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TECHNICAL PROGRESS REPORT

For the period:

April 1, 1993, through June 30, 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:

United States Department of Energy
Pittsburgh Energy Technology Center

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LEGAL NOTICE

Table of Contents

1.0 INTRODUCTION AND PURPOSE

This report describes the technical progress made on the Advanced Coal Conversion Process (ACCP) Demonstration Project from April 1, 1993, through June 30, 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 has operated in an extended startup mode through the current period. 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	• 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	• Stored approximately 1,200 tons of SynCoal® in an 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	• Stored approximately 4,650 tons of SynCoal® in an 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 & Health Administration (MSHA) safety training.

Table 2.1. Significant Accomplishments for 1993 (cont'd.)

April 1993	• Stored approximately 6,500 tons of SynCoal(R) in inerted product silos. • Continued testing methods to reduce spontaneous combustion tendency and dustiness.
May 1993	• Stored approximately 4,000 tons of SynCoal(R) in inerted product silos. • 462 tons of SynCoal(R) delivered to MPC Corette Plant by rail. • Continued testing methods to reduce spontaneous combustion tendency and dustiness.
June 1993	• Stored approximately 4,000 tons of SynCoal(R) in inerted product silos. • Approximately 110 tons of SynCoal(R) delivered to industrial customers by truck. • Continued testing methods to reduce spontaneous combustion tendency and dustiness.

2.2 PROJECT PROGRESS SUMMARY

Although the plant's reliability is still limited, the facility's operating factor has improved to about 37.1 percent and raw coal feed rate to 18 percent of nominal design capacity for the quarter. To date, about 70,862 tons of raw coal have been fed to the process, producing about 36,000 tons of uncleaned and cleaned product. A little over 12,400 tons have been test shipped. 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:

- repairing first stage fan motor;
- repairing furnace temperature transmitter;
- repairing a process gas heater ruptured expansion joint; and
- installing the new dust handling system.

During the First Quarter of 1993, modifications and major maintenance work involved:

- modifying the drag conveying and processed fines handling 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. The 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
Second Quarter Product					
Average	2.58	9.11	0.56	11,781	0.94
Standard Deviation	0.26	0.24	0.04	129	0.07
Min.	1.93	8.47	0.49	11,305	0.83
Max.	3.10	9.60	0.66	12,018	1.13

TM - % Total Moisture　PS - % Sulfur　SO_2 - lbs. of SO_2/MMBtu
PA - % Ash　HHV - Btu/lb.

Work during the next reporting period will continue to focus on understanding and controlling the product's stability and evaluating additional dust inhibitors.

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-feet-wide by 30-feet-long vibratory fluidized bed dryer/reactors in series, followed by a water spray section, and a 5-feet-wide by 25-feet-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 fist-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. 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.

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.

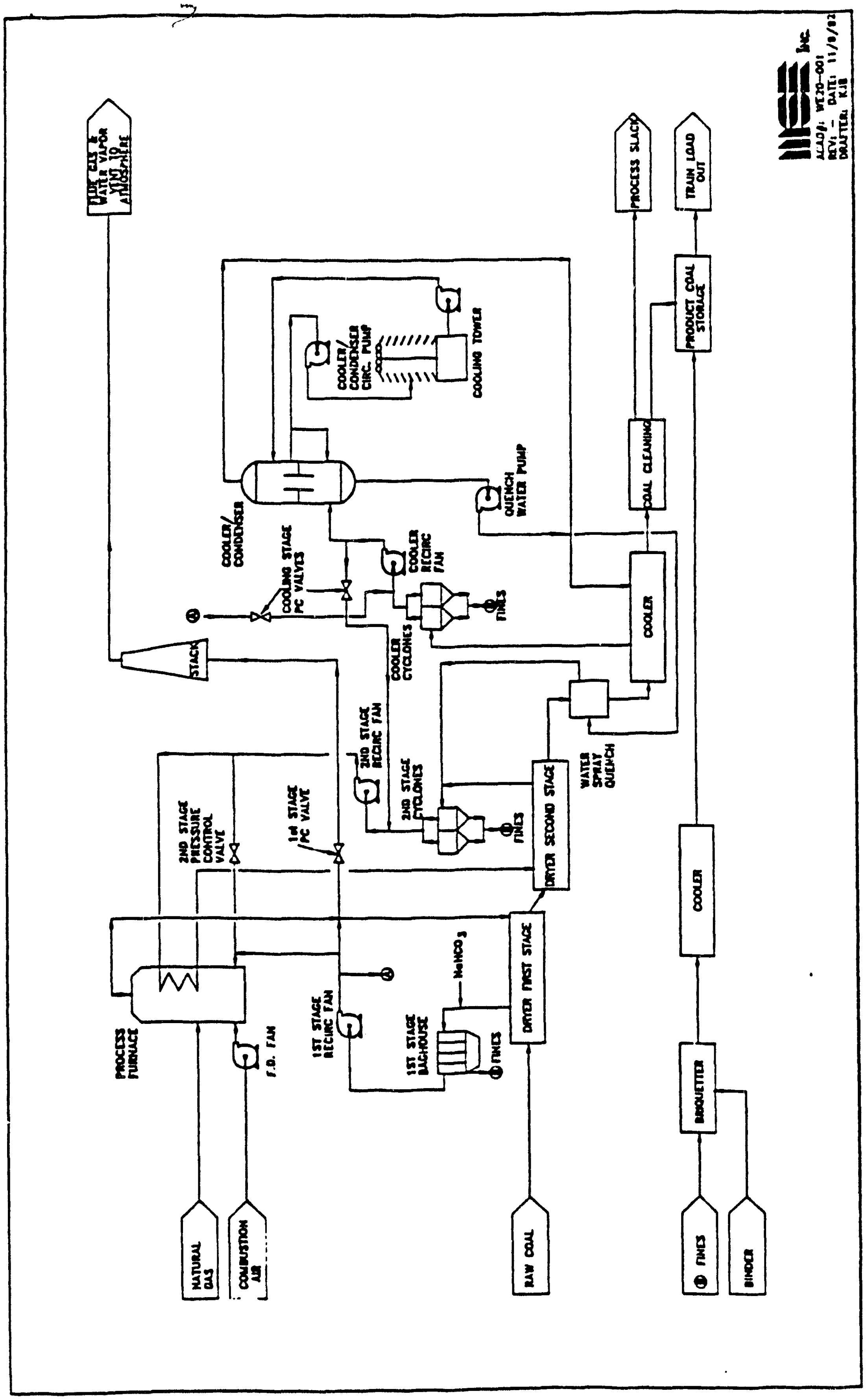

Figure 3.1 Central Processes

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.

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 provide 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 PE - Process Equipment EC - Emissions Control
CF - Common Facilities CC - Coal Cleaning 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. Also, the cooler bed holes were bored out in both the first stage dryers and the vibratory coolers to increase cooling gas flow. The drive support plates had to replaced as a result of the extensive cracking and repairs resulting from the differential thermal expansion described previously.

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.

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 of 1992, a temporary slurry fines disposal system was installed. The redesigned process fines conveying and handling system was upgraded and being made into a permanent operational system. 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 and resulted in a unique explosion vent sealing system which was completed on May 6, 1993, and being 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. The Department of Health and Environmental Sciences completed stack tests on the east and west baghouse outlet ducts and the first stage drying gas baghouse stack. The emission rates of 0.0013 and 0.0027 (limit of 0.018 grains/dry standard cubic feet) (gr/dscf) and 0.015 gr/dscf (limit of 0.031), respectively, are well within the limits stated in the air quality permit.

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. However, because the direct contact cooling condensers directly quench the cooling gas with circulated cooling water, fines were building up in the circulating cooling water system. Increased makeup water was required for the cooling tower to allow blowdown from the direct contact cooling condensor in order to clean up the circulated cooling water. The system was being evaluated to determine possible options to make the system more efficient.

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 power distribution system was upgraded by installing an uninterruptible power supply (UPS). The UPS system does not keep the plant running if there is a problem; however, it does keep the control system, emergency systems, and office lights operating.

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:

Second Quarter 1993:

Forced Draft Fans:
- **repairing first stage fan motor;**

Process Gas Heater:
- **repairing furnace temperature transmitter,**
- **repairing a ruptured expansion joint; and**

Processed Fines Handling System:
- **installing the new dust handling system.**

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	/	
Uninterruptible Power Supply	Best Power Technologies Company	CF	Added	
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 dust fines, which are captured in the dust handling system and returned to the mine for disposal. Very little dust is actually lost to the atmosphere.

Approximately 1,223 tons of product coal were shipped to MPC's Corette Power Plant in Billings, Montana. Approximately 490 tons of product coal were shipped to industrial clients.

4.2 FACILITY TESTING

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

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

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%	8,626	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	
LTD Totals	2,377	25.0%	3,905	58.9%	42.5%	50,421	21.21		10,768		
April '93	353	49.0%	216	70.0%	70.0%	8,514	24.12	22.7%	745	6,500	
May '93	352	47.3%	168	77.4%	61.1%	9,175	26.07	24.5%	768	4,000	
June '93	106	14.7%	576	20.0%	73.6%	2,752	25.96	7.3%	199	4,000	
2nd Quarter 1993 Summary	811	37.1%	960	56.0%	66.3%	20,441	25.20	18.2%	1,712	4,000	
LTD Totals	3,188	27.3%	4,865	58.4%	46.7%	70,862	22.23		12,480		

Table 4.2. ACCP Demonstration Project Monthly Shipments

Month	Total Shipments	Shipments by Customer				
		Corette (tons)	Units 3 & 4	Bentonite	Continental Lime	NSP Riverside
Jan. '93	by rail/truck	200	3,458	0	0	0
Feb. '93	by rail/truck	174	741	0	0	0
Mar. '93	by rail/truck	352	277	0	0	0
1st Quarter 1993 Summary		726	4,476	0	0	0
Totals		3,870	6,505	0	0	0
April '93	by rail/truck	745	0	0	0	0
May '93	by rail/truck	478	0	221	226	42
June '93	by rail/truck	0	0	199	0	0
2nd Quarter 1993 Summary		1,223	0	221	226	42
Totals		5,093	6,505	221	226	42

Table 4.3. ACCP Demonstration Plant Testing Summary

Test Number	Test Description	Test Dates
9313	Determined if a chemical treatment produces a stable product.	4/5/93
9314	Determined the longevity and dust levels in SynCoal® and SynCoal® blends during rail car transit and while placed in a pile.	4/6/93
9315	Determined if a large test pile (500 tons) could be stabilized by incorporating pile management.	4/7/93
9316	Identified future fouling problems that might occur with the heat exchanger that will be installed for coal fines cooling.	4/9/93
9317	Determined if adding oil coupled with CO_2 treatment of SynCoal increased the life as well as decreased coal dustiness.	5/3/93
9318	Test cancelled.	
9319	Determined the longevity and handling characteristics of SynCoal® blended with raw coal at two power plants and determined if coal could be blended successfully.	4/21/93
9320	Evaluated various moisture contents versus product stability.	5/13/93
9321	Test not completed during the reporting period.	
9322	Determined the rate expression for the oxygen absorption onto the SynCoal® product.	5/17/93
9323	Determined the dust levels and stability of various blends when sent to Montana Power Company's Corette plant.	5/9/93
9324	Determined the blend dustiness after spraying a known dust suppressant on the raw coal and the SynCoal® prior to blending.	5/24/93
9325	Not conducted.	
9326	This demonstration determined five points: 1. the effectiveness of the ACCP Demonstration plant on BNI lignite; 2. a rough mass balance for lignite in the ACCP process; 3. raw lignite handling characteristics; 4. lignite process dust characteristics; and 5. product coal stability.	5/27/93

Table 4.3. ACCP Demonstration Plant Testing Summary (cont'd.)

9327	Determined the stability of various blends of SynCoal® with raw coal. Dust levels were not a consideration in this test.	5/28/93
9328	Test not completed during the reporting period.	
9329	Determined the dust levels from compartmentalized blends using various dust suppressants on both the raw coal and SynCoal®.	7/16/93
9330	Determined the dust levels from belt blends using various dust suppressants on both the raw coal and SynCoal®.	7/19/93
9331	Not started.	

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 Second Quarterly Report

	PRODUCT							
	SAMPID	SAMPDATE	TM	PA	PS	HHV	SO2	COMM
SECOND QUARTER, 1993	498	04/15/93	2.98	9.41	0.57	11,764	0.97	standard production to silo T-98.
PRODUCT		04/15/93	3.00	9.40	0.57	11,764	0.97	
	499	04/16/93	2.50	9.39	0.58	11,830	0.95	Standard production to silo T-98.
		04/16/93	2.50	9.40	0.58	11,830	0.95	
	500	04/17/93	2.55	9.37	0.53	11,797	0.90	Standard production to silo T-98.
		04/17/93	2.60	9.40	0.53	11,797	0.90	
	501	04/18/93	2.88	9.13	0.54	11,795	0.92	Standard production to silo T-98.
		04/18/93	2.90	9.10	0.54	11,793	0.92	
		04/19/93	3.10	9.10	0.54	11,754	0.92	
	509	04/20/93	3.07	9.07	0.54	11,754	0.92	Standard production to T-98 silo
	525	04/21/93	2.93	9.17	0.54	11,823	0.91	
		04/22/93	2.60	9.10	0.55	12,018	0.92	
	545	04/23/93	2.63	9.25	0.55	11,830	0.93	
		04/23/93	2.60	9.30	0.55	11,830	0.93	
	547	04/24/93	2.58	9.07	0.55	12,018	0.92	
		04/24/93	2.50	9.20	0.57	11,536	0.99	
	548	04/24/93	2.54	9.18	0.57	11,536	0.99	
	544	04/25/93	2.67	9.31	0.60	11,808	1.02	
		04/25/93	2.70	9.30	0.60	11,808	1.02	
	550	04/26/93	2.40	9.41	0.58	11,819	0.95	
		04/26/93	2.40	9.40	0.58	11,819	0.95	
	570	05/02/93	2.50	9.49	0.54	11,749	0.92	
		05/02/93	2.50	9.50	0.54	11,749	0.92	
	572	05/03/93	1.93	9.12	0.50	11,983	0.83	5GPT VISERX 10 P-5
	571	05/03/93	2.91	8.64	0.52	11,369	0.91	60 MESH REPEATER
	580	05/03/93	2.70	9.59	0.54	11,795	0.92	
	573	05/03/93	2.41	8.47	0.52	11,798	0.88	5GPT VISREX 10 P-1
		05/03/93	2.70	9.60	0.54	11,795	0.92	
	571	05/04/93	2.39	8.54	0.51	11,305	0.90	5GPT VISREX 10 P-3
	602	05/10/93	2.79	8.80	0.50	11,775	0.85	
		05/10/93	2.80	8.80	0.50	11,775	0.85	
		05/11/93	2.60	9.20	0.59	11,838	1.00	
	609	05/12/93	2.56	9.15	0.59	11,838	1.00	
	624	05/13/93	2.80	8.92	0.68	11,789	1.12	STANDARD PRODUCTION TO SILO T-98
		05/13/93	2.80	8.90	0.68	11,789	1.12	
	663	05/18/93	3.00	8.98	0.68	11,731	1.13	CONTINENTAL LIME 93-1
		05/18/93	3.00	9.00	0.68	11,731	1.13	
	668	05/21/93	2.58	8.65	0.55	11,855	0.93	
		05/21/93	2.60	8.70	0.55	11,855	0.93	
		05/22/93	2.40	9.20	0.58	11,825	0.95	
	658	05/23/93	2.93	9.13	0.55	11,743	0.94	
	667	05/23/93	2.68	9.17	0.59	11,748	1.00	60 MESH REPEATER
	667	05/23/93	2.38	9.17	0.58	11,825	0.95	
		05/23/93	2.90	9.10	0.55	11,743	0.94	
	660	05/24/93	2.28	9.14	0.53	11,868	0.89	
		05/24/93	2.30	9.10	0.53	11,868	0.89	
	659	05/25/93	2.23	8.92	0.52	11,910	0.87	
		05/25/93	2.20	8.90	0.52	11,910	0.87	
		05/25/93	2.20	8.90	0.52	11,910	0.87	

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 Second Quarterly Report (cont'd.)

	669	05/26/93	2.76	8.93	0.56	11,805	0.95	60 MESH REPEATER
	669	05/26/93	2.56	8.98	0.57	11,833	0.96	
		05/26/93	2.60	8.90	0.57	11,833	0.96	
	666	05/27/93	2.26	9.02	0.62	11,775	1.05	60 MESH REPEATER
	666	05/27/93	2.57	9.09	0.56	11,800	0.96	
		05/27/93	2.60	9.10	0.56	11,800	0.96	
	695	06/03/93	2.41	9.08	0.49	11,834	0.83	
		06/03/93	2.40	9.10	0.49	11,834	0.83	
	693	06/05/93	2.18	9.23	0.55	11,822	0.93	
	694	06/05/93	2.22	9.07	0.57	11,452	1.00	
		06/05/93	2.20	9.10	0.57	11,452	1.[illegible]	
		06/05/93	2.20	9.20	0.55	11,822	0.93	
	AVERAGE		2.58	9.11	0.56	11,781	0.94	
	STANDARD DEVIATION		0.26	0.24	0.04	129	0.07	
	MIN		1.93	8.47	0.49	11,305	0.83	
	MAX		3.10	9.60	0.66	12,018	1.13	

DSE CONDITIONED PRODUCT

	SAMPID	SAMPDATE	TM	PA	PS	BLB	SO2	COMM
SECOND QUARTER, 1993	682	06/02/93	11.20	8.09	0.58	10,704	1.08	9328-S1 REHYDRATION TEST
DSE CONDITIONED PRODUCT	715	06/11/93	17.21	7.44	0.49	9,967	0.98	9328a-1 REHYDRATED
	714	06/11/93	17.29	7.29	0.50	9,997	1.00	9328a-2 REHYDRATED
	743	06/18/93	14.69	8.06	0.51	10,201	1.00	9328-C1 15% MOISTURE
	744	06/18/93	14.91	8.36	0.49	10,155	0.97	9328-C2 15% MOISTURE
	763	06/25/93	5.80	8.53	0.60	11,382	1.05	9328-F1 15%H2O/DT100A
	780	06/29/93	6.80	8.72	0.54	11,211	0.96	9328-F2 15%H2O/DT-100A
	786	06/30/93	9.66	7.88	0.59	10,607	1.11	9328-D-3 15%H2O
	AVERAGE		12.20	8.05	0.54	10,528	1.02	
	STANDARD DEVIATION		4.21	0.47	0.04	509	0.05	
	MIN		5.80	7.29	0.49	9,967	0.96	
	MAX		17.29	8.72	0.60	11,382	1.11	

5.0 PROCESS STABILITY/PILOT WORK

During the initial plant startup tests which occurred in January through June 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 was determined, as well as the typical SynCoal® oxidation rate expressions.

The oxidation tests were completed and the results calculated. The values were then used to design the air stabilization pilot-scale equipment.

Carbon Dioxide Trials

In the literature on methods for controlling spontaneous combustion, carbon dioxide is described as a method to control spontaneous heating. Testing is ongoing to determine the effectiveness of using carbon dioxide to prevent or delay spontaneous heating and to optimize the rate of application. Initial tests indicate the carbon dioxide provides some surface chemistry effects for up to three days.

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. Preliminary results indicated a significant increase in the life of the SynCoal® product from blending specific quantities of product and raw coal; however, the product was extremely dusty.

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. Initial efforts indicate that this technique results in a stabilized product after a one to two week period.

Stabilization Process Step Pilot Test

After ensuring operability of the pilot-scale testing of the equipment, process test variables, including residence time, air flow, material temperatures, feed coal size, and flow rate, were tested. Under operating conditions, the process variables are found to be dependent; therefore, care is required not to operate in a "run-away" mode.

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 were tested and evaluated. These compounds included oil, anionic polymers, latex polymers, and various oil-based emulsions. Oil was found to be an effective though expensive dust suppressant when applied at the required rates; however, due to environmental concerns, oil was removed from consideration. Another effective suppressant that is also environmentally safe is an anionic polymer. However, this chemical is also expensive to apply and impacts the overall process economics. Additionally, testing is on-going for applying the dust suppressant in rail cars and testing and evaluating chemical addition to the blended coal.

Zig-Zag Testing

In addition to spray application of chemicals, a pilot-scale, zig-zag blender is being tested to apply dust suppressant compounds. The objectives of these tests are to maximize compound efficiency and to ensure spray application test results are not biased by inconsistent coating.

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.
June	**1990**	Reach a negotiated agreement with DOE on the Cooperative Agreement, June 13, 1990.

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

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 10/2/92.
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. Completed annual MSHA safety training.
June	**1993**	Initiated deliveries of SynCoal® under long-term contract with an industrial customer.