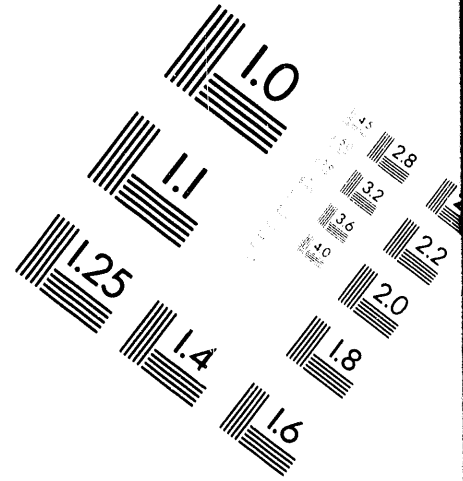
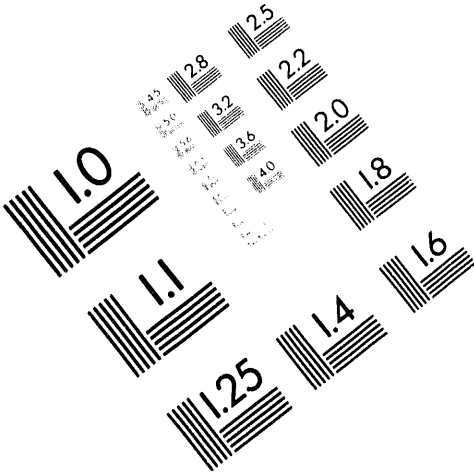




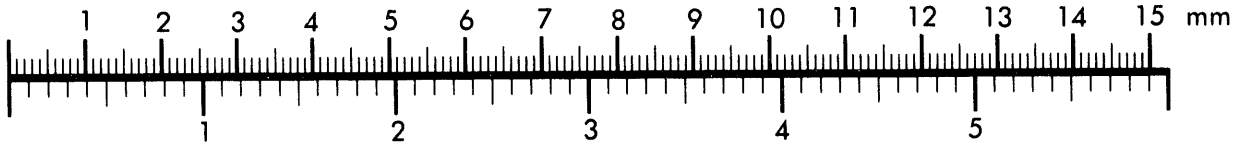
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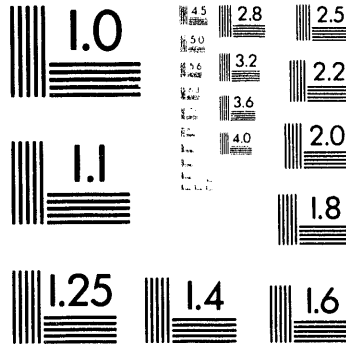
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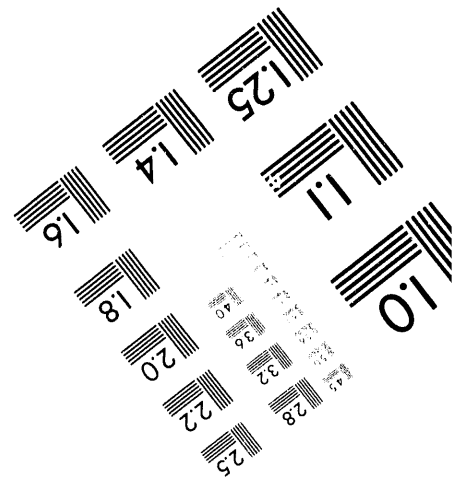
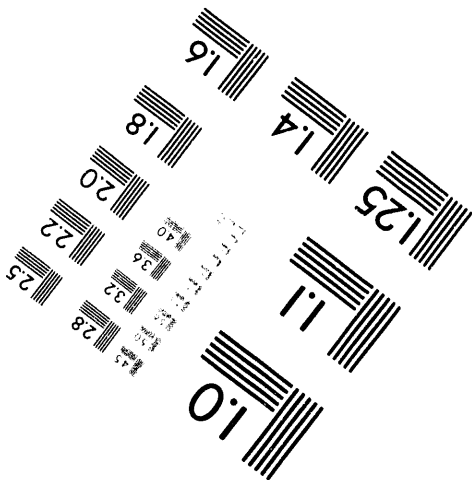
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BY APPLIED IMAGE, INC.



1 of 1

TECHNICAL PROGRESS REPORT

For the period:

January 1, 1993, through March 31, 1993

Prepared for:

Rosebud SynCoal Partnership
Advanced Coal Conversion Process Demonstration
Colstrip, Montana

DOE Contract
DE-FC22-90PC89664

Prepared by:

POWER Environmental Services, Inc.
Butte, Montana

March 1994

For submittal to:

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APPENDIX A - Significant Accomplishments from Origination of Project to Date

1.0 INTRODUCTION AND PURPOSE

This report describes the technical progress made on the Advanced Coal Conversion Process (ACCP) Demonstration Project from January 1, 1993, through March 31, 1993.

The ACCP Demonstration Project is a U.S. Department of Energy (DOE) Clean Coal Technology Project. The Cooperative Agreement defining this project is between DOE and the Rosebud SynCoal Partnership. In brief, Western Energy Company, which is a coal mining subsidiary of Entech, Inc., Montana Power Company's (MPC's) non-utility group in Colstrip, Montana, was the original proposer for the ACCP Demonstration Project and Cooperative Agreement participant. To further develop the ACCP technology, Entech created Western SynCoal Company. After the formation of the Rosebud SynCoal Partnership, Western Energy Company formally novated the Cooperative Agreement to the Rosebud SynCoal Partnership to facilitate continued participation in the Cooperative Agreement. The Rosebud SynCoal Partnership is a partnership between Western SynCoal Company and Scoria, Inc., a subsidiary of NRG Energy, Inc., Northern States Power's non-utility group.

This project demonstrates an advanced, thermal, coal drying process, coupled with physical cleaning techniques, that is designed to upgrade high-moisture, low-rank coals to a high-quality, low-sulfur fuel, registered as the SynCoal® process. The coal is processed through three stages (two heating stages followed by an inert cooling stage) of vibrating fluidized bed reactors that remove chemically bound water, carboxyl groups, and volatile sulfur compounds. After drying, the coal is put through a deep-bed stratifier cleaning process to separate the pyrite-rich ash from the coal.

The SynCoal® process enhances low-rank, western coals, usually with a moisture content of 25 to 55 percent, sulfur content of 0.5 to 1.5 percent, and heating value of 5,500 to 9,000 British thermal units per pound (Btu/lb), by producing a stable, upgraded, coal product with a moisture content as low as 1 percent, sulfur content as low as 0.3 percent, and heating value up to 12,000 Btu/lb.

The 45-ton-per-hour unit is located adjacent to a unit train loadout facility at Western Energy Company's Rosebud coal mine near Colstrip, Montana. The demonstration plant is sized at about one-tenth the projected throughput of a multiple processing train commercial facility. The demonstration drying and cooling equipment is currently near commercial size.

2.0 PROJECT PROGRESS

2.1 SIGNIFICANT ACCOMPLISHMENTS

Rosebud SynCoal Partnership's ACCP Demonstration Facility entered Phase III, Demonstration Operation, in April 1992 and operated in an extended startup mode through December 1992. Rosebud SynCoal Partnership instituted an aggressive program to overcome startup obstacles and now focuses on supplying product coal to customers. Significant accomplishments in the history of the SynCoal® process development are shown in Appendix A. Table 2.1 lists the significant accomplishments for the year to date.

Table 2.1. Significant Accomplishments for 1993

Period	Significant Accomplishments
January 1993	<ul style="list-style-type: none"> • Trucked 3,494 tons to Colstrip Units 3 and 4. • Continued process testing to reduce spontaneous combustion tendency. • Produced 200 tons of passivated product that lasted 13 days in the open storage pile. • The plant had a 53 percent operating factor for the month. • Identified dryer reactor structural design problem. • Installed silo inerting system. • Started process fines handling modification design.
February 1993	<ul style="list-style-type: none"> • Stored approximately 1,200 tons of SynCoal® in inerted product silo. • The plant had a 62 percent operating factor between January 1 and February 15. • Shipped 174 tons of SynCoal® to MPC's J.E. Corette Plant by rail. • Trucked 741 tons of SynCoal® to Colstrip Units 3 and 4. • Continued process testing to reduce spontaneous combustion tendency and dustiness.
March 1993	<ul style="list-style-type: none"> • Stored approximately 4,650 tons of SynCoal® in inerted product silo. • Identified an environmentally compatible dust suppressant that inhibits dust release from the SynCoal® product. • Shipped 352 tons of SynCoal® to MPC's J.E. Corette Plant by rail. • Trucked 277 tons of SynCoal® to Colstrip Units 3 and 4. • Continued process testing to reduce spontaneous combustion tendency and dustiness. • Completed annual Mine Safety and Health Administration (MSHA) safety training.

2.2 PROJECT PROGRESS SUMMARY

Although the plant's reliability is still limited, the facility's operating factor has improved to about 47 percent and raw coal feed rate to nearly 20 percent of nominal design capacity for the quarter. To date, about 50,421 tons of raw coal have been fed to the process, producing about 25,000 tons of uncleaned and cleaned product. A little over 10,768 tons have been test shipped, showing that product dustiness is an issue that needs to be addressed. An environmentally compatible dust suppressant has been identified; however, work continues to identify further suppressant options.

Modifications and maintenance work during the reporting period focused on:

- modifying the drag conveying and processed fines conveying equipment;
- repairing structural cracks in the second-stage dryer/reactor; and
- repairing first-stage baghouse due to electrical problems which caused freezing, blocking, and eventually smoldering in the baghouse.

The product produced to date has been exceptionally close to the design basis product from a chemical standpoint. Typical product analyses are shown in Table 2.2.

Table 2.2. ACCP Quarterly Analyses Summary

	TM	PA	PS	HHV	SO ₂
First Quarter Product					
Average	2.22	9.29	0.56	11,864	0.95
Standard Deviation	0.42	0.79	0.13	119	0.23
Min.	1.62	8.49	0.47	11,502	0.79
Max.	3.41	11.45	1.02	11,975	1.75
TM - % Total Moisture PA - % Ash		PS - % Sulfur HHV - Btu/lb.		SO ₂ - lbs. of SO ₂ /MMBtu	

3.0 PROCESS DESCRIPTION

In general, the ACCP is a drying and conversion process that uses combustion products and superheated steam as fluidizing gas in vibrating fluidized beds. Two fluidized stages are used to heat and dry the coal, and one water spray stage followed by one fluidized stage is used to cool the coal. Other systems that service and assist the coal conversion system include:

- Coal Conversion;
- Coal Cleaning;
- Product Handling;
- Raw Coal Handling;
- Emission Control;
- Heat Plant;
- Heat Rejection; and
- Utility and Ancillary.

3.1 ORIGINAL DESIGN PROCESS DESCRIPTION

The designed central processes are depicted in Figure 3.1 on the proceeding page. The following discusses plant design aspects and expected results. Modifications and operating results are summarized in Section 3.2.

Coal Conversion

The coal conversion is performed in two parallel processing trains. Each train consists of two, 5-foot-wide by 30-foot-long vibratory fluidized bed dryer/reactors in series, followed by a water spray section, and a 5-foot-wide by 25-foot-long vibratory cooler. Each processing train is fed up to 1,139 pounds per minute of 2-by-½ inch coal.

In the first-stage dryer/reactors, the coal is heated by direct contact with hot combustion gases mixed with recirculated dryer makegas, removing primarily surface water from the coal. The coal exits the first-stage dryer/reactors at a temperature slightly above that required to evaporate water. After the coal exits the first-stage dryer/reactor, it is gravity fed to the second-stage dryer/reactors, which further heats the coal using a recirculating gas stream, removing water trapped in the pore structure of the coal and promoting decarboxylation. The water, which makes up the superheated steam used in the second stage, is actually produced from the coal itself. Particle shrinkage that occurs in the second stage liberates ash minerals and passes on a unique cleaning characteristic to the coal.

As the coal exits the second-stage dryer/reactors, it falls through vertical quench coolers where process water is sprayed onto the coal to reduce the temperature. The water vaporized during this operation is drawn back into the second-stage dryer/reactors. After water quenching, the coal enters the vibratory coolers where the coal is contacted by cool inert gas. The coal exits the vibratory cooler(s) at less than 150°F and enters the coal cleaning system. The gas that exits the vibratory coolers is dedusted in a twin cyclone and cooled by water sprays in direct contact coolers prior to returning to the vibratory coolers.

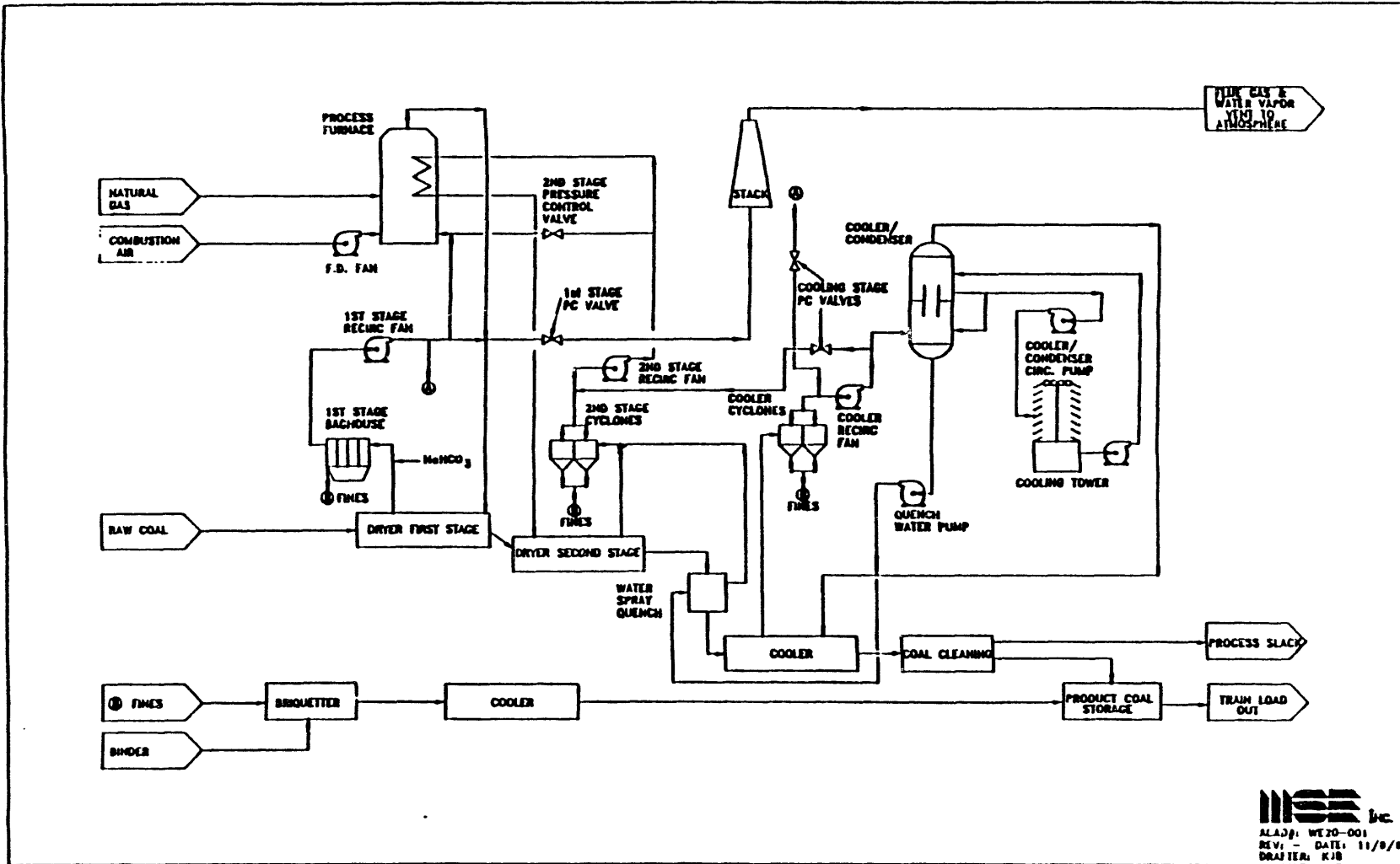
Three interrelated recirculating gas streams are used in the coal conversion system; one each for the dryer/reactor stages and one for the vibratory coolers.


Gases enter the process from either the natural gas-fired process furnace or from the coal itself. Combustion gases from the furnace are mixed with recirculated makegas in the first-stage dryer/reactors after indirectly exchanging some heat to the second-stage gas stream. The second-stage gas stream is composed mainly of superheated steam, which is heated by the furnace combustion gases in the heat exchanger. The cooler gas stream is made up of cooled furnace combustion gases that have been routed through the cooler loop.

A gas route is available from the cooler gas loop to the second-stage dryer/reactor loop to allow system inerting. Gas may also enter the first-stage dryer/reactor loop from the second-stage loop (termed makegas) but without directly entering the first-stage dryer/reactor loop; rather, the makegas is used as an additional fuel source in the process furnace. The final gas route follows the exhaust stream from the first-stage loop to the atmosphere.

Gas exchange from one loop to another is governed by pressure control on each loop, and after startup, will be minimal from the first-stage loop to the cooler loop and from the cooler loop to the second-stage loop. Gas exchange from the second-stage loop to first-stage loop (through the process furnace) may be substantial since the water vapor and hydrocarbons driven from the coal in the second-stage dryer/reactors must leave the loop to maintain a steady state.

In each gas loop, particulate removal devices that remove dust from the gas streams, protect the fans. The control emissions are upstream from the fans. Particulates are removed from the first-stage process gas by a pair of baghouses in parallel. The second-stage process gas is treated by a quad cyclone arrangement, and the cooler-stage process gas is treated by a twin cyclone arrangement.





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Figure 3.1 Central Processes

Coal Cleaning

The coal entering the cleaning system is screened into four size fractions: plus ½ inch, ½ by ¼ inch, ¼ inch by 6 mesh, and minus 6 mesh. These streams are fed in parallel to four, deep-bed stratifiers (stoners) where a rough specific gravity separation is made using fluidizing air and a vibratory conveying action. The light streams from the stoners are sent to the product conveyor, and the heavy streams from all but the minus 6 mesh stream are sent to fluidized bed separators. The heavy fraction of the minus 6 mesh stream goes directly to the waste conveyor. The fluidized bed separators, again using air and vibration to effect a gravity separation, each split the coal into light and heavy fractions. The light stream is considered product, and the heavy or waste stream is sent to a 300-ton, storage bin to await transport to an off-site user or alternately back to a mined out pit disposal site. The dried, cooled, and cleaned product from coal cleaning enters the product handling system.

Product Handling

Product handling consists of the equipment necessary to convey the clean product coal into two, 6,000-ton, concrete silos and to allow train loading with the existing loadout system.

Raw Coal Handling

Raw coal from the existing stockpile is screened to provide 2-by-½ inch feed for the ACCP process. Coal rejected by the screening operation is conveyed back to the active stockpile. Properly sized coal is conveyed to a 1000-ton, raw coal, storage bin which feeds the process facility.

Emission Control

Sulfur dioxide emission control philosophy is based on injecting dry sorbents into the ductwork to minimize the release of sulfur dioxide to the atmosphere. Sorbents, such as trona or sodium bicarbonate, are injected into the first-stage dryer gas stream as it leaves the first-stage dryers to maximize the potential for sulfur dioxide removal while minimizing reagent usage. The sorbents, having reacted with sulfur dioxide, are removed from the gas streams in the particulate removal systems. A 60-percent reduction in sulfur dioxide emissions should be realized.

The coal cleaning area fugitive dust is controlled by placing hoods over the sources of fugitive dust conveying the dust laden air to fabric filter(s). The bag filters can remove 99.99 percent of the coal dust from the air before discharge. All fines will report to a briquetter and ultimately the product stream.

Heat Plant

The heat required to process the coal is provided by a natural gas-fired process furnace, which uses process makegas from coal conversion as fuel. This system is sized to provide a heat release rate of 74 MM Btu/hr. Process gas enters the furnace and is heated by radiation and convection from the burning fuel.

Heat Rejection

Most heat rejection from the ACCP is accomplished by releasing water and flue gas into the atmosphere through an exhaust stack. The stack design allows for vapor release at an elevation great enough that, when coupled with the vertical velocity resulting from a forced draft fan, dissipation of the gases will be maximized. Heat removed from the coal in the coolers is rejected using an atmospheric-induced, draft cooling tower.

Utility and Ancillary Systems

The coal fines that are collected in the conversion, cleaning, and material handling systems are gathered and conveyed to a surge bin. The coal fines are then agglomerated and returned to the product stream.

Inert gas is drawn off the cooler loop for other uses. This gas, primarily nitrogen and carbon dioxide, is used only for baghouse pulse. The makeup gas to the cooler loop is combustion flue gas from the stack. The cooling system effectively dehumidifies and cools the stack gas making the inert gas for the system. The cooler gas still has a relatively high dew point (about 90°F). Due to the thermal load this puts on the cooling system, no additional inert gas requirements can be met by this approach.

The common facilities for the ACCP include a plant and instrument air system, a fire protection system, and a fuel gas distribution system.

The power distribution system includes a 15 kV service; a 15 kV/5 kV transformer; a 5 kV motor control center; two, 5 kV/480 V transformers; a 480 V load distribution center; and a 480 V motor control center.

The process is semi-automated, including dual control stations, dual programmable logic controllers, and distributed plant control and data acquisition hardware. Operator interface is necessary to set basic system parameters, and the control system adjusts to changes in the process measurements.

3.1.1 ORIGINAL EQUIPMENT

The originally designed and installed major equipment for the ACCP Demonstration Facility is shown in Table 3.1 on the following page.

Table 3.1. Advanced Coal Conversion Process Major Plant Equipment

System Description	Equipment Vendor	Type
Coal Dryers/Coolers	Carrier Vibrating Equipment, Inc.	PE
Belt Conveyors	Willis & Paul Group	MH
Bucket Elevators	FMC Corporation	MH
Coal Cleaning Equipment	Triple S Dynamics, Inc.	CC
Coal Screens	Hewitt Robbins Corporation	MH
Loading Spouts	Midwest International	MH
Dust Agglomerator	Royal Oak Enterprises, Inc.	DH
Silo Mass Flow Gates	SEI Engineers, Inc.	MH
Vibrating Bin Dischargers	Carman Industries, Inc.	MH
Vibrating Feeder	Kinergy Corporation	MH
Drag Conveyor	Dynamet	DH
Process Gas Heater	G.C. Broach Company	PE
Direct Contact Cooler	CMI-Schneible Company	PE
Particulate Removal System	Air-Cure Howden	EC
Dust Collectors	Air Cure Environmental, Inc.	EC
Air Compressors/Dryers	Colorado Compressor, Inc.	CF
Diesel Fire Pumps	Peerless Pump Company	CF
Forced Draft Fans	Buffalo Forge Company	PE
Pumps	Dresser Pump Division Dresser Industries, Inc.	PE
Electrical Equipment-4160	Toshiba/Houston International Corporation	CF
Electrical Equipment-LDC	Powell Electric Manufacturing Company	CF
Electrical Equipment-480v MCC	Siemens Energy & Automation, Inc.	CF
Main Transformer	ABB Power T&D Company	CF
Control Panels	Utility Control & Equipment Corporation	CF
Control Valves	Applied Control Equipment	CF
Plant Control System	General Electric Supply Company	CF
Cooling Tower	The Marley Cooling Tower Company	PE
Dampers	Effox, Inc.	PE
Dry Sorbent Injec. System	Natech Resources, Inc.	EC
Expansion Joints	Flexonics, Inc.	PE
MH - Materials Handling CF - Common Facilities	PE - Process Equipment CC - Coal Cleaning	EC - Emissions Control DH - Dust Handling

3.2 AS-BUILT PROCESS DESCRIPTION

The ACCP has been modified as necessary during start-up and operation of the ACCP Demonstration Plant. Equipment has been improved; additional equipment installed; and new systems designed, installed, and operated to improve the overall plant performance. Those adjustments are listed below and on the following pages.

Coal Conversion

In 1992, several modifications were made to the vibratory fluidized bed dryer/reactors and processing trains to improve plant performance. An internal process gas bypass was eliminated, and the seams were welded out to reduce system leaks. Due to the high temperature inside the vibrating fluidized beds and the bearing drive design, the differential expansion between the reactor shell and the drive assembly in cold weather would crack the reactor drive assembly loose. This required the system insulation to be redesigned and retrofitted.

The originally designed, two-train fines, conveying system could not keep up with the system. To operate closer to design conditions, obtain better control over operating conditions, and minimize dustiness, the ACCP plant capacity was being redesigned as one process train to reduce the overall fines loading prior to modifying the fines handling system. As the March 1993 reporting period ended, the operating process train was fed about 25 to 30 tons per hour of 1¼-by-½ inch coal.

The ACCP design included a briquetter for agglomeration of the process fines. However, initial shakedown of the plant required the briquetting system be completely operational. Since the briquetting operation was delayed to focus on successfully operating the plant, the process design changes included disposal of the fines by slurry to an existing pit in the mine. During the Third Quarter 1992, a temporary slurry fines disposal system was installed. Design of a replacement fines conveying system is proceeding.

The main rotary airlocks were required to shear the pyrite and "bone" or rock that is interspersed with the coal; however, the design of the rotary airlocks was insufficient to convey this non-coal material. Therefore, the drive motors were retrofitted from 2 to 5 horse power for all eight process rotary airlocks. Also, an electrical current reversing circuit was designed, tested, and applied to the rotary airlocks. This circuitry is able to sense a rotor stall and reverse the motor to clear the obstruction.

The original plant startup tests also revealed explosion vent discrepancies in all areas, thus preventing extended operation of the plant. The design development for the vents was a cooperative effort between an explosion vent manufacturing company and the ACCP personnel who are working on a unique explosion vent sealing system that will be implemented at the ACCP facility.

Coal Cleaning

The coal entering the cleaning system is screened into four size fractions: plus ½ inch, ½ by ¼ inch, ¼ inch by 6 mesh, and minus 6 mesh. These streams are fed in parallel to four, deep-bed stratifiers (stoners) where a rough, specific, gravity separation is made using fluidizing air and a vibratory conveying action. The light streams from the stoners are sent to the product conveyor, and the heavy streams from all but the minus 6 mesh stream are sent to fluidized bed separators. The heavy fraction of the minus 6 mesh stream goes directly to the waste conveyor. The fluidized bed separators, again using air and vibration to effect a gravity separation, each split the coal into light and heavy fractions. The light stream is considered product, and the heavy or waste stream is sent to a 300-ton, storage bin to await transport back to the mined out pit disposal site. The dried, cooled, and cleaned product from coal cleaning enters the product handling system. Modifications were made in the Third Quarter of 1992 that allows product to be sent to the waste bin with minimal reconfiguration.

Product Handling

Work is continuing on testing and evaluating technologies to enhance product stabilization and reduce fugitive dustiness. During the Fourth Quarter of 1992, a liquid carbon dioxide storage and vaporization system was installed for testing product stability and providing inert gas for storage and plant startup/shutdown.

The clean product coal is conveyed into two, 5,000-ton capacity, concrete silos that allow train loading with the existing loadout system. This capacity is due to the relatively low SynCoal density.

Raw Coal Handling

Raw coal from the existing stockpile is screened to provide 1 ¼-by-½ inch feed for the ACCP process. Coal rejected by the screening operation is conveyed back to the active stockpile. Properly sized coal is conveyed to a 1,000-ton, raw coal, storage bin which feeds the process facility.

Emission Control

It was originally assumed that sulfur dioxide emissions would have to be controlled by injecting chemical sorbents into the ductwork. As of the March 1993 reporting date, the longest operational period was about 200 hours from January 4 through January 12. Preliminary data indicated that the addition of chemical sorbent would not be necessary to control sulfur dioxide emissions under the operating conditions. A Mass Spectrometer was being installed during this reporting period to monitor emissions and process chemistry; however, the injection system is in place should a higher sulfur coal be processed or if process modifications are made and sulfur dioxide emissions need to be reduced.

The coal-cleaning area's fugitive dust is controlled by placing hoods over the sources of fugitive dust conveying the dust laden air to fabric filter(s). The bag filters appear to be effectively removing coal dust from the air before discharge; however, the Department of Health and Environmental Sciences will perform stack testing to ensure the emission rates are in compliance with the particulate emission limits stated in the air quality permit. All coal fines currently go to the pit.

Heat Plant

The heat required to process the coal is provided by a natural gas-fired process furnace, which uses process makegas from coal conversion as fuel. The vibration problems and conversion system problems discussed previously initiated removing and redesigning the process gas fans shaft seals to limit oxygen infiltration into the process gas. This system provides a maximum heat release rate of up to 74 MM Btu/hr. depending on the feed rate.

Heat Rejection

Heat removed from the coal in the coolers is rejected indirectly through cooling water circulation using an atmospheric-induced, draft-cooling tower. A substantial amount of the heat added to the system is actually lost by releasing water vapor and flue gas into the atmosphere through an exhaust stack. The stack allows for vapor release at an elevation great enough that, when coupled with the vertical velocity resulting from a forced draft fan, maximized dissipation of the gases.

Utility and Ancillary Systems

The coal fines that are collected in the conversion, cleaning, and material handling systems are gathered in the slurry system as produced. A replacement fines conveying system is in the process of being designed.

Inert gas is drawn off the cooler loop for other uses. This gas, primarily nitrogen and carbon dioxide, is used only for baghouse pulse. The makeup gas to the cooler loop is combustion flue gas from the stack. The cooling system effectively dehumidifies and cools the stack gas making the inert gas for the system. The cooler gas still has a relatively high dew point (about 90°F). Due to the thermal load this puts on the cooling system, no additional inert gas requirements can be met by this approach.

The common facilities for the ACCP include a plant and instrument air system, a fire protection system, and a fuel gas distribution system.

The process is semi-automated including dual control stations, dual programmable logic controllers, and distributed plant control and data acquisition hardware. Graphic interface programs are continually being modified and upgraded to improve the operator interface and provide more reliable information to the operators and engineers.

3.2.1 MODIFIED OR REPLACED EQUIPMENT

Facility modifications and maintenance work to date have been dedicated to obtaining an operational facility.

The modifications to the original system performed for the year to date (with modifications during this reporting period shown in bold print) involved:

First Quarter 1993:

Drag Conveyor:

- Designing a replacement fines conveying system.

Coal Dryer/Reactor:

- Repairing a structural crack between the drive and the main housing of dryer R552. Insulation is being added to protect this area.

First-stage Baghouse:

- A mine electrical ground fault tripped the entire substation's power. After restarting, the plant was tripped by a voltage dip when a dragline started. This resulted in the fines in the dust collectors freezing from condensation and washdown water. The fines blocked the discharges. When the plant was restarted, fines backed up into the bags and began smoldering, thus, damaging the bags.

Table 3.2 shows the equipment that has either been modified or replaced since plant startup. If replacement was required, the new equipment is listed.

Table 3.2. Advanced Coal Conversion Process Modified Major Plant Equipment

System Description	Equipment Vendor	Type	Modified No/Yes	Replaced With
Coal Dryers/Coolers	Carrier Vibrating Equipment, Inc.	PE	✓	
Belt Conveyors	Willis & Paul Group	MH	/	
Bucket Elevators	FMC Corporation	MH	/	
Coal Cleaning Equipment	Triple S Dynamics, Inc.	CC	/	
Coal Screens	Hewitt Robbins Corporation	MH	/	
Loading Spouts	Midwest International	MH	/	
Dust Agglomerator	Royal Oak Enterprises, Inc.	DH	/	
Silo Mass Flow Gates	SEI Engineers, Inc.	MH	/	
Vibrating Bin Dischargers	Carman Industries, Inc.	MH	/	
Vibrating Feeder	Kinergy Corporation	MH	/	
Drag Conveyor	Dynamet	DH	✓	
Screw Conveyor	Farm Aid Equipment Company	MH	Added	
Process Gas Heater	G.C. Broach Company	PE	/	
Direct Contact Cooler	CMI-Schneible Company	PE	✓	
Particulate Removal System	Air-Cure Howden	EC	✓	
Dust Collectors	Air Cure Environmental	EC	/	
Air Compressors/Dryers	Colorado Compressor, Inc.	CF	✓	
Diesel Fire Pumps	Peerless Pump Company	CF	/	
Forced Draft Fans	Buffalo Forge Company	PE	✓	
Pumps	Dresser Pump Division Dresser Industries, Inc.	PE	/	
Electrical Equipment-4160	Toshiba/Houston International Corp.	CF	/	
Electrical Equipment-LDC	Powell Electric Manufacturing Corp.	CF	/	
Electrical Equipment-480v MCC	Siemens Energy & Automation, Inc.	CF	/	
Main Transformer	ABB Power T&D Company	CF	/	
Control Panels	Utility Control & Equipment Corp.	CF	/	
Control Valves	Applied Control Equipment	CF	/	
Plant Control System	General Electric Supply Company	CF	✓	
Cooling Tower	The Marley Cooling Tower Company	PE	✓	
Dampers	Effox, Inc.	PE	/	
Dry Sorbent Injec. System	Natech Resources, Inc.	EC	/	
Expansion Joints	Flexonics, Inc.	PE	✓	
MH - Materials Handling PE - Process Equipment EC - Emissions Control CF - Common Facilities CC - Coal Cleaning DH - Dust Handling				

4.0 TECHNICAL PROGRESS

4.1 FACILITY OPERATIONS/PLANT PRODUCTION

Table 4.1 summarizes the ACCP Demonstration Facility's operations and plant production levels that have been achieved through the reporting period and the facility's lifetime to date. Table 4.2 lists the ACCP Demonstration Facility's monthly shipments of the SynCoal® product.

The difference between the feed coal and the amount of clean coal produced is due to water loss; samples removed for analysis; and process fines, which are captured in the particulate removal system and returned to the mine for disposal. Very little dust is actually lost to the atmosphere.

Approximately 726 tons of product coal were shipped to MPC's Corette Power Plant in Billings, Montana, and 4,476 tons of product coal were shipped to MPC's Colstrip Project, Units 3 and 4.

4.2 FACILITY TESTING

Facility modifications and maintenance work to date have been dedicated to obtaining a more reliable facility, therefore, concentrating on the dust handling equipment and the coal dryer/reactor.

Facility testing to date has focused on understanding and controlling product stability and dust mitigation measures. Thirteen tests have been performed at the facility during the reporting period and are summarized in Table 4.3

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Table 4.1. ACCP Demonstration Project Monthly Operating Statistics

Month	Operating Hours	Operating Factor	Non-Scheduled Hours	Schedule Factor	Scheduled Operating Factor	Feed Tons	Ave. Feedrate	Feed Capacity Factor	Total Shipments	Ending Silo Inventory	Comments
Jan. '93	396	53.2%	211	71.6%	74.3%	8,628	21.78	23.0%	3,658	0	Second-stage Dryer Structural Problem Encountered
Feb. '93	297	44.2%	308	54.2%	81.6%	6,544	22.03	17.5%	915	1,200	Continued Testing/Baghouse Damage
Mar. '93	327	44.0%	248	66.7%	65.9%	6,565	20.08	17.5%	629	4,650	Continued Testing
1st Quarter 1993 Summary	1,020	47.2%	767	64.5%	73.2%	21,735	21.31	19.3%	5,202	4,650	
Totals	2,377	25.0%	3,905	58.9%	42.5%	50,421	21.21		10,768		

Table 4.2. ACCP Demonstration Project Monthly Shipments

Month	Total Shipments	Shipments by Customer	
		Corette (tons)	Units 3 & 4
Jan. '93	by rail/truck	200	3,458
Feb. '93	by rail/truck	174	741
Mar. '93	by rail/truck	352	277
1st Quarter 1993 Summary		726	4,476
Totals		3,870	6,505

Table 4.3. ACCP Demonstration Plant Testing Summary

Test Number	Test Description	Test Dates
9217	Determined if a known moisture inhibiting process added on processed coal during the cold temperatures would prolong the life of the coal.	1/4/93
9218-B	Determined what the effects of purging the processed coal with water would have on the stability of the coal.	1/18/93
9301	Determined the effect of pacifying a large quantity of coal with CO ₂ for shipping by rail.	2/1/93
9302	Determined the effects of pacifying product coal by increasing CO ₂ in the cooler loop.	2/3/93
9303	Determined the effects of combining the CO ₂ treatment with a known moisture inhibiting process.	2/3/93
9304	Determined the stability of pacifying a large quantity of product coal with CO ₂ and shipping by rail.	3/8/93
9305	Determined what the effects of purging processed coal with CO ₂ for various lengths of time would have on the stability of the coal.	2/9/93
9306	Developed a useable technique for measuring the stability of the coal and determining how fast and how much oxygen the coal absorbs from air.	3/30/93
9308	Compared the dust levels and stability of a blend of raw coal and SynCoal® to those of both 100 percent raw coal and 100 percent SynCoal®.	2/26/93
9309	Determined the effectiveness of adding a foam dust suppressant to treat coal dust at the Corette power plant.	3/2/93 - 3/3/93
9310	Determined if adding a particle charge chemistry emulsion would reduce the dustiness of the SynCoal® product.	3/6/93 - 3/16/93
9311	Determined the longevity and dust levels in SynCoal® and blended SynCoal® and managed the pile after it initially heated.	3/26/93
9312	Tested and evaluated the relationship between various treatments and moisture contents on the dustiness and stability of the SynCoal® product.	3/21/93 - 3/27/93

4.3 PRODUCT TESTING

The product produced to date has been exceptionally close to the design basis product from a chemical standpoint but has not been acceptable from a physical standpoint due to instability (spontaneous heating) and dustiness. The coal appears to continue to heat after processing.

Product analyses during the reporting period are shown in Table 4.5.

Table 4.5. ACCP Quality Analyses for 1993 First Quarterly Report

UNCLEANED COAL										
SAMPID	SAMPDATE	TONNAGE	TM	PA	PS	HHV	SO2	COMM		
FIRST QUARTER, 1993	01/04/93		3.13	10.95	0.88	11,504	1.18			
UNCLEANED COAL	01/05/93		2.10	10.74	1.00	11,608	1.72			
	01/05/93		1.82	11.26	1.02	11,648	1.75			
	01/08/93		1.81	11.32	1.13	11,587	1.95			
	01/07/93		1.85	10.89	0.93	11,708	1.59			
	01/08/93		1.47	12.97	1.21	11,519	2.10			
	01/19/93		2.19	11.38	1.12	11,589	1.94			
	01/20/93		2.28	12.54	1.28	11,456	2.23			
	01/22/93		2.12	12.02	1.12	11,520	1.94			
	01/22/93		2.32	12.84	1.37	11,408	2.40			
	01/23/93		2.07	11.60	1.01	11,588	1.74			
	01/25/93		1.88	12.95	1.38	11,445	2.38			
	02/02/93		2.18	12.89	1.59	11,407	2.79			
	02/08/93		2.25	12.28	1.17	11,488	2.04			
	02/09/93		2.29	12.77	1.17	11,383	2.05			
	02/10/93		2.11	12.28	1.08	11,488	1.88			
	AVERAGE		2.13	11.97	1.14	11,520	1.98			
	STANDARD DEVIATION		0.33	0.77	0.20	88	0.36			
	MIN		1.47	10.74	0.88	11,383	1.18			
	MAX		3.13	12.97	1.59	11,708	2.79			

LEGEND	
TM	% Total Moisture
PA	% Ash
PS	% Sulfur
HHV	Btu/lb.
SO ₂	lbs. of SO ₂ /MMBtu
COMM	Comments

Table 4.5. ACCP Quality Analyses for 1993 First Quarterly Report (cont'd.)

SAMPLE	SAMPLE NO.	SAMPLE DATE	TONNAGE	TM	PA	PS	BLB	SO2	COMM	PRODUCT	
										PA	PS
FIRST QUARTER, 1993	11	01/04/93		1	3.41	11.02	0.72	11,502	1.25	No reference kept. Sample too small.	
	25	01/05/93		1	2.28	9.34	0.55	11,872	0.83		
	26	01/05/93		1	2.17	11.45	1.02	11,844	1.75		
	23	01/05/93		1	2.52	9.21	0.54	11,841	0.91		
	24	01/05/93		1	2.08	9.14	0.55	11,899	0.82		
		01/06/93			1.83	9.14	0.53	11,928	0.89		
		01/06/93			1.84	9.38	0.54	11,917	0.91		
		01/10/93			1.64	9.28	0.49	11,908	0.82		
		01/12/93			1.62	9.14	0.53	11,975	0.89		
		01/18/93			1.89	9.13	0.57	11,822	0.86		
		01/18/93			2.27	9.28	0.53	11,873	0.86		
		02/03/93			2.25	9.54	0.50	11,899	0.84		
		02/05/93			2.67	8.53	0.47	11,855	0.79		
		02/06/93			2.10	8.70	0.49	11,935	0.82		
		02/07/93			2.34	8.49	0.47	11,833	0.79		
		02/08/93			2.35	8.83	0.50	11,887	0.84		
AVERAGE					2.22	9.29	0.56	11,864	0.85		
STANDARD DEVIATION					0.42	0.79	0.13	119	0.23		
MIN					1.62	8.49	0.47	11,502	0.79		
MAX					3.41	11.45	1.02	11,975	1.75		

5.0 PROCESS STABILITY/PILOT WORK

During the initial plant startup tests which occurred in January through June of 1992, the product was noted to be dusty and susceptible to spontaneous combustion. Stability investigations and dust mitigation tests are on-going to lower costs and continually refine the application and improve product quality. A summary of product stability and dust mitigation testing to date is described below.

5.1 PRODUCT STABILITY

The dried, cooled, and cleaned coal produced to date has exhibited spontaneous heating and combustion. When any significant mass of coal (more than 1 to 2 tons) is exposed to any significant air flow for periods ranging from 18 to 72 hours, the coal reaches temperatures necessary for spontaneous combustion or auto ignition to occur. Spontaneous heating of run-of-mine, low-rank coals has been a common problem but usually occurs after open air exposure periods of days or weeks, not hours. However, dried, low-rank coals have universally displayed spontaneous heating tendencies to a greater degree than raw, low-rank coals.

Additional process steps and applying additives to the coal both during and after the process are being tested to mitigate this problem.

Butte Pilot Plant Verification Tests

The Butte pilot plant was operated to confirm that the SynCoal® produced by the ACCP was equal in reactivity to that of the pilot plant. The spontaneous heating characteristic was not identified at the pilot stage because product was generated at a comparatively low rate which allowed enough time for the material to passively stabilize prior to it being covered by subsequent layers of SynCoal®.

Oxidation Tests

Tests were performed on a bench-scale to determine the completeness of oxidation, the potential for accelerating the rate of oxidation, and the thermodynamics of oxidation. From these tests, the mass uptake of oxygen is determined, as well as the typical SynCoal® oxidation rate expressions. This work is on-going and will continue into the Second Quarter.

Carbon Dioxide Trials

In the literature search on methods for controlling spontaneous combustion, carbon dioxide was described as a method to control spontaneous heating. Testing was initiated to determine the effectiveness of using carbon dioxide to prevent or delay spontaneous heating and to optimize the rate of application.

Pore Blocking Trials

The literature search also indicated several compounds are commercially available to prevent spontaneous combustion by blocking the reactive sites on the surface of coal. Several chemicals are being tested on SynCoal® at varying flow rates and concentrations.

Blending Trials

Based on a market analysis, it was determined that blending SynCoal® with raw coal may be an effective method of delivering fuel to market. Testing is being performed to determine the effectiveness of blending SynCoal® with raw coal in achieving a stable product, determining the optimum blend ratios, and identifying the resulting fuel characteristics.

Rehydration Testing and Shipping Treated SynCoal®

Based on the blending trials, rehydration is being conducted to determine the effectiveness of using water to control spontaneous combustion and to determine the optimum moisture content and water application method.

Pile Management Testing

Pile management tests are being performed to determine whether periodic heat rejection would result in a stabilized product.

5.2 PRODUCT DUSTINESS

The product is basically dust free when it exits the processing facility due to numerous steps where the coal is fluidized in process gas or air, which removes the dust-size particles. The gas and air entrains any dust that has been produced since the last process step.

Typical to coal handling systems, each handling activity performed on the product coal after the coal leaves the process degrades the coal size and produces some dust. The fall into the product silos, which can be up to 90 feet, can be especially degrading to the coal. Quantifying dustiness of coals is difficult, but once the product coal has passed through the nine transfer points between the process and a rail car, the coal is visibly dustier than run-of-mine coal. The SynCoal® product is actually no dustier than the raw coal; the dust is just more fugitive. Because the SynCoal® product is dry, it does not have any inherent ability to adhere small particles to the coal surfaces. This allows any dust-size particles that are generated by handling to be released and become fugitive.

Transfer points have been modified to reduce impacts, methods of reducing degradation in the silos have been examined, and dust suppression options tested.

SynCoal® Attrition Study and Dust Suppressant Testing

SynCoal® dustiness was reviewed to determine a dust control strategy based on results obtained from attrition testing. Initial tests were accomplished with standard, water-based chemicals, which included surfactant, inorganic salts, and lignosulfonate-based suppressants. None of the products tested at normal economic concentration levels were effective at mitigating SynCoal® dustiness.

After water-based compounds proved to be ineffective for mitigating SynCoal® dustiness, more exotic and expensive compounds are being tested and evaluated. These compounds include oil, anionic polymers, latex polymers, and various oil-based emulsions. Additionally, testing is on-going for applying the dust suppressant in rail cars and testing and evaluating chemical addition to the blended coal.

6.0 FUTURE WORK AREAS

Work continues on improving product stability and dustiness. Once stable and maintainable systems have been obtained and the product is adequate for shipping, bulk production to produce test burn quantities will be the primary facility goal while continuing process testing and optimization.

APPENDIX A

**Significant Accomplishments
from Origination of Project to Date**

SIGNIFICANT ACCOMPLISHMENTS (SINCE CONCEPT INCEPTION)

- September 1981** Western Energy contracts Mountain States Energy to review LRC upgrading concept called the Greene process.
- June 1982** Mountain States Energy built and tested a small batch processor in Butte, Montana.
- December 1984** Initial patent application filed for the Greene process, December 1984.
- November 1984** Initial operation of a 150 lb/hr continuous pilot plant modeling the Greene drying process at Montana Tech's Mineral Research Center in Butte, Montana.
- November 1985** Added product cooling and cleaning capability to the pilot plant.
- January 1986** Initiated process engineering for a demonstration-size Advanced Coal Conversion Process (ACCP) facility.
- October 1986** Completed six month continuous operating test at the pilot plant with over 3,000 operating hours producing approximately 200 tons of SynCoal®.
- October 1986** Western Energy submitted a Clean Coal I proposal to DOE for the ACCP Demonstration Project in Colstrip, Montana, October 18, 1986.
- December 1986** Western Energy's Clean Coal proposal identified as an alternate selection by DOE.
- February 1988** First U.S. patent issued February 16, 1988, No. 4, 725,337.
- November 1987** Internal Revenue Service issued a private letter ruling designating the ACCP product as a "qualified fuel" under Section 29 of the IRS code, November 6, 1987.
- May 1988** Western Energy submitted an updated proposal to DOE in response to the Clean Coal II solicitation, May 23, 1988.
- May 1989** Second U.S. patent issued March 7, 1989, No. 4, 810,258.
- December 1988** Western Energy was selected by DOE to negotiate a Cooperative Agreement under the Clean Coal I program.

**SIGNIFICANT ACCOMPLISHMENTS (cont'd.)
(SINCE CONCEPT INCEPTION)**

- June 1990** Reach a negotiated agreement with DOE on the Cooperative Agreement, June 13, 1990.
- September 1990** Signed Cooperative Agreement, after Congressional approval, September 13, 1990.
- September 1990** Contracted project engineering with Stone & Webster Engineering Corporation, September 17, 1990.
- December 1990** Formed Rosebud SynCoal Partnership, December 5, 1990.
- December 1990** Started construction on the Colstrip site.
- March 1991** Novated the Cooperative Agreement to the Rosebud SynCoal Partnership, March 25, 1991.
- March 1991** Formal ground breaking ceremony in Colstrip, Montana, March 28, 1991.
- December 1991** Initiated commissioning of the ACCP Demonstration Facility.
- April 1992** Completed construction of the ACCP Demonstration Facility and entered Phase III, Demonstration Operation.
- June 1992** Formal dedication ceremony for the ACCP Demonstration Project in Colstrip, Montana, June 25, 1992.
- August 1992** Successfully tested product handling by shipping 40 tons of SynCoal® product to MPC's Unit #3 by truck.
- October 1992** Completed 81 hour continuous coal run October 2, 1992.
- November 1992** Converted to a single process train operation.
- December 1992** Produced a passivated product with a two-week storage life.
- January 1993** Produced 200 tons of passivated product that lasted 13 days in the open storage pile.
- February 1993** The plant had a 62 percent operating factor between January 1 and February 15.
- March 1993** Identified an environmentally compatible dust suppressant that inhibits fugitive dust from the SynCoal® product.

DATE

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7/28/94

END

