BASIN ELECTRIC
POWER COOPERATIVE

1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA 58503-0564
PHONE 701-223-0441
FAX: 701/224-5336

December 29, 2006

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol, 10th Floor
Bismarck, ND 58505

Dear Ms. Fine:

Enclosed are the original, one hard copy and an electronic copy of the amended proposal "Lignite Coal Test at a Transport Reactor Gasification Facility in Wilsonville, Alabama". The work to date has been accomplished under contract FY05-LI-129. The $100.00 application fee will be submitted next week.

If you have any questions or comments, please contact me by phone at (701) 355-5691 or email at mikepaul@bepc.com.

Sincerely,

David [signature], Acting V.P., E&C

Michael W. Paul, P.E.
Vice President, Engineering and Construction

/sh
Enclosures
cc: Gavin McCollam (w/o enclosures)
Tom Spaulding (w/o enclosures)
Curtis Jabs (w/o enclosures)

Grant Application for a
Lignite Coal Test at a
Transport Reactor Gasification Facility in
Wilsonville, Alabama

Presented to:

Ms. Karlene Fine, Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue
Bismarck, ND 58505

Submitted by:

Michael W. Paul, P.E.
Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck, ND 58503

Principal Investigator:

Power System Development Facility
PO Box 1069
Wilsonville, AL 35186
Department of Energy
Southern Company

Additional Funds Requested From the North Dakota Industrial Commission: $135,000

December 29, 2006

Table of Contents

Abstract

Coal gasification is the latest advanced technology being researched and developed by the Department of Energy to demonstrate that coal can be used as a fuel in electric generation in an environmentally enhanced manner.

The advance Integrated Gasification Combined Cycle (IGCC) system is designed to gasify coal, use the synthetic gas (syngas) produced to fuel a gas generation turbine. The captured waste heat from the gas turbine goes through a heat exchanger to produce steam, which in turn drives a steam generation turbine. This advanced process improves the plant efficiency while reducing plant emissions significantly.

The objective of the proposed grant is to evaluate the performance of lignite fuel in a nominal 4 MW to 8 MW pilot scale advanced coal gasification system at the Department of Energy's Power System Development Facility (PSDF), located in Wilsonville, Alabama. To date, two 250-hour tests and the first portion of the current 750-hour campaign have been conducted with very promising results using low sodium lignite, but some agglomeration issues were encountered when processing high sodium lignite. The specific technical issues include determining the effects of the coal gasification operating conditions using high sodium lignite on the carbon conversion and quantity and quality of synthetic gas production. The PSDF gasification technology, unlike other current IGCC designs, has a dry feed system to the gasifier and operates at favorable operating temperatures that work well for high moisture lignite.

On November 8, 2006, the PSDF initiated the 750-hour Low/High Sodium campaign to prove out some of the system configuration changes recently implemented to ensure previously identified agglomeration issues have been adequately addressed (refer to LEC and Southern Company letters in Appendix-B). Preliminary reports indicate that the low sodium portion of the 750-hour

campaign yielded favorable results, however, some problems encountered shortly after transitioning to high sodium lignite resulted in a subsequent shutdown. The PSDF testing facility tentatively plans to resume the high sodium portion of the 750-hour TC21 campaign on January 18, 2007. Following the 750-hour campaign, two consecutive 1000-hour high sodium lignite test runs are scheduled in an effort to further examine variable processing conditions while operating in both air and oxygen modes respectively.

The results from additional testing will define operating conditions and parameters that establish acceptable standards of performance as well as identifying other possible high sodium processing problems inherent to technology. This information is vital to understanding operational challenges associated with Transport Reactor Integrated Gasification (TRIG) technology and how it can possibly be applied to future commercial applications/projects using North Dakota lignite coal.

Project Summary

Today coal currently provides over 50% of the electricity consumed in the United States and will remain a necessary part of our energy mix for some time to come. One of the technologies being developed for advanced coal-based electric power-generating systems is an IGCC system. The IGCC process converts coal to a combustible gas, cleans the pollutants from the gas, and combusts it in a gas turbine to generate electricity. The exhaust from the gas turbine is used to generate steam to generate more electricity in a steam turbine.

Exploring how lignite coal performs in an advanced gasification process could have a significant economic impact on the North Dakota power industry. The construction of new power plants and the re-powering of existing North Dakota plants using this advanced gasification process could lead to new development of cost-competitive, environmentally acceptable coal-based power generation in the state.

Specific Department of Energy program 2010 goals for baseload IGCC systems using lignite include attaining a net electric system efficiency of 40%, reducing sulfur dioxide (SO_2) by 97% emitting no more than 0.08 lbs of Nitrous Oxide (NO_x) emissions per million British Thermal Unit (BTU) and achieving substantial reductions in mercury (Hg) reductions.

One of the most recent IGCC gasification concepts to be investigated by the Department of Energy and Southern Company is the “transport reactor” gasifier (Figure 1, page 9). The transport reactor functions as a circulating fluid-bed while operating in the air-pressure transport system of solid-particle flow. The gasifier concept provides excellent solid-gas contacting of relatively small particles to promote high gasification rates.

The advantage of an advanced transport reactor IGCC for electricity production from lignite needs to be demonstrated through additional gasification tests at Wilsonville, Alabama and includes:

- Testing the transport reactor gasifier, part of an advanced high-efficiency IGCC system, will ultimately result in less carbon dioxide (CO_2) emissions/greenhouse gases per unit of power output.
- Low sulfur and nitrous oxide emissions – IGCC emissions of sulfur dioxide and nitrogen oxides, gases linked to acid rain, are a small fraction of allowable limits under the Clean Air Act.
- Transport reactor gasifier can handle coal fines – no coal fines separation necessary.
- High fuel reactivity results in higher conversion of lignite to fuel gas at temperatures low enough to prevent ash deposit problems.
- Use of hot or warm gas cleanup before combustion in a gas turbine results in little negative impact on cycle efficiency from high moisture coal.
- Oxygen-blown operations may generate CO_2 capture readiness. Oxygen-blown IGCCs may be well suited for application of future technologies to capture, sequester or recycle CO_2.
- The design of the transport reactor is applicable for lignite use with possible scale up commercialization possibilities. The transport reactor's circulating fluidized bed design with a dry feed system appears to offer a good solution for gasification of high moisture lignite without the production of problematic tars and oils.
- The successful use of lignite in a IGCC system will benefit the North Dakota lignite industry by demonstrating the technical and economic viability of lignite fuel in a high efficient gasification power plant. Clearly, this technology could provide lignite-based options for new generation plants, as well as for re-powering existing plants.

The participants include Basin Electric Power Cooperative, Dakota Gasification Company, Montana-Dakota Utilities Company, Otter Tail Power Company, SaskPower, The North American Coal Corporation, Westmoreland Coal Company, BNI Coal, Great River Energy and Great Northern Power Development, L.P.

Based on recent shipping costs for 1,731 tons of low/high sodium lignite coal to Wilsonville, Alabama, the total estimated costs for coal and freight related expenses needed to conduct additional testing is approximately $270,000. Grant applicants are requesting additional matching funds in the amount of $135,000 from the North Dakota Industrial Commission.

Project Description

The objective of the proposed tests is to evaluate the performance of high sodium lignite fuel in a high-efficient advanced transport reactor gasification system. Specific technical issues include determining the effects of the transport reactor's operating conditions on carbon conversion and gas yields and quality while monitoring for the increased ash agglomeration and deposition potential of the high sodium lignite.

Two exploratory 250-hour runs using Falkirk and Freedom coal have been conducted at the Power Systems Development Facility in Wilsonville, Alabama, with the transport reactor with promising results but with some unanswered questions. Results observed from the two 700-ton tests using Falkirk and Freedom lignite in the transport reactor in both air and oxygen blown modes concluded:

- Good operation and successful gasification of Falkirk and low sodium at Freedom
- Acceptable gas heating values
- Excellent carbon conversions
- No tar or oil at high or low temperatures

At low temperature and high sodium, no agglomerations were formed. However, there was reduced carbon conversions and lower gas heating values. At high temperatures and high sodium lignite, agglomerations deposits formed.

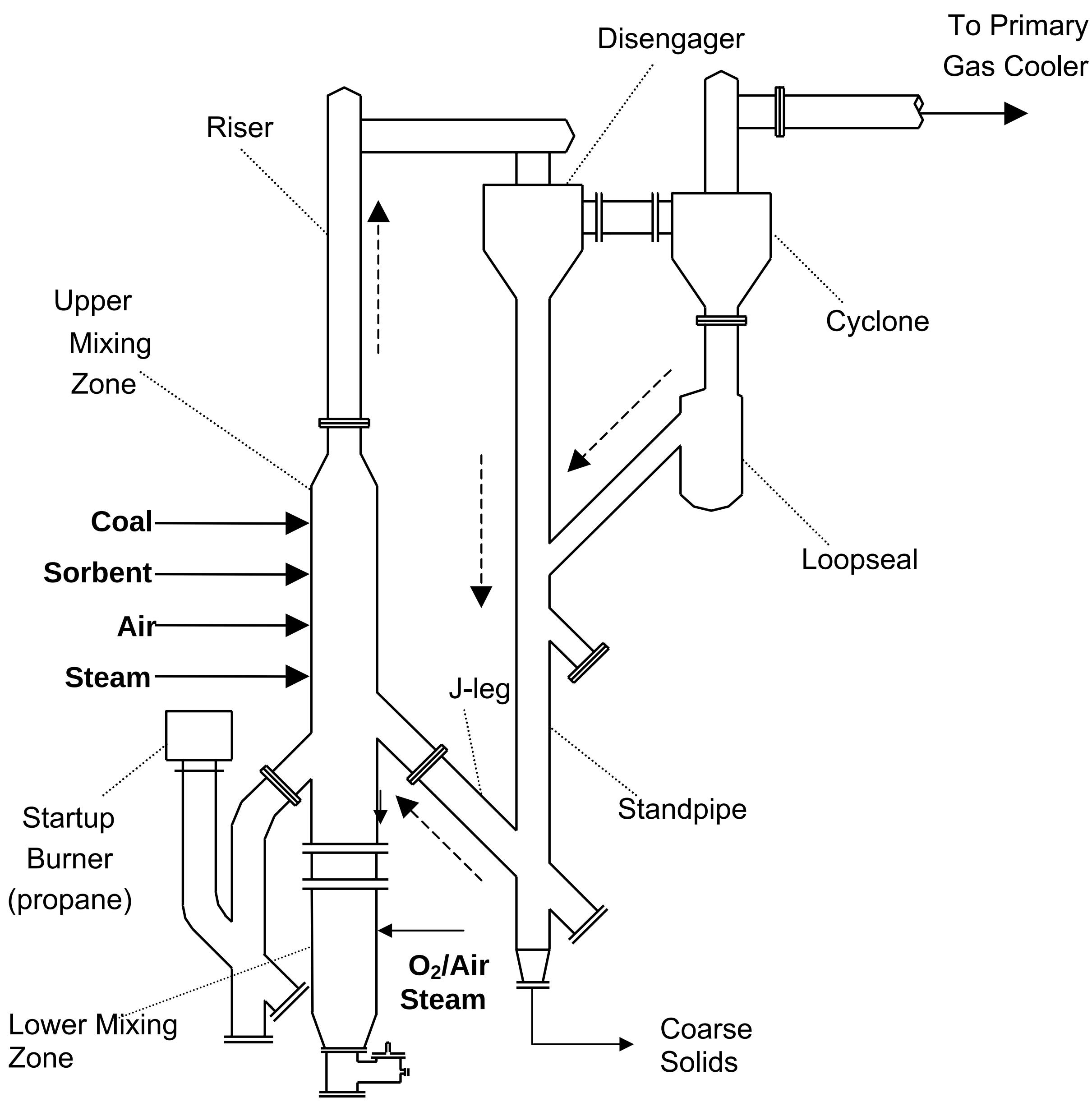
The next step to further advancing and characterizing transport reactor capabilities with high sodium lignite coal was to conduct a 750-hour low/high sodium test run. This campaign was inserted into the schedule to prove out new TRIG configuration changes recently implemented to address previously encountered agglomerate formation problems. The low sodium portion of the 750-hour campaign was completed in November 2006 and the high sodium portion is expected to resume operation in January 2007 followed by two separate, continuous 1000-hour campaigns.

The Power Systems Development Facility staff at Wilsonville recommends additional tests where the operating envelope can be expanded for high sodium lignite to achieve acceptable carbon conversion and gas heating values without agglomerations. Two continuous 1000-hour campaigns are needed to better understand the effects of high sodium coal on the transport reactor and determine operational/process design changes necessary to alleviate agglomerate formations. Parameters and objectives for the additional testing are as follows:

- Conduct two 1000-hour campaigns (e.g. 1-air blown mode, 1-oxygen blown mode) exclusive of start-up conditions; as needed, additional lignite could be provided for shakedown and operational startup activities.
- Represent commercial operation with continued operations to reject added bed material (sand) to achieve commercial like mass and energy steady state.
- Characterize gasifier over a wide range of operating conditions (including turndown capability) to optimize process performance and maximize carbon conversion.
- Demonstrate agglomerate free operation during both 1000-hour test runs; conduct post run equipment inspections to quantify agglomerate formation(s).
- Demonstrate recycle syngas fluidization capabilities in terms of reduced nitrogen consumption to enhance carbon conversion and fuel energy value.
- Optimize reactor conditions to minimize energy value of ash-char products.
- Verify long-term combustion stability of low BTU syngas in the combustion turbine without propane calorific enhancements.
- Monitor gasifier temperature/pressure differential profiles and solids samples.
- Evaluate operation and performance of coal feed and ash removal systems.

The additional runtime from these two high sodium 1000-hour campaigns will provide valuable information as well as identifying other possible operational challenges that may need to be addressed prior to considering TRIG technology commercially viable for future North Dakota lignite coal energy generation applications.

Figure One: Transport Reactor
Air or Oxygen Blown



Standard of Success

The use of lignite as a fuel in the transport reactor gasifier will be considered a success if four criteria are satisfied. First, the transport reactor must exhibit stable operation without significant ash agglomerations during two separate, continuous 1000-hour test runs. Second, the fuel gas heating value must be acceptable for commercially available gas turbine operation with high carbon conversion. Third, the system emissions should be 10% of New Source Performance Standards (NSPS). Fourth, the hot-gas filters system should show stable operation with only a small increase in filter baseline differential pressure.

If these criteria are met, the technical advantages of using lignite in the transport reactor gasifier will have been demonstrated. Successful testing of the transport reactor gasifier using lignite could lead to acceptance of the IGCC technology with possible commercialization in the future.

Background

POWER SYSTEMS DEVELOPMENT FACILITY
Test Run TC13: Gasification Test Run
Operating Summary for 9/31/03 – 11/02/03

- The Transport Gasifier operated for 501 hours in TC13 using Powder River Basin (PRB) coal and two different types of lignite from the Freedom Mine in North Dakota. The two types of lignite differed primarily in sodium content. The raw high-sodium lignite contained over 6% sodium (ash mineral analysis), whereas the raw low-sodium lignite possessed a sodium content of around 1.5%. The gasifier operated on PRB coal to commission the new syngas-to-turbine system and to test the Piloted Syngas Burner (PSB) with syngas.

- The majority of the test run was air-blown (432 hours), with around 47 hours in enriched-air mode and over 22 hours in oxygen-blown mode. All of the oxygen-blown testing occurred while feeding high-sodium lignite. About 10 hours of enriched-air operation occurred during low-sodium lignite feed. Of the 47 hours of enriched-air gasification, 21 hours was co-feeding high-sodium lignite with low-sodium lignite, and 26 hours was feeding high-sodium lignite.

- The test run experienced stable air-blown operation using PRB as well as the two lignite fuels. Gasifier operating temperatures mostly varied from 1750°F to 1775°F during PRB operations, from 1640°F to 1750°F during low-sodium lignite operations, and from 1400°F to 1700°F during high-sodium lignite operations. The gasifier exit pressure ran between 90 and 180 psig during air-blown operations and between 110 and 130 psig in oxygen-blown operations.

- Despite operating at lower temperatures with the high-sodium lignite, the gasifier produced a syngas free of oils and tar.

- Typical riser velocities ranged from 35 to 50 ft/s during air-blown operations, and were around 40 ft/s during air-blown operations. Standpipe differential pressures were smaller, and the reactor temperature profile was more uniform when the riser velocity was above 35 ft/s.

- For Powder River Basin coal in air-blown mode, the raw lower heating values were between 50 and 60 BTU/SCF resulting in projected heating values for large-scale operations of between 80 and 95 BTU/SCF. PRB lower heating values were slightly lower than previous PRB lower heating values at similar operating conditions due to low coal feed rates.

- In air-blown mode, the Freedom Mine high-sodium and low-sodium lignite achieved raw lower heating values of up to 45 and 61 BTU/SCF, respectively, resulting in projected heating values of up to 85 and 94 BTU/SCF. Higher coal feed rates can improve the lower heating values.

- Using oxygen-enhanced air, the Freedom Mine high-sodium and low-sodium lignite achieved raw lower heating values of up to 60 and 64 BTU/SCF, respectively, resulting in projected heating values of up to 120 and 109 BTU/SCF for the two coals.

- The lower heating values of syngas generated from the Freedom Mine lignite in air-blown mode were consistent with those of syngas generated from Falkirk lignite at comparable coal feed rates, while the syngas lower heating values for the Freedom Mine lignite in oxygen-blown mode were slightly higher than those of the syngas derived from Falkirk lignite.

- Powder River Basin coal carbon conversions were between 94% and 98.5%.

- The carbon conversions for the low-sodium Freedom lignite were between 93% and 98.5% for air-blown testing.

- The carbon conversions for the high-sodium Freedom lignite were between 75% and 99.5% for air-blown testing and were about 98% during oxygen-blown testing. The lower air-blown carbon conversions were during periods of operating at lower temperatures.

- The low-sodium lignite portion of the test run was smooth. Although some deposits occurred while feeding high-sodium lignite at gasifier operating temperatures above 1650°F, lower reactor temperatures (1400°F to 1575°F) allowed for steady high-sodium lignite operations for long periods of time without any detectable signs of deposits in the reactor system.

- The coal grinding system showed promise in drying the lignite from a moisture content of 35% to a moisture content of 25%. The coal feeder experienced no difficulties in feeding the lignite to the gasifier.

- The primary gas cooler performed well, exhibiting no signs of oils or tar deposits.

- PCD operations were stable throughout TC13, which included the use of the three types of coal and the transitions to each type. Also, no problems were encountered with PCD operations during operation of the PSB. During most of the coal run, the baseline pressure drop was about 50 to 75 in water. During steady state operations, the inlet temperature was about 600°F to 800°F, and the face velocity was maintained at about 3 to 4.5 ft/min.

- During the run, backpulse pressures of 320 psid on the top plenum and 400 psid on the bottom plenum were used. As in recent runs, the backpulse timer was varied from 5 to 20 minutes in an effort to further optimize backpulse parameters.

- The fines removal system operated fairly well during most of the run. However, during the run, the FD0520 lock vessel Everlasting valve failed to operate several times, presumably due to solids in the valve. The lock vessel Spheri valve was operated successfully during the times when the Everlasting valve was not functioning. Also, the drive end seal on the FD0502 screw cooler failed and caused a short delay in the run while it was repaired.

- Outlet loading samples indicated good sealing of the filter vessel. All the measurements showed outlet concentrations below the sampling system lower limit of detection of 0.1 ppmw except for two samples indicating loading of 0.25 and 0.11 ppmw.

- In the development of reliable level indicators in the FD0520 lock hopper system, evaluation of new resistance probes was continued. For this run, a new probe and transmitter were installed and tested with reliable results.

- The PCD was shut down "clean," in that backpulsing was continued for over half a day after coal feed stopped. The residual cake was thin and comparable to that seen from recent runs. There was no indication of patchy cleaning on any of the filter elements.

- A preliminary inspection of the PCD internals revealed no obvious problems. No g-ash bridging was present, and there were no apparent filter element failures. In addition, there was no plugging found in the Westinghouse inverted filter element assemblies.

- Unlike previous test runs, the gasifier bed material changed rapidly during TC13, as process-derived materials replaced the sand present at startup. Standpipe samples taken during the test run consist of small particles that preliminary analyses show has a mean diameter (D_{50}) of about 250 to 350 μm. The process-derived solids created during the high-sodium lignite portion of the test run appear to be agglomerates of fine ash particles. Most of the agglomerates are spherical and either hollow-centered or have a glassy solidified silica core. The bulk density of the agglomerates is around 60 lb/ft^3.

- The solids circulation rate remained high as the process-derived bed material replaced the startup sand. The riser differential pressure was above one inch of water per foot of riser length.

- Both the coarse and fine ash depressurization systems worked well. Since the gasifier accumulated process-derived materials in the bed, the intermittent removal of coarse solids from the gasifier was more frequent than in past test runs. Almost one-half of the solids removed from the gasifier loop were coarse solids, resulting in a time-averaged removal rate of about 120 pph of coarse solids.

- For the first time, the combustion turbine at the PSDF ran on syngas, using the PSB (piloted syngas burner). The syngas used in the PSB came from PRB coal. Establishing/increasing syngas flow to the PSB, as well as decreasing/terminating syngas flow, exhibited smooth behavior, and neither caused any fluctuations in gasifier operations.

- To ensure safe operation of the PSB, several new interlocks were commissioned. All performed as expected during the interlock trials. When interlocks tripped the process gas to the PSB, valves diverted the flow to the flare to avoid causing reactor pressure upsets. Once the syngas flowed to the flare, logic controls restored the flow through the main pressure letdown valve to the atmospheric syngas burner (thermal oxidizer)—slowly, to avoid swings in reactor pressure. In practice, the gasifier pressure changed less than 2.0 psig during each trip.

- PSB operations were mostly steady with the generator producing a steady 1.2 MW. As the syngas flow to the PSB increased, the supplemental propane flow to the PSB decreased from 1200 to 400 pph and could have decreased further had the PLC logic not prevented the controller from reducing flow below 400 pph. A future goal for the system is to reduce the propane flow to zero, while maintaining the generator output.

- The PSB flame remained steady throughout testing. Process variances, such as the PCD backpulse, did not affect PSB operations. PSB testing on syngas was completed after about six hours. Upon restarting the following day, the hydraulics on the cranking motor failed. Once the repairs to the hydraulic system are complete, plans call for the PSB to run on syngas as often as possible in the future.

- During the test run, extractive gas samples were taken for determining the amounts HAPS trace metals present in the syngas. The lab is currently analyzing the samples, and the results should be available soon.

- The deposition of naphthalene and three-member ring compounds hindered much of the extractive gas analysis that occurred in previous test runs. A new recently tested crystal knock-out pot should assist in future extractive gas testing and could provide stable, uninterruptible syngas flow to online gas analyzers and other processes that require low temperature syngas.

- The test run was interrupted twice when deposits formed in the loop seal and once when deposits formed in the standpipe. Although aeration flows dislodged the standpipe deposit, each loop seal deposit forced a complete system shutdown and depressurization to clear the material. The deposits were small, around 2-3 inches in diameter, and very easily broken by hand. By interlocking with each other, however, the deposits were able to form an obstruction that would not dislodge on their own. The exact cause of the deposits is not clear, but none formed toward the end of the test run, when gasifier temperatures were significantly lower

(1400°F to 1575°F). Although the deposits were below the bed level in the loop seal, they seem to have formed somewhere else and traveled there from another part of the gasifier.

- The carbon conversion with the low-sodium lignite was about 98%. However, with high-sodium lignite, the carbon conversion was lower (about 80% to 90%) than in past test runs. The capacity of the spent solids systems limited the coal feed rate to around 3500 pph. Studies are underway to determine whether higher high-sodium lignite feed rates (and higher syngas heating values) are possible. Future tests to address the low carbon conversions include increasing the reactor temperature and recycling the char solids back to the gasifier.

- The atmospheric syngas burner ran well during the test run, easily combusting the syngas derived from the PRB and lignite fuels.

- Most of the gas analyzers were online for the majority of the test run, presenting good gas composition data. The dry gas compositions added up to between 98% and 100% on a consistent basis.

- For PRB coal the sulfur emissions were 200 to 300 ppm (air blown).

- For the low-sodium (high sulfur) lignite from the Freedom Mine, the sulfur emissions were 1400 to 1800 ppm during air-blown operation and 2000 to 2500 ppm during oxygen-blown operation.

- For the high-sodium (low sulfur) lignite from the Freedom Mine, the sulfur emissions were 500 to 1800 ppm during air-blown operation and between 1500 and 2500 ppm during oxygen-blown operations. The high variation in air-blown sulfur emissions was due to the wide range of coal rates.

- Unlike PRB coal, minimal sulfur capture occurred without limestone injection. The sulfur emissions decreased about 20% during one period of limestone injection.

- During air-blown mode, PRB coal had ammonia emissions between 1000 and 1500 ppm in air-blown operation, while the low-sodium Freedom lignite had 500 to 1000 ppm emissions with a 3000 pph coal rate and about 1300 ppm emissions with 5500 pph coal rate. The high-sodium Freedom lignite had ammonia emissions varying between 750 and 2300 ppm while in air-blown mode. The ammonia emissions from the high-sodium lignite were a strong function of the coal feed rate.

- During oxygen-blown operations, the low-sodium Freedom lignite had 2000 to 2500 ppm ammonia emissions.

- During air-blown operations, the high-sodium Freedom Mine lignite had ammonia emissions varying between 1500 and 2500 ppm.

- The solids obtained from the standpipe sampling system had a mass mean particle diameter of between 250 and 350 microns and an LOI typically below 1%. Solids obtained from the spent fines feeder possessed a mean particle diameter of around 20 microns and an LOI varying from under 15% to over 70%.

- The sulfator ran relatively smooth during the test run, generating large quantities of high quality superheated steam for use in the gasifier. The bed level stayed fairly constant and only occasionally required additional sand. Whenever solid fuel was unavailable, the fuel oil system worked well at maintaining sulfator temperatures. During the test run, a spot of high skin temperature developed near one of the steam coil bundles where some of the refractory had apparently been damaged. Future inspections will reveal the degree of damage the sulfator refractory has experienced.

- The new FD0530 feeder fed gash at a rate that was much steadier than that seen in previous test runs, although it still fed over a relatively narrow range of feed rates. The feeder needs to be capable of handling higher and lower feed rates. The carryover rate and carbon content in the FD0530 solids was large during the low temperature testing, thus the sulfator had difficulty combusting the material at a rate sufficient to keep pace with the solids collected. The FD0530 conveying line continues to develop leaks and will be replaced soon.

- The test run ended as scheduled on the afternoon of November 2, 2003. The shutdown was smooth, leaving no transient cake on the PCD filter candles. The post-run inspections showed that no further deposits made their way into the loop seal.

- For additional PSDF operating background information, refer to Appendix C Status Reports which summarizes events from the TC16 (consisted of approximately 250-hours of lignite) and 750-hour PRB TC20 campaigns respectively. The 750-hour TC20 campaign was inserted into the schedule first to prove out the recently implemented configuration changes on PRB coal before attempting the 750-hour high sodium lignite campaign (TC21) which is characteristic of more agglomerate formations and processing difficulties.

Qualification

Power Systems Development Facility

The Power Systems Development Facility (PSDF), located near Wilsonville, Alabama, is a flexible test facility designed to provide an engineering-scale demonstration of advanced coal-fueled power systems and key components at sufficient scale to provide data for commercial scale-up. The U.S. Department of Energy (DOE) has jointly developed the PSDF, with Southern Company and other industrial partners including Electric Power Research Institute (EPRI), Siemens Westinghouse, Kellogg Brown & Root, Inc. (KBR), and Peabody Holding Company. The purpose of the PSDF is to lead America's development of cost-competitive, environmentally acceptable coal-based power generation.

The PSDF started operations in 1996 accumulating about 5,000 hours of combustion testing with the Transport Reactor and Siemens Westinghouse Particulate Control Device (PCD). In 1999 the Transport Reactor was modified to operate as an air-blown gasifier (Transport Gasifier) and again in 2001 to operate as an oxygen-blown gasifier. The Transport Gasifier has operated over 2900 hours and over 500 hours in air- and oxygen-blown modes respectively. In gasification mode with subbituminous coal more than 95% carbon conversion can be achieved with little tar formation. The PCD outlet loading is normally below the lower limit of detection of 0.1 ppmw.

The Department of Energy conceived the PSDF as the premier advanced coal power generation research and development facility in the world and work there thus far has fulfilled this expectation. The Department of Energy's vision is that: "The Wilsonville PSDF will serve as the proving ground for many new Advanced Power Systems and Vision 21 Technologies…. The Wilsonville Power Systems Development Facility gives U. S. industry the world's most cost-effective flexible test center for testing tomorrow's coal-based power-generating equipment…. Capable of operating at pilot to near-demonstration scales, the facility is large enough to give industry real-life data, yet small enough to be cost-effective and adaptable to a variety of industry needs." A key feature of the PSDF is its ability to test new systems at an integrated, semi-commercial scale. Integrated operation allows the effects of system interactions to be understood that are typically missed in unintegrated pilot-scale testing and to advance the development of the proposed technology towards commercialization. The semi-commercial scale allows the maintenance, safety, and reliability issues of a technology to be investigated at a cost that is an order of magnitude below the cost of testing at commercial scale.

The PSDF has developed testing and technology transfer relationships with over 50 vendors to ensure that test results and improvements developed at the PSDF are incorporated into future plants by the systems suppliers. Major subsystems tested and some highlights of the test program at the PSDF include:

- **Transport reactor:** An air-blown, fast circulating-bed reactor called a transport reactor was originally selected because of its flexibility in providing a variety of combustion gases and synthesis gases for testing various downstream subsystems. The transport reactor has been operated successfully as a pressurized combustor (5000 hours) and as a gasifier (3400 hours) in both oxygen- and air-blown modes and, as a result has exceeded its primary purpose of generating gases for downstream testing. It is now projected to be the lowest capital cost coal power generation option while also providing the lowest cost of electricity with excellent environmental performance.

- **Advanced particulate control:** Two advanced particulate removal devices and 28 different filter elements types have been tested to clean the product gases, and material property testing is routinely conducted to assess their suitability under long-term operation. Based on the material testing results, an understanding of the filter element properties required for reliable operation in a commercial power system has been developed. Filter elements have been identified that can withstand the expected level of upset conditions and the material requirements have been shared with vendors to aid their filter development programs.

- **Filter safe guard device:** To further enhance reliability and protect downstream components, a "safe guard" device was successfully developed that reliably and completely seals off the filter element upon failure, thus preventing damage to the combustion turbine. Particulate levels of <0.1 ppm have been achieved, well below gas turbine specifications.

- **Coal feed and ash removal subsystems:** The key to pressurized operation is reliable operation of the feed system to the pressurized reactor and ash removal system from the pressurized reactor and filter vessel. Modifications developed at the PSDF and shared with the equipment supplier have increased the reliability of these systems to a level that is acceptable for commercial operation in either the combustion or gasification mode.

- **Syngas cooler testing:** Syngas cooling is of considerable importance to the gasification industry. Ferrules made of several different materials were tested at the inlet of the gas cooler with varying degrees of success. One ceramic material has been shown to perform well in this application.

- **Direct Sulfur Recovery Process (DSRP)**: The DSRP, provided by RTI, was operated on a synthesis gas slipstream from the transport gasifier.

- **Electronic data collection, management, and dissemination system:** A system was installed to allow vendors to view data from their equipment at the PSDF from their home office.

- **Instrumentation:** Several instrumentation vendors have worked with the PSDF to develop and test their instruments under realistic combustion and gasification conditions. Instruments tested include: 1) Nuclear-based solids flow-measurement; 2) Several types of gas analyzers; 3) Real-time high-temperature/high-pressure particulate monitors; 4) Solids level-measurement probes; 5) Thermographic phosphor high-temperature measurement in reducing atmospheres; and 6) Combustion turbine ignition detection and flame analysis.

- **Highly experience staff:** In addition to this physical infrastructure, a highly experienced staff has been created that has a demonstrated ability to solve complex technical problems and rapidly move new technologies to commercial applications.

Lignite Coal – Transport Reactor:

The demonstration of the transport reactor capabilities using lignite coal, with its characteristic low BTU content, high moisture, high alkali and high ash properties may qualify TRIG technology for future lignite-based power plants or re-powering of existing North Dakota power plants.

Basin Electric Power Cooperative

Basin Electric Power Cooperative is a consumer-owned, regional cooperative headquartered in Bismarck, North Dakota. We produce clean energy for a healthy economy, based on the Ecowatts® concept. Our history as an electric cooperative is rooted in the beginnings of the electrification of rural America.

Basin Electric operates electricity-generating power plants with a total capacity of 3412 megawatts. We serve 120 rural electric member cooperative systems that in turn serve approximately 1.8 million consumers in the nine states of North Dakota, South Dakota, Montana, Wyoming, Minnesota, Nebraska, Iowa, Colorado and New Mexico.

Basin Electric has several subsidiaries, including Dakota Gasification Company, which produces natural gas from the coal gasification process and products such as chemicals and fertilizers; Dakota Coal Company, which purchases lignite for our power plants and owns a lime processing plant.

Basin Electric and its subsidiaries employ about 1,700 people.

Basin Electric's subsidiary: Dakota Gasification Company (DGC)

Basin Electric has extensive institutional knowledge of coal gasification with its ownership and operation of DGC.

The Great Plains Synfuels Plant is the only commercial-scale coal gasification plant in the United States that manufactures natural gas. The synfuels plant is owned and operated by Dakota Gasification Company (DGC), a subsidiary of Basin Electric Power Cooperative (BEPC).

The $2.1 billion plant began operating in 1984. Using the Lurgi gasification process, the synfuels plant gasifies lignite coal to produce valuable gases and liquids. The average daily production is 150 million standard cubic feet of synthetic natural gas (SNG), the majority of which is piped to Ventura, IA, for distribution in the eastern United States. The plant capacity is 170 million standard cubic feet. Many byproducts and alternate products are produced and marketed in the United States and worldwide. A portion of the plant's gas output is directed to manufacture 1100 tons per day of anhydrous ammonia.

The synfuels plant daily consumes about 18,500 tons of lignite supplied by the nearby Freedom Mine. The mine is owned and operated by the Coteau Properties Company, a subsidiary of the North American Coal Corporation.

Value To North Dakota

The successful use of lignite in a transport reactor IGCC system will benefit North Dakota lignite industry by demonstrating the technical and economic viability of lignite fuel in a high-efficient gasification power plant. Clearly, this technology could provide lignite-based options for new generation plants, as well as for re-powering existing plants.

The Department of Energy's goals of the transport reactor gasification project include the development of a high-efficient power system attaining a net electric system efficiency of 40% or more, reducing sulfur dioxide (SO_2) by 97%, emitting no more than 0.08 lbs of Nitrous Oxide (NO_x) emissions per million British Thermal Unit (BTU) and achieving substantial reductions in mercury (Hg) reductions.

Demonstrating that the highly reactive lignite fuels will produce gas without deposition and agglomerating related problems during the operation of the advanced transport reactor gasifier will help market North Dakota's low cost lignite reserves as a viable fuel for the future. The high reactivity of lignite provides a market advantage against other coals for this IGCC technology, and the impact of high moisture is minimized.

These coal gasification systems also offer the best potential competition to natural gas-based generation and the future vision of coal-based generation. IGCC systems are being developed and promoted under DOE's Vision 21 program, which should help facilitate market acceptance.

Management

Michael W. Paul will coordinate the project. Mr. Paul is a registered Professional Engineer in the State of North Dakota with over 28 years of electric utility experience. Mr. Paul has the responsibility for the technical review of projects related to the gasification technology performance and determining if the IGCC technology is applicable to future applications.

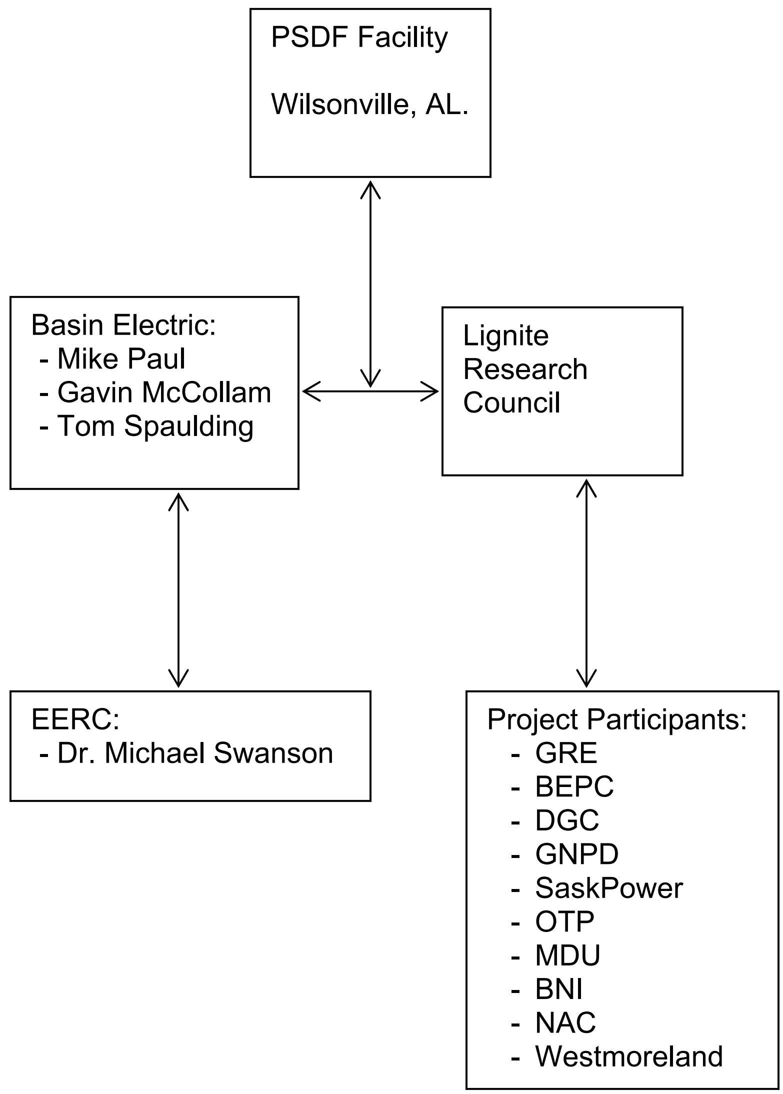
Additionally, Gavin McCollam and Tom Spaulding will provide engineering support for the project as needed. Mr. McCollam is a registered Professional Engineer in the State of North Dakota with over 17 years of gasification and electric utility experience. Mr. Spaulding is a mechanical engineer with over 15 years experience in chemicals/plastics industries and 2 years of gasification/electric utilities experience.

Dr. Michael Swanson, Senior Research Manager, Energy and Environmental Research Center (EERC), will provide consultant expertise for the project. Dr. Swanson is currently involved with the demonstration of advanced power systems such as the integrated gasification combined cycle and pressured fluid-bed combustors, with an emphasis on hot-gas cleanup issues. He is currently project manger on a U.S. Department of Energy funded project testing a pilot-scale advanced transport reactor gasification system. Dr. Swanson's principle areas of interest and expertise include pressurized fluid-bed combustions, integrated gasification combined cycle, hot-gas cleanup, coal reactivity in low rank coal combustion supercritical solvent extraction, and liquefaction of low-rank coals.

Communication

Communications are essential for a successful project. In an effort to accommodate project participants with planning, scheduling and facilitating discussion on the project the following communication flow will be followed.

Communications Flow Diagram:



Timetable

A commitment of additional funding from both the North Dakota Industrial Commission (NDIC) and project participants will allow necessary testing of high sodium lignite coals in both air- and oxygen-blown modes to move forward at the PSDF test facility in Wilsonville, Alabama. Timetables below provide a glance back as well as a look forward to the 750-hour, 1000-hour (air-blown) and 1000-hour (oxygen-blown) campaign activities. Dates may be subject to change should additional TRIG system improvements need to be implemented in order to achieve high sodium operating excellence.

250-Hour TC16 Campaign Timetable (Actual):

- Transport Coal to Wilsonville	June 2004
- 250 Hour Test	July - August 2004
- Project Participants Witness Test	July - August 2004
- Evaluation Overview – Wilsonville	December 2004
- Final Report	January 2005

750-Hour TC21 Campaign Timetable:

- Transport Coal to Wilsonville	October 2006
- Low/High Sodium Test	November 2006
- High Sodium Test (Resume)	January 2007
- Project Participants Witness Test	November 2006 - January 2007
- Evaluation Overview – Wilsonville	February 2007
- Final Report (Expected)	July 2007

1000-Hour (Air-Blown) TC22 Campaign Timetable (Anticipated):

- Transport coal to Wilsonville	January 2007
- High Sodium Test	February – March 2007
- Project Participants Witness Test	February – March 2007
- Evaluation Overview – Wilsonville	April 2007
- Final Report (Expected)	September 2007

1000-Hour (Oxygen-Blown) Campaign Timetable (Anticipated):

- Transport coal to Wilsonville	June 2007
- High Sodium Test	July – September 2007
- Project Participants Witness Test	July – September 2007
- Evaluation Overview – Wilsonville	October 2007
- Final Report (Expected)	February 2008

The 1000-hour (oxygen-blown) campaign has not been assigned a "TC" test campaign number yet. Following the 1000-hour (air-blown) TC22 campaign, the PSDF facility will conduct a Mississippi lignite campaign (TC23); therefore, the 1000-hour (oxygen-blown) North Dakota lignite campaign will likely be later designated as either "TC24" or "TC25".

Budget

This proposal requests additional matching funds in the amount of $135,000 from the NDIC to allow additional testing of North Dakota lignite in the PSDF transport reactor gasifier in Wilsonville, Alabama. These extended tests will further demonstrate the practicability of lignite as a fuel for the advanced high-efficient IGCC concept. If successful, lignite may be viewed as a viable fuel for use in this advanced technology for new North Dakota power plants or re-powering existing power plants. Coal gasification may be one option to help lignite remain competitive as a fuel for power generation in the deregulated wholesale power market and help industry and the state achieve the strict regulatory environment being administered by the Environmental Protection Agency (EPA).

The original and revised budget below pertains to the project shortfall and the need for the request of additional funding.

Original Budget Itemization:

3700 tons coal	$3,700.00
Shipping 500 tons for 250 hour campaign	$25,000.00
Shipping 3200 tons for 1000 hour campaign	$160,000.00
Consultant Fees	$5,000.00
Coal transfer (nearest load out to test facility)	$50,000.00
Misc. (additional coal, shipping, transfer)	$6,300.00
Total	$250,000.00

Revised Budget Itemization:

250-hour TC16 campaign (actual)		$27,561.00
750-hour TC21 campaign (actual)		$128,969.00
1000-hour (air-blown) TC22 campaign (estimated)		$175,000.00
1000-hour (oxygen-blown) campaign (estimated)		$175,000.00
Misc. (additional coal, shipping, transfer)		$13,470.00
	Revised Total	$520,000.00
	Original Total	($250,000.00)
	Shortfall	$270,000.00

The shortfall and subsequent request for additional funding results from a combination of additional tests needed to prove out recent TRIG system configuration changes made at the PSDF site, as well as an escalation of BNSF rail freight costs due to increased variable fuel surcharges in excess of 18%.

Matching Funds

Based on discussions with the interested participants, this proposal assumes a match of $135,000 for the cost of additional testing at the PSDF site in Wilsonville, Alabama. The matching funds commitment would be subject to the North Dakota Industrial Commission approval for additional project funding as well as the Board of Directors approval from each of the participating organizations (as required). These organizations include Basin Electric Power Cooperative, Dakota Gasification Company, Montana-Dakota Utilities Company, Otter Tail Power Company, Great River Energy, SaskPower, The North American Coal Corporation, Westmoreland Coal Company, BNI Coal and Great Northern Power Development L.P. These organizations continue to express interest in participating in a review board to evaluate the viability of transport reactor technology for possible future commercial development.

Tax Liability

I, Rod Kuhn, certify that Basin Electric Power Cooperative does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

Rod Kuhn
Manager
Tax & Insurance

12/29/06
Date

Confidential Information

All data will be placed in the public domain as part of the PSDF gasification test with lignite coal.

The final report summarizing the project and its findings will be public information.

References

1. From Power Systems Development Facilities Website at http://psdf.southernco.com

2. Department of Energy Fossil Energy Website at http://fossil.energy.gov

3. TC13 Lignite Test Review Meeting held at the PSDF site in Wilsonville, Alabama

4. TC16 Lignite Test Review Meeting held at the PSDF site in Wilsonville, Alabama

Appendix A – Resumes

MICHAEL W. PAUL, P.E.

GAVIN McCOLLAM, P.E.

TOM SPAULDING

Dr. MICHAEL L. SWANSON

MICHAEL W. PAUL, P.E.
Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck, ND 58503-0564
(701) 355-5691
mikepaul@bepc.com

Qualifications

- B.S., Mechanical Engineering, University of North Dakota
- Registered Professional Engineer, North Dakota
- Over 28 years of electrical utility experience with six years stationed at three coal-based power plants

Professional Experience

December 2005 to present

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND
Vice President, Engineering & Construction
Provide central engineering and construction support services to meet the needs of Basin Electric. The Engineering & Construction Division is responsible for providing a broad range of strategic planning, research, design engineering, project management, construction management for Basin Electric, including new and existing operating facilities.

May 2001 to December 2005

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND
Manager, Mechanical and Performance Engineering
Manage the Mechanical and Performance Section of the Generation Department, Engineering and Construction Division to provide professional engineering support for Basin Electric's existing operating facilities, members, and subsidiaries. Also conduct studies and planning for future generation resources as well as options for meeting future needs at existing facilities. Served as Project Coordinator for the Wyoming Distributed Generation Project and currently assigned as Project Coordinator for the Leland Olds Station Repowering Project Study.

March 1987 to May 2001

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND
Mechanical/Performance Engineering Supervisor
Supervised the Mechanical/Performance Section of the Operations & Engineering Department, Engineering Division to provide professional, cost-effective and timely mechanical design and performance engineering activities for each of our coal-fired plants, as well as for our members and subsidiaries. Activities focused on coal-based power plant operations, performance, and maintenance activities to help ensure safe, reliable, and efficient operation. Assigned as Project Engineer for the Wyoming Distributed Generation project and was actively involved in the future coal-based generation and Leland Olds Station future options studies.

January 1986 to March 1987

Minnkota Power Cooperative, Milton R. Young Station, Center, ND
Engineering Superintendent

Managed the overall generation engineering needs of Minnkota including supervision of professional staff and employees represented by a bargaining agreement. Established and directed the overall plant performance program, coordinated design changes and procurement of equipment and systems, monitored plant water management and chemistry programs, conducted economic and technical feasibility studies, provided technical support and recommendations on plant operations, prepared budgets, and directed plant documentation and drafting efforts. Responsibilities also included working with Minnkota headquarters departments and the other Square Butte project participant.

August 1983 to January 1986

Basin Electric Power Cooperative, Antelope Valley Station, Beulah, ND
Results Engineer

Monitored and reported performance of plant equipment and systems, ensured proper chemistry control of all plant systems, directed plant water management including environmental concerns, supervised lab technicians, assisted in design and operational modifications of plant equipment and systems, and monitored coal quality.

September 1982 to August 1983

Basin Electric Power Cooperative, Antelope Valley Station, Beulah, ND
Mechanical Engineer

Involved with initial Unit 1 start-up, including design changes, supervised boil-out and boiler chemical cleaning, prepared and supervised equipment testing for a full American Society of Mechanical Engineers turbine test, participated in water balance and vibration monitoring, and provided technical support to plant operations and maintenance. Worked closely with design, construction and start-up groups.

October 1979 to September 1982

Basin Electric Power Cooperative, Production/Design Division, Bismarck, ND
Mechanical Design Engineer

Monitored and directed the design and purchase of mechanical equipment and systems for the Antelope Valley and Laramie River Stations.

May 1978 to October 1979

Basin Electric Power Cooperative, Wm. J. Neal Station, Velva, ND
Mechanical Engineer

Engineering and supervision of a plant upgrade to 50 MW, compliance testing of retrofit precipitators, monitored progress of a Babcock & Wilcox pilot dry scrubber, engineering and initial test burns of sunflower hulls in the main boilers, and operating plant engineering and supervision as required.

September 1977 to May 1978

Engineering Experiment Station, University of North Dakota, Grand Forks, ND
Student Engineer

Involved in the engineering of several solar energy and heat pump projects.

June 1977 to August 1977

Clark Equipment Company, Melroe Division, Gwinner, ND
Summer Engineer

Quality control for welding, fabricating, machining, and assembling various models of the Bobcat skid steer loader.

Professional Memberships, Certifications, Organizations

- American Society of Mechanical Engineers
- Registered Professional Engineer in the State of North Dakota
- North Dakota State Department of Health, Certification as a Class II Water Treatment Plant Operator
- Energy Generation Conference Executive Committee – five years

GAVIN A. McCOLLAM, P.E.
Basin Electric Power Cooperative
1717 E. Interstate Avenue
Bismarck, N.D. 58503-0561
(701) 355-5770
gmccollam@bepc.com

Qualifications

- B.S., Mechanical Engineering, North Dakota State University
- M.S., Systems Management, University of Southern California
- Registered Professional Engineer, North Dakota
- Over 17 years of energy generation experience with six years stationed at a coal gasification facility

Professional Experience

January 2006 to present

Basin Electric Power Cooperative, Bismarck, ND
Manager, Mechanical and Performance Engineering
Manage the Mechanical and Performance Section of the Engineering and Construction Division to provide professional engineering support for Basin Electric's existing operating facilities, members, and subsidiaries. Also conduct studies and planning for future generation resources as well as options for meeting future needs at existing facilities.

March 2005 to January 2006

Basin Electric Power Cooperative, Bismarck, ND
Mechanical Engineering Supervisor
Supervised the Mechanical Engineering Section of the Engineering and Construction Division to provide professional, cost-effective and timely mechanical design engineering activities for Basin Electric's coal-fired plants, members, and subsidiaries.

September 2000 to March 2005

Dakota Gasification Company, Beulah, ND
Mechanical & Civil Engineering Supervisor
Supervised the Mechanical & Civil Engineering Section of the Plant Engineering Department to provide professional, cost-effective and timely mechanical and civil engineering designs for the operation and maintenance departments of the facility.

February 2000 to September 2000

Dakota Gasification Company, Beulah, ND
Mechanical Engineer
Provided cost-effective and timely mechanical engineering designs for the operation and maintenance departments of the facility.

June 1998 to February 2000

Sargent & Lundy, Chicago, IL
Senior Mechanical Engineer
Provided consulting engineering design services to various clients in the energy generation field.

March 1991 to June 1998

Basin Electric Power Cooperative, Bismarck, ND

Mechanical Engineer

Provided professional, cost-effective and timely mechanical designs for Basin Electric's coal-fired plants, members, and subsidiaries.

November 1989 to March 1991

Dakota Gasification Company, Beulah, ND

Plant Engineer

Provided cost-effective and timely mechanical designs for the operation and maintenance departments of the facility.

July 1987 to November 1989

Naval Warfare Assessment Center, Corona, CA

Mechanical Engineer

Participated in Technical Program Reviews of Quality Assurance programs at contractors and navy facilities involved with the Trident II ballistic missile program.

TOM SPAULDING
Basin Electric Power Cooperative
1717 E. Interstate Avenue
Bismarck, N.D. 58503-0561
(701) 355-5716
tspaulding@bepc.com

Qualifications

- B.S., Mechanical Engineering, North Dakota State University
- 15 years chemicals/plastics industry experience and 2 years gasification/electrical utilities experience

Professional Experience

May 2006 to present

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND
Mechanical Engineer
Participated in various stages of development for the NextGen project that utilizes GE IGCC entrained-flow technology. Currently involved with Wilsonville-PSDF related activities.

January 2005 to May 2006

Dakota Gasification Company, Beulah, ND
Mechanical Engineer
Provide engineering support to meet plant operating, environmental and safety performance objectives. Typical responsibilites included: 1) defining job scopes, 2) prepare estimates, 3) prepare/evaluate bid proposals, 4) prepare equipment specifications, 5) perform preliminary/final designs and 6) prepare design packages for submittal.

September 1995 to January 2005

Chevron Phillips Chemical Company, LP, Borger/Houston, TX
Team Leader/Production Engineer
Responsible for various operational aspects of polyphenylene sulfide (PPS) and K-Resin, production including product quality, environamental and safety performance. Typical responsibilities included: 1) preparing daily operating instructions, 2) preparing month end finanical/production reports, 3) initiating/overseeing maintenance activities, 4) providing technical/troubleshooting support and work direction, 5) initiating/implementing improvement projects, 6) preparing annual operating budget forecasts, and 7) investigating quality/environmental/operating excursions.

October 1989 to September 1995

Phillips Petroleum Company, Borger TX
Plant-Design Engineer
Provide engineering support to meet plant operating, environmental and safety performance objectives. Managed Capital Budget Projects from inception phase through completion. Summary of typical design related activities included: 1) Develop scope/establish Premises, 2) Preliminary Design, 3) Process Hazards Analysis, 4) Prepare Equipment Specifications, 5) Prepare/submit/evaluate bid packages, 6) Prepare Cost Estimate, 7) Prepare Economic Analysis & Safety Justification for Funds Approval, 8) Final Design, 9) Equipment/Material Procurement, 10) Oversee construction activities and 11) Conduct Pre Start-Up Safety Review (PSM requirement).

DR. MICHAEL L. SWANSON
Senior Research Manager
Energy & Environmental Research Center (EERC)
University of North Dakota (UND)
PO Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone (701) 777-5000 Fax (701) 777-5181
E-Mail: mswanson@undeerc.org

Principal Areas of Expertise

Dr. Swanson's principal areas of interest and expertise include integrated gasification combined cycle (IGCC), pressurized fluidized-bed combustion (PFBC), hot-gas cleanup, coal reactivity in low-rank coal (LRC) combustion, supercritical solvent extraction, and liquefaction of LRCs.

Qualifications

Ph.D., Energy Engineering, University of North Dakota, 2000. Dissertation: Modeling of Ash Properties in Advanced Coal-Based Power Systems.
M.B.A., University of North Dakota, 1991.
M.S., Chemical Engineering, University of North Dakota, 1982.
B.S., Chemical Engineering, University of North Dakota, 1981.

Professional Experience

1999 – Senior Research Manager, EERC, UND. Dr. Swanson is currently involved with the demonstration of advanced power systems such as PFBC and IGCC, with an emphasis on hot-gas cleanup issues.

1997 – 1999 Research Manager, EERC, UND.

1990 – 1997 Research Engineer, EERC, UND.

1986 – 1990 Dr. Swanson supervised a contract with the U.S. Department of Energy (DOE) to investigate the utilization of coal–water fuels in gas turbines. He has designed, constructed, and operated research projects that evaluated the higher reactivity of LRCs in short-residence-time gas turbines and diesel engines.

1983 – 1986 Dr. Swanson's responsibilities included the design, construction, and operation of supercritical fluid extraction (SFE) and coal liquefaction apparatus; characterization of the resulting organic liquids and carbonaceous chars; and preparation of reports.

1982 – 1983 Associated Western Universities (AWU) Postgraduate Fellowship, DOE Grand Forks Energy Technology Center. Dr. Swanson’s responsibilities included the design and construction of a SFE apparatus.

1981 – 1982 Graduate Teaching Assistant, Department of Chemical Engineering, UND.

Summer 1982 Research Assistant, Department of Civil Engineering, UND.

1980 – 1981 AWU Student Participant, DOE Grand Forks Energy Technology Center.

Professional Memberships
- American Institute of Chemical Engineers
- American Chemical Society, Fuel Chemistry Division

Publications and Presentations
- Has authored or coauthored over 80 publications

Appendix B – Correspondence

Lignite Energy Council – Jeff Burgess

Southern Company Generation – Randall Rush

Lignite Energy Council
PO Box 2277
Bismarck, ND 58502
Telephone: (701) 258-7117
Fax: (701) 258-2755

March 28, 2006

Randall Rush, Director
Power Systems Development Facility
Southern Company Services, Inc.
Highway 25 North
PO Box 1069
Wilsonville, AL 35186

Dear Randall:

The North Dakota lignite industry IGCC Team was encouraged during our December 2, 2005 dinner meeting and discussion about Southern Company and KBR's intent to commercialize the TRIG gasifier for power and F-T liquids. The team was also encouraged that the high-sodium lignite test has been rescheduled targeting the 4th quarter of 2006 – 1st quarter of 2007. We understand that on-going modifications will address properties of Fort Union lignite, and that shakedown and a long-term PRB test will be conducted to compare TRIG performance to previous PRB tests, prior to the lignite test.

During a recent IGCC team meeting, our members discussed TRIG performance and information needed for industry engineers' to fully evaluate a Fort Union, high-sodium lignite using this technology. Following are some of our industry engineers' expectations for information to further support evaluation of the TRIG technology for high-sodium North Dakota lignite applications:

- Continuous air-blown 1,000-hour test using lignite with sodium levels ranging from 8 % to 12 % at operation parameters that would be representative of chemical and thermal equilibriums anticipated in commercial practice. Requested information includes:
    - The 1000-hour test duration should represent chemical and thermal equilibriums.
    - Characterize coal feed operation and performance.
    - With respect to optimizing performance, characterize gasifier temperatures, coal feed, ash fluidization-recycle flows, operation of the particulate filters and pressure drop.
    - Following the test completion, visual inspection of critical area should be conducted to evaluate agglomerates due to the high-sodium lignite.
    - Unburned carbon: less than 5%.

- Detailed chemical analyses of chemical and coal input spanning test initiation and steady state duration.
  - Syngas chemical composition prior to combustion and pollutant emission levels.
  - Detailed energy and mass flows of inputs and outputs.
  - Agglomeration growth (as a function of time) in the combustion zone and circulation/recycle loop, and agglomerate deposits in duct passages, and methods to minimize agglomeration and deposition.

- Commercial expectations:
  - Air-blown TRIG for power generation with Heat Rate efficiency of 36% to 38% with gas quality and composition suitable for a commercially available combustion turbine.
  - Full vendor commercial guarantee wrap (including operation with high-sodium levels)
  - Capacity of 95 %, availability of 90 %.
  - Unburned carbon less that 5 %.
  - Emissions are environmentally compliant.
  - Adaptable for economically competitive carbon dioxide removal.
  - SCS/KBR commercialization strategy.
  - ND lignite application economics.

Following completion of the high-sodium lignite test, the IGCC team respectfully requests a detailed report and meeting at your PSDF facility to discuss and review the test results and impacts on equipment (if any). In summary, our lignite industry engineers remain very interested in the TRIG gasifier as an option for future IGCC and coal-to-liquids applications and look forward to the upcoming lignite test.

If you have questions of our information expectations and needs, please call Mike Paul at (701) 355-5691 or me at (701) 258-7117.

Sincerely,

Jeff Burgess, P.E., Director
Research & Development Program
Lignite Energy Council

Lignite Coal: America's Abundant Energy Resource
www.lignite.com

Randall E. Rush
Director
Power Systems
Development Facility
Research & Environmental
Affairs

Southern Company Generation
Post Office Box 1069
Wilsonville, Alabama 35186

Tel 205.670.5842
Fax 205.670.5843
rerush@southernco.com

SOUTHERN COMPANY
Energy to Serve Your World®

April 21, 2006

Jeff Burgess, P.E., Director
Research and Development Program
Lignite Energy Council
P. O. Box 2277
Bismarck, ND 58502

Dear Jeff,

We appreciate your letter of March 28th and the Lignite Energy Council's continued interest in ongoing technology development at the Power Systems Development Facility. Transport gasifier modifications are proceeding and are expected to be complete in July. After commissioning tests are completed, a test with PRB in air-blown mode and oxygen-blown mode is expected to begin in late summer. This test is planned to last 750 hours, but the length may be shorter or longer depending on the pace at which we gain comfort with operations in the new configuration. In preparation for a long-term test with high-sodium lignite, we currently plan to complete a test of nominally 750 hours with both low- and high-sodium lignite in air-blown mode in the fall. A 1000-hr test with high-sodium lignite in air-blown mode is scheduled for early 2007. The order of and approach to this testing is based on suggestions in your letter, conversations with Mike Paul of Basin Electric, and recent conversations with the Department of Energy (DOE). A summary of the test schedule is enclosed.

During these tests the gasifier and particulate filter will be characterized over a range of conditions to optimize process performance and maximize carbon conversion. The gasifier temperature and pressure differential profiles and solids samples will be closely monitored. A key issue during high-sodium lignite testing will be to evaluate the potential of agglomerate formation. Additional objectives will include evaluation of the coal feed and ash removal system's operation and performance. Following each run, a detailed gasifier and particulate filter inspection will be performed. All observations and results will be documented and discussed in a meeting at the PSDF following the run. As we begin development of the detailed test plan we will welcome input from representatives of your organization.

Your letter also mentioned some specific expectations related to guarantees for a commercial plant that might follow successful testing of high-sodium lignite. Southern Company and KBR are in the process of finalizing our commercialization strategy for coal-to-power and coal-to-chemicals based on transport reactor integrated gasification (TRIG™) technology. In our respective businesses as a power plant owner/operator and as a world-scale supplier of chemical and energy technology both Southern and KBR appreciate that commercial issues will be critically important to customers of TRIG™ technology. It would be premature to comment in detail on commercial issues, but we are confident that the relevant issues can be dealt with when specific projects are discussed in the future.

Again, I thank you for taking the time to formally express the Lignite Energy Council's interest in the work at the PSDF. I believe that our relationship has been mutually beneficial and expect that future work will benefit not only our respective organizations, but the DOE and the Nation as a whole.

Sincerely,

cc: Mike Paul

Appendix C – Status Reports

POWER SYSTEMS DEVELOPMENT FACILITY
TEST RUN TC16 :: GASIFICATION RUN
OPERATING SUMMARY FOR 07/13/04 – 08/24/04

Process Observations/Accomplishments

- The Transport Gasifier operated for a total of 835 hours in TC16, 653 hours using Powder River Basin (PRB) coal and 182 hours using high sodium lignite from the Freedom mine in North Dakota. The total amount of time the Transport Gasifier has operated is now 6109 hours. The total amount of time the gasifier has operated in oxygen-blown mode is 1665 hours.
- The table below summarizes the gasifier performance based on fuel type and oxidant:

	PRB		Lignite
	Air	**Oxygen**[1]	**Air**
Hours of Operation	465	395	182
Maximum Temperature, °F	1760 -1850		1500-1600
Gasifier Exit Pressure, psig	200-220	155-200	150-160
Carbon Conversion, %	92-97	92-97	82-86
Actual Lower Heating Value, Btu/SCF	55-72	64-91	42-59
Commercial Lower Heating Value, Btu/SCF	99-126	147-193	101-115
Sulfur Emissions, ppm	200-350	300-475	750-970
Standpipe Particle Size, microns	170-225	~275	~175

- Typical riser velocities ranged from 40 to 50 ft/s during both air- and oxygen- blown operations.
- As the test run began, the gasifier continuously lost a small amount of bed material due to low coal feed rate and lower cyclone/disengager efficiency. The loss of material continued for several days, but eventually stopped and the bed level began to increase. Unfortunately, the standpipe screw cooler would not operate due to a piece of debris that wedged between the screw flights and housing, preventing rotation. A short outage in the middle of the test run was necessary to clear the screw cooler and determine if the cyclone was experiencing the same erosion problem that was found in TC14. The notch that appeared after TC14 appeared to be reforming.

[1] Another 25 hours were enriched-air periods during air-to-oxygen transitions.

- Standpipe operations were smooth during most of the test run. Recent data indicate that (for normal operations) the standpipe will not pack as long as the loop seal inlet is not blocked by the circulating solids. The data also show that whenever severe packing does occur the standpipe is able to recover.
- During the lignite portion of the test run, the size and shape of the standpipe particles did not change over time indicating that no agglomerations were forming and that sodium did not accumulate in the standpipe. During Test Run TC13, the standpipe particle size increased over time eventually leading to deposits which blocked the loopseal, stopping circulation.
- Due to the gasifier operating conditions, no deposits formed during the high sodium lignite portion of the test run. One of the differences between TC13 and TC16 was the use of dolomite as an additive. The dolomite used in TC16 seems to have reacted with the sodium in the lignite to create a complex with a melting point above the gasifier operating temperature. Also in TC16, solids removed from the gasifier from the first part of the run were used as startup bed material.
- Selected horizontal thermowells in the mixing zone were lengthened for evaluating the effects of stem losses and thermal shunting. Wells extending one inch past centerline did not suffer the effects of stem loss temperature errors as the bed material transitioned from dense to dilute phase. The shorter thermowells, penetrating 2 inches past the refractory, yielded measurement errors in excess of 30 degrees.
- Parametric tests were performed using the fluidized bed coal feeder during TC16. Data compression was turned off for several process variables to increase the resolution for the model development. Each test was performed when the gasifier was at steady state conditions. All manipulated variable controllers were in automatic except for the targeted bump test controller. Except for gasifier pressure and coal conveying line differential pressure, all tests were performed by moving the controller output by a pre-determined percentage.
- Robust thermowells 1.5 inch diameter penetrating 12 inches into the riser section at a steep 30 degree angle to the gasifier shell were added at three elevations in the riser. The wells were made of Hastelloy X for coefficient of expansion compatibility with the Pyrocil D sheath material of the 0.375" diameter type N thermocouple. The Hastelloy X was coated with approximately one-eight inch of Stellite # 1 using a plasma transfer process. The penetration of these wells into the process provided baseline measurements since stem loss effects and thermal shunting were negligible. The proper length to diameter ratio for mitigation of stem losses and thermal shunting was established in a thermowell test during TC15.
- Many wet samples were carefully collected at various locations in the process both to analyze for trace metals and organics in the raw syngas and to determine the removal efficiencies with pure condensate (from syngas) and with condensate scrubbing. The samples are being analyzed.
- The annual air compliance stack testing was performed on August 2nd by Sanders Engineering and the results submitted to the Alabama Department of Environmental Management on August 27th. Testing was performed on the Kellogg stack and on the

Foster Wheeler stack with the PSB fired on syngas. The test results confirmed the facility is in compliance with its air permit.

- The test run ended as scheduled on September 24, 2004. The shutdown was smooth, leaving no transient cake on the PCD filter candles.

Equipment Summary

- A Delphi solid oxide fuel cell operated on syngas generated in the Transport Gasifier for 118 hours during the test run. The first fuel cell stack ran for 28 hours, during which time the performance declined significantly. A high concentration of high molecular weight hydrocarbons in the syngas likely contributed to the fast degradation. A new hydrocarbon cracker in the hot gas cleanup train was in service during the testing of the second fuel cell stack. The new hydrocarbon cracker slowed the degradation, and the fuel cell performance only degraded slightly during the first eight hours of testing, then remained steady for 82 hours. Although the second test could have continued for a long period of time, the test stand control system malfunctioned and shut the system down after the 82 hours of steady operation.
- To prepare for fuel cell operation, the syngas cleanup units tested desulfurization sorbents, HCl sorbents, and a nickel-based catalyst for ammonia and organics cracking. The syngas cleanup units operated for 577 hours. Both the hot and cold gas cleanup units ran well without plugging. Improvements in gas conditioning techniques provided consistent gas samples to the analyzers. The gas cleanup units were able to supply the fuel cell with clean syngas that contained less than 100 ppb sulfur compounds and less than 1 ppm HCl. During the last 72 hours of fuel cell operation, the gas cleanup system was able to reduce the total condensable organic content in the syngas to below 300 ppm by cracking the organics using the nickel-based catalyst at 1600°F.
- The piloted syngas burner (PSB) operated on syngas for around seven hours on 7/30/04 and 8/3/04, at syngas flow rates up to 13,000 pph and the combustion turbine (CT) operated for about 20 hours. However, a high frequency noise in the turbine curtailed subsequent turbine testing for both simple cycle and syngas operation. Large syngas burners in the past have experienced damage from pressure pulsations initiated by flow induced harmonics or an unstable flame. The SCS Engineering Testing group and Siemens-Westinghouse (SWPC) determined that destructive pressure pulsations were not present in the PSB combustor, but test conditions did not permit further turbine testing in TC16.
- The atmospheric syngas burner ran well during the test run, easily combusting the syngas derived from the PRB coal. The energy input of the pilot propane was often less than 5% of the total energy input to the burner.
- The new steam/oxygen eductor operated for the first time. It worked very well, blending the steam and oxygen and allowing oxygen addition at higher gasifier pressures. The gasifier exit pressure ranged between 145 and 155 psig using the standard oxygen/steam mixer. The eductor system boosted the oxygen pressure to support operations at gasifier exit pressures from 155 psig up to 200 psig (around 215 psig in the lower mixing zone).

- The original coal feeder (FD0210) operated well in TC16, feeding about 1362 tons of fuel to the gasifier over a 27 day period. Occasionally, coal fines accumulating in the silo, causing the coal feeder to have difficulty transporting the coal through the lock vessel. The feeder did not have any problems with the moisture in either the PRB coal or the lignite. The fluidized bed coal feeder (FD0200) fed for a period of about 20 hours.
- Most of the gasifier gas analyzers were online for the majority of the test run, providing good gas composition data. The dry gas compositions added up to between 101.5 and 102.5% on a consistent basis.
- The atmospheric fluidized bed combustor ran smoothly during the test run, generating large quantities of high quality superheated steam for use in the gasifier. The atmospheric fluidized bed combustor ran on fuel oil for the entire test run. The spent solids feeder fed gasification ash to the silo for collection.

PCD system observations

- PCD operations were stable throughout the run. PCD temperatures, pressure drop, and outlet sampling showed stable operation while testing the different fuel/sorbent combinations. Bridging did occur during the first portion of the run, but did not recur during the second portion which consisted of both PRB and lignite fuels.
- The rupture disc failsafe tester was successfully used with the Pall fuse to simulate catastrophic filter failure. Outlet loading after the test was below the detection limit.
- Outlet loading sampling indicated a small amount of particle penetration of up to 0.4 ppmw during the first two days of the run. However, outlet loading was below the lower limit of detection of 0.1 ppmw for the majority of the run.
- During the July portion of the run, the top and bottom back-pulse pressures were initially kept at 150 psi above system pressure for both plenums, while the back-pulse cycle time was varied from 5 to 20 minutes. After bridging was indicated by filter thermocouples and resistance probes, back-pulse pressure and frequency were increased to prevent further build-up of material.
- Following the first shutdown in July, a manway inspection was completed. During this inspection, bridging was found to cover a large portion of the bottom plenum, about 25% of the filter surface area, and the majority of these deposits were physically removed.
- Controlled combustion of the filter dust cake was performed immediately after coal feed was stopped during both portions of the run. Filter thermocouples showed well-controlled combustion initially starting at around 2 to 3% oxygen at PCD temperatures of 600 to 700°F. The combustion apparently did not affect the extent of bridging present during the first portion of the run, but did successfully combust some of the dust cake in both cases.
- During the run, back-pulse testing was conducted with varying parameters. Pressure changes inside a filter, inside the plenum, and in the PCD vessel were measured with a high speed data acquisition device.

- The continuous fine ash depressurization system (CFAD) worked very well and ran for 834 hours during TC16. Since the PCD solids collection rate was over 400 pph for most of the test run, the CFAD unit operated in continuous mode. The new automatic level control was tested at the end of the test run and worked well.

Post-run Inspections

- Initial post-run inspections showed the riser, standpipe, secondary crossover, and lower mixing zone to be clean. A loose pile of material had accumulated in the riser crossover, and the disengager showed a few small deposits on the wall. The loop seal downcomer contained the usual few soft deposits, but were slightly thicker. The cyclone cone section was lined with a thin coating of deposits.
- The primary gas cooler inspection revealed only a light coating of dust, although the ferrules had a small amount of material in them.
- The PCD inspection showed one broken filter. The iron aluminide filter element was broken at a welded junction, possibly by bridged material. The Pall fuse failsafe above this filter was apparently effective in preventing significant particle penetration since the outlet loading samples were below the detectable limit for the majority of the run.

Power Systems Development Facility
Test Run TC16 :: Gasification Test Run
Summary Event Log for 07/13/04 – 08/24/04

Startup Activities

Prior to TC16, operators checked the gasifier for leaks, and maintenance crews repaired the leaks. Once the gasifier was sealed, the PCD preheat began with a gasifier pressure of 60 psig. Since the new sand feeder was capable of filling the system with sand at pressure, we added sand after achieving a pressure of 60 psig. Since the gasifier nozzles all had flow through them at this point, none of them plugged. Once the PCD temperature was above 200°F for over one hour, the test run commenced with the lighting of the startup burner on Tuesday, July 13, 2004. Motor problems on the atmospheric syngas burner fan prevented going to coal feed until the next day.

Tuesday, July 13, 2004 (night)

The startup burner heated the gasifier during the night. The operators ran the standpipe screw cooler to test the system, but it depleted the gasifier solids at a rate faster than desired, so they shut it off after a few seconds. The spent fines system experienced problems in that several valves leaked, preventing the lock hopper from pressurizing. Thus, using the CFAD all night was necessary.

The replacement motor for the blower on the atmospheric syngas burner arrived around 2:00 AM. Several gas detector alarms went off around 4:00 AM for no apparent reason. Operations built drum pressure and tripped the atmospheric syngas burner around 4:30 AM to take clearance on the system.

Wednesday, July 14, 2004 (day)

Maintenance successfully replaced the atmospheric syngas burner blower motor. Operations then increased the atmospheric syngas burner firing rate to increase the steam drum pressure to 300 psig. Fuel oil heated the sulfator up to its normal operating temperature. Operators were unable to open the coal feeder dispense vessel vent valve, delaying the starting of coal feed. Eventually, E&I found the broken wires and repaired them, enabling the valve to open.

Operations reduced the riser velocity to stem the loss of solids level in the gasifier standpipe. Once the riser velocity had decreased, we initiated coal feed and reduced the burner firing rate. The gasifier pressure in the upper mixing zone (UMZ) was around 125 psig, and the riser velocity is about 50 ft/s, at this time.

Wednesday, July 14, 2004 (night)

Throughout the night, the coal feeder kept tripping on dispense vessel spheri valve failure to close due to sluggish operation. A small adjustment in the PLC logic prevented any more nuisance trips, and the feeder began working normally. When conditions stabilized, we tripped the startup burner, and began slowly ramping up the gasifier temperature by feeding coal (via the FD0210 coal feeder) at a low, controlled feed rate. When the gasifier temperature increased above 1650°F, we increased the coal feed rate, and syngas quality improved dramatically.

As the night progressed, we began to add steam to various locations in the gasifier. The upper mixing zone steam nozzles were plugged, however, with the exception of the FD0210 coal feeder steam shroud. Around 2:45 AM, the coal feeder tripped on what appeared to be a motor inverter fault. We reset the breaker, and coal feed resumed. The highest temperature in the gasifier was in the upper mixing zone—around 1825°F—while the gasifier exit temperature ran a little below 1650°F. The high mixing zone temperature may have been due to the extra long thermocouples being tested during the TC16 test campaign. The maximum coal feed rate was around 3000 pph during the night. The gasifier pressure was around 200 psig.

Thursday, July 15, 2004 (day)

During the day, the gasifier began to continuously lose solids at a rate of about 20 lb/hr. In the morning, we added sand to increase the standpipe level for LI339 to increase from 20 to 120 inH_2O. Then, the level gradually decreased about 3 inH_2O/hr, for no apparent reason.

Other than the loss of solids, the gasifier performed well. The temperatures in the mixing zone and riser were uniform, within 20°F of each other. The temperatures measured by extra long test thermocouples read the same as the shorter ones, indicating good mixing and solids circulation.

The CFAD functioned well, allowing the testing of the pinch valve in the discharge line. The pinch valve could be closed at 80 psi of casing pressure. The range of pressure difference in which the pinch valve can be operated to control a proper char discharge rate was narrow and provided inconsistent char flow rates.

We tested the new upper oxygen distribution nozzles (with air, however). The flow meter read correctly. The steam flow meter read well after the line heated.

Thursday, July 15, 2004 (night)

The gasifier operated well over the night with the highest temperature around 1800°F and the exit temperature around 1700°F. The exit pressure ran around 217 psig, with a coal feed rate of between 3500 and 3900 pph. The gasifier continued to lose sand at a variable rate throughout the night, but was often as high as 10 inches of water according to LI339 per hour. Therefore, adding sand was necessary via the new sand feeder. It fed at a high rate and upset gasifier temperatures briefly, but the system recovered quickly, and operated well for the remainder of the night.

Since the PCD differential pressure was low, we increased the back-pulse timer to 15 minutes. Shortly thereafter, we performed a few tests with the PCD, using back-pulse pressures of 150, 200, 250, and 300 psi above the system pressure. When the tests were complete, we left the back-pulse pressure at 150 psi above the system pressure.

We increased steam and air flows to the lower mixing zone (LMZ) and decreased flows to the new air/oxygen nozzles in the UMZ. We also introduced steam flow to the UMZ oxygen nozzles to further test the flow indication. In the middle of the night several carbon monoxide gas detector alarms went off. The leaks were impossible to find, however. The CFAD ran for most the night, and it operated well, using the orifices rather than the pinch valve.

Friday, July 16, 2004 (day)

In preparation for transitioning to oxygen-blown mode, we reduced the gasifier pressure. The air flow rates, coal feed rate, and aeration rates were also reduced to maintain a proper riser velocity. The initial attempt to introduce oxygen resulted in a rapid increase in riser temperatures likely due to the low carbon content in circulating solids. The manual valve on the oxygen feed line to the upper mixing zone was closed to ensure that no oxygen leaked by the automatic valves, causing the higher temperatures in the riser.

To maintain proper temperatures, we increased the coal feed rate and decreased the air flow rate to the upper mixing zone, and the riser temperatures decreased. Increasing the air flow rate to the lower mixing zone maintained overall gasifier temperatures. The second oxygen transition attempt around noon was successful. Later, the gasifier pressure was reduced further to improve mixing zone operations. The steam flow rate through the lower mixing zone was increased to maintain lower relative temperatures in the lower gasifier.

Friday, July 16, 2004 (night)

The night went smoothly. The gasifier continued to lose sand, necessitating the sand addition that occurred at 9:00 PM. The riser differential pressure began bouncing slightly thereafter. The bouncing differential pressure might have indicated slugging. The CFAD continued to remove material, during the night, but it continuously tripped, requiring multiple restarts. The carryover rate was high, since the vessel above the CFAD filled up quickly between CFAD feed periods. The coal feed rate was around 2800 pph during the night, with a maximum gasifier temperature (in the lower riser) ranging between 1800 and 1825°F. The gasifier exit pressure was 145 psig throughout the night. The steam flow rate to the gasifier was high, generating syngas with a moisture content of around 27%.

Saturday, July 17, 2004 (day)

The coal feed remained around 3000 lb/hr. Gasifier operations were stable with a uniform temperature profile. However, material loss from the gasifier continued to be excessive. We adjusted the aeration on the downcomer without any apparent effect. Periodic sand addition was necessary to maintain bed levels in the gasifier. Small adjustments in the coal feed rate and oxygen flow rate maintained the temperature profile during this time. The PCD back-pulse remained low, so we increased the timer to 20 minutes.

During the day, syngas flow to the fuel cell gas cleanup processes began so that we could evaluate gas analysis systems in preparation for sending syngas to the fuel cell. CFAD operation continued, this time using the pinch valve instead of the orifices.

Saturday, July 17, 2004 (night)

The gasifier operated rather steadily through the night. We maintained a coal feed rate of about 3100 pph. We closed all the aeration associated with the cyclone, and we seem to have had a modest effect on the cyclone. Adding sand to the gasifier is still necessary periodically. Also during the night, the fuel cell preheating took place.

Sunday, July 18, 2004 (day)

Gasifier has operated well during the day. The syngas LHV was 85 Btu/SCF (183 Btu/SCF corrected). The coal feed rate was at about 3000 pph, the oxygen flow rate at 2150 pph, the air flow rate at 1300 pph, and the steam flow rate at 3750 pph. The carbon conversion was 94%. Syngas flow to the fuel cell started during the day.

Sunday, July 18, 2004 (night)

The gasifier and all auxiliary systems ran well throughout the night. Only one sand addition was necessary. We tried to start feeding with a lower differential pressure and limited the conveying gas flow in order to lessen the effects of adding the sand, but the temperature swings seemed to be greater than normal.

Monday, July 19, 2004 (day)

The gasifier continued to run well. We still continued to add sand periodically. The particle size of the PCD samples seem to be similar to those of previous test runs. We made several small changes to the gasifier operating parameters to see their effects on the decline in standpipe level. The CFAD continued to run throughout the shift, performing well.

Monday, July 19, 2004 (night)

The unit ran without any major problems. We ran the limestone feeder for a while and the decrease in the standpipe level almost stopped. When the feeder ran out of limestone, we did not refill it, and the standpipe level remained constant for a short period of time, but after midnight, it began declining again. Some of the resistance probes in the PCD seemed to have indicated a leak in the PCD, but the thermocouples continued to respond to back-pulses.

Tuesday, July 20, 2004 (day)

The gasifier continued to ran well. Around 3:00 PM, operations shut down the fuel cell. The CFAD continued to function smoothly and was easy to operate. Throughout the day, we continuously added limestone at a rate of roughly about 150 lb/hr and were about to keep the standpipe level constant (according to LI339, around 100 inH_2O).

Tuesday, July 20, 2004 (night)

We did not have to add any sand to the gasifier all night. We increased the coal feed rate slightly and maintained the sorbent feed at 10% to try and hold the standpipe level. Although the gasifier did not require any additional sand, the standpipe level still decreased at a rate of 2 to 5 inches of water per hour, according to LI339.

We performed pressure testing on the PCD at various levels of back-pulse pressure. The higher pressure did lower the resistance probe readings. Later, we adjusted the back-pulse pressure to 150 psi above reactor pressure on both plenums, and changed the valve open time to 0.5 seconds.

The sulfator required 6000 pounds of sand addition to bring the level back to optimum. We also reduced the air flow rate to the sulfator slightly and reduced the diesel fuel flow rate.

Wednesday, July 21, 2004 (day)

The unit was steady all day. The syngas LHV was 86 Btu/SCF (180 Btu/SCF corrected). The coal rate was at about 3,500 pph, the oxygen flow rate at 2,250 pph, the air flow rate at 925 pph, and the steam flow rate at 3,300 pph.

We adjusted the back-pulse timer to five minutes to see the response of the resistance probes in the PCD. The resistance probes began to respond better to the back-pulse. We also changed the open time of the valve to 0.2 seconds on the top plenum.

Wednesday, July 21, 2004 (night)

The gasifier operated smoothly throughout the night at 155 psig and with a highest temperature around 1800°F. The coal feed rate was around 3400 pph, and the feeder ran in automatic for a large portion of the night, but was restored to manual feeder control when the controller allowed the gasifier temperatures to climb too high. The limestone feed rate was around 170 pph. The gasifier continued to lose sand at faster than expected rates, though the limestone fed to the gasifier reduced the level loss slightly.

Sulfator operations were not smooth due to a faulty oxygen analyzer. The analyzer kept tripping the fuel oil system, reducing the sulfator and superheated steam temperatures. Towards the end of the shift, the Foster Wheeler coal mill reject line plugged, requiring the use of the Kellogg mill (which had been shut down).

Thursday, July 22, 2004 (day)

The gasifier continued to run well. The gasifier inventory increased gradually throughout the day due to the coal from MWK silo being slightly coarser. The highest temperature in the gasifier remained 1800°F. The cyclone exit temperature, however, increased to 1685°F.

The CFAD also operated well. With a solids removal rate of around 800 to 1000 lb/hr, the CFAD discharge pressure was around 20 psig.

The PCD resistance probes continue to read values, but they are stable with a five minute back-pulse timer, a pressure of 150 psi above system pressure, an open timer of 0.2 seconds for the top plenum back-pulse, and an open time of 0.5 seconds for the bottom plenum. During the day, SRI performed PCME solids injection testing today.

Maintenance repaired the sulfator oxygen analyzer in the morning. Since then the sulfator operated well. The oxygen, carbon dioxide, and the exit gas flows fluctuated a great deal, however, but all of the other measurements were steady.

Thursday, July 22, 2004 (night)

The gasifier operated well throughout the night. Due to the coarse coal and the high limestone feed rate, the standpipe level actually began to increase. A reduced coal feed allowed the gasifier to maintain a nearly constant standpipe level and solids circulation rate. The limestone silo ran out of material midway through the night, marking the end of limestone feed for TC16 in order to prepare for the dolomite testing that will occur during the lignite portion of the test run.

Friday, July 23, 2004 (day)

The gasifier ran smoothly. In the early morning, the coal feed rate was about 3000 lb/hr, and the standpipe level gradually decreased about 2 inH_2O per hour according to the differential pressure measurements. When the coal feed rate was slowly increased to 3600 lb/hr, the solids level in the standpipe started to increase. Around 10:30 AM, the sorbent feeder began adding dolomite to the gasifier. When dolomite feed began, the standpipe level started growing, and it reached 150 inH_2O around 1:00 PM.

Gas cleanup liquid sampling took place around noon. Some of the PCD resistance probes increased in value, and we adjusted several parameters to reduce them. Later in the day, SRI continued PCME testing.

Friday, July 23, 2004 (night)

The gasifier continued to run well at a coal feed rate of around 3300 pph. During the night, the standpipe level began to climb. We stopped the sorbent feeder to maintain a set level and to conserve dolomite. The feeder had been feeding dolomite at a rate of around 120 pph. The fuel cell ran on calibration hydrogen throughout the early morning.

Saturday, July 24, 2004 (day)

The gasifier operated smoothly throughout the day. Both coal feeder and the CFAD ran well also. Even without feeding dolomite (since 8:00 PM last night), the gasifier inventory remained constant. Apparently, with the particle size in MWK coal silos, the cyclone performance was sufficient. To prepare for the lignite run and to minimize amount of sand in the circulation, we decided to feed dolomite around 12:30 PM. Then, the solids level in the gasifier started increasing again. When LI339 read 170 inH_2O, we ran the standpipe solids removal system for 25 minutes to reduce LI339 to 145 inH_2O.

During the day, the PCD resistance probes began to decline in value on their own. None of the thermocouples in the PCD indicate bridging.

The minigasifier (in the hot gas cleanup system) started heating up in the early morning. Syngas flow to the minigasifier began around at 10:30 AM. The minigasifier appeared to be functioning as a hydrocarbon cracker and converted over 95% of the benzene and over 70 of the methane, with a flow rate of 20 lb/hr. At 25 lb/hr, the hydrocrabon conversion was about 90%. Syngas was sent to the Fuel Cell system via the hot gas cleanup slipstream at 3:30 PM.

Saturday, July 24, 2004 (night)

The gasifier ran smoothly all night at the same conditions as in previous nights. During the night, the coal feeder dumps began to drop off, indicating that some fines had entered the system. We swapped back to the Kellogg coal silo and the coal feeder performance improved. The standpipe level increased gradually throughout the night, requiring us to run the screw cooler once for a few minutes. Dolomite feed to the gasifier occurred all night long to help remove sulfur compounds and prevent fuel cell degradation. Other than a brief trip that occurred due to a software problem with the fuel cell, a small slipstream of syngas flowed to the fuel cell all night long.

Sunday, July 25, 2004 (day)

All system were in good order during the shift. A continuous dolomite feed existed at a rate of 100 lb/hr. Periodically, the increasing gasifier inventory required the use of the standpipe solids removal system to to keep solids level constant.

The fuel cell also ran well generated around 550 W at 22 V. The rate of degradation of the output of fuel cell seems to be much slower compared to the last test. The minigasifier continuously converted over 90% of the hydrocarbons in the syngas.

Sunday, July 25, 2004 (night)

The gasifier ran well during the night, but the fuel cell tripped a few times due to software communication problems. We continued to feed dolomite at a rate just below 100 pph. The standpipe level remained constant without any sand addition, and even required the occasional use of the standpipe screw cooler to remove excess bed material.

Monday, July 26, 2004 (day)

Gasifier operations were stable. The gasifier solids removal system operated periodically to maintain a constant solids level in standpipe. The gas cleanup system and fuel cell operated continuously throughout the day. Minor adjustments to the sulfator operating parameters optimized its performance.

Monday, July 26, 2004 (night)

The gasifier tripped during the night when coal feeder experienced difficulty transferring fine coal from the surge bin to the dispense vessel. The operators also struggled with CFAD for much of the night, when material plugged in its exit line. Also, the nitrogen tanks level ran very low on nitrogen tank levels during the night, but BOC delivered the nitrogen in time to continue operations. After these periods of unsteady conditions, we were able to restore the gasifier to steady state oxygen-blown operations.

Tuesday, July 27, 2004 (day)

Gasifier operations were smooth for the day with the exception of one problem with the coal feed system. Due to changes in coal particle size, the lock vessel was overfilled causing the vent lines to plug. The coal and oxygen flow rates were reduced to conserve coal while the lines were unplugged. The gasifier returned to steady state operations after the problem was resolved.

Tuesday, July 27, 2004 (night)

The gasifier operated well throughout the night. A few differential pressure ports plugged around midnight, and some of the thermocouples show signs of failing. A steady stream of nitrogen trucks has brought the tank levels back up to sufficient values.

Wednesday, July 28, 2004 (day)

The gasifier operation was smooth by all indications. The solids level in the standpipe continuously grew over time at a coal feed rate of 3300 lb/hr and a dolomite feed rate of 110 lb/hr. According to the FD0530 weigh cell, the solids discharge rate from the PCD was roughly 300 lbs/hr. The gasifier temperatures were uniform from the bottom to the top. With the lone exception of one new thermocouple, which extended deep into the riser and was located at the entrance to the riser, all other thermocouple readings are within the difference of 75°F.

The CFAD ran well also, and the flow resistance through the granular filter has stayed low after operations back-flushed it on Sunday. The solids discharge rate was around 600 lb/hr.

Delphi completed the fuel cell testing for the run today. .

Wednesday, July 28, 2004 (night)

At the beginning of the shift, the coal feeder began to have difficulty transferring coal from the surge bin to the dispense vessel. Since the coal mill was down for a portion of the day, a large amount of fines had collected in the surge bin, causing material bridging that hindered the transfers. Once the coal mills began to operate, the problem rectified itself.

Despite the instability of the coal feeder, the gasifier ran well at 155 psig and at a gasifier exit temperature of around 1675°F. The coal feed rate was around 3200 pph, and the dolomite feed rate was around 110 pph. The standpipe level grew slowly over the shift, but the screw cooler was out of service. The bed material blew through the screw cooler, however, lowering the standpipe level. During the night, syngas preheated the line to the piloted syngas burner (PSB), in preparation for the turbine testing scheduled for the next morning.

Thursday, July 29, 2004 (day)

The gasifier ran fine other than some trouble with the screw cooler for the bottom ash removal system. The screw cooler would not rotate for some reason. The process of trying to solve the screw cooler problems disturbed the solids circulation twice for a short duration each time.

The preheating of the syngas line to the turbine continued , while simple cycle tested occurred on the turbine. General Electric also performed several gas analysis tests.

Thursday, July 29, 2004 (night)

The gasifier ran well throughout the night at the same conditions as in the past few days. Since General Electric (GE) did not complete their testing, the gasifier remained in oxygen-blown mode overnight. The standpipe level remained relatively constant while the coal feed rate was around 3100 pph, and the dolomite feed rate was around 100 pph.

Friday, July 30, 2004 (day)

After GE completed their analyzer tests in oxygen-blown mode, the PSDF gasifier operations were switched to air-blown mode. GE continued their analyzer tests during the one hour transition and for five hours in air-blown mode. The condensate sample at the exit of the minigasifier was clear and contained no trace of organics. The PSB and controls were tested by running the combustion turbine (CT) with syngas to get ready for the turbine stack testing.

Friday, July 30, 2004 (night)

At the beginning of the shift, the gasifier pressure was increased to 217 psig to keep the riser velocity below 50 ft/s. The gasifier continued to operate in air-blown mode with an exit temperature of around 1675°F while the coal feed rate was reduced from 4400 pph to 3400 pph. During the night an increasing standpipe level required the removal of solids via the standpipe solids conveying system. The conveying system did not appear to remove any solids, but seemed to shift the standpipe solids density to the lower standpipe from the upper standpipe. Based on gasifier temperatures, the circulation rate actually improved at this time. The coal feeder experienced a period of difficulty feeding fine coal at the beginning of the shift, but the problem disappeared upon swapping to the MWK coal silo.

Saturday, July 31, 2004 (day)

The gasifier and the rest of the process ran well. The standpipe level increased by two inches of water on LI339 per hour. Trying to remove solids by venting through standpipe solids removal system resulted in packing in the lower standpipe and a subsequent loss of circulation. However, the system recovered immediately upon closing the vent. The FTIR analyzers ran for the first time without any condensate problems. The CFAD also ran well. The demineralized water tank level gradually decreased for some reason.

Saturday, July 31, 2004 (night)

The gasifier continued to run well, with the exception of the standpipe screw cooler. Venting gas from the conveying system removed some material, but the situation is less than desirable. The coal feed rate was reduced to minimize the accumulation of solids in the gasifier. In the middle of the night, a spurious rate of change alarm on one of the PCD thermocouples caused the quench nitrogen valve to open and caused the spent fines screw cooler to run back to a slow speed. The condition passed quickly, and the PCD quickly returned to normal operations.

Sunday, August 01, 2004 (day)

The gasifier operations were stable with a slow increase in the standpipe level. The coal feed rate was reduced further to evaluate the standpipe level rate of increased with a lower coal feed rate.

Sunday, August 01, 2004 (night)

The gasifier continued to operate steadily in air-blown mode at a reduced coal feed rate of around 2500 pph. The low coal feed rate minimized the accumulation of solids in the gasifier. The standpipe level, according to LI339, only increased by 10 inches of water over a 12 hour period.

Monday, August 02, 2004 (day)

The gasifier operated smoothly and remained at conditions suitable for the needs for emissions tests that occurred during the day. The coal feed rate was 4000-4500 lb/hr, and the air flow rate was around 12,000 lb/hr. The operating pressure was 217 psig, and the gasifier temperatures were between 1700-1800°F.

PCD pressure measurement testing occurred early in the morning. The pressure inside the B2 candle behaved abnormally. Syngas flowed to the gas turbine for about four hours at a flow rate of 12,000 lb/hr. The turbine output was 1.6 MWe with a propane flow rate of 700 lb/hr. Sanders Engineering performed turbine stack analysis tests during the running of GT.

In the afternoon, syngas to turbine was stopped and sent back to the atmospheric syngas burner. Sanders Engineering started to take samples from MWK stacks around 3:30 PM.

The condensate system continued to lose demineralized water throughout the day. The problem appears to be a leak in either the steam condenser or the subcooler.

Monday, August 02, 2004 (night)

Since the standpipe screw cooler was out of service, we spent much of the night trying to remove solids from the standpipe, since the standpipe levels were high. Using the bypass around the conveying system did not prove to be successful and resulted in upsetting the circulation of the gasifier. Otherwise, however, the gasifier operated well, albeit at a higher standpipe level than normal.

Tuesday, August 03, 2004 (day)

We set the PCD back-pulse pressure at 150 psi above reactor pressure on both plenums, and started the failsafe testing. Later, we increased the lower plenum to 250 psi above the reactor pressure and changed the timer to ten minutes. SRI conducted PCD outlet sampling that indicated that the Pall fuse did not leak four hours after the test device opened.

Later in the day, we shut down the entire system and depressurized to repair the standpipe screw cooler and inspect the cyclone. During the shutdown, we attempted to burn the filter cake in the PCD. About three minutes into the attempt, the candle temperatures increased sharply.

Outage: Tuesday, August 03, 2004 through Monday, August 09, 2004

A scheduled outage occurred to allow crews to inspect the screw cooler, the cyclone and the PCD filter cake. Inspections revealed that the lower plenum of the PCD was bridged with material. Crews removed the bridged material. When maintenance opened the screw cooler and drained the standpipe, the workers found a few pieces of refractory and deposited material, apparently left over from TC17. Even though the screw cooler began to operate normally, none of the material in the screw cooler appeared to be large enough or hard enough to have clogged the system.

The cyclone was missing a piece of refractory at the gas inlet, and the notch that had formed in the cyclone after TC15 seemed to be returning. During the outage, maintenance crews repaired the leak in the condensate system. When all of the work was complete, the test run resumed.

Monday, August 09, 2004 (day)

The test run resumed, when operators relit the startup burner. Gasifier temperatures slowly increased. Fuel oil injection to sulfator was also started.

Monday, August 09, 2004 (night)

After the startup burner heated the gasifier to around 1100°F, coal feed began. Initially, the coal feed rate was low to control tar formation at the low temperatures. The heat-up rate was around 200°F per hour. As the gasifier temperature increased, the burner was ramped down and tripped. Just before coal feed began, steam flow to the LMZ and coal steam shrouds was started. The PCD ran with a backpulse timer of 30 minutes until after coal feed began, when it ran with a backpulse timer of five minutes.

Tuesday, August 10, 2004 (day)

In preparation for oxygen-blown testing, we increased the coal feed rate, the steam flow rate, and the system pressure. The gasifier was transitioned to oxygen-blown mode operation at a coal feed rate of about 3000 lb/hr. Operations were smooth. Further tuning of the oxygen flow rate controller was performed as well as lining the system up to commission the eductor (to admit steam and oxygen at higher pressures). We ran the spent fines conveying system during the day, since it was operational. The PCD resistance probes are reading normal values. Later during the shift, we shut down the spent fines system and began operating the CFAD.

Tuesday, August 10, 2004 (night)

The gasifier ran very smoothly through the night. We started using the eductor for steam and oxygen mixing early in the shift. The transition was extremely smooth. Because standpipe levels were decreasing, we increased coal feed rates about 20%. The increase in coal feed rate caused the standpipe level to start slowing increasing. We experimented with different steam flow rates through the eductor during the night to explore its operating envelope. We were careful to keep the same total steam flow through the LMZ constant to minimize the temperature swings that occur when adjusting the eductor flows. We also performed pressure testing on the PCD and adjusted the back-pulse valve open time to 0.4 seconds from 0.5 seconds.

Wednesday, August 11, 2004 (day)

We increased the gasifier operating pressure to 200 psig from 160 psig early in the shift. The transition was smooth other than the maximum pressure setting (195 psig) in the logic tripped oxygen valve closed twice. Once I&C corrected the logic, the remaining day of operation was smooth at an operating pressure of 200-205 psig.

Later, the FTIR analyzers was online to measure hydrocarbon concentrations. Also, one of the PCD thermocouples began to spike occasionally. The spike appeared to be carbon burning on the filter element.

Wednesday, August 11, 2004 (night)

For most of the night, the gasifier smoothly ran at the new high pressure oxygen-blown conditions. We added two bags of sand (6000 pounds) to the sulfator. Later in the shift, the main air compressor tripped for some unknown reason, causing the entire gasifier to trip. We restarted the entire system and transitioned back to oxygen-blown mode quickly.

Wednesday, August 12, 2004 (day)

The gasifier performed well throughout the day at an operating pressure of 200 psig in oxygen-blown mode. We tested the effect of the gasifier exit temperatures on the concentrations of hydrocarbon species. The benzene concentration decreased from 1400 - 1000 ppm as the exit temperature increased from 1650 to 1700°F. E&I also tuned the oxygen and steam flow control valves.

The ball-valve orifice on the CFAD discharge line was enlarged from 3/16" to 7/32" and installed online at 11:00 AM. After that, the CFAD operated in continuous mode at a solids discharge rate about 200 lb/hr. SRI measured the solids discharge rate of 261 lb/hr by the kinetic probe.

Thursday, August 12, 2004 (night)

The unit ran fairly well through night. We tried to empty the coal out of the FW silo to the gasifier until we started having problems with fine coal in the FD0210 coal feeder. We swapped to the other MWK silo and emptied it to ash silo. Near the end of shift we tried using the new UMZ oxygen nozzles.

Friday, August 13, 2004 (night)

The gasifier ran very well. I&C successfully tuned the eductor steam flow controller. We successfully distributed oxygen flow to the upper mixing zone, resulting in a lower temperature drop from the upper mixing zone to the gasifier exit.

Friday, August 13, 2004 (night)

The beginning of the shift was plagued by ongoing issues with the coal feeder, and coal did not flow freely from the surge bin to the dispense vessel. Eventually we turned off the surge bin fill cycle and let the surge bin empty. The coal feeder performance improved thereafter. We then increased the gasifier pressure to 202 psig on PI287. We then transitioned to air-blown operations and performed parametric tests through the rest of the night.

Saturday, August 14, 2004 (day)

The gasifier ran well. The FD0200 fluidized bed coal feeder was tested successfully, feeding coal to the gasifier. Automation parametric tests took place throughout the day. Once we started the FD0200 feeder, the PCD differential pressure increased dramatically.

Saturday, August 14, 2004 (night)

The first session parametric testing concluded at the beginning of the shift when the FD0200 coal feeder plugged. The feeder unplugged itself, but since the testing was complete for the day, operations shut the feeder down and transitioned back to the FD0210 coal feeder. Since both feeders had significantly dropped the level in the coal silo, a large amount of fines entered the FD0210 feeder and caused difficulty in transferring coal from the surge bin to the lock vessel and dispense vessel. The effect became so pronounced that the feeder could not supply coal to the gasifier quickly enough, and the coal feed rate was reduced to compensate. The low coal feed rate—along with a small amount of air—kept the gasifier warm until all of the fines had left the surge bin. Once the fines were out of the surge bin, the feeder worked well, and we restored the gasifier to normal operations.

Sunday, August 15, 2004 (day)

We used the FD0200 coal feeder to feed coal to the gasifier after some controls improvements were made, while it was operating in offline mode. Operations were smooth except of one line plug which resulted in temperature swings in the gasifier. Automation parametric tests continued during the day.

Sunday, August 15, 2004 (night)

Early in the shift, I&C completed the parametric testing of the gasifier. Once the testing was complete, operations ramped down the FD0200 coal feeder and shut it down, while restoring coal feed to the FD0210 coal feeder. Shortly thereafter, the FD0210 coal feeder began experiencing problems transferring coal from the surge bin to the lock hopper. Eventually the performance improved, but only after a short coal feeder trip. The trip was short-lived, and the test run resumed quickly.

Monday, August 16, 2004 (day)

The entire system ran well. We started the FD0200 coal feeder around noon. Other than a few minor problems, the feed rate from the feeder operated smoothly. The uniform coal feed rate made the gasifier temperatures smooth. The solids circulation rate was also steady throughout the day. The standpipe level controller ran in automatic mode and kept LI339 between 140-155 inH_2O. We increased the dolomite feed rate to about 120 lb/hr to replace as much sand from the gasifier inventory as possible. The CFAD ran in continuous mode, throughout the day.

Monday, August 16, 2004 (Night)

The FD0200 feeder plugged several times, and we decided to take it offline. The gasifier ran well all night with a coal feed rate of around 4600 pph. The dolomite feed rate was around 140 pph. The gasifier pressure was 226 psig, while the maximum temperature was mostly between 1780 and 1800°F.

Tuesday, August 17, 2004 (day)

We started the shift transitioning from PRB coal to lignite by reducing the gasifier pressure, coal feed rate and temperatures simultaneously to keep roughly the same riser velocity. Once gasifier temperatures reached 1550°F, we transferred lignite from the FW silo to the FD0210 coal feeder. Except for a minor plugging of the FD0210 conveying line by fine PRB coal, the transition process was smooth. At the end of the process, the highest gasifier temperature was about 1550°F, and the gasifier pressure was 150 psig. The lignite feed rate was about 2500 lb/hr.

Tuesday, August 17, 2004 (night)

The gasifier ran well during the night at a lignite feed rate of about 3000 pph and a pressure of 150 psig. The maximum gasifier temperature was just above the coal inlet at 1550°F. The sorbent feed rate was between 170 and 200 pph, throughout the night. Despite using the high sodium lignite, no agglomerations were present in the loop seal or standpipe solid samples. The spent fines screw cooler started leaking during the night, but maintenance was able to quickly remedy the problem.

Wednesday, August 18, 2004 (day)

Gasifier and PCD operations were stable. Due to changes in the properties of the circulating solids, the dolomite feed rate was increased.

Wednesday, August 18, 2004 (night)

The coal feed rate remained around 2700 pph throughout the night, while the dolomite feed rate was around 200 pph. Around 8:00 PM, the standpipe level according to LI339 began decreasing at a noticeable rate. At the same time, the lower standpipe differential pressure increased slightly.

Thursday, August 19, 2004 (day)

The gasifier continued to operate well with virtually no changes in operation.

Thursday, August 19, 2004 (night)

The night was very uneventful. The operator tweaked on the coal and air rates all night to try and maintain a steady gasifier temperature and standpipe level. The coal feed rate was low to moderate, but the dolomite feed rate was relatively high.

Friday, August 20, 2004 (day)

We increased the coal feed rate to about 3200 pph while maintaining the gasifier temperatures around 1500°F. The maximum gasifier temperature was around 1535°F, and the gasifier exit was around 1435°F. The effect of sodium on gasifier solids seems to be minimal, based on the samples collected today. The CFAD ran well as we continuously removed solids maintaining level. Also, we tried automating the CFAD level control.

Friday, August 20, 2004 (night)

The gasifier continued to operate well. We maintained the coal feed and temperature profile. The standpipe screw ran periodically to maintain standpipe level.

Saturday, August 21, 2004 (day)

Gasifier operations were stable. The coal feed rate and temperature were increased, and the steam flow rate was reduced.

Saturday, August 21, 2004 (night)

We maintained smooth gasifier operations during the night. Maximum gasifier temperatures ranged from about 1555 to 1575°F.

Sunday, August 22, 2004 (day)

The gasifier and PCD operated well. The gasifier temperature was decreased slightly due to a decrease in standpipe level. Within a few hours the standpipe level increased, and the automatic standpipe level control was enabled again.

Sunday, August 22, 2004 (night)

The gasifier continued to run smoothly during the night. There was an on going problem with the spent fines screw cooler. The packing on the non-drive end began to leak. The leak periodically set off the area gas detectors. Maintenance worked on the screw once, but the problem later returned.

Monday, August 23, 2004 (day)

The gasifier operated well throughout the day. The coal feed rate remained around 3600 lb/hr, and the dolomite feed rate was around 275 lb/hr. The fines discharge rate to the PCD by the weigh cells was around 420 lb/hr.

Monday, August 23, 2004 (night)

The process and all equipment operated well. The condenser appeared to have developed a small leak. But with 38 psig drain pot pressure, the system lost only a minimum amount of condensate to circulating water.

The lower standpipe differential pressure, PDI259, decreased much more slowly than in TC13, likely due to decreasing density. For most of the shift, the gasifier exit temperatures stayed around 1465°F, while the highest temperature in the mixing zone was around 1565°F. Towards the end of the shift, the gasifier temperatures increased by 20°F. The carbon conversion appeared to have increased significantly according to the PCD differential pressure. The peak differential pressure decreased from an average of 138 inches of water to 120 inches of water while the baseline differential pressure remained at 100 inches of water. We could not determine the PCD loading, since the FD0530 weigh cells were not reading accurately.

Tuesday, August 24, 2004 (day)

We increased the coal feed rate from 3500 to 4200 pph. The air flow rate increased from about 9300 to 10,000 pph. We also increased the gasifier pressure by PI287 from 152 to 159 psig to maintain the riser velocity at 52 ft/s. The maximum gasifier temperature remained around 1585°F, and the exit temperature was around 1470°F. The raw syngas dry heating value increased from 53 to 60 Btu/scf. The dolomite feed rate remained around 300 pph. The gasifier operated well at these conditions. The PCD, CFAD and the process were all as stable as before the operating conditions changed.

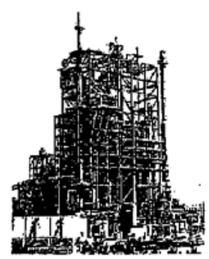
Tuesday, August 24, 2004 (night)

The lower standpipe differential pressure, PDI259, continued to decrease except for a time period between 06:00 AM and 10:00 AM when the carbon conversion was high. We lowered standpipe level to see its effect on lower portion of the standpipe. The ceramic orificed ball valve at the CFAD exit appears to be working well. After depleting our supply of lignite, we stopped coal feed at 11:03 PM, giving a total of 836 hours of coal feed for TC16. We also conducted controlled burn tests of filter cake on the PCD candles. At about 3% oxygen, the PCD temperatures increased by about 300°F in 15 minutes. When the tests were over, we shut down the remained systems, emptied the gasifier of solids, and prepared for the outage.

TC16 Test Objectives

- **Fuel Cell**
- **High Pressure Oxygen**
- **Freedom mine High Sodium Lignite**

- Oxygen Distribution System Commissioning
- Air Compliance Stack Tests
- Failsafe Testing
- Pulse Pressure Characterization
- Controlled "Removal" of PCD dust cake
- Continued Equipment Testing
  - CFAD
  - PSB
  - Hot Gas Cleanup
  - Pressurized Sand Feeder
- Process Performance Studies
- Sensor Development
- Automation Tests



one team ◦ one future

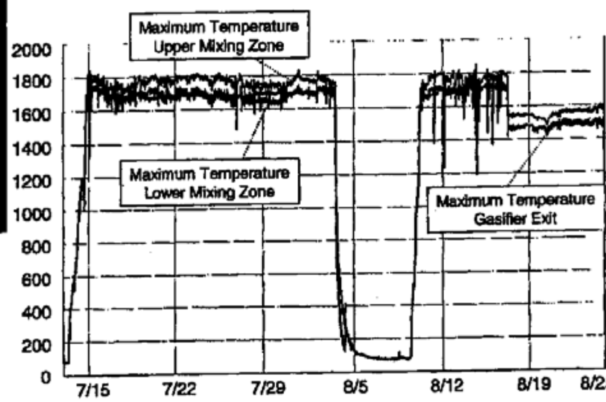
TC16 Operating Parameters

	PRB		Lignite
	Air	**Oxygen**	**Air**
Hours of Operation [1]	465	395	182
Maximum Temperature, °F	1760 -1850		1500-1600
Gasifier Exit Pressure, psig	200-220	155-200	150-160
Coal Feed Rate, lb/hr	3800-4300	2700-4100	2500-4100
Solids Circulation Rate, 100k lb/hr	300-350	200-500	300-430

[1] Another 25 hours were enriched-air periods during air-to-oxygen transitions.

one team ◦ one future

TC16 Temperature (deg F)



High Na Lignite Operations

- After mid-run shutdown, "recycled" solids were added for startup bed material
- Operated for 174 hours on PRB with dolomite before transition to lignite
- Initial conditions were conservative to observe transition in gasifier solids
- Gradually increased coal feed rate and temperature and reduced steam flow rate
- Continuously fed dolomite during lignite testing

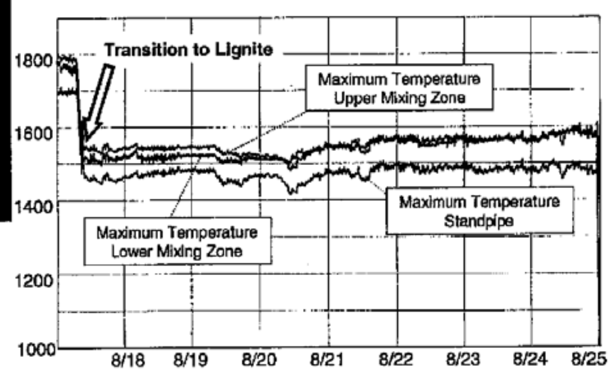
3

High Na Lignite Observations

- Coal feeder worked well
- Solids circulation was smooth
- Size and shape of the standpipe particles did not change over time
- Muffle furnace tests were conducted
- PCD operations were stable
- Post-run inspections were completed

one team • one future

Gasifier Operating Temperatures (deg F)

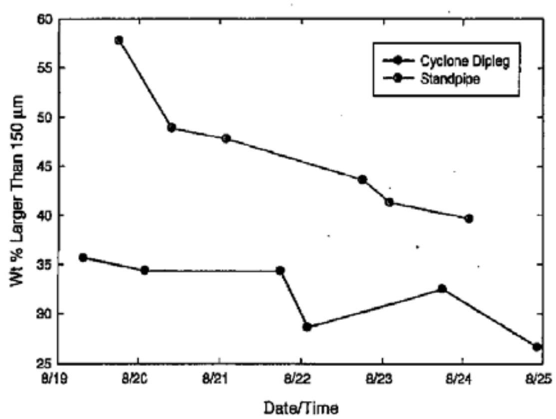


one team • one future

Loopseal Temperatures (deg F)

one team ◦ one future

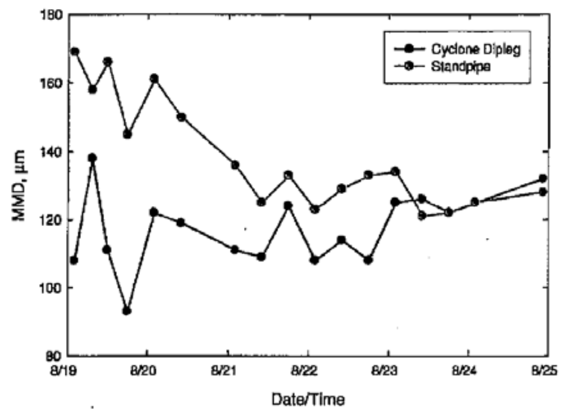
Large Particle Content of Loopseal and Standpipe Samples



one team ◦ one future

5

MMD's of Loopseal and Standpipe Samples



one team • one future

Conclusions

Accomplished all objectives

- Annual air compliance stack testing completed
- Equipment testing results
  - Pressurized sand feed worked well
  - CFAD operated very well
    - 834 hours of operation
    - new automatic level control performed well
  - Coal Feeder operated well
    - Fed 1362 tons of fuel to gasifier
  - PSB operated
  - Gasifier thermowell modifications tested
- Parametric tests to support automation successfully completed
- Commissioned oxygen distribution system
- Successfully operated gasifier at higher pressure during oxygen blown mode

one team • one future

Conclusions (cont.)

- Freedom High Sodium Lignite Testing
  - Agglomerations leading to deposits with high Na Freedom lignite
    - Dependent upon temperature and bed material
    - Operation with dolomite shows promise for higher operating temperature
    - Below 1600°F, lessened chance of deposits from agglomerations but at cost of carbon conversion
  - No tar or oil even at low operating temperatures
  - Need additional testing
    - Continue to evaluate operating envelope
    - Explore alternative bed materials

one team • one future

7

POWER SYSTEMS DEVELOPMENT FACILITY
TEST RUN TC20: GASIFICATION RUN
OPERATING SUMMARY FOR 07/31/06 – 09/23/06

Process Observations/Accomplishments

- The Transport Gasifier operated with Powder River Basin (PRB) coal for a total of 870 hours in TC20, 835 hours in air-blown mode and 35 hours in oxygen-blown mode. The total amount of time the Transport Gasifier has operated in gasification mode is now 9152 hours and in oxygen blown mode is 1700 hours.
- The table below summarizes the gasifier performance based on oxidant:

	PRB	
	Air	Oxygen
Hours of Operation	835	35
Maximum Temperature, °F	1730 - 1850	
Gasifier Exit Pressure, psig	140 - 260	160
Riser Velocity, ft/s	16 - 35	20 - 23
Air to Coal Ratio, lb/lb	3.0 - 4.3	
Oxygen to Coal Ratio, lb/lb	0.70 - 0.99	0.60 - 0.95
Coal Feed Rate, lb/hr	2000 - 5000	2000 - 3900
Carbon Conversion, %	97 - 99*	97 - 99*
Raw Wet Lower Heating Value (LHV), Btu/SCF	51 - 87	48 - 100

*Preliminary data analysis based on Particulate Control Device (PCD) fines LOI (loss on ignition)

- The modified Transport Gasifier configuration produced LHV's approximately 10 to 20% higher than the previous design when compared to equivalent air to coal ratios.
- TC20 carbon conversions were between 97% and 99% and averaged 98%. This was 3% higher than air blown PRB with the original Transport Gasifier configuration.
- Several parametric tests were performed. The gasifier temperature, pressure, solids circulation rate, and riser velocity were varied to evaluate the operating envelope. Data analysis is ongoing to determine effects on gasifier operations and performance.
- Air was used as the coal conveying gas for about 290 hours. Gasifier operations remained steady during and after the transition from transport nitrogen to transport air, and the heating value increased slightly.
- In TC20, the lower mixing zone (LMZ) air flow rates were operated at higher rates than in previous test runs. At one test point, the LMZ air flow rates represented

approximately 80% of the total air flow to the gasifier. As in previous tests, the LMZ temperatures increased with increasing air flow until the air flow rate relative to the carbon content of the solids in the LMZ was over the stoichiometric amount. The temperatures then decreased with increases in LMZ air flow.

- Ammonia injection tests were conducted to confirm NH_3 decomposition in the gasifier. Anhydrous NH_3 was injected into the air-rich mixing zone to simulate an NH_3 concentration from 2250 ppmv to 5800 ppmv in the syngas. During these tests, the NH_3 concentration did not change at the gasifier exit as compared to normal operation. Also, there was no indication of any additional NO_x at the gasifier or atmospheric syngas combustor exit. The NH_3 injection tests were successful and had no adverse impact on gasifier performance.
- After initial sand circulation testing was complete and the gasifier reached steady state conditions, sand was not added for the remainder of the test run. Solids were removed from the gasifier as needed via the continuous coarse ash depressurization (CCAD) system to maintain a constant standpipe level. The gasifier solids collection system efficiency was higher in TC20 than in previous test runs.
- The steady state standpipe particle size of the gasifier solids was 98 microns Sauter mean diameter (SMD) with a standard deviation of 7 microns SMD. The particle size of the gasifier solids was less than previous PRB test campaigns which averaged 155 to 230 microns SMD.
- Solids samples were taken from the riser, and gas samples were taken from the riser and mixing zone during TC20. Analyses of the samples are currently underway.
- A new sampling system for evaluating the performance of the solids collection system was commissioned during TC20. The system performed well and daily solids samples were collected. Results obtained during both sand circulation and coal gasification suggest that an optimum cyclone inlet velocity results in maximum cyclone collection efficiency.
- The loss on ignition (LOI) for the solids samples taken during TC20 are shown below:

	LOI (wt%)	
	Range	**Average**
Riser	0.0 – 2.3	0.3
Seal Leg	0.0 – 0.9	0.2
Standpipe	0.0 – 1.2	0.2
PCD	11 – 42	29

- Sensor development continued as new ceramic tips were evaluated on six pressure taps in the riser. These taps did not plug at any time, and the experimental differential pressure measurements read well in comparison to the other riser indications. Analysis is ongoing to determine if the ceramic tips had any effects on the differential pressure measurements. In addition, preliminary observations show that thermocouple performance during TC20 was much better than the previous test runs;

however, detailed thermowell inspections are ongoing. All of the thermowells in the modified gasifier lasted the entire test run compared to seven of twelve ceramic riser thermowells in TC19, and nine of fourteen in TC18.

- The annual air compliance stack testing was performed during TC20 by Sanders Engineering and confirmed the facility is in compliance with the air permit.
- The Transport Gasifier successfully operated in oxygen blown mode for 35 hours. During this time, the coal, oxygen, and steam flow rates were varied in attempt to reach optimum operating conditions.
- There was only one extended outage during TC20. The outage lasted approximately nine days and occurred as a result of the primary pressure indication plugging. The plug caused the Transport Gasifier pressure letdown valve to respond incorrectly, ultimately resulting in a large pressure fluctuation. Upon recovering from the gasifier trip, the primary gas cooler performance was degraded, resulting in a high inlet temperature to the PCD. The primary gas cooler was inspected and some tubes were partially plugged. The cooler was cleaned and the system was restarted.

Equipment Summary

- The original coal feeder ran for a total of 815 hours. The spheri valves cycled over 6900 times without failure, and the feeder achieved rates of 5000 pph during high feed rate testing. Operation of the new dispense vessel vent valve resulted in a decreased frequency of vent line plugging than had been observed in previous runs. However, during periods of variations in particle size distribution, the vent lines still plugged sporadically. Design analysis and additional modifications are currently being explored to eliminate future plugging.
- The developmental coal feeder ran for a total of 108 hours and achieved rates as high as 4400 pph. The variation of feed particle size distribution resulted in a few operational problems during the run. As a result, additional design modifications are being considered to prevent future occurrences.
- The gas coolers operated well during the majority of the test run. The primary gas cooler performance degraded as a result of a process upset approximately 240 hours into the run and caused an unexpected outage for approximately 9 days. For most of the test run, both the primary and secondary gas coolers had heat transfer coefficients higher than design and very low pressure drops.
- The atmospheric syngas burner ran well during the test run, easily combusting the syngas derived from the PRB coal. The heat recovery boiler had difficulty maintaining the outlet temperature within the design specifications due to higher syngas quality; however, data are being analyzed to overcome this limitation.
- The continuous fine ash depressurization (CFAD) system was in service for normal operation, discharging fines at a rate of 150 to 200 pph. Fines were accumulated in the surge vessel and high discharge rate tests were conducted.
- The continuous coarse ash depressurization (CCAD) system operated well, discharging solids from the Transport Gasifier as needed throughout the test run. Solids were successfully removed at a rate of approximately 120 pph.

PCD System Observations

- Particulate sampling at the PCD inlet during TC20 showed that the modifications made to the Transport Gasifier substantially reduced the solids carryover to the PCD. The particle-size distribution also became significantly finer with mass-median diameters (MMDs) in the range of about 6 to 12 microns compared to typical MMDs of 15 to 20 microns in previous tests with the old gasifier configuration. Based on preliminary results, the changes did not have an adverse effect on PCD pressure drop.
- Sampling at the PCD outlet showed that the particle loadings were initially higher than in previous runs, possibly due to the longer seasoning required for the Pall HR160 metal fiber filter elements. Even after the seasoning period, the particle emissions were somewhat higher than the results achieved with the Pall sintered powder FEAL elements and the old gasifier configuration, although the outlet loadings stabilized at values near the lower limit of resolution (~ 0.1 ppmw). While the sintered powder elements may also have lower collection efficiency with the new gasifier configuration, previous testing in the PCD cold-flow model has shown that the sintered powder elements have higher collection efficiency than the metal fiber elements.
- Failsafe testing during TC20 was performed using an HR160 internal failsafe. Outlet sampling completed shortly after the test began showed a loading of about 0.3 to 0.45 ppmw. The solids concentration was reduced below the limit of detection, 0.1 ppmw, by the next day with continuous exposure.
- The online process particulate monitor (PPC) was tested during the run, and several issues were identified that are being addressed during the outage to improve its performance.
- The filter elements installed, which included 14 FEAL and 76 HR160 elements, performed without any failures. Several elements were removed after the run for flow testing and further inspection.

Gas Cleanup Observations

- Syngas COS hydrolysis tests continued using the catalyst that was previously exposed for a period of 250 hours during TC19. The catalyst was tested for an additional 73 hours during TC20. The syngas flow was maintained at 30 lbs/hr. The test was conducted at 420ºF temperature and 160 to 190 psig pressure. The COS conversion efficiency was 80%.
- Four additional COS hydrolysis catalysts were tested during TC20. The catalysts were exposed to syngas from 58 to 130 hours at about 390°F and pressures varying from 120 to 230 psig. The syngas flow rate was maintained at 30 pph, and the COS conversion efficiency ranged from 82 to 93%. All the catalysts removed from the process showed varying degrees of discoloration.
- The syngas cooler (HX700) ran for 300 hours using a recirculating loop chiller to collect the condensate from the syngas. The syngas flow rate was 30 pph, the inlet syngas temperature was 500°F, and the outlet syngas temperature was 120°F. During

normal gasifier operation, the condensate that was collected was clean. However, some of the exchanger tubes were plugged with organics possibly resulting from various gasifier trips.

- The syngas cooler (HX700) ran for another 200 hours using cooling water instead of chilled water. The condensate collected was clean. During these tests, the outlet temperature was higher than before, at approximately 150°F. No exchanger tube plugging with organics was observed.
- During TC20, Sensidyne detector tubes were used to measure chloride in the syngas. With a single pump stroke, the lowest detectable limit was 400 ppb. By applying 100 strokes, the detectable limit was lowered to 4 ppb. No chlorine was detected at either detection limit.
- During normal Transport Gasifier operation, no organics were visually observed in the syngas during impinger sampling when the syngas was cooled to about 120°F. However, some discoloration was detected when the syngas was cooled to below 90°F. The condensates have been sent for analysis.

Power Systems Development Facility
Test Run TC20: Gasification Test Run
Summary Event Log for July 31, 2006 – September 23, 2006

Pre Startup Activities

The Transport Gasifier was successfully pressure tested. The pressure was increased, and flows were set on differential pressure transmitters. An initial cure of the new refractory joints was necessary using the startup burner as a heat source.

Sand Circulation

Monday, July 31, 2006
The startup burner continued to heat the Transport Gasifier. When the refractory cure was complete, the gasifier temperatures were slowly ramped down in accordance with the refractory cure procedure.

Tuesday, August 1, 2006
The startup burner was shutdown to replace the flame rod and to unplug one nozzle in the lower standpipe. A small amount of sand was added the gasifier to perform initial commissioning tests. The startup burner was restarted, and the gasifier temperatures were increased to about 600°F to allow the initial commissioning tests to begin.

Wednesday, August 2, 2006
The initial commissioning tests were completed, and additional sand was added to the gasifier. After the sand was added, testing to determine the effect of riser velocity on gasifier performance began. During the low velocity test, the gasifier inventory shifted from the standpipe into the startup burner leg due to a low gas flow rate through the burner. After the riser velocity testing, the startup burner firing rate was increased to heat the gasifier to 1000°F.

Thursday, August 3, 2006
Solids flow from the first solids separation device was stopped to determine how it would affect gasifier operations. The second separation device did well in handling the material that escaped the first device. Later, testing began to determine the effect of circulation rate on gasifier performance, but was interrupted when the startup burner tripped. The burner could not be relit due to problems with the igniter and the flame rod.

Friday, August 4, 2006
The gasifier was depressurized to install a new flame rod and igniter on the startup burner. Once the repairs were complete, the system was pressurized, and solids circulation was initiated.

Saturday, August 5, 2006
The startup burner was lit, and the gasifier temperatures were increased to 1000°F. Sand was added to increase the standpipe level to 100 inches of water on LI339 (the standpipe level by differential pressure) for testing. Flows were adjusted to test various riser velocities at this standpipe level. Sand was then added to increase the standpipe level to 225 inches of water on LI339 for additional testing.

Sunday, August 6, 2006
The standpipe level was increased to 350 inches of water on LI339 to continue circulation rate testing. When the circulation testing was complete, the gas distribution was modified to determine its affect on gasifier operations.

Monday, August 7, 2006
Gas distribution testing continued throughout the day. Gasifier operations were smooth during the gasifier distributions tests over the full range of the flow splits. Later in the day. the coarse ash depressurization (CCAD) system was operated to lower the standpipe level to 250 inches of water on LI339. The gasifier temperatures were slowly increased using the startup burner in preparation for coal feed.

Coal Feed

Tuesday, August 8, 2006 (Day)
The original coal feeder was started to initiate coal feed to the gasifier, and the startup burner was shutdown. Problems with the original coal feeder logic caused several trips during the first few hours of operation.

Tuesday, August 8, 2006 (Night)
After the logic issue was addressed, the coal feeder ran well for a few hours, and the system remained in combustion mode until the gasifier temperature reached 1650°F. Eventually, the vent lines on the coal feeder dispense vessel plugged, tripping the unit and requiring the startup burner to be relit to maintain the system temperatures.

Wednesday, August 9, 2006 (Day)
Once maintenance cleared the vent lines on the original coal feeder, coal feed was restarted, and the startup burner was shutdown. When the temperatures reached 1650°F, the coal feed rate was increased to transition to gasification mode. The system pressure was increased to maintain the riser velocity. Once operations were steady, gas samples were successfully taken from the mixing zone and riser. The CCAD operated to lower the standpipe level to around 225 inches of water on LI339, but the level rebounded to 280 inches of water within a few hours.

Wednesday, August 9, 2006 (Night)
In the early evening, the gasifier operated with a coal feed rate of close to 4500 pph through the original coal feeder. The gasifier temperature profile remained uniform even at the higher coal feed rates, a marked improvement from previous test runs. Later in the night, the developmental coal feeder was started with a feed rate of about 1000 pph to

check the feeder operation. The feed rate on the original was decreased to around 2700 pph at that time.

At midnight, the developmental coal feeder was shutdown. Shortly thereafter, the vents on the original coal feeder dispense vessel plugged with fines and tripped the system. The line cleared on its own, and the feeder was restarted. Normal operations resumed with the gasifier operating at 210 psig and a coal feed rate of 4000 pph. The maximum gasifier temperature was 1760°F, and the gasifier outlet temperature was about 1700°F.

Thursday, August 10, 2006 (Day)
Air distribution testing occurred, varying the staging of air to the gasifier. The control nitrogen filter plugged on the original coal feeder, and tripped the unit. The filter was replaced, and operations resumed.

Thursday, August 10, 2006 (Night)
The gasifier operated well for a majority of the night, while gasification ash slowly replaced the startup bed material. The developmental coal feeder was run for a short period of time to ensure proper operation. The feeder ran well and was shutdown. Air distribution testing continued. As the lower mixing zone (LMZ) air flow was increased, the gasifier inventory shifted, resulting in a higher standpipe level. Later some fine material caused operational difficulties with the original coal feeder so the developmental coal feeder was started.

Friday, August 11, 2006 (Day)
Air distribution testing was completed, and evaluation of the effect of riser velocity on gasifier operations and performance was started. The original coal feeder was shutdown so maintenance could unplug the dispense vessel vent lines. The developmental coal feeder ran well throughout the day.

Friday, August 11, 2006 (Night)
The developmental coal feeder continued to operate well throughout the night. When maintenance completed the work on the original coal feeder, it was placed back in service. The presence of fines in the system continued to cause operational difficulties with the original coal feeder, however, so the feeder was lined up for operation in off-line mode to empty the surge bin. After all of the fines were removed, the system returned to normal operation and was lined back up to the gasifier.

Saturday, August 12, 2006 (Day)
Evaluation of the effects of riser velocity on gasifier operations and performance was continued throughout the day. Both the original and developmental coal feeders operated well. Gasifier and Particulate Control Device (PCD) operations were stable except for one trip caused by a logic error.

Saturday, August 12, 2006 (Night)
The evaluation of the effect of riser velocity on gasifier operations and performance was continued, however, the presence of fines once again caused operational problems with

the original and developmental coal feeders. After the fine material was fed, both systems resumed normal operations.

Sunday, August 13, 2006 (Day)
Evaluation of riser velocity on gasifier operations and performance was completed by performing the maximum velocity test. Gasifier and PCD operations were stable except for one system runback due to a logic error.

Sunday, August 13, 2006 (Night)
Testing on the standpipe level effect on riser density test was started. The gasifier continued to operate well with an approximate coal feed rate of 4000 pph through the original coal feeder. The gasifier temperature profile remained uniform throughout the night.

Monday, August 14, 2006 (Day)
Evaluation of the effects of standpipe level on riser density continued throughout the day. The original coal feed system remained stable. Gasifier and PCD performance was stable with the exception of two high temperature excursions. Normal operation was reestablished shortly after each event.

Monday, August 14, 2006 (Night)
The unit ran well at a coal feed rate of 4300 pph. The CCAD (continuous coarse ash depressurization system) maintained the standpipe level from 120 to 130 inches of water. The syngas quality remains much higher than it did in previous test runs, while the PCD collection rate remained low.

Tuesday, August 15, 2006 (Day)
The standpipe level effect on riser density test was completed. The gasifier operated well at a pressure of 230 psig and a coal feed rate of 4600 pph. The FD0220 sorbent feeder was started to increase the standpipe level 250 inches of water. Syngas quality remains higher than previous runs.

Tuesday, August 15, 2006 (Night)
The unit operation was steady with a coal feed rate of approximately 4500 pph at 210 psig gasifier pressure. The syngas quality was high with a dry lower heating value (LHV) of 90 BTU/SCF. The standpipe level was raised to 250 inches of water by 20:00 and maintained throughout the shift.

Wednesday, August 16, 2006 (Day)
The gasifier operated well throughout the day. Part one of the coal feed rate effect on solids separation device efficiency testing occurred with a gasifier pressure of 210 psig. The coal feed rate remained approximately 4500 pph, and the standpipe level was maintained between 215 and 220 inches of water via the CCAD.

Wednesday, August 16, 2006 (Night)
The system continued to operate well at a coal feed rate of 4600 pph and a standpipe level of 210-235 inches of water. Operating conditions were held steady to complete the first set of conditions for air distribution testing, and air feed will be redistributed for the next test phase. The syngas quality remained high with a 90 BTU/SCF dry LHV.

Thursday, August 17, 2006 (Day)
Gasifier operation was smooth throughout the day. Conditions remained stable for the second phase of air distribution testing. The gasifier operated at 210 psig with a coal feed rate of approximately 4700 pph.

Thursday, August 17, 2006 (Night)
Operations were stable throughout the night, and the second set of conditions for air distribution was held. The developmental coal feeder was tested for a short period of time. A high pressure differential from the feeder to the gasifier was required for coal to feed. The coal feed rate was 4700 pph. The syngas quality was high with an 88 BTU/SCF dry LHV.

Friday, August 18, 2006 (Day)
Early in the morning a pressure instrument plugged, causing the pressure control loop to behave erratically, ultimately causing a gasifier trip. As a result of the trip, the primary gas cooler heat transfer coefficient was significantly lower. The coal feed rate at the end of the shift was 3500 pph, and the standpipe level was 190 inches of water.

Friday, August 18, 2006 (Night)
The reduced performance of the primary gas cooler resulted in high PCD temperatures, forcing the system to be shut down. A dirty shutdown was performed, leaving a transient dust cake on the PCD filter elements for analysis.

Saturday, August 19, 2006 – Friday, August 25, 2006
During the outage the primary gas cooler was inspected and cleaned. During the cleaning, some of the ferrules were damaged and had to be replaced.

Saturday, August 26, 2006 (Day)
The system was successfully leak tested, and all pressure differential transmitter purge flows were checked. Aeration flows were set, and auxiliary systems were started in preparation for lighting the startup burner. The startup burner was successfully lit.

Saturday, August 26, 2006 (Night)
Preheating of the gasifier continued throughout the shift. The gasifier was heated by the startup burner at a ramp rate of 100°F per hour. The PCD backpulse sequence was initiated with a minimal pressure setting.

Sunday, August 27, 2006 (Day)
Gasifier temperatures continued to be increased using the startup burner. The primary gas cooler inlet temperature was held constant at 900°F for 8 hours to properly cure the new

refractory. When the gasifier temperatures reached approximately 1150°F, the original coal feed system was started, and the system was ramped up for normal operations.

Sunday, August 27, 2006 (Night)
Gasifier temperatures were increased using the original coal feeder in combustion mode. Later in the evening, the startup burner was tripped, and the unit was transitioned to gasification mode. The original coal feeder conveying gas flow was erratic during the night, however, and the feeder tripped several times.

Before midnight, a small syngas leak was detected. The coal feeder was removed from service until the leak could be repaired. The startup burner was lit to maintain temperatures around 1100°F until early morning.

Monday, August 28, 2006 (Day)
The startup burner firing rate was decreased to lower temperatures in the gasifier to around 700°F. The leak was repaired. After pressure testing was complete, the startup burner firing rate was increased to raise gasifier temperatures in preparation for coal feed. The original coal feeder was successfully started in off-line mode after modifications were made to the programmable logic controller (PLC).

Monday, August 28, 2006 (Night)
Preheating of the gasifier continued using the startup burner. When gasifier temperatures reached approximately 1100°F, the original coal feeder system was placed in service, and the startup burner was ramped down. The gasifier temperatures were increased to approximately 1650°F, and the startup burner was removed from service. The gasifier was then transitioned from combustion mode into gasification mode. Startup was smooth with the exception of a coal feeder trip due to an erroneous reading on the coal feeder line skin thermocouple. The coal feed rate was later increased to about 1500 lb/hr, and the system pressure remained at 90 psig for the low pressure test.

Tuesday, August 29, 2006 (Day)
Part one of testing the effect of the coal feed rate on solids separation efficiency started with a gasifier pressure of 160 psig. Operations were stable during the shift with the original coal feeder feeding at a rate of 2200 pph. Tuning of the remaining gasifier process air flow controllers was completed after reaching the new gasifier pressure. Also, the ammonia injection system was successfully pressure tested and left under 325 psig of nitrogen pressure.

Tuesday, August 29, 2006 (Night)
The gasifier system operated well during the night, however, the coal feed conveying line partially plugged, resulting in a gasifier trip. The coal feeder conveying line was cleared, and gasifier operations returned to steady state conditions.

Wednesday, August 30, 2006 (Day)
The original coal feeder was restarted and ran well with increased purge flows. The gasifier tripped due to an insufficient flow rate on the startup burner purge. After

increasing the purge flow rate, operations restarted the coal feeders, and the gasifier ran in a stable manner for the remainder of the shift.

The coal feed rate was around 2200 pph at a gasifier pressure of 160 psig. The gasifier exit temperature was approximately 1700°F. Syngas heating values remained high, at 65 BTU/SCF, despite the low coal feed rate.

Wednesday, August 30, 2006 (Night)
The gasifier operated well throughout the night. The coal feed rate was increased to approximately 3,000 pph. The air and steam flow rate were adjusted slightly to maintain a uniform temperature profile.

Thursday, August 31, 2006 (Day)
Gasifier operation remained steady throughout the day, while the effects of coal feed rate on solids separation efficiency was evaluated. The coal feed rate was increased to 3,000 pph while gasifier pressure was maintained at 160 psig. The standpipe level was controlled at 225 inches of water by CCAD. Ash removal system enhancements were also tested, requiring slight adjustments in steam and air flow rates to the gasifier. During the shift, syngas heating values of 80 BTU/SCF (dry LHV) were achieved.

Thursday, August 31, 2006 (Night)
The gasifier system operated well during the night. Steady state conditions were maintained from the previous shift in preparation for PCD fail safe testing in the morning. The dry syngas LHV remained near 80 BTU/SCF.

Friday, September 1, 2006 (Day)
Coal feed rates were raised to 4,000 pph, increasing riser velocity for PCD fail safe testing. As the coal feed rate increased, the syngas heating value rose to 90 BTU/SCF. The standpipe density fell slightly during the transition to higher coal feed rates, requiring slight adjustments to aeration flow rates. Also, the standpipe level was decreased from 225 to 210 inches of water. At the end of the shift, gasifier pressure was raised to 220 psig to evaluate the effects of coal feed rate on solids separation efficiency at a higher operating pressure.

Friday, September 1, 2006 (Night)
Early in the shift the original coal feeder discharge line plugged, causing a gasifier trip. After recovering from the trip, the gasifier system operated well for the remainder of the night. The coal feed rate remained at 4000 pph and the gasifier pressure at 220 psig. The standpipe level was also maintained at 210 inches of water.

Saturday, September 02, 2006 (Day)
Ammonia injection testing was successfully performed during the shift. Gasifier pressure was decreased to 210 psig, and the standpipe level was increased to 215 inches of water. After ammonia testing was complete, a filter plugged on the original coal feeder pressurization line, tripping the feeder and resulting in several gasifier upsets. As a result,

the coal feeder was stopped for maintenance to clean the filter. When work was complete, the feeder was put back in service, and the gasifier system returned to normal operations.

Saturday, September 02, 2006 (Night)
The gasifier operated well early in the shift, but the presence of fines in the system later caused problems for the original coal feeder. As a result of decreasing coal particulate size, the coal feed rate to the gasifier was reduced. After the fines were removed from the feeder, the consistency of the coal feed rate improved, and gasifier operations returned to normal.

Sunday, September 03, 2006 (Day)
Gasifier operation was smooth throughout the day. Early in the shift, the original coal feeder was transitioned from nitrogen to air as the coal conveying gas. After the transition was made, and operations stabilized, the syngas heating value increased to approximately 90 BTU/SCF. Testing of the methane prediction formula then began. During this time, the coal feed rate was 4000 pph, the gasifier pressure was 220 psig, and the average riser temperature was around 1780°F. At the conclusion of the shift, the dry raw syngas heating value had increased further to 95 BTU/SCF.

Sunday, September 03, 2006 (Night)
Gasifier operation was hampered due to the presence of fines in the original coal feeder. Coal feed continued at reduced rates for the majority of the shift while the fines worked through the system. After the fine material was removed, normal operations resumed.

Monday, September 04, 2006 (Day)
The methane prediction formula testing took place. Afterwards, the original coal feeder was brought down for maintenance to repair a leaking vent valve. The feeder was then brought back online, and the unit successfully transitioned from combustion to gasification mode. When conditions stabilized, the gasifier pressure was increased to evaluate the effects of gasifier pressure on methane concentration.

By the end of the shift, the coal feed rate was around 4000 pph, the gasifier pressure was 245 psig, and the standpipe level was between 200 and 210 inches of water. The syngas heating value achieved during this time was approximately 94 BTU/SCF.

Monday, September 04, 2006 (Night)
Methane prediction testing continued during the night at gasifier pressures of 245 psig and 230 psig. At the higher pressure, the standpipe appeared to show signs of restricted circulation based on temperatures. As the pressure decreased, the bed expanded, and the fluidization in the lower standpipe improved. The coal feed was around 4000 pph, and the syngas quality in dry lower heating value was around 95 BTU/SCF for both tests.

Tuesday, September 05, 2006 (Day)
Gasifier pressure was further decreased to 215 psig for methane prediction testing. The coal feed was erratic at times due to the presence of fines in the coal feeder system. The

standpipe level indication on LI339 rose as the pressure was decreased. Coal feed rates, gasifier outlet temperatures, and syngas quality remained steady throughout the day.

Tuesday, September 05, 2006 (Night)
At the beginning of the shift, the gasifier tripped when a nitrogen line became detached from the upper coal feeder spheri valve. This prevented operation of the valve and allowed the coal feeder to run out of coal. Maintenance repaired the line, and coal feeder operation returned to normal. Methane prediction testing continued during the night at pressures of 200 psig and 180 psig. The coal feed rate was around 4300 pph during the tests. The syngas heating value remained high at 95 BTU/SCF.

Wednesday, September 06, 2006 (Day)
Gasifier operation was steady through the day. The Transport Gasifier pressure was decreased from 180 psig to 160 psig for further evaluation for pressure effects on the syngas methane concentration. The coal feed rate remained stable, at approximately 4300 pph.

Wednesday, September 06, 2006 (Night)
The gasifier pressure was further decreased from 160 psig to 140 psig; however, the unit tripped shortly after decreasing the pressure due to low conveying gas velocity on the original coal feeder. When trying to re-establish stable operation, a controls problem prevented the coal feeder speed controller from operating properly. Therefore, the feeder was run in manual for the remainder of the shift until additional troubleshooting could be performed. After the feeder was restarted, stable operation was achieved with a coal feed rate of 4300 pph. The methane concentration continued to show a stronger relationship with gasifier temperature than pressure.

Thursday, September 07, 2006 (Day)
The gasifier pressure was maintained at 140 psig as multiple process samples were taken, and the system pressure was increased to 170 psig later in the day. When the original coal feeder was put back in automatic, the conveying gas velocity dropped below the trip point. Therefore, the unit was tripped for few minutes until the conveying velocity was reestablished.

Thursday, September 07, 2006 (Night)
The gasifier pressure was increased from 170 psig to 225 psig, and the standpipe level was increased from 200 to 250 inches of water. Gasifier temperatures were stabilized at 1700°F, and the first phase of methane prediction testing as a function of temperature was started. During this portion of the test, temperatures were decreased in increments of 25°F. The coal feed rate was maintained around 4800 pph.

Friday, September 08, 2006 (Day)
Gasifier operations remained stable during the shift. The evaluation of methane concentration as a function of temperature continued with temperatures decreased to 1650°F. Toward the end of the shift, the gasifier pressure was decreased to 215 psig in preparation for placing the developmental coal feeder back in service. The standpipe

level was maintained at approximately 250 inH_2O, and the coal feed rate around 4800 pph via the original coal feeder. The dry raw heating value was between 99 and 104 btu/SCF throughout most of the day.

Friday, September 08, 2006 (Night)
Methane concentration evaluation was suspendedn and gasifier temperatures were increased to 1700°F prior to starting the developmental coal feeder. After gasifier temperatures stabilized, the developmental coal feeder rate was slowly increased while the coal feed rate from the original coal feeder was decreased. At the end of the shift, the feed rates from the developmental and original coal feeders were 2000 pph and 2400 pph, respectively.

Saturday, September 09, 2006 (Day)
The original coal feeder was brought offline early in the shift to replace the V-ball vent valve with the globe valve that was previously used. The original feeder was then brought back online while the V-ball vent valve was put on the developmental coal feeder for further testing. Operations were smooth for the remainder of the day, and the unit was left in preparation for ammonia injection testing the following day.

The original coal feeder was the sole feeder, providing approximately 4000 pph of coal. The gasifier pressure was 215 psig, and the standpipe level was approximately 230 inches of water.

Saturday, September 09, 2006 (Night)
Gasifier operation was steady throughout the night, while conditions were maintained for ammonia injection testing. The gasifier pressure was maintained at 215 psig, the coal feed was around 4000 pph, and the standpipe level was approximately 230 inches of water.

Sunday, September 10, 2006 (Day)
Gasifier operation was steady throughout the day, with the exception of one coal feeder trip due to the discharge line plugging momentarily. Operations were returned to steady state quickly. The ammonia injection tests were successfully completed. The original coal feeder provided around 4500 pph, and the dry heating value was between 94 and 98 BTU/SCF.

Sunday, September 10, 2006 (Night)
Gasifier operation was steady throughout the night. The evaluation of methane concentration as a function of temperature resumed at a gasifier temperature of 1725°F. The system was at a pressure of 225 psig, a coal feed rate of approximately 4000 pph, and a standpipe level of 240 inches of water.

Monday, September 11, 2006 (Day)
The gasifier operated well throughout the day. Temperatures were increased from 1725°F to 1750°F as methane concentration testing continued. The coal feed rates were held at 4000 pph and the standpipe level at approximately 230 inches of water.

Monday, September 11, 2006 (Night)
The unit remained stable throughout the night. Coal inventory was shifted among silos to minimize particle size stratification, and the coal feed systems ran well. The original coal feeder provided approximately 4000 pph, and the average gasifier temperature was 1750°F. The standpipe level was maintained at approximately 230 inches of water.

Tuesday, September 12, 2006 (Day)
Gasifier operations remained stable throughout the day. Air compliance testing was conducted today on the stack. After testing was complete, air distribution repeatability testing was started. Coal feed rates were maintained at 4000 pph, and gasifier temperatures were held at 1750°F. The gasifier pressure was held constant at 225 psig, and the standpipe level was around 220 inches of water. The heating value ranged from 87 to 92 BTU/SCF throughout the day.

Tuesday, September 12, 2006 (Night)
The air flow rate distribution was adjusted as the gasifier ran steadily through the night. The coal feed rate was 4000 pph. The solids separation inlet temperature was around 1750°F, the gasifier pressure was 225 psig, and the standpipe level around 225 inches of water on LI339.

Wednesday, September 13, 2006 (Day)
Gasifier operations remained steady during the day with the exception of a brief trip. The cause of the trip, a leaking nitrogen valve on original coal feeder, was replaced with a new valve. When the repair was complete, the original coal feeder was restarted, and the feed rate was increased to 4000 pph. The gasifier pressure was maintained at 225 psig with a standpipe level of 225 inches of water. The remaining phase of the air flow rate distribution testing was also completed.

Wednesday, September 13, 2006 (Night)
The gasifier operate well during the night at a high coal feed rate of around 5000 pph. The dry lower heating value was approximately 100 BTU/SCF, without using transport air. The pressure range was between 220 and 230 psig. The major process limitation was the temperature at the exit of the cooler downstream of the atmospheric syngas burner. It increased to almost 700°F due to the high quality of the syngas.

Thursday, September 14, 2006 (Day)
High coal feed rate testing continued with stable gasifier operation throughout the day. The air flow to the gasifier was redistributed to improve the temperature profile. The coal feeder was swapped to transport air. After the change was made, the syngas dry lower heating value increased approximately 6.0 percent. The gasifier pressure was maintained at 220 psig and the standpipe level at 225 inches of water during the day.

Thursday, September 14, 2006 (Night)
The gasifier continued to operate well during the night with the exception of a nitrogen leak on the three way valve on the original coal feeder dispense vessel. The leak did not

hamper operations, and a high coal feed rate of 5000 pph was maintained at a gasifier pressure of 235 psig and riser temperature of 1750°F.

Friday, September 15, 2006 (Day)
The developmental coal feeder was brought online for a short time this morning to replace a leaking three way valve on the original coal feeder. After the valve was repaired, the feeder was brought back online and fed at approximately 5000 pph. At this point, the developmental feed was shut down. A couple of gasifier trips occurred during the feeder transition and the attempt to transition to transport air. Conditions were restored quickly with nitrogen as the conveying gas.

At the end of the shift, the gasifier pressure was at 260 psig, and the standpipe level was maintained around 230 inches of water.

Friday, September 15, 2006 (Night)
Gasifier operations remained steady during the night. The transition to transport air was made early in the shift without incident. Increased total air flow from 13900 lb/hr to 15400 lb/hr to obtain 1800°F riser exit temperature. Coal feed rate was maintained at 4500 pph with gasifier pressure constant at 250 psig.

Saturday, September 16, 2006 (Day)
Gasifier operation was smooth throughout the day. The unit was operated at higher operating temperatures, and high speed pressure measurement tests were conducted. The original coal feeder operated on transport air and provided approximately 4500 pph of coal. The riser exit temperature was around 1795°F. The syngas dry lower heating value was between 92 and 96 BTU/SCF.

Saturday, September 16, 2006 (Night)
The riser exit temperature was reduced to 1775°F to maintain mixing zone temperatures below 1825°F. The gasifier continued to operate well with a coal feed rate of 4500 pph. The gasifier pressure remained constant at 246 psig.

Sunday, September 17, 2006 (Day)
The unit ran well during the day. The wet syngas lower heating value was 77 BTU/SCF. The coal feed rate was about 4,400 pph, and the air flow rate was around 14,600 pph, yielding an air to coal ratio of 3.3. The steam rate was 1,000 pph. The carbon conversion appeared to be around 98%, higher than previous PRB testing at this air to coal ratio.

Sunday, September 17, 2006 (Night)
Operations were interrupted early in the shift when the original coal feeder vents plugged. The developmental coal feeder supplied coal to the gasifier while maintenance cleaned the lines. Once the vents were clear, the developmental feeder was shut down, and the original feeder restarted.

The unit ran well for the remainder of the night with a coal feed rate of around 4000 pph at a pressure of 245 psig. Transport air was in use. The heating value seemed lower after the trip, however, perhaps due to a higher steam flow rate.

Monday, September 18, 2006 (Day)
The original coal feeder vent line plugged again early in the shift. The developmental coal feeder was placed in service and ran the remainder of the shift at a feed rate of 4000 pph. The gasifier pressure was maintained at 245 psig. Steam flow rates to the gasifier were also reduced in order to improve syngas heating value.

Additionally, the recycle gas compressor was started on hot nitrogen before being switched to syngas flow. The recycle ran only in bypass mode to the atmospheric syngas combustor to check operation. The compressor ran well and was shutdown when testing was complete.

Monday, September 18, 2006 (Night)
The original coal feeder vent line plugged again, and coal feed was switched to the spare system. The gasifier pressure was maintained at 245 psig with solids separator temperatures at approximately 1750°F. The standpipe level remained steady at 210 inches of water. Maintenance unplugged the vent line on the original coal feeder. At the end of the shift, the original coal feeder was brought back online, and the developmental feeder was tripped in order to supply a sufficient amount of coal for the testing today.

Tuesday, September 19, 2006 (Day)
The original coal feeder ran well during the shift with a feed rate of 4000 pph with the exception of one brief trip due to low fluidization nitrogen flow. The gasifier exit temperatures were lowered to 1625°F to characterize gasifier operation at low temperatures. The gasifier pressure was maintained at 245 psig, and the standpipe level was controlled at 210 inches of water.

Tuesday, September 19, 2006 (Night)
Gasifier operation was interrupted again by coal feeder problems. The coal conveying line partially plugged, tripping the feeder. Also, fines plugged the vent line. The developmental feeder supplied coal to the gasifier for the remainder of the night at a low coal feed rate.

At the coal feed rates, the fine ash removal was extremely low, indicating high carbon conversion and solids recovery. The coal feed rate ranged from 1500-3500 pph. The standpipe level was 200 inches of water. The gasifier temperature was approximately 1750°F.

Wednesday, September 20, 2006 (Day)
The vents on the original coal feeder were cleaned out by mid morning, and the original feeder was restarted, while the developmental feeder was shut down. The unit ran steadily afterwards. The raw dry syngas LHV was 92 BTU/SCF. The coal feed rate was

at about 4,200 pph, the air flow rate was 13,950 pph, and the steam flow rate was 900 pph. Carbon conversion was around 98%.

Wednesday, September 20, 2006 (Night)
The gasifier ran well during parametric testing of fluidization flows, air flow rate, steam flow rate, and gasifier pressure. Fluidization and steam flow had a minimal effect on gasifier conditions while step changes in air flow rate and gasifier pressure affected conditions significantly. The gasifier temperature ranged from 1710°F to 1750°F at pressures between 205-235 psig. The standpipe level was 150 inches of water, and the raw dry syngas quality was 90 BTU/SCF. The coal feed rate was 4000 pph during the tests.

Thursday, September 21, 2006 (Day)
Parametric testing of air distribution and coal feed rate continued during the day. The gasifier ran well at a pressure of 240 psig and a coal feed rate of 4000 pph. Both air distribution and coal feed rate significantly effected conditions. Gasifier temperatures ranged from 1700°F to 1750°F and the standpipe level from 210 to 195 inches of water. The syngas quality remained at 90 BTU/SCF.

Thursday, September 21, 2006 (Night)
A problem with the DCS interrupted gasifier operation earlier in the shift. Once controls were restored and operations lined out, gasifier conditions were adjusted in preparation for oxygen blown testing. The gasifier pressure was dropped to 180 psig. The gasifier temperature was adjusted to around 1750°F.

Friday, September 22, 2006 (Day)
The original coal feeder vent line plugged early in the shift, and the developmental coal feeder was placed in service until the vent line was unplugged. Afterwards, the original coal feeder was placed back in service at a feed rate of 3000 pph. The gasifier pressure was lowered to 160 psig, and operation was successfully transitioned to oxygen blown mode with a targeted temperature of 1740°F.

Due to a restriction in the inlet piping, the CCAD system was not able to remove solids from the standpipe. When the DCS problem occurred on the previous day, the discharge valve on CCAD was unable to close, and material lodged in the burner leg causing a loss of flow to the removal system. As a result, the coal feed rate was decreased in the afternoon to minimize solids accumulation.

Friday, September 22, 2006 (Night)
Without the CCAD available to remove material, the standpipe level continued to grow, making it necessary to operate the bypass to remove solids. The level was decreased from 230 to 160 inches of water on LI339.

Saturday, September 23, 2006 (Day)
Operations were stable throughout the day. Bed material was added to increase the standpipe level to approximately 200 inches of water. The increased inventory improved

the circulation rate, decreasing the differential temperature between the mixing zone and the riser outlet. The steam flow was minimized in attempt to optimize oxygen blown operations.

At the end of the shift, the coal feed rate was about 3800 pph, the standpipe level approximately 223 inches of water, and the oxygen flow rate was 2300 pph. The dry lower heating value was maintained around 130 BTU/SCF throughout the day.

Saturday, September 23, 2006 (Night)
After the gasifier operated for a short period of time at optimized oxygen blown conditions, the shutdown occurred as planned at 10:30 PM. The gasifier accumulated 870 hours of on coal operation.