MASTER

United States Department of Energy

DELIVERABLE No. 7-B

CRITICAL SPECIFICATIONS AND PARAMETERS FOR THE DETAILED DESIGN AND CONSTRUCTION OF THE DEMONSTRATION PLANT

SYNTHESIS GAS DEMONSTRATION PLANT PROGRAM
PHASE I

OCTOBER 1979

PREPARED UNDER CONTRACT No. ET-77-C-01-2577

GRACE

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Memphis, Tennessee

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SYNTHESIS GAS DEMONSTRATION PLANT PROGRAM,
PHASE I, ~~II~~ ~~III~~ ~~IV~~

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Prepared for the

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Assistant Secretary for Energy Technology
Office of Fossil Fuels

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DATE

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CRITICAL SPECIFICATIONS AND PARAMETERS
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CRITICAL SPECIFICATIONS AND PARAMETERS
FOR THE DETAILED DESIGN AND CONSTRUCTION OF THE DEMONSTRATION PLANT

Paragraph 10, Article (4) I. Technical Direction and Contract Administration of Prime Contract No. ET-77-C-01-2577 states as follows:

"Prior to any mutual determination to proceed to Phase II in accordance with Article (1) VIII above, the Government and the Industrial Partner shall agree to certain critical specifications and parameters to be used in the detailed design and construction of the Demonstration Plant, including, inter alia, the size and materials for major pieces of equipment. Such agreement shall be set forth in writing and shall be signed by the Industrial Partner's Project Director and by the Government's Program Director and Contracting Officer. Anything to the contrary in this Article (4) I notwithstanding, the Demonstration Plant shall be designed and constructed in strict accordance with all specifications and parameters set forth in such agreement, unless the Industrial Partner and the Government mutually agree otherwise."

This document has been prepared to delineate and define the critical specifications and parameters to be used in the detailed design and construction of the Demonstration Plant in accordance with the above and includes the following:

- 1.0 Major design parameters
- 2.0 Design codes and standards
- 3.0 General Specifications
- 4.0 Specifications of Major Equipment Items
- 5.0 Process Schematics
- 6.0 Flow Diagrams
- 7.0 Plot Plans and Elevations

1.0 Major Design Parameters

1.1 Plant Size

The Demonstration Plant is designed to produce 11,825 pound moles per hour of Synthesis Gas with a Hydrogen to Nitrogen molar ratio of 3 to 1 at 940 psia and 23°F. The plant will deliver the design quantity of Synthesis Gas when the catalysts are operating at end of run conditions and when the wet and dry bulb temperatures are at their design values.

1.2 On Stream Factor

The plant is expected to be in operation at rated capacity 330 days per year.

1.3 Design Coal

The Demonstration Plant Design is based on the use of West Kentucky No. 9 coal with the following range of composition:

Ultimate Analysis

Moisture Free Basis

<u>Component</u>	<u>Design Basis</u>	<u>Range</u>
	Wgt. %	Wgt. %
Carbon	67.0%	64.5 - 75.3
Hydrogen	4.8	4.1 - 5.4
Nitrogen	1.2	1.0 - 1.2
Sulfur	3.8	2.3 - 5.1
Oxygen	6.5	4.8 - 7.3
Chlorine	0.1	0 - 0.2
Ash	16.6	8.5 - 20.3
Higher Heating Value,		
Btu/lb	11,914	11,523 - 13,551

Coal from this seam is classified as high sulfur and agglomerating.

1.4 Plant Site

Pertinent data are summarized below. More detail may be found in the Site Confirmation Report. (Deliverable No. 25)

1.4.1 Location

Baskett, Henderson County, Kentucky, on Green River, approximately 2 miles upstream from confluence with the Ohio River.

1.4.2 Elevation

Upland region, where principal facilities will be constructed, is at an elevation of 420 feet above mean sea level (MSL). This compares to a 100-year Green River flood elevation of 380 feet above MSL. Balance of site, adjacent to river, is within the flood plain. Facilities erected in the flood plain will be elevated to overcome potential operation interruptions.

1.4.3 Earthquake Potential

International Category. Zone II.

1.4.4 Rainfall

Maximum hourly	2.79 in.
Maximum 24 hour period	6.94 in.
Average Annual	41.88 in.

1.4.5 Snowfall

Maximum daily	10.6 in.
Maximum monthly	21.3 in.
Average Annual	13.4 in.

1.4.6 Temperature

For the period from June through September, the Wet Bulb Temperature is expected to equal or exceed:

79°F - 1% of the time
78°F - 2 1/2% of the time
77°F - 5% of the time

For the same period, the Dry Bulb Temperature is expected to equal or exceed:

96°F - 1% of the time
94°F - 2 1/2% of the time
91°F - 5% of the time

Maximum recorded temperature (1941-1976) 105°F.

Minimum recorded temperature (1941-1976) -23°F.

1.5 Water Supply

Potable water is expected to be supplied through a connection to the existing county water system.

Process water will be derived from the Green River. Under normal operating conditions the plant is expected to withdraw approximately 4.7 million gallons per day. Up to 1.4 million gallons per day may be returned to the river depending upon the system selected in the design phase for Waste Water Treatment.

Additional details are presented in the "Plan for Obtaining Water for the Demonstration Plant." (Deliverable No. 27)

1.6 Power Supply

The electrical power required, approximately 48,000 Kilo Volt Amperes (KVA), for operation of the Demonstration Plant will be purchased from the Henderson Union Rural Electrical Cooperative Corporation (HURECC). Two 161KV transmission lines from the utility's Henderson substation will supply a switching station at the plant site. Stepdown transformers and the low voltage equipment (described in Paragraph 4.4) provide for the following subsystems within the Demonstration Plant complex:

- Medium voltage distribution system (4.16KV)
- Low voltage distribution system (480V)
- 125V DC system
- 120V AC system

In the event of total loss of the incoming power, a Steam Driven Turbo-Generator is provided to supply emergency power requirements of essential loads such as communications, lighting, and essential ventilation and other plant services e.g., the burner cooler circulating pump on the gasifier. The turbo-generator shall be powered from an auxiliary Fuel Oil/Gas Boiler which can be maintained on line during a power outage.

Additional details for power supplies for construction and plant operation are found in the "Plan for Obtaining Electrical Power for the Demonstration Plant". (Deliverable No. 27)

1.7 Transportation

Docking and material handling facilities will be constructed at the Green River to receive coal and to ship ammonia in river barges. These facilities are designed to handle 100% of the total coal requirements and 100% of the ammonia requirements.

Rail facilities connecting with the Louisville and Nashville Railroad will be constructed on site for receiving coal and miscellaneous chemicals and supplies and also for shipments of ammonia, sulfur, sulfuric acid and other materials as required. These facilities are designed to handle 100% of the total coal requirements and 100% of the ammonia requirements.

An access road into the plant area will be provided from the adjacent public road. In-plant roads will be provided for the shipment of ammonia by tank truck, for the receipt of coal and other essential materials by truck and for servicing the various areas within the plant complex.

1.8 Design Basis

1.8.1 Process Summary

The Demonstration Plant is comprised of various processing operations including Coal Grinding and Slurry Preparation, where the coal is prepared to the required grind size distribution and slurry (coal/water) concentration; Gasification, where the coal slurry is reacted with oxygen to produce raw gas, by the Texaco Coal Gasification Process; Gas Quenching & Scrubbing, where the gases are cooled and impurities removed; Carbon Monoxide (CO) Shift, where the CO is shifted to hydrogen (H_2) and carbon dioxide (CO_2) by water in the presence of a catalyst; Acid Gas Removal (AGR), where hydrogen sulfide (H_2S), CO_2 and other acid gases are selectively removed from the process gas; and Nitrogen Wash, where the gas is further cleaned and nitrogen is added to obtain the correct ratio for ammonia synthesis.

Two Coal Fired Boilers generate steam in addition to that produced in the process systems in order to meet overall requirements. An Air Quality Control System (AQCS) is used in association with the boilers to remove particulates and sulfur dioxide (SO_2) in the stack gas. This system produces a waste stream which, with H_2S from the Acid Gas Removal System, is fed to the Sulfur Recovery System to produce by-product elemental sulfur or is fed directly to an on-site facility to produce sulfuric acid.

A Fuel Gas/Oil Fired Boiler provides for the recovery of the heating value of the process purge gases during normal operation as well as capacity to meet emergency conditions.

Ancillary systems are provided for air separation, coal handling and storage, process and cooling water treatment and distribution, fire protection, flare, sewage and waste water treatment, ash and slag disposal, and other auxiliary plant services.

1.8.2 Equipment Arrangement

The Demonstration Plant process systems are designed as follows:

<u>Process System</u>	<u>Arrangement</u>
a. Coal Grinding and Slurry Storage	Three grinding trains each with a capacity of 65% of the design throughput, feeding two-193,000 gallon Slurry Holding Tanks.
b. Gasification, Quenching and Slag Handling Systems	Two trains each with a capacity equal to 100% of design throughput.
c. CO Shift	One train.
d. Acid Gas Removal	One train.
e. Nitrogen Wash	One train.
f. Sulfur Recovery	One train. Recovers elemental sulfur from the off-gas from the Acid Gas Removal System and other sulfur-containing gas discharges.

Capacity to process the following gases: Gas from AGR-159,180-Standard Cubic Feet per Hour (SCFH)
 Condensate Flash Gas - 52,530 SCFH.
 Gas from AQCS - 37,770 SCFH.

- g. Sulfuric Acid Production One train to produce 93% sulfuric acid from Sulfur, H_2S and/or SO_2 with a capacity equivalent to 255 tons of 100% Sulfuric Acid per day.
- h. Air Separation One train with a capacity to produce 1965 Short Tons Per Day (STD) of oxygen.

As noted previously, the plant will contain two coal-fired boilers, each with a capacity of 230,000 pounds per hour of steam at 1515 psia and 940 F. The steam generation system will be supplemented by an oil/gas fired auxiliary boiler with capacity of 150,000 pounds per hour. One coal-fired unit and the auxiliary are designed to sustain operations at 70% of capacity.

Each coal-fired boiler will have a downstream train to remove particulate matter and sulfur dioxide (SO_2).

The equipment layout is shown on the plot plan drawing number WRG-8375-M-002. Individual area plot plans and elevations have been developed for each of the plant and process areas and are listed in Paragraph 7.

1.8.3 Design Pressure

The design pressure for all equipment in the plant shall not be less than:

- a. 10 percent above the maximum expected continuous operating pressure, or
- b. 15 psig above the maximum expected continuous pressure, or
- c. The maximum pressure to which equipment can be subjected, this being a function of the pressures which can be generated by the equipment in the plant area in question.
- d. For equipment in ammonia service the design pressure shall not be less than 250 psig.

All equipment items located between block valves within a process section and protected by a single system relief valve

or valves shall be specified with the same design pressure. This pressure will be calculated by applying the above criteria to the equipment items which are subjected to the highest operating pressure within the system. This basis shall apply to all equipment, notwithstanding the operating range.

1.8.4 Materials of Construction

Material selection shall be in accordance with equipment specifications as noted in Paragraph 4. Consideration shall be given to vendor recommendation when such recommendations for process or delivery reasons are superior to the specifications. For such cases final decision will be made by the Industrial Partner.

1.8.5 Equipment Sizing

Sizing of equipment shall be in accordance with specifications as noted in Paragraph 4.

1.8.6 Redundancy Philosophy

Provisions are made to assure plant integrity and operation in the event of equipment failure based on a review of the state-of-the-art of commercial applications of all plant systems. In general the principles applied include but are not limited to the following:

1.8.6.1 Pumps

- a. A spare shall be provided for each critical continuous service.
- b. For critical services, an alternate drive will be considered for the spare.
- c. All pumps shall be designed for a minimum of 115 percent of the maximum expected flow requirement.
- d. Maximum size impellers shall not be used. Pump casings shall be selected to allow the installation of an impeller larger in diameter than that supplied for the design requirements.

1.8.6.2 Vessels and Towers

Design temperatures shall be a minimum of 25°F above the maximum expected operating temperature, and where appropriate, a minimum of 25°F below the lowest anticipated operating temperature. Specific recommendations, deviating from project design parameters, may be made as a result of consultation with vendors. Final decision in such cases will be made by the Industrial Partner.

1.8.6.3 Heat Exchangers and Waste Heat Boilers

Heat Exchangers and Waste Heat Boilers shall be designed for the most severe expected operating condition with zero negative margins on the corresponding heat load and flows.

1.8.6.4 Compressors

Compressors shall be designed for the most severe anticipated operating conditions with zero negative margins on flow rates and delivery pressures.

1.8.6.5 Rotating Equipment Drivers

- a. Drivers (motors and turbines) for rotating equipment shall be specified to deliver a minimum of 1.1 times the power required by the compressor, pump, fan or blower.
- b. Drivers 250 HP and lower will generally be electric motors.
- c. Drivers above 250 HP will generally be steam turbines.
- d. All Drivers shall be non-overloading.

1.8.7 Additional Process Development

Additional data will be required to complete the final design of several of the plant subsystems. These include but are not limited to:

- Coal Grinding
- Carbon Ash Separation
- Waste Water Treatment
- Waste Solid and Sludge Disposal

The referenced documents in section 4.0 do include specific requirements for equipment based on currently available information. However changes in these specifications for equipment in these subsystems are expected as more data become available.

1.8.7.1 Coal Grinding

The design for coal grinding provides for wet grinding in a rod mill, diluting and screening of the process stream to remove oversize particles, and dewatering to obtain the desired concentration. The design further provides for recycling of the oversize particles to the rod mill and reuse of the water from dewatering for the dilution requirement. With this system, process interruption caused by oversized material in the pumping system will be eliminated.

Further, a pilot laboratory study is planned, to ascertain the process effects of a less costly system based on open circuit wet rod mill grinding with a trommel screen on the effluent to eliminate oversize particles. In addition, the effect of other variables, e.g. the recycle material from the carbon/ash recovery system, the use of recycle water rather than potable city water and a 2" x 0" size of the coal in the feed to the rod mill rather than 3/4" x 0" as in the initial tests, will be investigated.

1.8.7.2 Carbon Ash Separation

The present design is based on a carbon conversion efficiency of 93% based on the fresh coal charged to the process. The design, therefore, provides for the separation and recycle of the unconverted carbon (char) in the gasifier effluent to improve efficiency. The carbon efficiencies reported from the three short pilot runs at Texaco's Montebello laboratory were substantially higher e.g. 99%

The sustained pilot run scheduled in late 1979 will provide more comprehensive insight into the factors influencing the carbon/ash separation. Based on these data, the process and the equipment for this subsystem will be reevaluated.

1.8.7.3 Waste Water Treatment

The design for Waste Water Management is summarized in the Process Schematic - Waste Treatment - Drawing WRG-8375-M-910.

The design provides for two lined ponds. In the "Ash Pond" any process effluent and plant area run-off containing fly-ash is collected. This pond is designed for zero liquid discharge with level control effected by a spraying system to assist evaporation. In the second pond, the "Bottom Ash Pond," the balance of the plant run-off and process effluent is collected prior to primary treatment before discharge to the Green River.

Additional study is planned prior to final design and engineering as follows:

1. Leachate testing of the bottom ash and fly-ash from boilers firing West Kentucky No. 9

coal and more definitive testing of soil porosity and water table level in the proposed pond siting areas in order to define the nature and type of lining required under environmental regulations is planned.

2. An evaluation of the number of ponds and the potential for tertiary treatment to remove organic contamination of the plant effluent will be further examined in light of existing and proposed changes in the regulations.
3. The present design provides for the effluent from the gasifier systems approximately 150 gallons per minute, containing 2000 parts per million of dissolved solids, to be processed through a six-effect evaporator system, Drawing WRG-8375-M-911, thus concentrating the trace materials in this stream. It is expected that the composition will be characterized during the course of the long term pilot runs at Montebello, noted above, to establish a basis for evaluating possibly less costly alternative methods such as ion exchange and/or reverse osmosis.
4. The present design, as noted above, provides for discharge of waste water to the Green River. In final design, the Industrial Partner will decide, based on the technical feasibility and environmental requirements at the time, if recycling of a portion or all of the effluent to replace some raw water intake is economically viable.

5. The design provides for chromate corrosion control in the cooling water circuit. In view of the existing environmental regulations, chromate destruction is also included. Additional work may be required to show that this proposal also meets the requirement with respect to the location of the cooling towers and the plant run-off containing salts from the cooling tower drift.

1.8.7.4 Waste Solid and Sludge Disposal

With the proposed changes in the regulations regarding solid waste management, additional efforts will be needed in the final design phases of the plant. For example, the nature and type of the lining of the pits for storage of flyash, bottom ash and slag must be determined in the same manner as described above for the ponds.

The characterization of the sludge from the gasifier (the solids from the evaporator noted above) will be better defined as a result of the extended pilot run at Montebello. Modifications to the current proposal may result.

The design for handling other solids, such as the sludge from the raw water coagulators, has been proposed consistent with standard practice. In as much as the regulations are expected to become final during the course of the work, modifications to the present design may be necessary.

2.0 Design Codes and Standards

2.1 Applicable Engineering Codes and Standards

Various professional societies, associations and organizations have developed engineering codes and standards which are generally accepted for design and construction. For the Demonstration Plant, a list is shown in Table I.

(Table follows)

TABLE I

LIST OF PROFESSIONAL SOCIETIES, ASSOCIATIONS AND ORGANIZATIONS
 WITH APPLICABLE ENGINEERING CODES & STANDARDS

AAR	Association of American Railroads
AASHO	American Association of State Highway Officials
ACI	American Concrete Institute
AFBMA	Antifriction Bearing Manufacturers Association
AGA	American Gas Association
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction
AITC	American Institute of Timber Construction
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
API	American Petroleum Institute
AREA	American Railway Engineering Association
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers, Boiler and Pressure Vessel Code
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association
CEMA	Conveyor Equipment Manufacturers Association
CTI	Cooling Tower Institute
FMRC	Factory Mutual Research Corporation
HEI	Heat Exchangers Institute
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of America
IPCEA	Insulated Power Cable Engineers Association
MSS	Manufacturers Standardization Society

TABLE I

LIST OF PROFESSIONAL SOCIETIES, ASSOCIATIONS AND ORGANIZATIONS
WITH APPLICABLE ENGINEERING CODES & STANDARDS

CONT'D.

NAFM	National Association of Fan Manufacturers
NB	National Board of Boiler and Pressure Vessel Inspectors
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
SAMA	Scientific Apparatus Makers Association
SJI	Steel Joist Institute
SSPC	Steel Structures Painting Council
SWIB	Southern Weighing and Inspection Bureau
TEMA	Tubular Exchanger Manufacturers Association
UBC	Uniform Building Code
UL	Underwriters Laboratory
HI	Hydraulic Institute

The specific application of these codes and standards for the design and construction of the Demonstration Plant is presented in Table II. These codes and standards provide a basis for minimum acceptability and may be exceeded where federal, state and/or local authorities require.

(Table follows)

TABLE II

APPLICATION OF
ENGINEERING CODES AND STANDARDS

<u>APPLICATION</u>	<u>CODE OR STANDARD</u>
1.0 <u>Columns, Vessels and Tanks</u>	
Columns and Pressure Vessels	ASTM AISC - Steel Construction Manual ANSI ASME - Boiler and Pressure Vessel Codes ASNT - Recommended Practices
Tanks	AISC - Steel Construction Manual ANSI API - 620 API - 650 ASME ASNT - Recommended Practices ASTM AWWA - D100

TABLE II

APPLICATION OF
ENGINEERING CODES AND STANDARDS

CONT'D.

<u>APPLICATION</u>	<u>CODE OR STANDARD</u>
2.0 <u>Heat Exchangers</u>	
Heat Exchangers	ANSI ASME - Boiler & Pressure Vessel Code ASNT ASTM HEI TEMA
Surface Condensers	ANSI ASME - Boiler & Pressure Vessel Code ASME - Power Test Code ASTM - A370 HEI TEMA

TABLE II

APPLICATION OF
ENGINEERING CODES AND STANDARDS

CONT'D.

<u>APPLICATION</u>	<u>CODE OR STANDARD</u>
3.0 <u>Heaters and Boilers</u>	
Fired Process Heaters	AISC - Steel Construction Manual ANSI ASME - Boiler & Pressure Vessel Code ASA ASNT - Recommended Practices ASTM - Standard Material Specifications HEI
Steam Raising Equipment (e.g. Waste Heat Boilers)	ASME - Boiler & Pressure Vessel Code
Steam Generators	ANSI - A58.1 -B18.2.1 -B18.2.2 -B31.1 ASME - Boiler & Pressure Vessel Code ASME - Power Test Code ASTM NAFM NB NFPA

TABLE II

APPLICATION OF

ENGINEERING CODES AND STANDARDS

CONT'D.

4.0 <u>Pumps</u>	API
	ANSI
	ASME
	ASTM
	HI
5.0 <u>Compressors</u>	API
	AGMA
	ANSI
	ASME
	ASTM
	AWS
	MSS
6.0 <u>Turbines</u>	UL
	API
	AGMA
	ANSI
	ASME
	ASNT
	ASTM
	AWS
7.0 <u>Piping</u>	HEI
	AAR
	AGA
	ANSI
	API
	ASME
	ASTM
	AWS
	AWWA
	MSS

TABLE II

APPLICATION OFENGINEERING CODES AND STANDARDS

8.0	<u>Instrumentation</u>	CONT'D.	ISA
			ANSI
			SAMA
			ASME
			AGA
			ANSI
			ASNT
			ASTM
			AWS
			NFPA
9.0	<u>Electrical</u>		NEC
			NEMA
			ANSI
			IEEE
			UL
			ASTM
10.	<u>Fans</u>		AMCA
			ANSI
			ASME
			ASTM
			AWS
			NAFM

TABLE II
APPLICATION OF
ENGINEERING CODES AND STANDARDS
CONT'D.

11. <u>Cooling Towers</u>	ACI
	AISC
	AITC
	AMCA
	ANSI
	ASCE
	ASME
	ASTM
	AWPA
	AWS
	CTI
	NAFM
	NFPA
	UL
12. <u>Insulation and Painting</u>	ASTM
	SSPC
13. <u>Civil and Structural</u>	ACI
	ANSI
	ASTM
	AISC
	AWS
	SSPC
	SJI
	AASHTO
	AREA
	AWPA
	AWWA
	OSHA
	ASCE

TABLE II

APPLICATION OF
ENGINEERING CODES AND STANDARDS

CONT'D.

14. Welding

AWS

ASME

15. Flare

API

2.2 Regulatory Standards

Standards for design, construction and operation of the Demonstration Plant as promulgated in the regulations of governmental agencies will be observed. These agencies include but are not limited to the following:

- U. S. Army Corps of Engineers
- Environmental Protection Agency
- Occupational Safety and Health Administration
- Kentucky Department of Natural Resources and
Environmental Protection
- Office of the State Fire Marshal
- Kentucky Department of Housing,
Building and Construction
- Henderson Planning and Zoning Board.

A more comprehensive survey of the concerned agencies may be found in the "Plan for Obtaining Approval of Permits and Licenses from Agencies." (Deliverable No. 30)

3.0 General Specifications

3.1 Civil

3.1.1 Site Preparation Specification

WRG-8375-A-025

3.1.2 Underground Sewerage and Drainage Specification

WRG-8375-A-040

3.2 Structural

3.2.1 Structural Steel

WRG-8375-B-500-75

3.3 Buildings

3.3.1 Demonstration Plant Building Summary pp 1 - 4

3.3.2 Major Buildings

3.3.2.1 Administration Building

SK WRG-8375-CE-10

3.3.2.2 Maintenance and Warehouse Building

SK WRG-8375-CE-11

3.3.2.3 Control Building

SK WRG-8375-CE-12

3.3.2.4 Compressor Building

SK WRG-8375-CE-13

3.3.2.5 Water Treatment Building

SK WRG-8375-CE-14

3.3.2.6 Guard and Change Houses

SK WRG-8375-CE-15

3.3.2.7 Chemical Storage Building

SK WRG-8375-CE-16

3.3.2.8 Sulfate Pit Building

SK WRG-8375-CE-16

3.3.2.9 Evaporator Bottoms Pit Building

SK WRG-8375-CE-16

3.4 Vessels

3.4.1 Field Fabricated Storage Tanks

WRG-8375-B-100001

- 3.4.2 Columns and Pressure Vessels
WRG-8375-B-100002
- 3.5 Heat Exchangers
 - 3.5.1 Heat Exchangers
WRG-8375-B-100003
 - 3.5.2 Surface Condenser and Accessories
WRG-8375-B-100008
- 3.6 Heaters and Boilers
 - 3.6.1 Fired Process Heaters
WRG-8375-B-100004
 - 3.6.2 Steam Generators
WRG-8375-B-100023
- 3.7 Pumps
 - 3.7.1 Centrifugal Pumps
WRG-8375-B-100005
- 3.8 Compressors
 - 3.8.1 Centrifugal Compressors
WRG-8375-B-100006
 - 3.8.2 Reciprocating Compressors
WRG-8375-B-100025
- 3.9 Turbines
 - 3.9.1 Mechanical Drive Steam Turbines
WRG-8375-100007
- 3.10 Water Demineralizer
 - 3.10.1 Makeup Water Demineralizer Plant
WRG-8375-100009
- 3.11 Piping System
 - 3.11.1 Prefabricated Piping
WRG-8375-B-100010 Part A
 - 3.11.2 Piping System Specifications
WRG-8375-B-100010 Part B

3.12 Instrumentation

3.12.1 Instrumentation

WRG-8375-100011

3.13 Electrical

3.13.1 460/575 Volt NEMA Frame Motor

WRG-8375-B-100012

3.13.2 Power Transformers

WRG-8375-B-100013

3.13.3 Motor Control Centers

WRG-8375-B-100014

3.13.4 Metal Enclosed Switchgear

WRG-8375-B-100015

3.13.5 600 Volt Metal Enclosed Switchgear

WRG-8375-B-100016

3.13.6 Bus Duct or Cable Bus

WRG-8375-B-100017

3.13.7 High Voltage Motor Controllers

WRG-8375-B-100018

3.13.8 Static Uninterruptible AC Power Supply

WRG-8375-B-100019

3.13.9 Batteries and Battery Chargers

WRG-8375-B-100020

3.13.10 Motors Rated Above 600 Volts & 200 HP

WRG-8375-B-100021

3.14 Fans

3.14.1 Mechanical Draft Fans

WRG-8365-B-100022

3.15 Cooling Towers

3.15.1 Mechanical Draft Cooling Towers and Accessories

WRG-8375-B-100024

3.16 Insulation

3.16.1 Heat, Cold, Antisweat & Personnel Protection Insulation

WRG-8375-B-100026

4.0 Specifications of Major Equipment Items

4.1 Equipment Index

WRG-8375-A-013 (0) (pp 1-37)*

4.2 Progress Duty and Mechanical Specification Sheets

4.2.1 Coal Handling - Unloading &

Reclaiming

WRG-8375-A-065 (0) (pp 1-22)

4.2.2 Coal Slurry Preparation

WRG-8375-A-066 (0) (pp 1-17)*

4.2.3 Coal Gasification

WRG-8375-A-120 (0) (pp 1-23)*

WRG-8375-A-130 (0) (pp 1-17)*

WRG-8375-A-132 (0) (pp 1-5)*

4.2.4 Carbon & Ash Recovery

WRG-8375-A-170 (0) (pp 1-17)*

WRG-8375-A-180 (0) (pp 1-18)*

4.2.5 CO Shift & Heat Recovery

WRG-8375-A-220 (1) (pp 1-19)

WRG-8375-A-230 (0) (pp 1-24)*

4.2.6 Acid Gas Removal

WRG-8375-A-320 (0) (pp 1-54)*

WRG-8375-A-340 (0) (pp 1-8)*

WRG-8375-A-345 (0) (pp 1-17)*

4.2.7 Nitrogen Wash

WRG-8375-A-370 (0) (pp 1-7)*

4.2.8 Sulfur Recovery

WRG-8375-A-520 (0) (pp 1-32)*

WRG-8375-A-530 (0) (pp 1-13)*

4.2.9 Air Separation Unit

WRG-8375-A-620 (0) (pp 6-1 to 6-29)

4.2.10 Steam Generation

WRG-8375-A-715 (1) (pp 1-36)

4.2.11 Steam Distribution

WRG-8375-A-716 (1) (pp 1-32)

4.2.12 Feedwater & Condensate

WRG-8375-A-717 (0) (pp 1-60)

4.2.13 Air Quality Control

WRG-8375-A-745 (1) (pp 1-9)

4.2.14 Ash Disposal

WRG-8375-A-765 (1) (pp 1-21)

4.2.15 Raw Water Supply & Cooling

Tower

WRG-8375-A-830 (0) (pp 1-103)

4.2.16 Treated Water

WRG-8375-A-880 (1) (pp 1-58)

4.2.17 Waste Treatment

WRG-8375-A-930 (1) (pp 1-117)

4.2.18 Flare

WRG-8375-A-940 (0) (pp 1-12)

WRG-8375-A-946 (1) (pp 1-3)

4.2.19 Fire Protection

WRG-8375-A-965 (2) (pp 1-12)

* See note page 36

4.3	<u>Summary Piping Specifications</u>	WRG-8375-A-014 (0) (pp 1-48)*
4.4	<u>Instrument Specifications</u>	WRG-8375-B-019 (0) (pp 1-37)*
4.5	<u>Electrical</u>	
4.5.1	One Line Diagram	WRG-8375-M-005 (R-1)*
4.5.2	480 Volt One Line Diagram Sheet 1	WRG-8375-M-006 (R-1)*
4.5.3	480 Volt One Line Diagram Sheet 2	WRG-8375-M-007 (R-1)
4.5.4	480 Volt One Line Diagram Sheet 3	WRG-8375-M-008 (R-1)
4.6	<u>Insulation Schedule</u>	(pp 1-2)
4.7	<u>Communications Systems</u>	WRG-8375-M-015 (0)

* See note page 36

5.0 Process Schematics

The design basis for the Demonstration Plant is further reflected in the several Process Schematics as developed for each of the process and plant areas. These are listed in the index that follows. Material balances for normal operating conditions (NOC) are shown based on the Design Coal as noted in Paragraph 1.3.

5.1	Process Coordination Diagram	WRG-8375-M-016 (0)
5.2	Coal Handling - Unloading & Reclaiming	WRG-8375-M-060 (R-1)
5.3	Coal Slurry Preparation	WRG-8375-M-061 (R-1)*
5.4	Coal Gasification	WRG-8375-M-110 (R-1)*
5.5	Coal Gasification - Slurry Mixing	WRG-8375-M-111 (R-1)*
5.6	Coal Gasification - Slag Handling	WRG-8375-M-112 (R-1)*
5.7	Carbon and Ash Recovery	WRG-8375-M-160 (R-1)*
5.8	CO Shift and Heat Recovery	WRG-8375-M-210 (R-1)
5.9	Acid Gas Removal - Gas Absorption	WRG-8375-M-310 (R-1)*
5.10	Acid Gas Removal - Methanol Regener- ation	WRG-8375-M-311 (R-1)*
5.11	Acid Gas Removal - Refrigeration & Methanol Storage	WRG-8375-M-312 (0)
5.12	Nitrogen Wash	WRG-8375-M-360 (R-1)*
5.13	Sulfur Recovery	WRG-8375-M-510 (R-1)*
5.14	Sulfuric Acid Plant - Sheet 1	WRG-8375-M-560 (R-1)
5.15	Sulfuric Acid Plant - Sheet 2	WRG-8375-M-561 (R-1)
5.16	Air Separation Unit	WRG-8375-M-610 (R-1)
5.17	Steam Generation	WRG-8375-M-710 (R-1)
5.18	Steam Distribution System	WRG-8375-M-711 (R-1)*
5.19	Feedwater and Condensate System	WRG-8375-M-712 (R-1)*
5.20	Air Quality Control - Flue Gas	WRG-8375-M-734 (R-1)
5.21	Air Quality Control - Sheet 1	WRG-8375-M-735 (R-1)*
5.22	Air Quality Control - Sheet 2	WRG-8375-M-736 (R-1)*
5.23	Air Quality Control - Sheet 3	WRG-8375-M-737 (R-1)*
5.24	Air Quality Control - Sheet 4	WRG-8375-M-738 (R-1)*
5.25	Ash Disposal	WRG-8375-M-760 (R-1)
5.26	Raw Water Supply & Cooling Water	WRG-8375-M-810 (R-1)*

5.27	Treated Water	WRG-8375-M-860	(R-1)
5.28	Waste Treatment - Sheet 1	WRG-8375-M-910	(R-1)
5.29	Waste Treatment - Sheet 2	WRG-8375-M-911	(R-1)
5.30	Flare System	WRG-8375-M-945	(R-1)
5.31	Fire Protection	WRG-8375-M-960	(R-1)

6.0 Flow Diagrams

The following Flow Diagrams have been prepared to provide a basis for estimating the capital cost of the Demonstration Plant. These are preliminary and are subject to change by detail engineering and design before approval by the Industrial Partner for construction.

6.1	Coal Slurry Preparation		WRG-8375-M-061 (R-1) *
6.2	Coal Handling - Unloading & Reclaiming		WRG-8375-M-070 (R-1)
6.3	Coal Slurry Preparation		WRG-8375-M-071 (R-1)
6.4	Coal Gasification Sheet 1		WRG-8375-M-125 (R-1)*
6.5	Coal Gasification Sheet 2		WRG-8375-M-126 (R-1)*
6.6	Coal Gasification Sheet 3		WRG-8375-M-127 (R-1)*
6.7	Carbon and Ash Recovery	Sheet 1	WRG-8375-M-175 (R-1)*
6.8	Carbon and Ash Recovery	Sheet 2	WRG-8375-M-176 (R-1)*
6.9	CO Shift and Heat Recovery	Sheet 1	WRG-8375-M-225 (R-1)
6.10	CO Shift and Heat Recovery	Sheet 2	WRG-8375-M-226 (R-1)
6.11	Acid Gas Removal	Sheet 1	WRG-8375-M-325 (R-1)*
6.12	Acid Gas Removal	Sheet 2	WRG-8375-M-326 (0)*
6.13	Acid Gas Removal	Sheet 3	WRG-8375-M-327 (0)*
6.14	Acid Gas Removal	Sheet 4	WRG-8375-M-328 (R-1)*
6.15	Acid Gas Removal	Sheet 5	WRG-8375-M-329 (0)*
6.16	Acid Gas Removal	Sheet 6	WRG-8375-M-330 (0)*
6.17	Acid Gas Removal	Sheet 7	WRG-8375-M-331 (R-1)*
6.18	Acid Gas Removal	Sheet 8	WRG-8375-M-332 (R-1)*
6.19	Acid Gas Removal - Refrigeration & Methanol Storage		WRG-8375-M-333 (R-1)
6.20	Nitrogen Wash	Sheet 1	WRG-8375-M-375 (R-1) *
6.21	Nitrogen Wash	Sheet 2	WRG-8375-M-376 (R-1) *
6.22	Nitrogen Wash	Sheet 3	WRG-8375-M-377 (0) *
6.23	Sulfur Recovery	Sheet 1	WRG-8375-M-525 (R-1) *
6.24	Sulfur Recovery	Sheet 2	WRG-8375-M-526 (R-1) *

* See note page 36

6.25	Sulfuric Acid Plant	Sheet 1	WRG-8375-M-560 (R-1)
6.26	Sulfuric Acid Plant	Sheet 2	WRG-8375-M-561 (R-1)
6.27	Air Separation Unit	Sheet 1	WRG-8375-M-625 (R-1)
6.28	Air Separation Unit	Sheet 2	WRG-8375-M-626 (R-1)
6.29	Steam Generation		WRG-8375-M-720 (R-1)
6.30	High Pressure Steam Distribution		WRG-8375-M-721 (R-1)
6.31	Medium & Low Pressure Steam		
	Distribution		WRG-8375-M-722 (R-1)*
6.32	Feedwater & Condensate System		
	Sheet 1		WRG-8375-M-723 (0)
6.33	Feedwater & Condensate System		
	Sheet 2		WRG-8375-M-724 (R-1)*
6.34	Feedwater & Condensate System		
	Sheet 3		WRG-8375-M-725 (R-1)
6.35	Air Quality Control	Sheet 1	WRG-8375-M-740 (R-1)
6.36	Air Quality Control	Sheet 2	WRG-8375-M-741 (R-1)
6.37	Air Quality Control	Sheet 3	WRG-8375-M-742 (R-1)
6.38	Air Quality Control	Sheet 4	WRG-8375-M-743 (R-1)
6.39	Ash Disposal		WRG-8375-M-770 (R-1)
6.40	Raw Water Supply		WRG-8375-M-820 (R-1)
6.41	Cooling Water		WRG-8375-M-821 (R-1)*
6.42	Treated Water	Sheet 1	WRG-8375-M-870 (R-1)
6.43	Treated Water	Sheet 2	WRG-8375-M-871 (R-1)
6.44	Treated Water	Sheet 3	WRG-8375-M-872 (F-1)
6.45	Treated Water	Sheet 4	WRG-8375-M-873 (R-1)
6.46	Waste Treatment	Sheet 1	WRG-8375-M-920 (R-1)
6.47	Waste Treatment	Sheet 2	WRG-8375-M-921 (R-1)
6.48	Flare System		WRG-8375-M-945 (R-1)
6.49	Fire Protection		WRG-8375-M-960 (R-1)

* See note page 36

7.0 Plot Plans and Elevations

In addition to the drawings noted below, models of the plant facilities and the docking area have been prepared with a scale of 1 inch = 100 feet.

7.1 General Plant

7.1.1	Site Plan	WRG-8375-M-001 (R-1)
7.1.2	Plot Plan	WRG-8375-M-002 (R-1)
7.1.3	Site Preparation	WRG-8375-M-020 (R-1)
7.1.4	Underground Sewage & Drainage	WRG-8375-M-030 (R-1)

7.2 Plant Areas

7.2.1	Coal Handling Unloading & Reclaiming	
7.2.1.1	Plan	WRG-8375-M-050 (R-1)
7.2.1.2	Elevation Sheet 1	WRG-8375-M-051 (R-1)
7.2.1.3	Elevation Sheet 2	WRG-8375-M-052 (R-1)
7.2.2	Coal Slurry Preparation	
7.2.2.1	Plot and Elevation	WRG-8375-M-053 (0)
7.2.3	Coal Gasification & Carbon Ash	
7.2.3.1	Plan	WRG-8375-M-100 (0)*
7.2.4	CO Shift & Heat Recovery	
7.2.4.1	Plan & Elevation	WRG-8375-M-200 (0)
7.2.5	Acid Gas Removal & Nitrogen Wash	
7.2.5.1	Plan & Elevation	WRG-8375-M-300 (0)*
7.2.6	Sulfur Recovery	
7.2.6.1	Plan & Elevation	WRG-8375-M-500 (0)
7.2.7	Sulfuric Acid Plant	
7.2.7.1	Plan	WRG-8375-M-550 (0)
7.2.8	Air Separation Unit	
7.2.8.1	Plan & Elevation	WRG-8375-M-600 (0)
7.2.9	Steam Generation	
7.2.9.1	Plan	WRG-8375-M-700 (R-1)
7.2.9.2	Elevation	WRG-8375-M-701 (R-1)

* See note page 36

7.2.10	Air Quality Control	
7.2.10.1	Plan	WRG-8375-M-727 (0)
7.2.10.2	Elevation	WRG-8375-M-728 (0)
7.2.11	Ash Disposal	
7.2.11.1	Plan	WRG-8375-M-750 (0)
7.2.12	Raw Water Supply & Cooling Water	
7.2.12.1	Plan & Elevation	WRG-8375-M-800 (R-1)
7.2.13	Treated Water	
7.2.13.1	Plan & Elevation	WRG-8375-M-850 (R-1)
7.2.14	Waste Treatment	
7.2.14.1	Plan	WRG-8375-M-900 (R-1)

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