	50.0
MANGANESE (UG/L)	261.4	700.0	0.0
NICKEL (UG/L)	29.3	100.0	0.0
ZINC (UG/L)	315.0	600.0	50.0
ALUMINUM (UG/L)	273.1	3760.0	0.0
MERCURY (UG/L)	5.0	5.0	5.0

*Based on EPA Storet Data.

TABLE 4

MINE DRAINAGE DISCHARGE POINTS

EASTERN MIDDLE FIELD

DISCHARGE POINT	FLOW RANGE* (GPM)	APPROXIMATE LOCATION WITH RESPECT TO PROPOSED SITE	ULTIMATE DRAINAGE
1. Jeddo Tunnel	14,500-54,030	4 miles Northwest	Susquehanna River
2. Beaver Meadows	2,564-59,677	3 miles South	Lehigh River
3. Owl Hole	690-7,669	6 miles Northeast	Lehigh River
4. Buck Mountain #1	5-125	5 Miles East	Lehigh River
5. Buck Mountain #2	284-900	5 Miles East	Lehigh River
6. Sandy Run	284-1680	5 Miles Northeast	Lehigh River
7. Pond Creek	5850-7200**	7 Miles Northeast	Lehigh River

* Flow information based on monitoring data compiled by the Pennsylvania Department of Resources.

**Based on USGS data.

TABLE 5

JEDDO TUNNEL

(DER Data from period 1965 to 1980)

Parameter	Range	Mean
Flow (GPM)	9000-54,000	27,000
pH	2.9-6.3	3.4
Acidity (mg/l as $CaCO_3$)	0-480	270
Sulfates (mg/l)	65-1630	560
Total Iron (mg/l)	0.2-33	310
Mn (mg/l)	0.1-30	12
Specific Conductivity (Mho/cm)	980-1900	1200

TABLE 6

BEAVER MEADOWS DRAINAGE TUNNEL

(Period of DER Record - 1965-1980)

Parameter	Range	Mean
Flow (GPM)	2,600-59,677	12,400
pH	3.1-4.2	3.3
Acidity (mg/l as $CaCO_3$)	20-340	180
Sulfates (mg/l)	120-520	290
Total Iron (mg/l)	0.4-8	3.3
Mn (mg/l)	0.4-9	6.3
Specific Conductivity	450-900	730

TABLE 7

EBERVALE WELL

GROUNDWATER QUALITY

Parameter	Value
pH	6.0
Total Alkalinity (mg/l as $CaCO_3$)	14.0
Chlorides (mg/l)	4.0
Sulfates (mg/l)	4.0
Total Solids (mg/l)	10.0
Turbidity (FTU)	1.0
Total Hardness (mg/l as $CaCO_3$)	20.0
Iron (ug/l)	10.0
Manganese (ug/l)	10.0
Mercury (ug/l)	2.0
Lead (ug/l)	50.0
Zinc (ug/l)	10.0
Chromium (ug/l)	10.0
Copper (ug/l)	10.0
Nickel (ug/l)	10.0
Silver (ug/l)	10.0
Barium (ug/l)	10.0
Sodium (mg/l)	10.0

TABLE 8

LATTIMER WELL

GROUNDWATER QUALITY

Parameter	Value
pH	5.3
Total Alkalinity (mg/l as $CaCO_3$)	10.0
Chlorides (mg/l)	14.0
Sulfates (mg/l)	4.0
Total Solids (mg/l)	68.0
Turbidity (FTU)	1.0
Total Hardness (mg/l as $CaCO_3$)	30.0
Iron (ug/l)	30.0
Manganese (ug/l)	110.0
Mercury (ug/l)	2.0
Lead (ug/l)	50.0
Zinc (ug/l)	20.0
Chromium (ug/l)	10.0
Copper (ug/l)	20.0
Nickel (ug/l)	10.0
Silver (ug/l)	10.0
Barium (ug/l)	100.0
Sodium (mg/l)	12.5

TABLE 9

LAND USE - EXISTING AND FUTURE

	Residential		Commercial		Industrial		Transportation		Public & Semi-Public		Open Space	
	1975	2000	1975	2000	1975	2000	1975	2000	1975	2000	1975	2000
rne County	24,747	36,768	4,044	4,700	12,200	11,405	22,260	25,118	24,035	30,394	491,989	470,888
: Township	575	948	339	378	5,464	4,281	1,758	2,043	316	1,227	22,022	21,598
lton	803	912	124	145	355	199	670	700	139	179	1,881	1,873

:e: Luzerne County Planning Commission, 1976.

TABLE 10

LUZERNE COUNTY EMPLOYMENT 1975-1979

	1975	%	1976	%	1977	%	1978	%	1979	%
Agriculture, Forestry, & Fisheries	190	.2	201	.2	203	.2	257	.2	313	.3
Mining	972	1.0	1,179	1.2	845	.9	982	1.0	978	.9
Construction	6,223	6.5	6,215	6.3	6,948	7.1	7,409	7.3	8,042	7.7
Manufacturing	40,938	43.0	42,157	42.9	40,158	41.2	39,470	39.0	41,146	39.3
Transportation & Public Utilities	5,877	6.2	5,817	5.9	5,898	6.1	6,713	6.6	6,872	6.7
Wholesale Trade	4,640	4.9	4,706	4.8	4,858	5.0	4,980	4.9	5,263	5.0
Retail Trade	18,506	19.4	19,669	20.0	19,906	20.4	20,746	20.5	20,625	19.7
Finance, Insurance, & Real Estate	4,672	4.9	4,821	5.0	4,788	4.9	4,821	4.8	5,114	4.9
Service	13,140	13.9	13,487	13.7	13,884	14.2	15,881	15.7	16,221	15.5
Total	95,158	100.0	98,252	100.0	97,488	100.0	101,259	100.0	104,574	100.0

Source: Pennsylvania Department of Labor and Industry, 1975-79

TABLE 11

UNEMPLOYMENT RATE (%) 1970-1980

	Luzerne County	N.E. Pennsylvania	Pennsylvania	U.S.
1970	4.2	5.2	3.7	6.8
1971	8.4	7.1	5.4	6.5
1972	8.8	7.1	5.9	6.3
1973	5.3	6.1	4.7	5.4
1974	5.7	7.1	5.6	5.2
1975	11.2	13.0	8.8	8.4
1976	10.7	12.0	9.6	8.4
1977	7.8	10.3	8.7	8.2
1978	7.4	9.7	7.8	6.8
1979	9.6	8.6	6.8	5.9
1980	11.0	10.5	7.8	6.8

Note: Unemployment rates are first quarter rates

Source: Economic Indicators of N.E. Pennsylvania, June 1979. Facts on northeastern Pennsylvania, 1980

TABLE 12

PLANT SPECIES RECORDED ON THE SHALE PIT SITE DURING FALL 1980 RECONNAISSANCE STUDIES

Family	Common Name	Scientific Name	Stratum[a]	Relative Abundance[b]: Dry Slope	Relative Abundance[b]: Mesic Woods	Relative Abundance[b]: Disturbed[c]	Relative Abundance[b]: Strip Mined
Osmundaceae							
	Cinnamon Fern	Osmunda cinnamomea	H		O		
	Interrupted Fern	Osmunda claytonia	H		O		
Polypodiaceae							
	New York Fern	Thelypteris noveboracensis	H		O		
	Lady Fern	Athyrium filix-femina	H		O		
	Bracken Fern	Pteridium aquilinum	H	FC		FC	
Pinaceae							
	Eastern Hemlock	Tsuga canadensis	C		O		
	White Pine	Pinus strobus	C		O		
	Pitch Pine	Pinus rigida	C,S	FC		FC	
	Red Pine (planted)	Pinus resinosa	C			O	
	White Spruce (planted)	Picea glauca	S			O	
Gramineae	Bent Grass	Agrostis scabra	H		O		
	Povertygrass	Danthonia spicata	H	O		FC	
	Hairy-seed Reedgrass	Calamagrostis cinnoides	H		O		
	Brome Grass	Bromus spp	H		O		
Cyperaceae							
	Wool Grass	Scirpus cyperinus	H		O		
	Carex	Carex viridula	H		O		
	Spikerush	Eleocharis spp	H		O	O	
	Sedges	Carex spp	H		O	O	
Juncaceae							
	Soft Rush	Juncus effusus	H			O	
	Path Rush	Juncus tenuis	H			O	
Liliaceae							
	Common Greenbrier	Smilax rotundifolia	S		O		
	Bristly Greenbrier	Smilax tamnoides	S		O		
	Canada Mayflower	Maianthemum canadense	H		FC		
	False Solomon's Seal	Smilacina spp	H	O	O		
Orchidaceae	Orchid		H		O		

a Stratum: C = Canopy, S = Shrub, H = Herbaceous
b Relative Abundance: Cm = Common, FC = Fairly Common, O = Occasional
c Disturbed Areas include made land, shale pit, and road borders
See Figure 3 for location of community types

TABLE 12 (Cont'd)

PLANT SPECIES RECORDED ON THE SHALE PIT SITE DURING FALL 1980 RECONNAISSANCE STUDIES

Family	Common Name	Scientific Name	Stratum[a]	Relative Abundance[b]			
				Dry Slope	Mesic Woods	Disturbed[c]	Strip Mined
Salicaceae							
	Upland Willow	Salix humilis	S			O	O
	Bigtooth Aspen	Populus grandidentata	C,S			O	O
	Quaking Aspen	Populus tremuloides	S,C			O	FC
Myricaceae							
	Sweet Fern	Comptonia peregrina	S	O	O	FC	FC
Juglandaceae							
	Bitternut Hickory	Carya cordiformis	S		O		
Corylaceae							
	Black Birch	Betula lenta	C,S		FC	FC	
	Yellow Birch	Betula lutea	C		O		
	Gray Birch	Betula populifolia	S,C	CM	O	Cm	Cm
Fagaceae							
	American Chestnut	Castanea dentata	S,C	FC	O		
	White Oak	Quercus alba	C		Cm		
	Chestnut Oak	Quercus prinus	C	FC	FC		
	Red Oak	Quercus rubra	C	O	FC	O	
	Scrub Oak	Quercus ilicifolia	S	CM		O	
	Blackjack Oak	Quercus marilandica	S				O
Polygonaceae							
	Arrowleaved Tearthumb	Polygonum sagittatum	H		O		
	Pennsylvania Smartweed	Polygonum pennsylvanicum	H			FC	
	Common Smartweed	Polygonum hydropiper	H		O		
	Redleg	Polygonum persicaria	H			FC	
	Japanese Bamboo	Polygonum cuspidatum	S			O	
Magnoliaceae							
	Yellow Poplar	Liriodendron tulipifera	C		O		
Lauraceae							
	Sassafras	Sassafras albidum	S,C	O	O	FC	
	Spicebush	Lindera benzoin	S		O		
Cruciferae							
	Field Peppergrass	Lepidium campestre	H			O	
	Tumble Mustard	Sisymbrium altissimum	H			Cm	
Hamamelidaceae							
	Common Witch-hazel	Hamamelis virginiana	S		FC		

TABLE 12 (Cont'd)

PLANT SPECIES RECORDED ON THE SHALE PIT SITE DURING FALL 1980 RECONNAISSANCE STUDIES

Family	Common Name	Scientific Name	Stratum[a]	Relative Abundance[b] Dry Slope	Mesic Woods	Disturbed[c]	Strip Mined
Rosaceae							
	Meadowsweet	Spiraea latifolia	S			O	
	Steeplebush	Spiraea tomentosa	S		FC		
	Roundleaf Juneberry	Amelanchier sanguinea	S		O		
	Downy Juneberry	Amelanchier arborea	S		O		
	Common Red Raspberry	Rubus idaeus	S			O	
	Common Dewberry	Rubus flagellaris	H	FC	Cm	D	
	Allegheny Blackberry	Rubus allegheniensis	S			FC	
	Fire Cherry	Prunus pennsylvanica		FC		Cm	FC
Leguminosae							
	White Clover	Trifolium repens	H			O	
	Yellow Sweetclover	Melilotus officinalis	H			FC	
Anacardiceae							
	Staghorn Sumac	Rhus typhina	S			O	O
	Winged Sumac	Rhus copallina	S			FC	
Aceraceae							
	Red Maple	Acer rubrum	C		FC	FC	O
Guttiferae							
	Canadian St Johnswort	Hypericum canadense	H			Cm	
Violaceae							
	Violets	Viola spp	H		FC		
Nyssaceae							
	Tupelo	Nyssa aquatica	S		FC		
Onagraceae							
	Common Evening Primrose	Oenothera biennis	H			O	
Araliaceae							
	Bristly Sarsaparilla	Aralia hispida	H		O		O
Umbelliferae							
	Wild Carrot	Daucus carota	H			O	
Pyrolaceae							
	Indian Pipe	Monotropa uniflora	H		O		

TABLE 12 (Cont'd)

PLANT SPECIES RECORDED ON THE SHALE PIT SITE DURING FALL 1980 RECONNAISSANCE STUDIES

Family	Common Name	Scientific Name	Stratum[a]	Relative Abundance[b] Dry Slope	Mesic Woods	Disturbed[c]	Strip Mined
Ericaceae	Flame Azalea	Rhododendron calendulaceum	S	O			
	Pink Azalea	Rhododendron nudiflorum	S	O			
	Sheep Laurel	Kalmia angustifolia	S	FC	FC	O	
	Mountain Laurel	Kalmia latifolia	S		FC		
	Maleberry	Lyonia ligustrina	S		O		
	Teaberry	Gaultheria procumbens	S	FC	O		
	Dryland Blueberry	Vaccinium vacillans	S	CM		FC	
	Constable's Blueberry	Vaccinium constablaei	S		O		
Primulaceae	Whorled Loosestrife	Lysimachia quadrifolia	H	FC	O	FC	
	Starflower	Trientalis borealis	H		O		
Gentianaceae	Narrow-leaved Gentian	Gentiana linearis	H		O		
Labiatae	Woundwort	Stachys polustris	H			O	
	Heal-all	Prunella vulgaris	H			O	
	Bugleweed	Lycopus spp	H		O		
Solanaceae	Bitter Night-shade	Solanum dulcamara	S			O	
Plantaginaceae	Pale Plantain	Plantago rugelli	H				O
Caryophyllaceae	Bouncing Bet	Saponaria officinalis	H				O
Caprifoliaceae	Common Elderberry	Sambucus canadensis	S			O	
	Smooth Blackhaw	Viburnum prunifolium	S			O	
Compopositae	Common Burdock	Arctium minus	H			O	FC
	Pilewort	Erechtitus hieracifolia	H			O	CM
	Thin-leaved Coneflower	Rudbeckia triloba	H				
	Spotted Knapweed	Centaurea maculosa	H				O
	Common Ragweed	Ambrosia artemisiifolia	H			FC	
	Whorled Wood Aster	Aster acuminatus	H		O		
	Aster	Aster spp	H		FC		
	Erect Goldenrod	Solidago erecta	H			O	FC
	Lance-leaved Goldenrod	Solidago graminifolia	H			FC	
	Rough-stemmed Goldenrod	Solidago rugosa	H			D	
	Biennial wormwood	Artemisia biennis	H			C	

p

TABLE 13

ESTIMATED SOLID WASTE GENERATION
(2500 ton/day Methanol Unit)

Solid Waste	Generation Rate (Ton/Year)
Gasifier Slag	520,000
Pyrites	170
Coal Pile Runoff Sludge	5
Water Pretreatment Sludge	2,100
Effluent Treatment Sludge	260
Chromium Removal Sludge	50
Evaporator System Residue	1,000
Plant Refuse	10
FGD Misc Catalyst, etc	150
Total	523,745

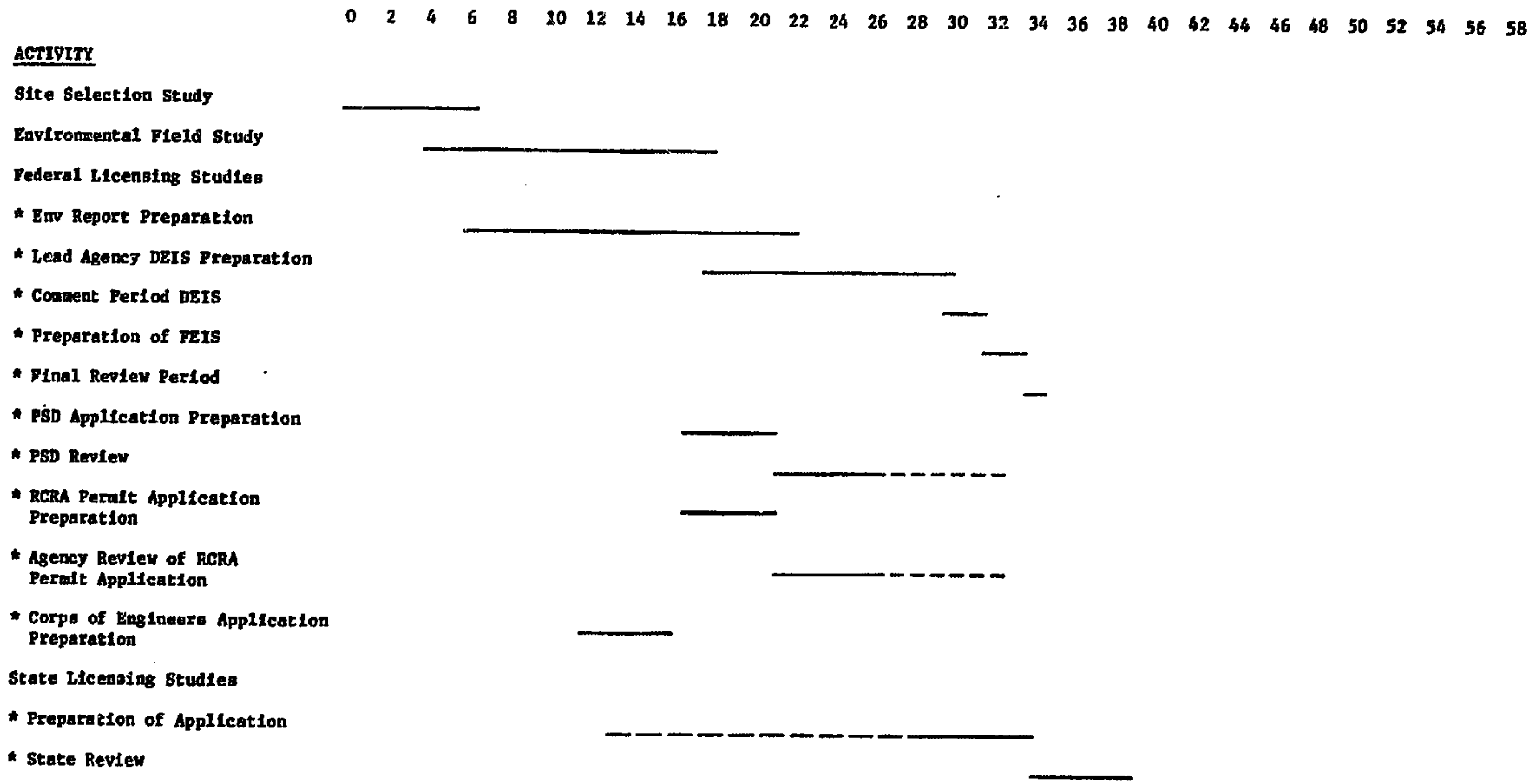
TABLE 14

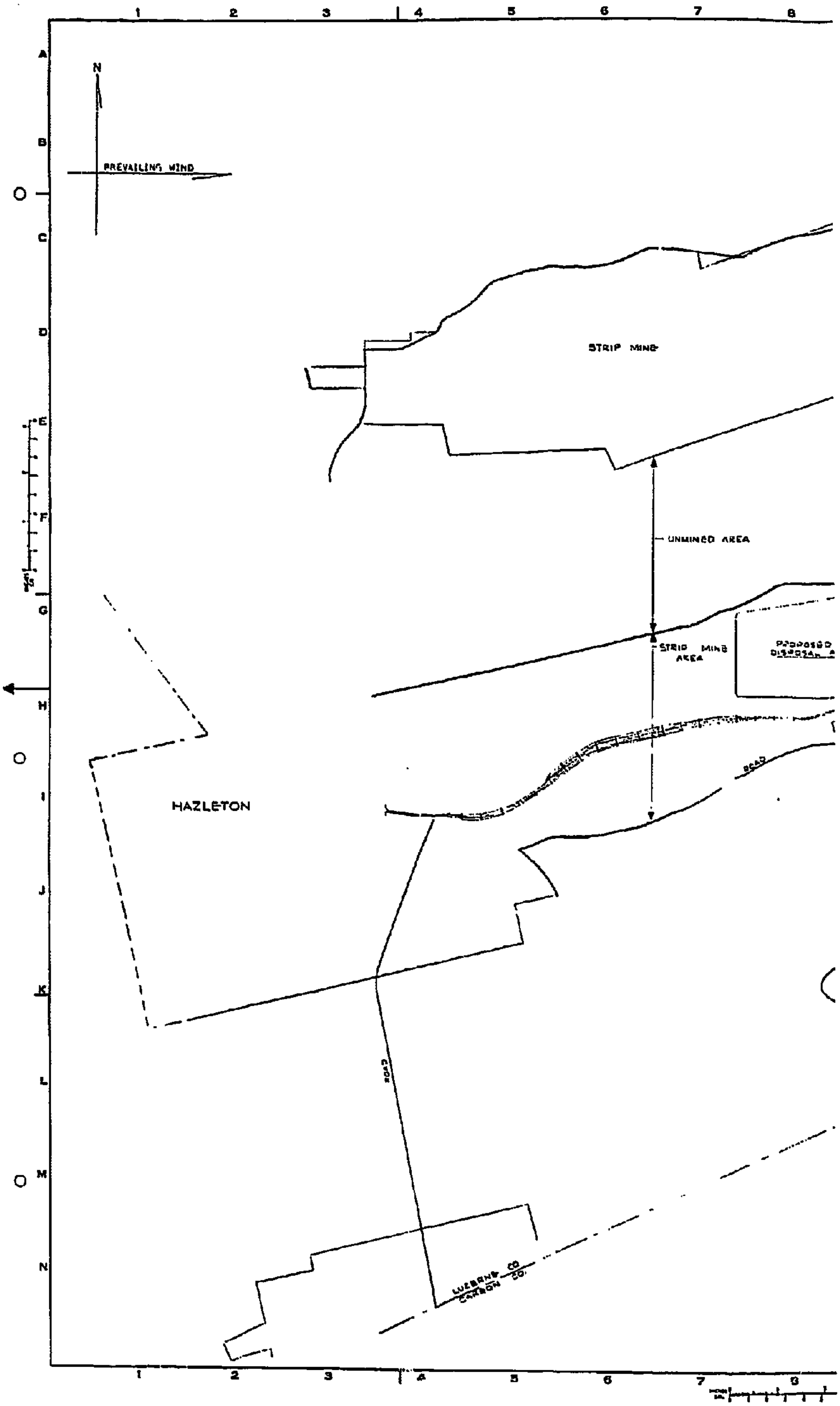
ESTIMATED AIR EMISSIONS

Emission	Tons per Year
Particulates	1,254
Carbon Monoxide	611
Hydrocarbons	219
Nitrogen Oxides	35
Sulfur Dioxide	23

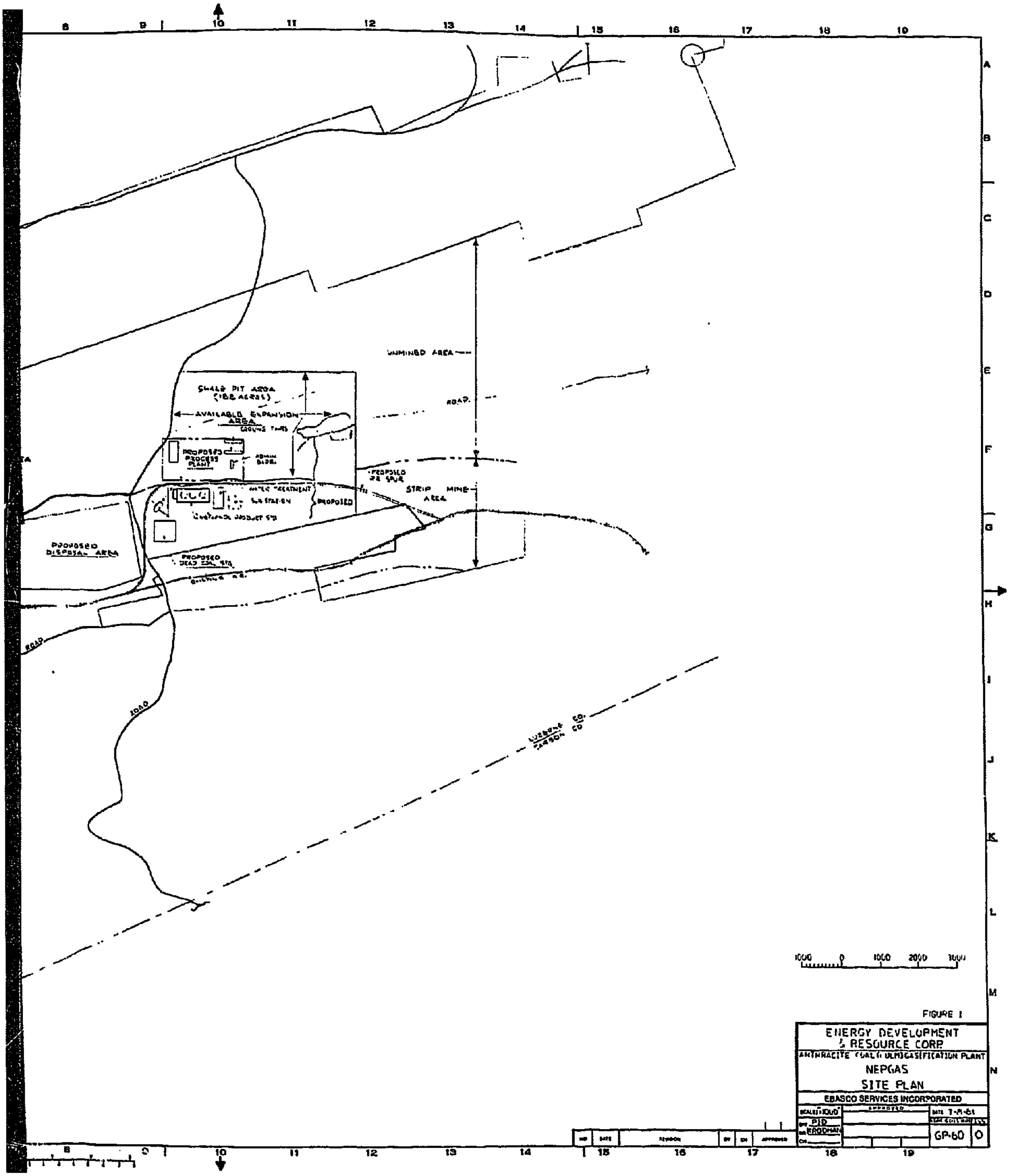
15

LICENSING SCHEDULE
(months)

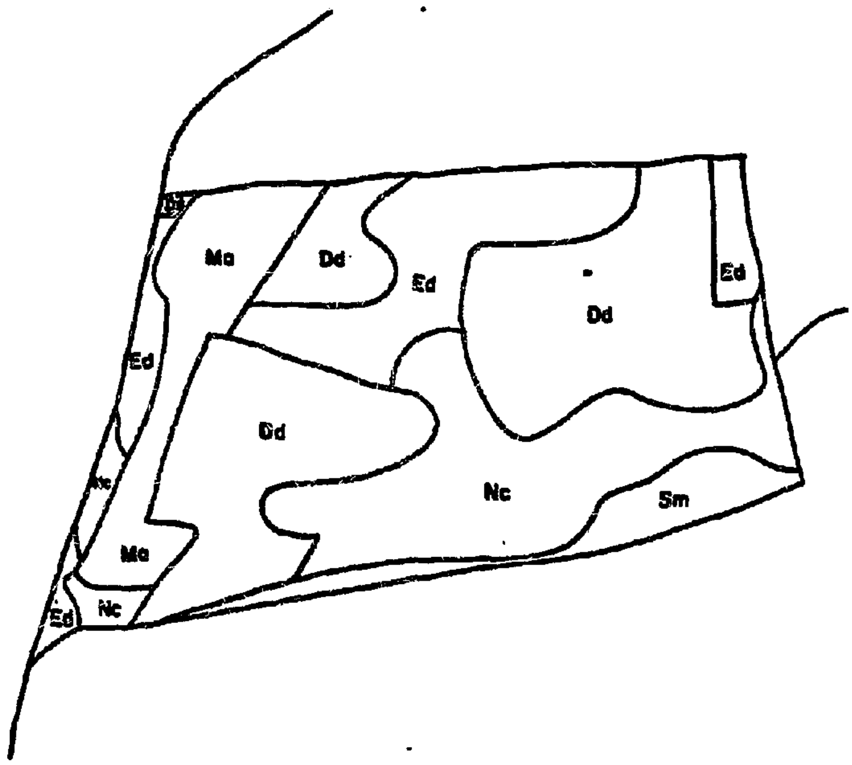




N
PREVAILING WIND
STRIP MINE
UNMINED AREA
STRIP MINE AREA
PROPOSED DISPOSAL A
HAZLETON
ROAD
ROAD
LUZERNE CO
CARBON CO.



UNMINED AREA
SHALE PIT AREA
AVAILABLE EXPANSION AREA
PROPOSED PROCESS PLANT
ADMIN. BLDG.
WATER TREATMENT
PROPOSED
PROPOSED RR SPUR
STRIP MINE AREA
ROAD
PROPOSED DISPOSAL AREA
PROPOSED
ROAD
1000 0 1000 2000 3000
FIGURE 1
ENERGY DEVELOPMENT & RESOURCE CORP
NEPGAS
SITE PLAN
EBASCO SERVICES INCORPORATED
GP-60
0



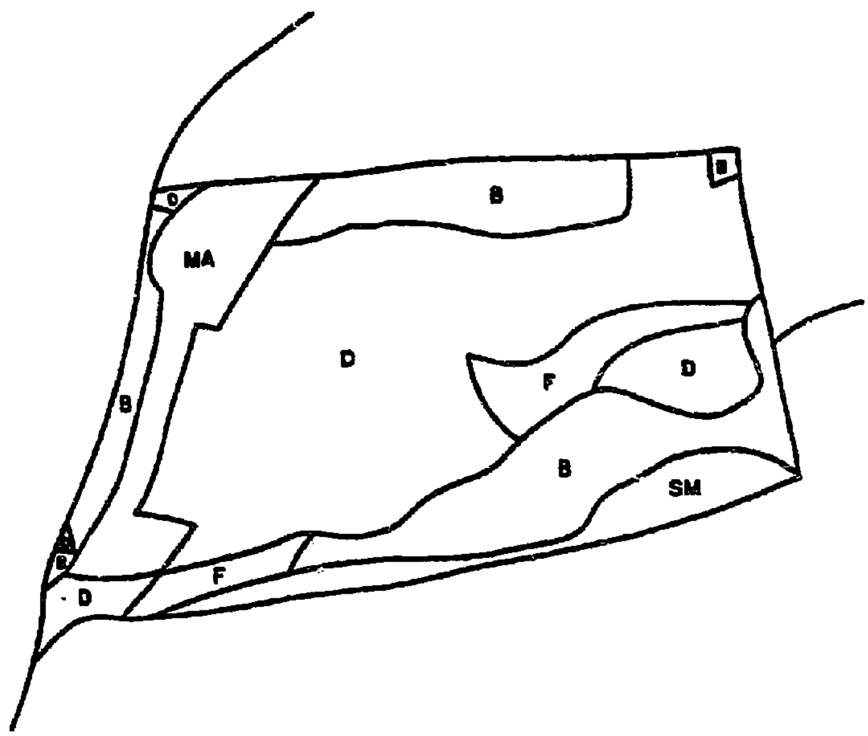
SOIL TYPE	DESCRIPTION	ACREAGE	PERCENTAGE
Dd	Dekalb extremely stony sandy loam	125	42
Ed	Pocono extremely stony sandy loam	56	19
Ma	Cut and filled land	32	11
Nc	Buchanan extremely stony loam	69	23
Sm	Strip-mined land	16	5

N

SCALE 1"= 1320'

FIGURE 2

SHALE PIT - SOIL TYPES

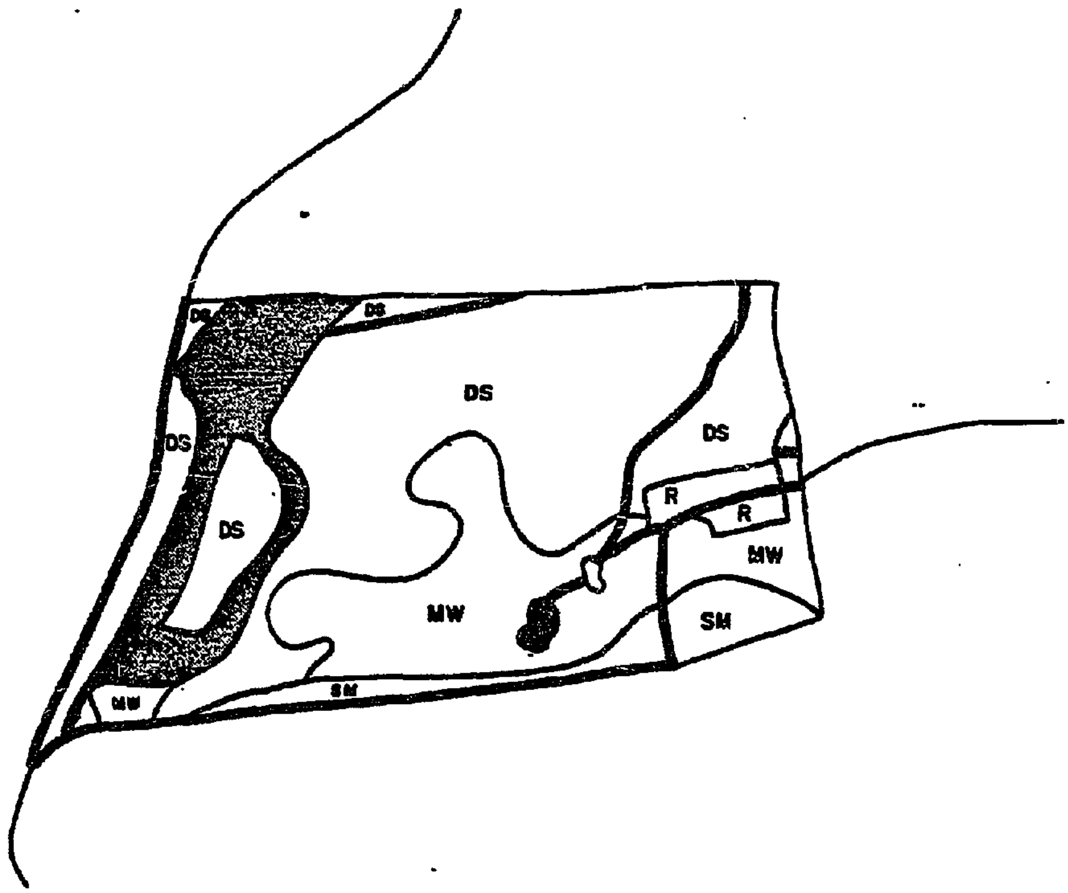


SYMBOL	SLOPE	ACREAGE	PERCENTAGE
B	3 to 8 %	76	26
D	15 to 25 %	155	52
F	Greater than 25 %	19	6
MA	Cut and filled land	32	11
SM	Strip-mined land	16	5

SCALE 1"= 1320'

FIGURE 3

SHALE PIT - SLOPE



SYMBOL	COMMUNITY TYPE	ACREAGE	PERCENTAGE
DS	Dry slope woods	149	50
MW	Mesic woods	68	23
SM	Strip-mined land	16	5
R	Residential	16	5
	Disturbed areas, road borders	49	17

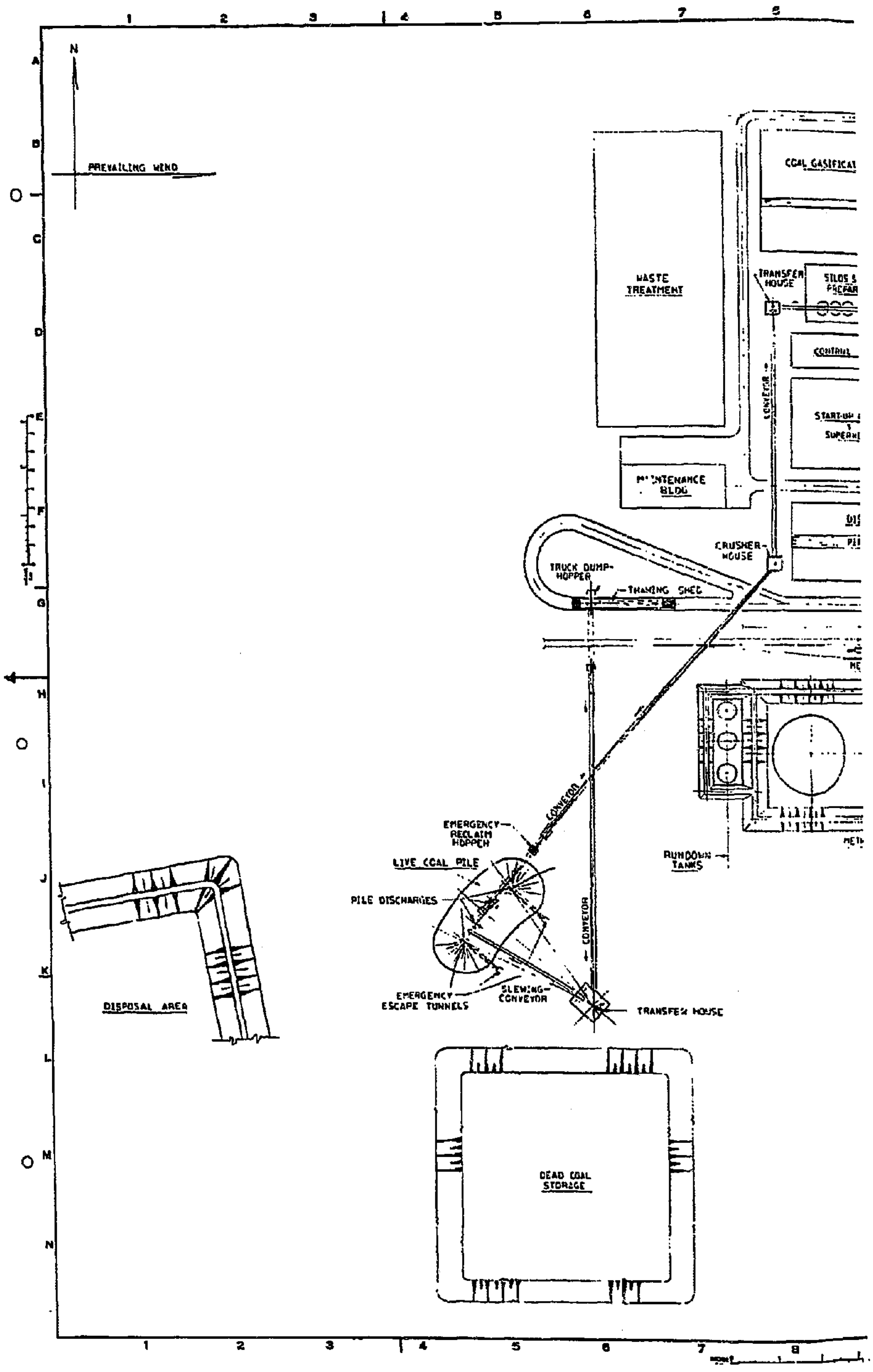
N

SCALE 1" = 1320'

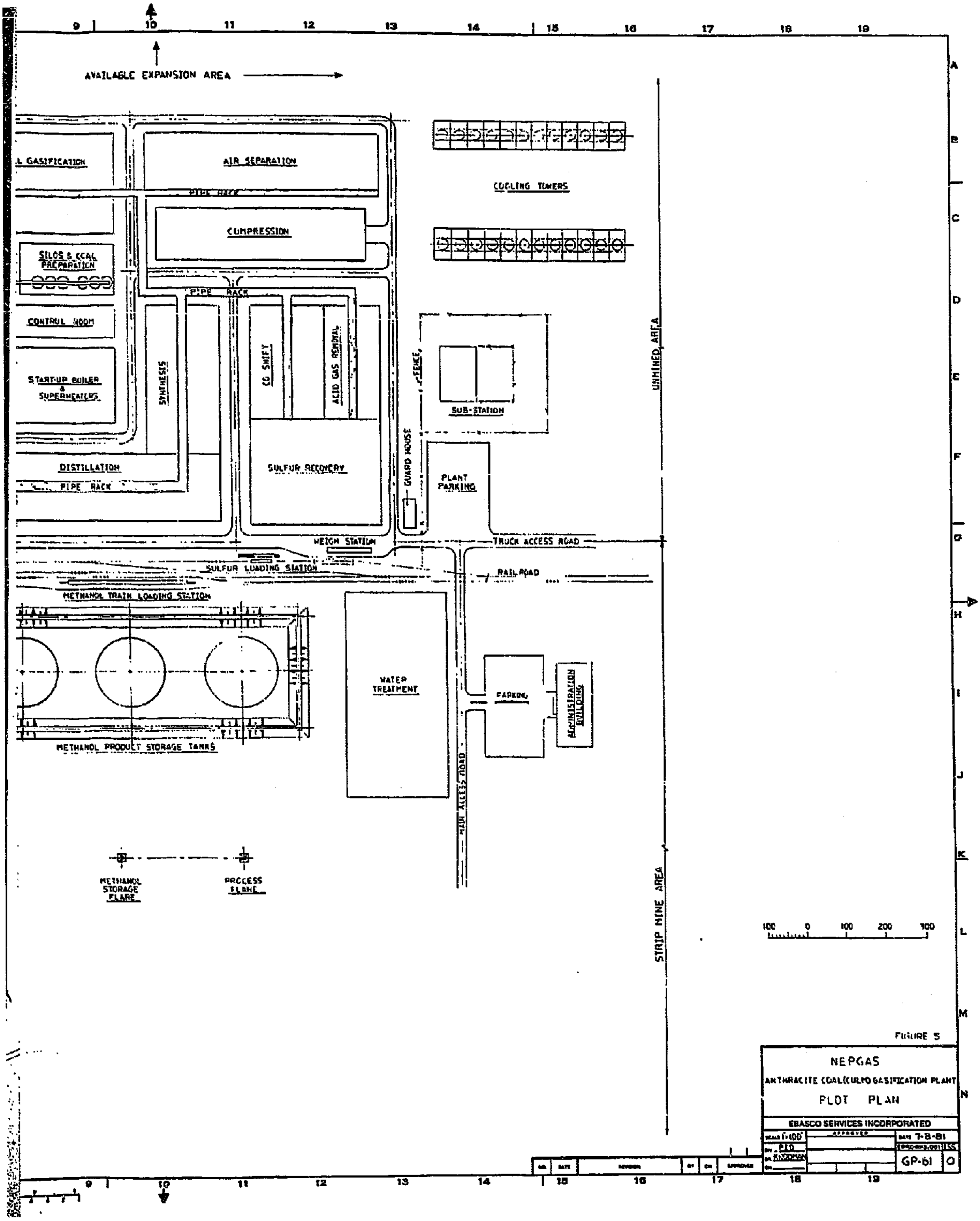
FIGURE 4

SHALE PIT - COMMUNITY TYPES

p



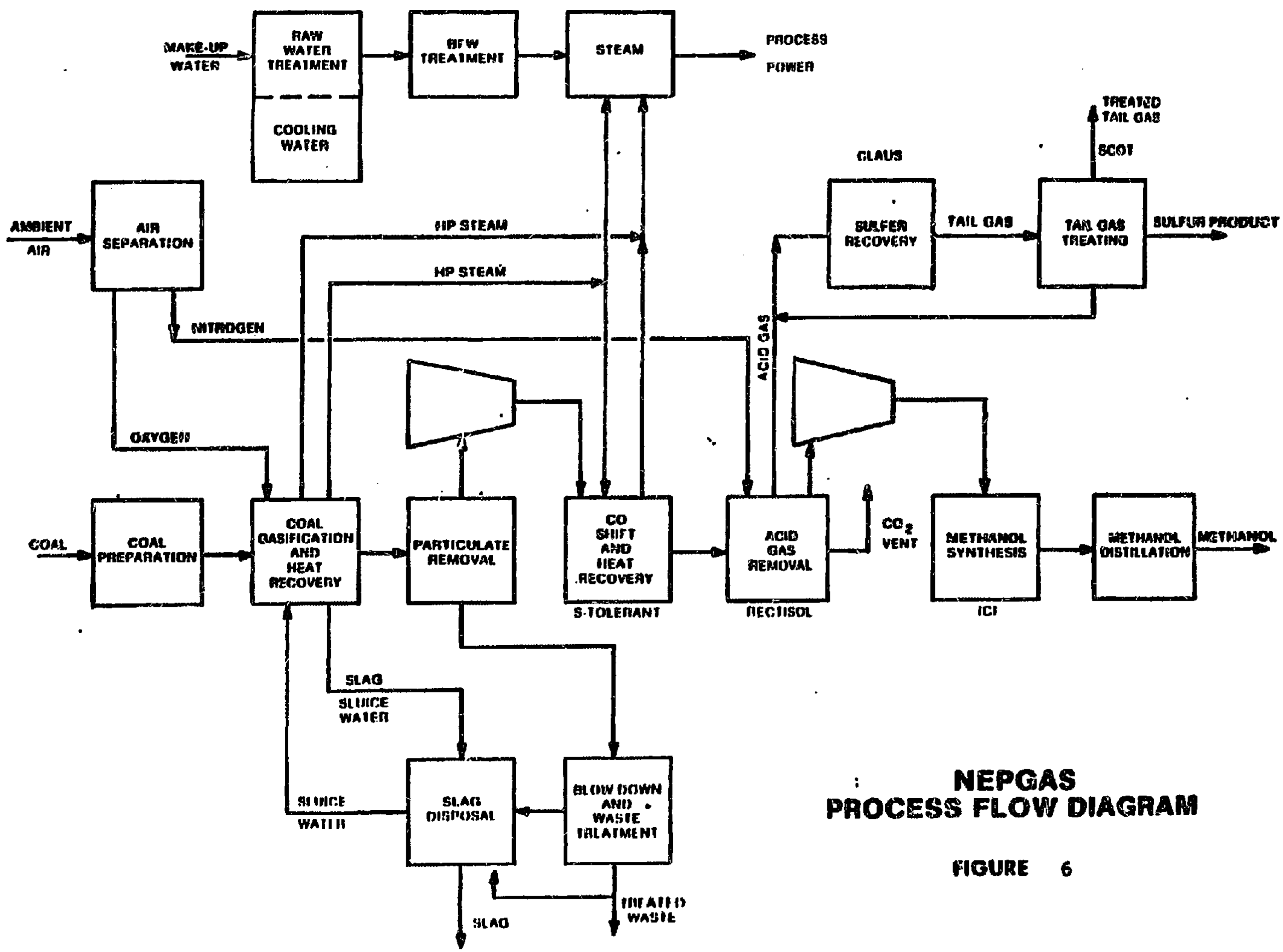
PREVAILING WIND
WASTE TREATMENT
COAL GASIFICAT
TRANSFER HOUSE
SILOS &
CONTROL
CONVEYOR
MAINTENANCE BLDG
CRUSHER-HOUSE
TRUCK DUMP-HOPPER
THAWING SHED
CONVEYOR
EMERGENCY RECLAIM HOPPER
LIVE COAL PILE
PILE DISCHARGES
RUNDOWN TANKS
CONVEYOR
DISPOSAL AREA
EMERGENCY ESCAPE TUNNELS
SLEWING CONVEYOR
TRANSFER HOUSE
DEAD COAL STORAGE



AVAILABLE EXPANSION AREA
GASIFICATION
AIR SEPARATION
PIPE RACK
COOLING TOWERS
COMPRESSION
SILOS & COAL PREPARATION
PIPE RACK
CONTROL ROOM
SYNTHESIS
CO SHIFT
ACID GAS REMOVAL
FENCE
SUB-STATION
UNMINED AREA
START-UP BOILER & SUPERHEATERS
GUARD HOUSE
DISTILLATION
SULFUR RECOVERY
PLANT PARKING
PIPE RACK
WEIGH STATION
TRUCK ACCESS ROAD
SULFUR LOADING STATION
RAILROAD
METHANOL TRAIN LOADING STATION
WATER TREATMENT
PARKING
ADMINISTRATION BUILDING
METHANOL PRODUCT STORAGE TANKS
MAIN ACCESS ROAD
METHANOL STORAGE FLARE
PROCESS FLARE
STRIP MINE AREA
NEPGAS
ANTHRACITE COAL(CULM) GASIFICATION PLANT
PLOT PLAN
EBASCO SERVICES INCORPORATED
1"=100'
7-8-81
GP-61

FIGURE 5

COAL TO METHANOL



NEPGAS
PROCESS FLOW DIAGRAM

FIGURE 6

NEPGAS
COAL TO METHANOL
TRAIN CONFIGURATION

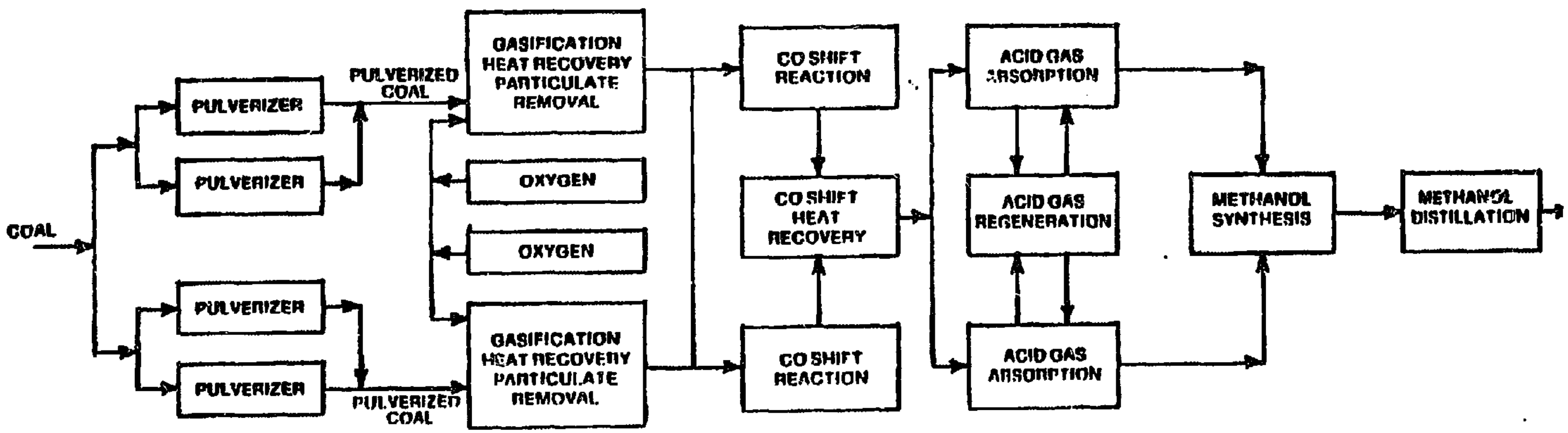


FIGURE 7

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NEPGAS CONTINUATION STUDY

SUPPLEMENTAL TASK IV

COMMERCIAL DEVELOPMENT

PREPARED FOR
ENERGY DEVELOPMENT AND RESOURCE CORP.
NANTICOKE, PENNSYLVANIA
BY
EBASCO SERVICES INCORPORATED
AUGUST 24, 1981

Commercial Summary

A. Background

In the Fall of 1979 the Energy Development & Resource Corporation (EDRC) was commissioned to undertake a "Conceptual Project Study" under authorization by the Department of Energy. That study has been accomplished with the additional assistance of the Economic Development Council of Northeastern Pennsylvania (EDCNP), and various agencies of the Commonwealth of Pennsylvania. The Architect and Engineer for the project is EBASCO Services of New York.

Elements of the study completed to date include the following:

- Market Assessment: including individual contact with over two dozen potential areas of product in the utility, Chemical and Fuel Industries, examination of alternative fuel market areas, and research concerning alternative fuel projections.
- Raw Material Supply: including culm (mine refuse), mined Anthracite, water and electric resources, and potential suppliers of coal and culm.
- Conceptual Design: including gasification facilities, overall configuration, evaluation of support process systems, system design specifications, system descriptions and equipment lists, buildings, technical risk assessment, and environmental and effluent treatment requirements and systems.
- Site Investigation: including water and coal requirements, environmental assessment, plot requirements, and selection of candidate sites.

- O <u>Capital Investment and Operation Requirements</u>: including cost estimates, operating and manpower requirements, costs of production, and commercial incentive review.
- O <u>Program and Project Schedule</u>: including overall schedule for the total program, and detail breakdown of the various program phases. These include Conceptual Design, Detail Design, Procurement/Construction, Start Up, and key decision points.
- O <u>Socio-Economic Characteristics of Northeast Pennsylvania</u>: including population, unemployment, out migration, Income, and the importance of the anthracite industry to Northeastern Pennsylvania.

In addition a continuation of the study was authorized in 1982 under the Appalachian Regional Commission. These tasks included:

I. <u>A Re-evaluation of Gasification Technology</u> to assure that current state of the art technology was evaluated which evolved toward commercialization during execution of the Concept Study, and to assure continued availability of the selected gasification technology.

II. <u>Technical Document</u> which included a technical support plan and staged data development requirements in order to assure applicability of technology to be used in the NEPGAS program.

III. <u>Environmental Licencing Review</u> to determine the major impacts of the project upon the environment, licencing requirements, and schedule required to complete environmental tasks.

IV. Commercial Development Summary

B. Commercial Summary:

I. Recommended Product and Plant Capacity

The recommended plant product, based upon the assessment of potential users, is fuel grade Methanol. The specific basis for the design of the first plant module (train) consists of gasifying approximately 5000 tons per day of a mixture of anthracite coal and culm (mine refuse) to produce 2500 TPD of fuel grade methanol. Expansion of the plant to four modules, with a total capacity of 10,000 TPD is recommended as a mature facility.

II. Concept Design Summary

The "Concept Study" concluded that two Babcock & Wilcox gasifiers, operating at a gas side pressure of 200 PSIG, are required for the 5000 TPD module.

The configurations recommended as a result of the conceptual study include:

----CoMO CATALYST for Co Shift

----RECTISOL System for Acid Gas Removal

----ICI Process for Methanol Synthesis

----Claus/Scot System for Sulfur Removal

The selection of these processes maximizes flexibility with respect to variations of feedstock and production of methanol. The technology which is used for the conversion of crude gas from the gasifier are in use throughout the Country, thereby reducing technical risk factors.

As noted, several gasifiers reached commercial applicability during the course of the concept study. Also, Babcock & Wilcox merged with

Koppers-Totzeh to form a new KBW system. It was determined during the re-evaluation phase of the ARC work tasks, that the KBW system was not suitable for the NEPGAS project.

The same re-evaluation has concluded that three gasifiers are suitable however and they are:

Westinghouse

Saarberg/Otto

KCN

It was also determined that these changes will not significantly effect the cost or the proposed process scheme as proposed in the Concept Study. Therefore, conclusions made in that study remain substantially unaltered.

III. Project Site and Environmental Issues

A prime site has been identified with an analysis of various alternative sites. Water, electric, coal supply, and other raw materials are readily available to the prime site. An Environmental examination indicates no critical flaws exist which will prevent the project from proceeding.

IV. Costs and Competitive Posture With Conventionally Derived Methanol

Capital costs for the project, in late 1979 dollars, total $450,000,000 for the initial module (or Train). These costs include everything but special site development costs, land, and licencing fees.

Operating costs will depend upon the amount of direct investment and the expected rate of return upon that investment. Models of various alternatives are discussed in the report. For example, based upon a 15% return on the project, after taxes, the price of methanol produced in late 1979 dollars is approximately \$12.00/MBTU, or 85 Cents per gallon, which is comparative with Methanol produced from oil or natural gas.

V. Raw Material Supply

a. Feedstock

The study concludes that sufficient quantity of culm and mined coal are available from qualified suppliers in the region to sustain operation of the plant beyond it's useful life.

b. Water

The study also concludes that sufficient water is available to operate the proposed plant on a regular basis. In addition, sufficient electric power in available to sustain the plant operation.

VI. Financial Incentives

Existing financing incentives include those available under the new Synthetic Fuels Corporation. These include loan guarantees and purchase agreements. Additional incentives include use of the additional 10% investment tax credit, existing fuel entitlements, leverage leasing based on long term market contracts, State and Local tax abatement, possible use of municipal equivalent interest rates on long term bonds, including non-tax status on the interest, and other incentives such as those provided through Federal grants for Economic Development.

In summary, the concept study has demonstrated that the resource base, technology, site and potential market exists to support construction of a Culm to Methanol Plant in Northeastern Pennsylvania. Remaining work tasks to achieve this goal include: final selection of the gasifier and approval of that technology by the sponsor and financial community;

acquisition of site and feed stock; and development of the detailed financing program to achieve construction and operation of the plant.

The immediate task is to select a sponsor or joint-sponsor that can demonstrate the capacity and will to design, construct and operate the plant.

VII. Outlook for Commercialization

Conditions with respect to governmental support to encourage coal gasification have altered substantially since inception of the concept study.

There has been a decided shift away from direct participation by the government to encourage a variety of technologies to achieve legislated alternative fuels goals.

Instead, the Congressionally created Synthetic Fuels Corporation leadership has enunciated a policy which seems to encourage only the largest firms that have direct access to private financing markets and which utilize existing mature technology in their processes. These perceptions have been heightened by the recent world wide oil surplus.

Whether this policy shift will result in the legislative goal of producing 10% of our Nation's energy needs by 1992, remains to be seen.

What can be discerned is that projects such as NEPGAS, which cannot economically utilize mature technology, and who's sponsors haven't the same relative competitive access to private financial markets, will be compelled to seek other assistance. Therefore, as a practical matter, any plan for an immediate continuation of the NEPGAS project would seem at the least, premature under the current circumstances.

In the long range view however, it would seem that pressure for alternative fuels is almost certain to build when the present world oil surplus shrinks or if for any reason there is another crisis in the Mid-East which threatens oil shipments from the region. In those circumstances, the NEPGAS project, which employs technology that can significantly lower operating costs relative to existing on line technology, should find favor with energy policy makers. In that event, the timetable for construction of the NEPGAS project would be accelerated.

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Using slag/ash produced in the gasification tests, the slag leaching rates must be determined. This data will be used to design the slag disposal system in an environmentally acceptable manner.

p

IV- PROCESS ENGINEERING CONSIDERATIONS

The Conceputal Project Study has addressed process areas for optimization during the final design stage.

These include:

- o The use of the Stretford System for Sulfur Removal and Recovery
- o The use of the Lurgi Methanol Synthesis Loop
- o The potential reduction in the Methanol Purification Equipment when producing Fuel Grade Methanol

In addition to the above, process selection and process design optimizations which should be considered include:

- o Temperature approaches on heat exchanges and the degree of waste heat recovery
- o Consideration should be given to alternate means of process cooling (air coolers) to minimize plant water requirements
- o Optimization of process modules, with respect to both other process modules and expected coal variation.
- o Plant operation analysis aimed at determining limiting turndown factor and potential means of improving operational range of plant.
- o Steam system analysis to assure stability during startup, shutdown and normal operations. Specific questions to be reviewed in this area are:
    - o Driver Selection
    - o Capacity
    - o Electric/Steam Balance.

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- Operational Assurance Review
  - Materials review to assure that selected materials are within safe boundaries for both normal and potential upset condition.
  - Controls and operational safty of gasifier and allied processes
  - Optimization of sparing philosophy to match economic and operational information considerations

- Potential Range of Feed Coal

  For the design phase two coal analyses must be established, the Typical Operating Coal (TOC) and the Extreme Operating Coal (EOC).

  The EOC specifications represent the potential upper limit in which the representative coal may deviate from the normal coal supply source. These deviations may be characterized by increases in chlorine, sulfur, moisture and ash contents. The TOC would represent the average coal analysis as determined from the representative samples obtained from the coal supply.

  A plant designed to meet all of the extreme coal conditions may result in a considerable expenditure of capital with a potentia for inefficient operation during periods with typical coal-feed. In early discussions with the client, a design concept must be established which is consistent with economic design and the clients operating needs and requirements.

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V. EXECUTION PLAN

The specific organization and teaming arrangements which will be adopted to execute the project will reflect the characteristics of the sponsoring organization. The following plan was prepared with the aim of guiding the Project Manager through the technical and cost audits of the program.

V-1 PROJECT GENERAL MANAGEMENT

The goal and objective of the Project Manager are to ensure that the responsibilities of the Program and its intent are discharged in a manner such that all the requirements and obligations are fulfilled. This will be achieved by meeting stipulated cost, stated project completion time, technically and environmentally sound design, acceptable quality of Engineering/Construction and a safe operable plant.

The Project Manager has complete responsibility for the project organization and the work expected from each position on the organization, in order to be able to administer and execute the project effectively.

In carrying out his responsibilities the Project Manager is guided by organizational procedures such as:

- o Engineering Procedures
- o Administration Procedures
- o Process Design Guides
- o Design Data Manuals
- o Multidiscipline Design Guides (Mechanical, Civil, Electrical, Instrumentation, etc.)
- o Estimating & Proposal Guides
- o Procurement Guides
- o Construction Guides

1. Control Systems and Reports
   a. Take-off Meeting
      As soon as the Program is initiated, the job shall be planned in a Project Take-off Meeting.

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This meeting is attended by every key member of the project staff. It's purpose is to familiarize the project team with the project background, project requirements, product, project duration, location, etc., in order that preparation of the basic technical, commercial and administrative documents can be initiated.

b. Coordination

The coordination procedure is the key control document. It should be a very carfully prepared. A precise document is needed as it will have a major impact on the management and execution of the project.

The Coordination Procedure describes the project and outlines the contract responsibilities of the parties involved. It identifies the responsible members of the team.

c. Process Control

The detailed Process Design should not start until the process is "frozen" and sufficient and correct information is available. Otherwise the effort may not be productive.

However, it should be understood that there may be situations where the conceptual design requires additional definition thus the preliminary studies may be required to define final basis of design.

d. Specifications

In order to proceed with the final design, purchasing of material and equipment, and preparation of a budget estimate, specifications approved for construction are prepared first.

e. Plot Plan

When the major pieces of equipment, such as pumps, compressors, towers, reactors, heat exchangers, air coolers, etc., have been selected and sized, a Plot Plan is drawn.

f. Piping and Instrument Diagrams (P&ID)

After the Process Flow Schematics have been developed, equipment sized, spares determined, and relative locations of equipment fixed, the development of Piping and Instrument Diagrams (P&ID's) is initiated.

g. Utility P&I Diagrams

The Utility P&I Diagrams are developed at the time when the Process P&I Diagrams are being prepared. Loads can be defined with sufficient accuracy before the equipment is purchased. Thus, the early routing of the utility lines is desirable as it will eliminate interference of electric, water and steam lines with process and the need for equipment rearrangement during detail design.

h. Cost Control

The Cost Control starts at the initial stage of the project when cost factors are determined on specified basic design concepts. Original basic decisions are not to be changed, particularly if it will increase cost.

When quotations are received, bid prices are compared with an estimate price. If an estimate is not yet available, a bid price should be compared with past cost of similar equipment or material. If the bid price is higher than the estimate, or prior cost of similar equipment or material, two alternatives should be considered:

- A more economical design must be found or project requirements should be changed in order to reduce cost.
- If the above is not possible, the increased cost should be accepted and the budget modified accordingly.

In summary, to ensure cost control is in effect, each detail of cost must be examined prior to making the commitment.

i. Scheduling

The development of a realistic project schedule for measuring and reporting the performance of design, procurement and construction is a must for every project.

j. <u>Procurement</u>

The key to successful procurement is the quality and thoroughness of the requisition. A precise requisition must define the following:

- o Equipment and type required
- o Quantity and what is an acceptable quality of equipment
- o Required performance guarantee by vendor
- o What data is required with proposal
- o What vendor date and client approval are required
- o Time limits for data submission and approvals
- o What field and shop tests will be performed
- o What shipping date is required.

k. <u>Start of Construction</u>

The Project Manager should resist all of the reasons for an early start until he assures himself that an adequate supply of drawings and material are available in sufficient volume for an efficient and continuous operation, before releasing the start of field work.

The necessary data for start of construction will consist of the following approved drawings:

- o Site Development Drawings
- o Plot Plans
- o Drawings for Temporary Facilities.

Assured schedule for release of the following approved drawings:

- o Foundations and Underground Sewers
- o Fire Water Lines
- o Grounding and Electrical Distribution and Supply.

In addition, all materials called for by these drawings, such as grounding and reinforcing rods, bare and wrapped piping, sewers, conduit, inserts, etc., must be available at the jobsite as required.

l. <u>Reports</u>

The preparation of all monthly progress, cost and profit reports will be prepared in a comparable manner so that management is given an accurate appraisal of progress, cost and profit.

m. Project Close-out

After owner's acceptance of the project, the job will be terminated by close-out of the files and preparation of a "Project Close-Out Report".

V-2 PROJECT SCHEDULE

The type of schedule to be used will depend on many factors, including size of project and its complexity. The type of presentation to be used will be that which most nearly coincides with the client's needs and desires.

Two of the many methods which have been used are the Bar Chart and the Network. Some of the parameters included in these methods are illustrated below.

- o Bar Chart Method

  Covers the general concepts of scheduling, the method to be used in determining the physical percentages of completion and the Bar Charts of schedule presentation as follows:

  - Work Definition
  - Proposed Project Schedule
  - Engineering Schedule
  - Construction Worksheets and Schedule
  - Weighting and Manpower Development
  - Overall Schedule.

- o Network Method

  Covers the Network Method of schedule presentation as follows:

  - Logic Diagram Drawing Philosophy
  - Departmental Coding
  - Node Identification
  - Account Code
  - Activity Description
  - Character Representation
  - Network Source Documents
  - Network Time Reports
  - Weighted Progress Curves
  - Resource Allocation Information
  - Update Reports
  - Network Input Data Requirements
  - Output Message
  - Standard Base Diagrams
  - Periodic Reports.

Comparison of Accomplishment with Plan

Immediately upon receipt of each issue of the forms, all parties concerned (Engineering Manager, Project Manager, Project Scheduler, Construction Group for the jobsite delivery dates) must scrutinize it thoroughly to determine which items are behind schedule and to expedite those which might jeopardize the job completion date.

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