DEMONSTRATION OF A FULL-SCALE RETROFIT OF THE ADVANCED HYBRID PARTICULATE COLLECTOR TECHNOLOGY

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ABSTRACT

The Advanced Hybrid Particulate Collector (AHPC), developed in cooperation between W.L. Gore & Associates and the Energy & Environmental Research Center (EERC), is an innovative approach to removing particulates from power plant flue gas. The AHPC combines the elements of a traditional baghouse and electrostatic precipitator (ESP) into one device to achieve increased particulate collection efficiency. As part of the Power Plant Improvement Initiative (PPII), this project was demonstrated under joint sponsorship from the U.S. Department of Energy and Otter Tail Power Company. The EERC is the patent holder for the technology, and W.L. Gore & Associates was the exclusive licensee for this project.

The project objective was to demonstrate the improved particulate collection efficiency obtained by a full-scale retrofit of the AHPC to an existing electrostatic precipitator. The full-scale retrofit was installed on an electric power plant burning Powder River Basin (PRB) coal, Otter Tail Power Company's Big Stone Plant, in Big Stone City, South Dakota. The \$13.4 million project was installed in October 2002. Project related testing concluded in December 2005.

The following Final Technical Report has been prepared for the project entitled "Demonstration of a Full-Scale Retrofit of the Advanced Hybrid Particulate Collector Technology" as described in DOE Award No. DE-FC26-02NT41420. The report presents the operation and performance results of the system.

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LIST OF ACRONYMS

A/C	air-to-cloth ratio
AG	(Swiss, translation roughly is Incorporation or consolidation)
AHPC	advanced hybrid particulate collector
APS	aerodynamic particle sizer
COHPAC	compact hybrid particulate collector
CPC	condensation particle counter
DOE	U.S. Department of Energy
EERC	Energy & Environmental Research Center
EPA	U.S. Environmental Protection Agency
ePTFE	expanded polytetrafluoroethylene
ESP	electrostatic precipitator
FF	fabric filter
HEPA	high-efficiency particulate air
HiPPS	high-performance power system
MWh	megawatt hours
μm	micrometer
NSPS	New Source Performance Standards
O&M	operating and maintenance
OEMs	original equipment manufacturers
OTP	Otter Tail Power Company
P&ID	Piping and Instrumentation Diagram
PID	Proportional-Integral-Derivative
PJBH	pulse-jet baghouse
PM	particulate matter
PPS	polyphenylene sulfide
PRB	Powder River Basin
PJFF	pulse-jet fabric filter
P-84	aromatic polyimide fiber
QAPP	quality assurance project plan
RGFF	reverse-gas fabric filter
SCA	specific collection area
SMPS	scanning mobility particle sizer
TR	transformer-rectifier
UND	University of North Dakota
W.C.	water column

EXECUTIVE SUMMARY

This document summarizes the operational results of a project titled “Demonstration of a Full-Scale Retrofit of the Advanced Hybrid Particulate Collector Technology”. The Department of Energy’s National Energy Technology Laboratory awarded under a program entitled the Power Plant Improvement Initiative Program.

The advanced hybrid particulate collector (AHPC) was developed with funding from the U.S. Department of Energy (DOE). The AHPC combines the best features of electrostatic precipitators (ESPs) and baghouses in novel manner. The AHPC combines fabric filtration and electrostatic precipitation in the same housing, providing major synergism between the two methods, both in particulate collection and in transfer of dust to the hopper. The AHPC provides ultrahigh collection efficiency, overcoming the problem of excessive fine-particle emissions with conventional ESPs, and solves the problem of reentrainment and recollection of dust in conventional baghouses.

Big Stone Power Plant operated a 2.5 MWe slipstream AHPC (9000 scfm) for 1½ years. The AHPC demonstrated ultrahigh particulate collection efficiency for submicron particles and total particulate mass. Collection efficiency was proven to exceed 99.9% by one to two orders of magnitude over the entire range of particles from 0.01 to 50 µm. This level of control is well below any current particulate emission standards. These results were achieved while operating at significantly higher air-to-cloth ratios (up to 12 ft/min compared to 4 ft/min) than standard pulse-jet baghouses. To achieve 99.99% control of total particulate and meet possible stricter fine-particle standards, the AHPC is being demonstrated as the possible economic choice over either ESPs or baghouses.

Otter Tail Power Company and its partners, Montana-Dakota Utilities and NorthWestern Energy, installed the AHPC technology into an existing ESP structure at the Big Stone Power Plant. The overall goal of the project is to demonstrate the AHPC concept in a full-scale application. Specific objectives are to demonstrate 99.99% collection of all particles in the 0.01 to 50 µm size range, low pressure drop, overall reliability of the technology and long-term bag life.

This is the project final report. It is meant to summarize the operational experience over the last three plus years (October 2002 – December 2005).

Addenda Note:

The final report is now being submitted after the initial draft of this final report was completed. This further information is intended to cover the material changes and information that occurred to the Advanced HybridTM system through 2005. The sections described, as “Addendum” will describe the events and conclusions during this period.

PROJECT NOMENCLATURE DISCUSSION

When this technology was originally developed, the device was referred to as the “Advanced Hybrid Particulate Collector”. Since the original development, from concept to an attempt at a commercial demonstration, the name of the technology has changed to “Advanced HybridTM”. This name was trademarked by W.L. Gore and Associates, Inc. to aid in the commercialization effort and tries to maintain the continuity of the successful history to date. Either “Advanced Hybrid Particulate Collector” (AHPC) or “Advanced HybridTM” refers to the same process and equipment.

1.0 INTRODUCTION

The *Advanced Hybrid*[™] filter combines the best features of ESPs and baghouses in a unique approach to develop a compact but highly efficient system. Filtration and electrostatics are employed in the same housing, providing major synergism between the two collection methods, both in the particulate collection step and in the transfer of dust to the hopper. The *Advanced Hybrid*[™] filter provides ultrahigh collection efficiency, overcoming the problem of excessive fine-particle emissions with conventional ESPs, and solves the problem of reentrainment and re-collection of dust in conventional baghouses.

The goals for the *Advanced Hybrid*[™] filter are as follows: > 99.99% particulate collection efficiency for particle sizes ranging from 0.01 to 50 μm , applicable for use with all U.S. coals, and cost savings compared to existing technologies.

The electrostatic and filtration zones are oriented to maximize fine-particle collection and minimize pressure drop. Ultrahigh fine-particle collection is achieved by removing over 90% of the dust before it reaches the fabric and using a GORE-TEX[®] membrane fabric to collect the particles that reach the filtration surface. Charge on the particles also enhances collection and minimizes pressure drop, since charged particles tend to form a more porous dust cake. The goal is to employ only enough ESP plate area to precollect approximately 90% of the dust. ESP models predict that 90%–95% collection efficiency can be achieved with full-scale precipitators with a specific collection area (SCA) of less than 100 ft^2/kacfm (1, 2). FF models predict that face velocities greater than 12 ft/min are possible if some of the dust is precollected and the bags can be adequately cleaned. The challenge is to operate at high A/C ratios (8–14 ft/min) for economic benefits while achieving ultrahigh collection efficiency and controlling pressure drop. The combination of GORE-TEX[®] membrane filter media (or similar membrane filters from other manufacturers), small SCA, high A/C ratio, and unique geometry meets this challenge.

Studies have shown that FF collection efficiency is likely to deteriorate significantly when the face velocity is increased (3, 4). For high collection efficiency, the pores in the filter media must be effectively bridged (assuming they are larger than the average particle size). With conventional fabrics at low A/C ratios, the residual dust cake serves as part of the collection media, but at high A/C ratios, only a very light residual dust cake is acceptable, so the cake cannot be relied on to achieve high collection efficiency. The solution is to employ a sophisticated fabric that can ensure ultrahigh collection efficiency and endure frequent high-energy cleaning. In addition, the fabric should be reliable under the most severe chemical environment likely to be encountered (such as high SO_3).

Assuming that low particulate emissions can be maintained through the use of advanced filter materials and that 90% of the dust is precollected, operation at face velocities in the range of 8–14 ft/min should be possible, as long as the dust can be effectively removed from the bags and transferred to the hopper without significant redispersion and re-collection. With pulse-jet cleaning, heavy residual dust cakes are not typically a problem because of the fairly high cleaning energy that can be employed. However, the high cleaning energy can lead to significant redispersion of the dust and subsequent re-collection on the bags. The combination of a very high-energy pulse and a very light dust cake tends to make the problem of redispersion much worse. The barrier that limits operation at high A/C ratios is not so much the dislodging of dust from the bags as it is the transferring of the dislodged dust to the hopper. The *Advanced Hybrid*[™] filter achieves enhanced bag cleaning by employing electrostatic effects to precollect a significant portion of the dust and by trapping in the electrostatic zone the redispersed dust that comes off the bags following pulsing.

1.1 History of Development

The *Advanced Hybrid*[™] filter concept was first proposed to DOE in September 1994 in response to a major solicitation addressing air toxics. DOE has been the primary funder of the *Advanced Hybrid*[™] filter development since that time, along with significant cost-sharing from industrial cosponsors. Details of all of the results have been reported in DOE quarterly technical reports, final technical reports for completed phases, and numerous conference papers. A chronology of the significant development steps for the *Advanced Hybrid*[™] filter is shown below.

- September 1994 - *Advanced Hybrid*[™] filter concept proposed to DOE
- October 1995 - September 1997 - Phase I - *Advanced Hybrid*[™] filter successfully demonstrated at 0.06-MW (200-acfm) scale
- March 1998 - February 2000 - Phase II - *Advanced Hybrid*[™] filter successfully demonstrated at 2.5-MW (9000-acfm) scale at Big Stone Plant
- September 1999 - August 2001 - Phase III - *Advanced Hybrid*[™] filter commercial components tested and proven at 2.5-MW scale at Big Stone Plant
- Summer 2000 – Minor electrical damage on bags first observed
- January–June 2001 – To prevent electrical damage, the *Advanced Hybrid*[™] filter perforated plate configuration was developed, tested, and proven to be superior to the original design
- July 2001 - December 2004 - Mercury Control with the *Advanced Hybrid*[™] Filter - Extensive additional testing of the perforated plate concept was conducted with the 2.5-MW pilot unit

1.2 Design of the Perforated Plate *Advanced Hybrid*[™] Filter Configuration

After bag damage was observed in summer 2000, extensive experiments were carried out at an Energy & Environmental Research Center (EERC) laboratory to investigate the interactions between electrostatics and bags under different operating conditions. The 200-acfm *Advanced Hybrid*[™] filter was first operated without fly ash under cold-flow conditions with air. The effects of electrode type, bag type, plate-to-plate spacing, the relative distance from the electrodes to plates compared to the distance from the electrodes to the bags (spacing ratio), and various grounded grids placed between the electrodes and bags were all evaluated. Several of the conditions from the cold-flow tests were selected and further evaluated in hot-flow coal combustion tests. While all of these tests resulted in very low current to the bags, there appeared to be a compromise in overall *Advanced Hybrid*[™] filter performance for some configurations.

A configuration that appeared to have promise was a perforated plate design in which a grounded perforated plate was installed between the discharge electrodes and the bags to protect the bags. On the

opposite side of the electrodes, another perforated plate was installed to simulate the geometric arrangement where each row of bags would have perforated plates on both sides, and no solid plates were used. The discharge electrodes were then centered between perforated plates located directly in front of the bags. With this arrangement, the perforated plates function both as the primary collection surface and as a protective grid for the bags. With the 200-acfm *Advanced Hybrid*[™] filter, the perforated plate configuration produced results far better than in any previous *Advanced Hybrid*[™] filter tests and provided adequate protection of the bags.

Based on the 200-acfm results, a perforated plate configuration was designed and installed on the 9000-acfm slipstream pilot unit at the Big Stone Power Plant. The differences between the new perforated plate design and the previous *Advanced Hybrid*[™] filter can be seen by comparing Figure 1 with Figure 2. Figure 1 is a simplified top view of the 9000-acfm *Advanced Hybrid*[™] filter configuration at the start of Phase III, which had a plate-to-plate spacing of 23.6 in. For the perforated plate configuration (Figure 2), the bag spacing was not changed, allowing use of the same tube sheet as in the previous configuration (Figure 1). However, the distance from the discharge electrodes to the perforated plates as well as the distance from the bags to the perforated plates can be reduced without compromising performance. Therefore, one of the obvious advantages of the perforated plate configuration is the potential to make the *Advanced Hybrid*[™] filter significantly more compact than the earlier design.

Another difference is that directional electrodes are not required with the perforated plate design. With the previous design, directional electrodes (toward the plate) were needed to prevent possible sparking to the bags. This means that conventional electrodes can be used with the *Advanced Hybrid*[™] filter. Electrode alignment is also less critical because an out-of-alignment electrode would simply result in potential sparking to the nearest grounded perforated plate, whereas with the old design, an out-of-alignment electrode could result in sparking to a bag and possible bag damage.

While the perforated plate configuration did not change the overall *Advanced Hybrid*[™] filter concept (precollection of > 90% of the dust and enhanced bag cleaning), the purpose of the plates did change. The perforated plates serve two very important functions: as the primary collection surface and as a protective grid for the bags. With approximately 45% open area, there is adequate collection area on the plates to collect the precipitated dust while not restricting the flow of flue gas toward the bags during normal filtration. During pulse cleaning of the bags, most of the reentrained dust from the bags is forced back through the perforated plates into the ESP zone. The 9000-acfm results as well as the 200-acfm results showed better ESP collection than the previous design while maintaining good bag cleanability. The better ESP collection efficiency is likely the result of forcing all of the flue gas through the perforated

plate holes before reaching the bags. This ensures that all of the charged dust particles pass within a maximum of one-half of the hole diameter distance of a grounded surface. In the presence of the electric field, the particles then have a greater chance of being collected. In the old *Advanced Hybrid*[™] filter design, once the gas reached the area between the electrodes and bags, it would be driven toward the bags rather than the plates, and a larger fraction of the dust was likely to bypass the ESP zone.

Figure 1. Top view of the old configuration for the 9000-acfm *Advanced Hybrid*[™] filter at Big Stone.

Figure 2. Top view of the perforated plate configuration for the 9000-acfm *Advanced Hybrid*[™] filter.

1.3 Pressure Drop Theory and Performance Evaluation Criteria

Pressure drop across the bags is one of the main operational parameters that defines overall performance. It must be within capacity limits of the boiler fans at the maximum system flow rate. Since acceptable pressure drop is so critical to successful operation, a detailed discussion of the theory and factors that control pressure drop follows.

For viscous flow, pressure drop across a FF is dependent on three components:

$$dP = K_f V + K_2 W_R V + \frac{K_2 C_i V^2 t}{7000} \quad [\text{Eq. 1}]$$

where:

- dP = differential pressure across baghouse tube sheet (in. W.C.)
- K_f = fabric resistance coefficient (in. W.C.-min/ft)
- V = face velocity or A/C ratio (ft/min)
- K_2 = specific dust cake resistance coefficient (in. W.C.-ft-min/lb)
- WR = residual dust cake weight (lb/ft²)
- C_i = inlet dust loading (grains/acf)
- t = filtration time between bag cleaning (min)

The first term in Eq. 1 accounts for the pressure drop across the fabric. For conventional fabrics, the pore size is quite large, and the corresponding fabric permeability is high, so the pressure drop across the fabric alone is negligible. To achieve better collection efficiency, the pore size can be significantly reduced, without making fabric resistance a significant contributor to pressure drop. The GORE-TEX[®] membrane filter media allows for this optimization by providing a microfine pore structure while maintaining sufficient fabric permeability to permit operation at high A/C ratios. A measure of the new fabric permeability is the Frazier number which is the volume of gas that will pass through a square foot of fabric sample at a pressure drop of 0.5 in. W.C. The Frazier number for new GORE-TEX[®] bags is in the range from 4 to 8 ft/min. Through the filter, viscous (laminar) flow conditions exist, so the pressure drop varies directly with flow velocity. Assuming a new fabric Frazier number of 6 ft/min, the pressure drop across the fabric alone would be 1.0 in. W.C. at an A/C ratio (filtration velocity) of 12 ft/min.

The second term in Eq. 1 accounts for the pressure drop contribution from the permanent residual dust cake that exists on the surface of the fabric. For operation at high A/C ratios, the bag cleaning must be sufficient to maintain a very light residual dust cake and ensure that the pressure drop contribution from this term is reasonable. The contribution to pressure drop from this term is one of the most important indicators of longer-term bag cleanability.

The third term in Eq. 1 accounts for the pressure drop contribution from the dust accumulated on the bags since the last bag cleaning. K_2 is determined primarily by the fly ash particle-size distribution and the porosity of the dust cake. Typical K_2 values for a full dust loading of pulverized coal (pc)-fired fly ash range from about 4 to 20 in. W.C.-ft-min/lb but may, in extreme cases, cover a wider range. Within this term, the bag-cleaning interval, t , is the key performance indicator. The goal is to operate with as long of a bag-cleaning interval as possible, since more frequent bag pulsing can lead to premature bag failure and require more energy consumption from compressed air usage. An earlier goal for the pilot-scale tests was to operate with a pulse interval of at least 10 min while operating at an A/C ratio of 12 ft/min. While this goal was exceeded in the pilot-scale tests, a pulse interval of only 10 min is now considered too short to demonstrate good *Advanced Hybrid*[™] filter performance over a longer period. With a shorter pulse interval, the *Advanced Hybrid*[™] filter does not appear to make the best use of the electric field, because of the reentrainment that occurs just after pulsing. Current thought is that a pulse interval of at least 60 min is needed to demonstrate the best long-term performance.

Total tube sheet pressure drop is another key indicator of overall performance of the *Advanced Hybrid*[™] filter. Here, the goal was to operate with a tube sheet pressure drop of 8 in. W.C. at an A/C ratio of 12 ft/min. Note that the average pressure drop is not the same as the pulse-cleaning trigger point. For many of the previous and current tests, the pulse trigger point was set at 8 in. W.C., but the average pressure drop was significantly lower.

To help analyze filter performance, the terms in Eq. 1 can be normalized to the more general case by dividing by velocity. The dP/V term is commonly referred to as drag or total tube sheet drag, D_T :

$$\frac{dP}{V} = D_T = K_f + K_2 W_R + \frac{K_2 C_i V t}{7000} \quad [\text{Eq. 2}]$$

The new fabric drag and the residual dust cake drag are typically combined into a single term called residual drag, D_R :

$$D_T = D_R + \frac{K_2 C_i V t}{7000} \quad [\text{Eq. 3}]$$

The residual drag term then is the key indicator of how well the bags are cleaning over a range of A/C ratios, but may still be somewhat dependent on A/C ratio. For example, it may be more difficult to overcome a dP of 10 in. W.C. to clean the bags than cleaning at a dP of 5 in. W.C. For most baghouses, the residual drag typically climbs somewhat over time and must be monitored carefully to evaluate the longer-term performance. Current thought is that excellent *Advanced Hybrid*[™] filter performance can be

demonstrated with a residual drag value of 0.6 or lower.

Between bag cleanings, from the second term in Eq. 3, the drag increases linearly with K_2 (dust cake resistance coefficient), C_i (inlet dust concentration), V (filtration velocity), and t (filtration time). For conventional baghouses, the C_i term is easily determined from an inlet dust loading measurement, and approximate K_2 values can be determined from the literature or by direct measurement. However, for the *Advanced Hybrid*TM filter, the concentration of the dust that reaches the bags is generally not known and would be very difficult to measure experimentally. From the Phase I laboratory tests, results indicated approximately 90% of the dust was precollected and did not reach the fabric. However, this amount is likely to fluctuate significantly with changes to the electrical field and with the dust resistivity. Since C_i is not known, for evaluation of *Advanced Hybrid*TM filter performance, the K_2 and C_i can be considered together:

$$K_2 C_i = \frac{(D_T - D_R)7000}{Vt} \quad [\text{Eq. 4}]$$

Evaluation of $K_2 C_i$ can help in assessing how well the ESP portion of the *Advanced Hybrid*TM filter is functioning, especially by comparing with the $K_2 C_i$ during short test periods in which the ESP power was shut off. For the Big Stone ash, the $K_2 C_i$ value has typically been about 20 without the ESP field. For the 9000-acfm pilot *Advanced Hybrid*TM filter, longer-term $K_2 C_i$ values of 1.0 have been demonstrated with the ESP field on, which is equivalent to 95% precollection of the dust by the ESP. Again, the goal is to achieve as low of a $K_2 C_i$ value as possible; however, good *Advanced Hybrid*TM filter performance can be demonstrated with $K_2 C_i$ values up to 4, but this is interdependent on the residual drag and filtration velocity.

Eq. 4 can be solved for the bag-cleaning interval, t , as shown in Eq. 5. The bag-cleaning interval is inversely proportional to the face velocity, V , and the $K_2 C_i$ term and directly proportional to the change in drag before and after cleaning (delta drag). The delta drag term is dependent on the cleaning set point or maximum pressure drop as well as the residual drag. The face velocity, delta drag, and $K_2 C_i$ terms are relatively independent of each other and should all be considered when the bag-cleaning interval is evaluated. However, as mentioned above, the drag may be somewhat dependent on velocity if the dust does not clean off the bags as well at high velocity as at low velocity. Similarly, the $K_2 C_i$ is somewhat dependent on velocity for a constant plate collection area. At the greater flow rates, the SCA of the precipitator is reduced, which will result in a greater dust concentration, C_i , reaching the bags.

$$t = \frac{(D_T - D_R)7000}{VK_2C_i} \quad [\text{Eq. 5}]$$

By evaluating these performance indicators, the range in possible A/C ratios can be calculated by using Eq. 1. For example, using the acceptable performance values of a 60-min pulse interval and a residual drag of 0.6, Eq. 1 predicts that a K_2C_i value of 2.33 would be needed when operating at an A/C ratio of 10 ft/min and a pulse trigger of 8 in. W.C. Obviously, deterioration in the performance of one indicator can be offset by improvement in another. Results to date show that performance is highly sensitive to the A/C ratio and that excellent *Advanced Hybrid*[™] filter performance can be achieved as long as a critical A/C ratio is not exceeded. If the A/C ratio is pushed too high, system response is to more rapidly pulse the bags. However, too rapid of pulsing tends to make the residual drag increase faster and causes the K_2C_i to also increase, both of which lead to poorer performance. The design challenge is to operate the *Advanced Hybrid*[™] filter at the appropriate A/C ratio for a given set of conditions.

1.4 9000-acfm Pilot-Scale Results

During the summer of 2002 the 9000-acfm *Advanced Hybrid*[™] filter was operated from June 28 through early September with minimal changes to the operating parameters. This is the longest time the pilot unit was operated without interruption and is the best example of the excellent performance demonstrated with the 9000-acfm *Advanced Hybrid*[™] filter. One of the main objectives of the summer 2002 tests was to assess the effect of carbon injection for mercury control on longer-term *Advanced Hybrid*[™] filter performance. In order to achieve steady-state *Advanced Hybrid*[™] filter operation prior to starting carbon injection, the *Advanced Hybrid*[™] filter was started with new bags on June 28 and operated continuously until the start of the carbon injection for mercury control in August. Operational parameters are given in Table 1, and the bag-cleaning interval, pressure drop, and K_2C_i data from June 28 to September 3 are shown in Figures 3-5. The daily average pressure drop data increased slightly with time as would be expected after starting with new bags. When the carbon was started on August 7, there was no perceptible change in pressure drop. The bag-cleaning interval was somewhat variable as a result of temperature and load swings, but, again there was no increase when the carbon feed was started. The K_2C_i values are an indication of the amount of dust that reaches the bags and subsequently relate to how well the ESP portion of the *Advanced Hybrid*[™] filter is working. Again, there was no perceptible change when the carbon was started. These data show that the *Advanced Hybrid*[™] filter can be expected to provide good mercury removal with upstream injection of carbon without any adverse effect on performance.

From August 21 to August 26, the *Advanced Hybrid*[™] filter current was deliberately reduced to 25 mA compared to the normal 55 mA setting (see Figures 3-5) to see if good mercury removal could be maintained. The bag-cleaning interval dropped to about one-half, and the K_2C_i value approximately doubled, which would be expected. Both of these indicate that about twice as much dust reached the bags at 25 mA compared to 55 mA. However, almost no effect on pressure drop was seen. This implies that it should be possible to optimize *Advanced Hybrid*[™] filter operational parameters to get the best overall mercury removal while maintaining good *Advanced Hybrid*[™] filter performance.

Table 1. 2.5-MW *Advanced Hybrid*[™] Filter Test Parameters and Operational Summary, June 28 - September 2, 2002

A/C Ratio	10 ft/min
Pulse Pressure	70 psi
Pulse Duration	200 ms
Pulse Sequence	87654321 (multibank)
Pulse Trigger	8.0 in. W.C.
Pulse Interval	260 - 400 min
Temperature	260° - 320°F
Rapping Interval	15 - 20 min
Voltage	58 - 62 kV
Current	55 mA

Figure 3. Daily average bag-cleaning interval for summer 2002 tests with the 9000-acfm *Advanced Hybrid*[™] filter.

Figure 4. Daily average pressure drop for summer 2002 tests with the 9000-acfm *Advanced Hybrid*[™] filter.

Figure 5. K_2C_i for summer 2002 tests with the 9000-acfm *Advanced Hybrid*[™] filter.

A summary of the results in Table 2 shows the excellent operational performance achieved with the 9000-acfm at an A/C ratio of 10 ft/min.

Table 2. Summary of 9000-acfm Pilot-Scale Results from Summer 2002

A/C Ratio	10 ft/min
Average dP	~6 in. W.C.
Bag-Cleaning Interval	2–5 hr
Residual Drag	0.4–0.5
K_2C_i	0.9–1.5

The 9000-acfm pilot *Advanced Hybrid*[™] filter was also used to vary the operational parameters to assess the most critical effects. One of the most important findings was the observed significant effect of the pulse interval on the K_2C_i value, as shown in Figure 6. The large increase in K_2C_i at the lowest pulse intervals indicates that the benefit of the electric field is diminished at lower pulse intervals. This indicates that for good *Advanced Hybrid*[™] filter performance, a minimum allowable pulse interval should be established. Based on Figure 6, a 60 min pulse interval would be a good minimum performance goal.

Figure 6. Effect of pulse interval on K_2C_i for 9000-acfm pilot *Advanced Hybrid™* filter.

1.5 Full-Scale Design and Differences Between Full and Pilot Scale

The original ESP at Big Stone consisted of a Lurgi-Wheelabrator design with four main chambers and four collecting fields in series within each chamber. Only the last three fields in each chamber were converted into an *Advanced Hybrid™* filter while the first field was unchanged (Figure 7). Since the ESP plates are 40 ft high, but the *Advanced Hybrid™* filter bags are only 23 ft long, there is a large open space between the bottom of the bags and the hoppers (Figure 8). The outer six compartments (Figure 7) are arranged with 20 rows and 21 bags per row, while the six inner compartments have 19 rows with 21 bags per row. The total number of planned bags for the 12 compartments was 4914. However, because of a spacing limitation from the electrode rapping mechanism, a total of 81 bags had to be removed, so the total number of bags in service is 4834.

The main differences between the 2.5-MW pilot *Advanced Hybrid™* filter and the full-scale Big Stone *Advanced Hybrid™* filter are as follows:

- The pilot unit has a small precollection zone consisting of one discharge electrode, while the full-scale unit has no precollection zone (without the first field on). The effect would be better ESP collection (lower K_2C_i) in the pilot unit. The pilot unit has shorter bags, 15 ft versus 23 ft for the

full-scale *Advanced Hybrid*[™] filter. The expected result would be better bag cleaning with the pilot unit (lower residual drag).

- The full-scale *Advanced Hybrid*[™] filter has an ESP plate spacing of 12 in. compared to 13.5 in. for the pilot-scale unit. The expected result is somewhat better ESP collection efficiency.
- The entrance velocity of the flue gas is 4–8 ft/s for the full-scale unit versus 2 ft/s in the pilot-scale unit. The expected effect is better ESP collection efficiency with the pilot unit.
- The pilot unit has very uniform side inlet flow distribution while the full-scale *Advanced Hybrid*[™] filter has flow from the side for the first *Advanced Hybrid*[™] filter compartment and from the bottom in the back 2 compartments.

In the pilot unit all of the flow is uniformly distributed from the side and none of the flow comes from the bottom. In the full-scale *Advanced Hybrid*[™] filter, flow entering the first *Advanced Hybrid*[™] filter chamber comes from the side (similar to the pilot unit). The flow to the back two compartments must first travel below the first *Advanced Hybrid*[™] filter compartment and then either directly up from the bottom into the compartment or up from the bottom into the areas between compartments and then horizontally into the compartments (Figure 8).

Big Stone Layout

Figure 7. Top view of the *Advanced Hybrid™* filter full-scale retrofit configuration at Big Stone.

Advanced Hybrid™ Filter Retrofit

Figure 8. Side view of the *Advanced Hybrid™* filter full-scale retrofit configuration at Big Stone.

2.0 EXPERIMENTAL

2.1 Independent Characteristics

2.1.1 Independent Characteristic Chart

The following chart lists the specific independent characteristics of the Advanced Hybrid System. If changes are made to the independent data, they will be described in the section listed under the “Notes” column.

Table 3.

Data	Status	Notes
ESP Collecting Surface	170,500 ft ²	Unchanged
# of Discharge Electrodes	2,706	Unchanged
# of Filter Bags	4833	Unchanged
Filter Bag Dimensions	7 Meters Long, 6 Inches Diameter	Unchanged
Filter Bag Surface Area	36.07 ft ²	Unchanged
Filter Bag Material	See 2.1.2	Unchanged
Pulse Pressure	80 psi	Unchanged
Cleaning Mode	Threshold Cleaning	Unchanged
TR Rating of AH Field	1500 ma, 55 kV	Unchanged
TR Rating of Inlet ESP Field	2000 ma, 55 kV	Unchanged
<u>Inlet ESP Field Data</u>		
Inlet Field Dimensions ¹	45 gas passages, 40 feet high, 14 feet deep/chamber	Unchanged
Inlet Field Plate Area ¹	50,400 ft ²	Unchanged
Inlet Field Electrodes ¹	Wheelabrator bed frame “Star” Electrodes	Unchanged

¹The inlet ESP field was left in place. The design is the original configuration as installed in 1975. It is not the intention to operate the inlet field, however it was left in place as an added benefit of the system.

2.1.2 Bag Layout

For specific bag layout and description over the life of the project, refer to Appendix B23.

2.2 Dependent Characteristics

2.2.1 Dependent Data

The dependent data is largely presented in graphical format in the Appendix. The specific data points that are instrumented and presented are as follows;

Plant Gross Load: Continuously monitored TDC-3000 calculated value based on the generator output voltage and current. When the plant trips offline or shuts down for maintenance, the plant gross load will be zero.

Total Flue Gas Flow: Continuously monitored using United Science Inc.'s Ultra Flow 100 ultrasonic flow monitor. The flow monitor is located at the stack midlevel (see position #6 on the figure in 2.2.2). The readout of the flow monitor is in kscfm using 68°F and 29.92 in HG as standard conditions. The flow is converted to kacfm using the following equation:

$$\text{Gas Flow (kacfm)} = \frac{(\text{Gas Flow(kscfm)} * (460 + \text{Inlet Gas Temp}^{\circ} F))}{(460 + 68^{\circ} F)} * \frac{29.92 \text{ in HG}}{(28.56 \text{ in HG} + \text{AHPC outlet Pressure})}$$

Inlet Flue Gas Temperature: Continuously monitored using a grid of Type E thermocouples. The thermocouples are located at the AHPC inlet (see position #1 on the figure in 2.2.2). There are eight thermocouples at the inlet of each of the four AHPC chambers for a total of 32 thermocouples.

Tubesheet Differential Pressure: Continuously monitored on two of the twelve compartments. Pressure taps above and below the tubesheet (see positions #3 and #4 on the figure in 2.2.2) are equipped with Honeywell 3000 Smart DP Transmitters.

Flange–Flange Differential Pressure: Continuously monitored using two Honeywell 3000 Smart DP Transmitters at the AHPC inlet (see position # 2 in the figure in 2.2.2) and two Honeywell 3000 Smart DP Transmitters at the AHPC outlet (see position #5 on Diagram 1). Continuously calculated by the TDC- 3000 by taking the difference between the flue gas pressure at the AHPC inlet and outlet.

Air-to-Cloth Ratio: Calculated by dividing the Gas Flow (acfm) by the total surface area of the bags.

Opacity: Continuously measured by the plant opacity monitor, Monitor Labs Model #LS541. Opacity is measured in the Plant Stack, position 6 on the figure in 2.2.2. Position 6 is approximately at the 300 ft. level from grade.

Flue Gas Outlet Pressure: Continuously monitored using two Honeywell 3000 Smart DP Transmitters at the AHPC outlet (see position #5 in the figure in 2.2.2). The inlet pressure can be determined by the difference between the outlet pressure, and the flange-to-flange pressure drop.

Temperature per Chamber: See Inlet Temperature above.

ESP Power Consumption: Continuously monitored with a watt-hour meter to each chamber.

Compressed Air Flow: Continuously monitored using a Diamond II Annubar flow sensor equipped with a Honeywell 3000 Smart DP Transmitter. This ANNUBAR instrument is in the compressed air supply line after the compressors but before the desiccant dryer.

The non-instrumented data that can be found in the appendix is as follows

- Coal Analysis
- Flyash Analysis
- Coal and Alternative fuel Burned

2.2.2 Instrument Location Diagram

- 1 & 2: Advanced Hybrid Inlet
- 3 & 4: Above and Below Tubesheet
- 5: Advanced Hybrid Outlet
- 6: Plant Stack

2.2.3 Data Retrieval

Big Stone Plant's Honeywell TDC-3000 process control system monitors and controls a large number of actuators, sensors, and processes using PID controllers, programmable logic controllers, and special-purpose programs. Data gathered by the TDC-3000 is retrieved using an existing plant historian database.

The dependent characteristic data presented in this report is calculated using 60-minute averages of the TDC-3000 readings, which are recorded every minute.

2.2.4 Data Reduction

Reported NO_x and SO₂ emissions have had 5% of data removed due to erroneous spikes occurring during daily calibration of CEMS instrumentation. No other assumptions or restrictions were used to transform the raw measured data into a form usable for interpretation.

3.0 RESULTS AND DISCUSSION

3.1 General Results and Discussion

3.1.1 Chronological History of Significant Accomplishments

Quarter 1 (October 2002 – December 2002)

System Startup	October 2002
Rapper Problems Realized	November 2002
Pulse Valve Problems Realized	November 2002
EERC Testing (99.99% particulate capture goal met)	November 2002
Inlet Field Energized	December 2002

Quarter 2 (January 2003 – March 2003)

Soybeans burned at Big Stone as Alternative Fuels	January 2003
Derates due to high dP across the AH system begin	January 2003
Comparative Testing of Pilot unit to full-scale unit	February 2003
Plant shut down to wash boiler	February 2003

Quarter 3 (April 2003 – June 2003)

Meeting to discuss improvement options	April 2003
Bags washed in two chambers	April/May 2003
Pitot data used for evaluation and decision	May 2003
Decision to replace filter bags	May 2003
Complete bag changeout	June 2003
Inlet field evaluated	June 2003
Plant restored to full load	June 2003

Quarter 4 (July 2003 – September 2003)

Big Stone limited to 440 – 445 MW not due to AH	July/Sept 2003
Performance Tests	July/Sept 2003
Fluent Analysis Plan	Sept 2003
Preliminary baffle design submitted	Sept 2003

Quarter 5 (October 2003 – December 2003)

Opacity rise attributed to initiation of bag failures	October 2003
Competitive bidding of replacement bags	November 2003
Fluent modeling results for flow baffles	November 2003
Test flow baffles installed	December 2003
Four compartments of bags replaced	December 2003

Quarter 6 (January 2004 – March 2004)

Stable system operation	Jan/March 2004
Fluent modeling work continues	February 2004
Technology goals reviewed	February 2004
Next phase of project reviewed & proposed by OTP	March 2004

<u>Quarter 7 (April 2004 – June 2004)</u>	
PPS Bags Failing and Opacity Rising	April/June 2004
Inlet Field AH Proposal	May 2004
All PPS Bags replaced with P-84 Bags	June 2004
Chamber 2B baffles installed	June 2004
One compartment of blowpipes modified	June 2004
Opacity returned to low levels	June 2004
Bag analysis performed	June 2004
Additional 8 bags removed for testing	June 2004
<u>Quarter 8 (July 2004 – September 2004)</u>	
Independent Lab Analysis of Bags Completed	July 2004
Evidence of NOMEX Bag failure	August 2004
Future project reviewed	July/Sept 2004
Failed P-84 bags discovered	September 2004
<u>Quarter 9 (October 2004 – December 2004)</u>	
NOMEX Bags replaced with fiberglass	October 2004
1/2 compartment of P-84 bags replaced	October 2004
High dP through the end of the year	Oct/Dec 2004
Independent Lab Analysis of P-84 Bags	December 2004
<u>Quarter 10 (January 2005 – March 2005)</u>	
Design for inlet field modifications finalized	January 2005
Fabrication of inlet field equipment	February 2005
Construction plans finalized	March 2005
<u>Quarter 11 (April 2005 – June 2005)</u>	
Modification of Inlet field	April/May 2005
Startup of lower A:C Ratio Advanced Hybrid	June 2005
Shakeout of new installation	July 2005
<u>Quarter 12 (July 2005 – September 2005)</u>	
Investigation of performance issues	July 2005
Corrected known ESP clearance problems	July 2005
Investigated TR Set issues	September 2005
<u>Quarter 13 (October 2005 – December 2005)</u>	
Replaced failed pulse header joints	December 2005
Corrected additional ESP clearance problems	December 2005
Final determination of technology (OTP)	December 2005

3.1.2 Discussion of Results of Significant Accomplishments

General Discussion (First Quarter 10/2002 – 12/2002)

Initial Startup Problems

The Plant was put on-line (after the scheduled maintenance outage) on October 25 at 17:37, which is the official beginning of commercial operation of the Advanced Hybrid system. Startup and checkout of the system went fairly smoothly. There were few significant issues that came up during system startup, as described below.

First, there appeared to be a problem with damper operability as the dampers were commanded to open and close to check functionality. The indication for opened and closed did not come in to the plant control room. This was a simple limit switch setting in the controller. Specific training needed to take place between the ELEX startup engineers and Big Stone Plant personnel, as setting the limit switches required knowledge of procedures that, if not followed correctly, would result in the unintended dismantling of the controller body. The manual wheel on the actuator would unscrew from the controller body allowing the oil to leak out, thus rendering the actuator inoperable. This occurred 3 or 4 times before startup personnel familiarized themselves and from that point it proceeded well.

Second, ice had formed in the pressure sensing lines after the advanced hybrid system (just prior to the ID fans). At startup, the pulse controller used the flange-to-flange pressure drop as the input for pulse frequency. If a high enough differential had been realized, the system would not have started pulsing because there would have been no pressure measurement. This could have delayed startup. The sensing lines were about 70 feet long and run 50 feet overhead. However, the ice buildup was not significant and was cleared using torches and poke rods.

Third, pre-coating the bags was a new experience and the procedure was not well developed. The bag manufacturer deemed pre-coating the bags necessary. A supplier delivered crushed limestone via truck and had to wait until the system was ready to be pre-coated. Pre-coating was a manual operation, as Big Stone Plant operators moved a four inch flexible line from duct to duct to inject the crushed limestone into the appropriate chambers. This process directly added to the critical path of the outage, and therefore the time that it takes to pre-coat the bags is directly related to delays in starting up the unit. If this must continue in the future, it would be necessary to install a silo and automatic feed system so the process could be completed in minutes rather than hours. This was an oversight in the project design and plans

should be taken into account for future installations if bag pre-coating is necessary.

Fourth, the pulse system was not tested with compressed air until the system was started up. The system worked to pulse the bags, however it required the ELEX startup engineers several days to work the bugs out of the pulsing program to consider it functional for normal operation.

Overall system startup went well and fairly trouble free. The operational issues listed above are only the points of interest, and in general, the system components fit and worked together.

Operational Experience

The operational experience was mixed during the initial phases of operation. W.L. Gore and Associates produced the graph in Figure 9. The graph shows that the drag on the system was running between 0.9 and 1.0 INH₂O/ft/min during the first few days of startup. However, the whole story includes the bag pulse

Figure 9 - A/C Ratio and drag during the first week of operation

frequency. The system is attempting to run at a flange-to-flange pressure drop at 9.0 INH₂O. It is accomplishing this by changing the rate at which the 504 pulse valves are firing. That rate is not currently being recorded so there is no history. In Figure 1, we do not know if the pulse valves are running continuously (about 1.2 seconds between pulses), or one tenth of that (about 12 seconds between pulses), or any amount between. As a result, it is very difficult to put a meaningful analysis together on how the system was operating. The system was pulsing very quickly (about 1.2 – 2.4 seconds between pulses), within days of initial operation. During the first month of operation, it was deemed necessary to get some type of pulse signal into history. Eventually (around December 5, 2002) a system was installed to measure and record the pulse frequency. By that time the system was in constant pulsing while at full load, and the recorded history was not very useful.

One of the first mechanical issues seen after startup was sticking solenoid valves. On October 28, the Monday after startup, it was noticed that a fair number of solenoid valves were not operational. This was traced to the compressed air supply lines that were not blown clear prior to being connected. The cutting oil and debris in the lines contaminated the solenoid valves. The Big Stone Plant technicians disassembled and cleaned a portion of the solenoid valves to alleviate this problem. After the initial rash of sticking valves, the problem disappeared.

One of the first tests run was the off-line bag cleaning function of the Hesch pulse valve controller. This function intended to enable one compartment (1/12 of the total) to be isolated from gas flow, and pulsed without gas going through the bags. This should have resulted in improved cleaning and a lower differential pressure. This feature was tested on October 29, but did not work as the pulse valves did not activate when the damper was closed to the compartment. This was a software problem and a software update was shipped from Hesch and installed on November 12. The software fix did allow the functionality of off-line cleaning, but through intermittent tests, it was not clearly defined as a benefit to the normal cleaning modes and was not implemented as the normal mode. The differential was too high with 12 compartments in service, and taking one of the compartments out of service raised the overall differential pressure to intolerable levels.

On October 31, forced cleaning mode was also tested. This mode continuously pulsed the cleaning

valves. This also did not work correctly, but the software fix mentioned in the paragraph above resolved this issue.

During the first week of operation, two filter bags were found in the ash hoppers below the Advanced Hybrid system. This was a strong concern at the time, as we were not sure if all of the bags were prone to being dislodged from the cage and tubesheet fit. It appears there were only a few ill-fitting or mis-installed bags which came loose and fell. Two bags represents 0.04% of the total bags installed.

The Big Stone Plant was derated on November 9 to replace these two bags, and inspect that portion of the AHPC. One bag was removed for examination by W.L. Gore personnel. During startup and limited first data, from the first two weeks, the bags were in good shape and there were no adverse effects from startup or short-term operation.

Alternative fuels burned at Big Stone were started back up on November 1. The specific amounts can be seen in Appendix B14.

On November 18, the Energy and Environmental Research Center (EERC) performed the first stack test to evaluate the particulate capture of the system. The full report can be found in the Appendix, but the summary chart in Figure 10 shows that the particulate capture of the system was very high as expected.

Table 6. Advanced Hybrid™ Particulate Collection Efficiency (From Appendix)

Date	Sample Method	Advanced Hybrid™ Inlet Dust Loading, grains/scf	Advanced Hybrid™ Inlet ¹ Dust Loading, lb/10 ⁶ Btu	Stack Dust Loading, grains/scf	Stack ¹ Dust Loading, lb/10 ⁶ Btu	Particulate Collection Efficiency, %
11/18/2002	EPA Method 17			0.00002	0.00003	99.998
11/19/2002	EPA Method 29	1.02092	1.38378			
	Multicyclones	0.64099	0.86882			
11/20/2002	EPA Method 17			0.00006	0.00008	99.994
	EPA Method 29	0.85856	1.16372			
	EPA Method 29	0.92151	1.24904			
11/21/2002	EPA Method 17			0.00003	0.00004	99.997
	Multicyclones	0.66113	0.89611			
	Multicyclones	0.70044	0.94940			

¹ Values were calculated based on the Fd factors shown in Table 3 for 100% PRB.

Figure 10 - Results of Stack Testing by the EERC

During the month of November, two more bags were found in the hoppers. On November 23, three fourths of the system was removed from service to complete an inspection of the system. Two more bags that had fallen from the tubesheet were located and replaced. There was significant ash buildup on the perforated plates and the rapping schedule was adjusted for a higher frequency of rapping.

The Big Stone Plant electricians completed routine external inspections of the plate rapper system by manual operation of the rapper system and observation from the exterior. During one of these inspections in later November, it was found that one of the rappers in Chamber 2B was not turning. Electricians disconnected the motor and verified that rapper shaft was jammed internal to the system. On the 17th of December, the system was removed from service and inspected. At the time, the rapper shaft was found to need repairs; there was a broken hammer, bent rollers, and hammer to anvil alignment problems. The collar that grips the rapper shaft appeared loose. There were two fundamental issues with the reliability of the plate rappers. First, the rapper shafts were the wrong diameter. The collars that grip these shafts to keep them from floating laterally could not effectively maintain the shaft alignment. Second, the internal walkways were mounted fixed at the opposite wall as the fixed point of the rapper shafts. As the system heats up when flue gas is put through it, the walkways and the rapper shafts expand in opposite directions and misalignment between the rapper hammers and the anvils occurs. The system was also taken down on December 31, with misalignment of the rapper shaft to the walkway components the cause of another frozen rapper.

The Goyen pulse valves appeared to have an operational problem during the month of November as observed by listening to the valves operating. Occasionally a valve would not pulse with as much energy as the adjacent valve. This indication was a loud squeak or a muffled noise as opposed to a strong pulse. A Goyen representative was dispatched to the site on December 18 to review the operation of the valves. He recommended removal of the silencers on each valve to reduce the noise. It is possible that these silencers might have been plugged during startup or normal operation. All 504 silencers were removed from the pulse valves and it seemed to take care of the problem. No significant improvement in overall differential pressure was realized, so it is doubtful if more than 5 – 10% of the valves had problems with these silencers.

As the differential pressure had risen in the first couple of months of operation, it was decided to energize the unmodified inlet ESP fields to reduce the ash loading to the Advanced Hybrid system. This was planned as an only-in-an-emergency contingency, but was implemented so a performance and improvement plan could be evaluated. There is one inlet field of original Wheelabrator ESP in each

chamber. These fields were energized on December 12 and have remained in service.

There appears to be a discrepancy in the gas flow and sizing of the system. It is our understanding that the system was sized on a stoichiometric flow value based on fuel flow into the boiler, the measured oxygen level after the economizer and the air heater leakage as has been measured at the plant. The flow value was 1,824,000 acfm. However, the stack flow monitor is reading 5 – 15% more flow than is predicted by the stoichiometric balance. Using the 1,824,000 acfm value and dividing by the installed cloth surface area would result in an air-to-cloth ratio of 10.5 fpm. The goal of the technology was demonstration of acceptable performance at an air-to-cloth ratio of 12 fpm so that it would be the clear economic choice when compared to other retrofit technologies. The gas flow through the system presented in Appendices B2, B3, & B7 are based on the stack flow monitor, which reads 5 – 15% more than the stoichiometric balance predicts.

General Discussion (Second Quarter 1/2003 – 3/2003)

The system to date has experienced significant operational problems. The focus is the high differential pressure across the bags. Some of the mechanical issues have been resolved, but the primary performance concerns appear to be design and/or process related. Very significant derates of power plant output have occurred as a result of ID fan limitations, caused by the high differential pressure across the bags of the Advanced Hybrid system. The factors that appear to be contributing to this are described below.

The first regular full-load plant derate due to the high differential pressure across the Advanced Hybrid system occurred on January 8, 2003. Since that date, the plant has experienced derates as high as 55 MW. This is a significant detriment to the plant and the company's portfolio of available energy. As a result, an aggressive stance to improve AHPC performance has been taken. The performance of the system still boils down to two factors, mechanical reliability and process performance.

Mechanical Issues

Two issues remain with the mechanical operation of the system, plate rapper alignment and compressed air supply pressure to the headers of the pulse valves.

Two of the plate rappers remain a problem with regards to internal clearances and binding of the rapper shafts while in operation. A derate was taken on January 19th to inspect the system, evaluate the cause, and develop possible solutions. The problem with the rapper shafts binding due to internal obstructions as the system heats up is related to two problems. First, the rapper shafts being too small for the retaining collars at the wall. The second issue is, the opposite expansion of the rapper shafts and walkways due to opposite fixed points. This problem is described in the first quarterly report from the period of October 2002 – December 2002. Several pictures can be found in Appendix B18. The most likely fix is the replacement of the section of the rapper shafts extending through the fixed bearing so the retaining equipment can prevent the shaft from sliding laterally. This would most likely occur during the outage in June, 2003.

The other likely fix is to modify the existing equipment binding due to thermal expansion differences. There are five collars per rapper shaft that have clearance issues. The collar bolting is the problem. The collars, bolts, and visual evidence of the damage that occurs are shown in the pictures in Appendix B18 titled "Missing Roller" and "Damaged Bolt & Nut". Modifications to this system will take place during the scheduled wash outage in June. Other damage that occurred can be seen in the pictures titled "Anvil - Front View" and "Anvil – Angle View". Since there is poor hot alignment, a portion of the hammers are

not striking the anvils squarely, damaging the anvils.

The other mechanical concern is the flow limitation from the pressure regulators in the compressed air system. As the system was installed, there were six regulators installed as described in the following table (location diagram of chambers and fields is included in multiple areas in the appendix). The AHPC system is capable of faster, more aggressive pulsing, but the regulators are limiting how much

Regulator #	Size	Compartment Supply
1	1.5"	Chamber 1A, Fields 2, 3, & 4
2	1.5"	Chamber 1B, Fields 3 & 4
3	1.5"	Chamber 2A, Fields 3 & 4
4	1.5"	Chamber 2B, Fields 2, 3, & 4
5	1.0"	Chamber 1B, Field 2
6	1.0"	Chamber 2A, Field 2

compressed air flow they allow through. During periods of off-line cleaning, we need to be able to pulse through all of the valves as quickly as possible to bring the off-line compartment back on-line. The following description of the efforts to resolve this issue can best be broken down by describing the “Compressed Air Flow” graph in Appendix B22.

Period 1. During this period, we removed regulators 2 and 3 from service and allowed full plant air system pressure to reach the headers, approximately 100 psig. Just prior to this date, the plant began

derating due to high differential across the bags. A slight increase in compressed air usage is seen on the graph. This made only slight improvements to lower the differential pressure (Appendix B5).

Period 2. We changed regulators 1 and 4 to 2" regulators and set the pulse cleaning cycle pause time to 0.1 seconds. We have been limited to 0.4 seconds of pause time between pulses due to the time required to refill the headers. A noticeable step change from 2250 acfm to 2800 acfm is seen on the trend. We were greatly exceeding the desiccant dryer capacity at this time, as this is rated for approximately 2000 acfm.

Period 3. We removed regulators 1 and 4 from service. This is the highest period of compressed air usage and we had great difficulty maintaining the compressed air system pressure in the plant.

Period 4. The plant was off-line to wash the steam heat transfer surfaces of the boiler. During this outage, we noticed the bags experiencing the highest pulse pressures were forming small concentric wear areas approximately 1 inch in diameter at the very bottom of the bags. This was likely due to the aggressive pulse energy and a poor bag-to-cage fit causing the bag to flex and rebound into the bottom of the cage. At that time we were exceeding the rating of the dessicant dryer. The plant compressed air system was not capable of supplying that continuous volume of compressed air. We put all regulators back in service and increased the pause time to 0.4 seconds.

Period 5. Twelve individual regulators were installed (one per compartment) and the cycle pause time was decreased from 0.4 seconds to 0.3 seconds. This has been the normal state since that time. Graphical data indicates constant pulsing with the pause time at 0.4 seconds results in compressed air usage of approximately 1900 acfm, and a pause time of 0.3 seconds results in a compressed air usage of approximately 2250 acfm.

With all twelve compartments having a dedicated pressure regulator, we have resolved the problem of not maintaining the pressure in the header during pulsing. After regulator installation, the headers have been maintaining a pulse pressure of approximately 80 psig.

System Performance

A great deal of effort has been put forth to both establish where we are at with the existing performance, and what can be done to improve performance. The very high differential pressure is significantly different than the previously reported results of the Pilot Unit operation. The first step in evaluating the

performance was to attempt baseline testing with the pilot unit in place. The pilot unit was started up on February 3, and testing took place on February 8. There were two parameters, K2Ci and Residual Drag, which needed to be evaluated to compare performance of the two units. A short explanation of these terms and how they are calculated follows.

K2Ci

K2Ci is a measure of the loading rate of dust to the filter bags. The measurement was completed by stopping the bag pulsing and measuring the rate of the rise in differential pressure. A slower rate of differential pressure rise would mean that the ESP portion of the Advanced Hybrid was taking out more dust prior to it reaching the bags. A faster differential pressure rise would mean that the ESP portion is not removing as much dust prior to it reaching the filter bags. Various tests were completed the night of February 8. A trend of the differential pressure of both the full-scale unit and the pilot unit is included below. A description of the individual tests follows.

Residual Drag

Residual Drag is the minimum resistance possible after pulse cleaning, or the resistance of the system with just the bags and whatever dust cake cannot be removed from the bags from pulsing. It is calculated by taking the differential pressure immediately after cleaning and dividing by the air-to-cloth ratio. The units for this measurement are INH₂O/ft/min. Although the test was not set up to measure the residual drag of the pilot plant, previously reported results are in the 0.5 – 0.6 range.

ESP Efficiency

For our test, ESP efficiency was calculated by a rule of thumb method. The loading rate with no ESP section in service was taken as the 0% ESP efficiency state. A 100% efficient ESP would have a 0 loading rate. Therefore, if the K2Ci value was found to be 5.0 IN H₂O/HR, and the no ESP loading rate was found to be 19.0, the efficiency value was calculated by the following equation;

$$\text{ESP Efficiency} = (19.0 - 5.0) / 19.0 * 100 = 73.7\%$$

This is an unconventional method of calculating ESP efficiency but works well for our comparison testing.

Test #1. The TRs to only the Advanced Hybrid fields were energized. Both the full-scale system and the pilot unit were operating at 10.4 fpm according to flow instrumentation. The pulsing of the full-scale

system was halted until the differential pressure reached unacceptable levels. Then the pulse system was started, but the rate of differential pressure increase was measured, and the differential pressure after one

cycle of cleaning was measured.

Test #2. The first test was repeated with all of the TRs, including the full-scale inlet field, energized.

Test#3. The same test was repeated with all of the TRs for both the pilot unit and the full-scale unit shut off. This test should be a good comparison of the overall ash loading rate to the bags without any electrostatic cleaning of the flue gas.

The following table is the summary of the test results.

	Air-to-cloth Ratio	K2Ci		ESP Efficiency		Residual Drag
		Full-Scale	Pilot	Full-Scale	Pilot	Full-Scale
Test #1	10.4	5.17	0.91	72.5 %	95.4 %	0.91
Test #2	10.4	3.02	1.5	83.9 %	92.5 %	0.83

Test #3	10.4	19.94	18.77	0 %	0 %	NA
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Very significant conclusions can be made by analyzing the results of this testing. The loading rate of ash to the bags is 3 – 5 times higher in the full-scale unit when compared to the pilot unit. This means that the amount of dust that is being removed by the ESP portion of the systems is significantly different.

The residual drag is significantly higher in the full-scale unit as noticed during the first few days of startup (see Quarter 1 report).

Running the inlet field of the full-scale system reduces the ash loading to the bags by about 40% $((5.17 - 3.02)/5.17 * 100)$. Improving the ESP portion of the system also has a significant effect by reducing the residual drag. By doing nothing more than improving the overall collection of the ESP sections (inlet field and Advanced Hybrid fields) from 72.5% to 83.9%, the residual drag has been reduced from 9.1 to 8.3, approximately 9%

The comparison results from Test 3 show a very good correlation to the full-scale unit and the pilot unit. This tells us that the inlet dust loading to both systems is about equal.

Possible Reasons for Performance Differences

Trying to formulate a plan for improving the performance of the system involves putting together several hypothesis as to why the performance may be different than expected, how it can be verified, and what can realistically be done to improve the system.

Possible explanations for the ESP efficiency difference have been a flow distribution difference as the pilot unit is a side entry system and the full-scale unit is more of a combination of 1/3 side entry and 2/3 bottom entry. Some flue gas may also be bypassing the ESP section if there is a significant portion of the flue gas that is coming up from the area below the bags.

A better description of the flow differences can be found in the following diagrams. The diagrams represent the flow as modeled by ELEX AG at the beginning of the project. Some of the flow is vertical as represented by the red arrows. However, the pilot unit flow is more represented by the flow only in the first field. After entering this field in the pilot, the gas flow is upwards and into the clean gas plenum. There are no “back fields” of Advanced Hybrid components in the Pilot unit.

At this time, no reasonable improvements to the Advanced Hybrid ESP portion could be ascertained. The only suggested improvements are power off rapping or the potential for flow baffles that would require significant funding and mechanical changes to the system.

Possible explanations to the residual drag issue are more resistance due to bag material or manufacture, cleaning system deficiencies, or ash characteristics limiting removal during pulsing.

We investigated the effect of the burning of soybeans in the Big Stone Plant as an alternative fuel. During the first two months of the year, approximately 15,000 tons of soybeans (5% of the total fuel) were burned, with the obvious effect of fouling the steam tube surfaces inside the boiler furnace. This might have had some effect on increasing the residual drag of the system by depositing ash on the bags that cannot be easily removed. The EERC analyzed the residual ash cake taken from a bag in service and found a high percentage of potassium. An analysis of soybeans and corn (which is also an alternative fuel fired at the Big Stone Plant) is included in Appendix B16. We should have documented the residual drag of the system at the end of December and the residual drag of the system after the soybeans were burned. This would have given us more information as to how much of the residual drag difference between the pilot unit and the full-scale unit was due to combustion of higher potassium fuels. The EERC determined

it is likely the flyash from the soybeans was a factor in the increase of the residual drag. The e-mail from Stan Miller from the EERC is included in Appendix B25.

Performance Improvement Plan

A great deal of effort was put into assembling a performance improvement plan. There were two tactics taken as a part of this effort; a short-term plan designed to help the plant get back to full-load capability, and a long-term plan to bring the Advanced Hybrid system performance up to expected levels.

Short-term Improvement Plan

- Testing the off-line cleaning system
- Testing power off rapping
- Improvements to the ESP Inlet Field
- Washing the filter bags
- Pitot tube data gathering

Off-line Cleaning

The intention of the off-line cleaning system was to close the outlet damper of one of the twelve compartments of the system and pulse that chamber while no gas flow is passing through the bags. In theory, this would allow a better cleaning of the bags, reducing the residual drag and the differential pressure of the system. Once the issues with the compressed air regulators were resolved, this technique was attempted several times. Although there were times when there appeared to be a slight improvement in differential pressure, the results were miniscule at best and this path was not further pursued. The existing cleaning system was removing the ash at the same rate in either cleaning mode. Another difficulty in this arrangement is that simply closing the outlet damper to a single compartment raised the dP by 1.0 – 1.5 INH₂O and this could cause the existing condition of limited fan capability to worsen and result in an ID fan stall.

Power Off Rapping

Power off rapping was also tried to improve the overall field strength of the ESP system. In almost all cases the field strength was increased, but the overall effect on differential pressure was minimal or non-existent. The existing system did not have a true power off rapping system installed, so the test of the system was done manually by shutting off the power to the TR to a certain field, and manually commanding the plate and electrode rappers to run. Since little to no benefit was seen with regards to power off rapping it was not adopted as a performance improvement strategy.

Improvements to the ESP Inlet Field

The performance of the inlet ESP field seemed to vary considerably from chamber to chamber. Since the original ESP equipment was over 25 years old and difficult to maintain improvements to plate spacing or rapping could be made to bring the ash removal abilities of the inlet field to the maximum. Although improving this section of the system does not improve the Advanced Hybrid system, it was determined that the field would be analyzed by technicians from ELEX AG and modifications made to try to improve the overall performance.

Washing the Filter Bags

W.L. Gore personnel recommended washing the existing bags to remove the residual dust cake that could not be removed by pulsing. This seemed like an attractive option as the concern over the potassium rich flyash from the soybeans burned in the Big Stone Boiler could be eliminated. However, there was an even larger concern that water would be in direct contact with the flyash in the Advanced Hybrid box. This material is much like concrete dust and if some of the dust were to get wet and not be removed, this could cause major problems inside the system. More investigation was needed to make this decision.

Pitot Tube Data Gathering

One of the corner stones to decision making was the effort by W.L. Gore and Associates to install a substantial number of pitot tubes directly over an individual bag. This should allow better specific information with regards to potential improvement options. The effort to complete this task was significant, and the decisions that were made with regards to bag washing and bag replacement were in large part based on this tool. A brief description of this effort is needed to understand the measurement history.

Pitot Tube Measurements

Pitot tube measurements were used successfully on the Pilot unit and reported to the NETL by the EERC.

The best description of the Pitot tube effort is the pictures included in Appendix B26. These are photographs depicting the installation of the pitot tubes as they were clamped on to the pulse pipes and extended into the bags. Also included in Appendix B27 is a document from Rich Gebert of W.L. Gore and Associates with more specific design and details of the pitot tubes. The placement of the Pitot tubes can be found on a specific bag layout chart in Appendix B28. These pitots were installed during the boiler wash outage from February 26 through March 2. Low pressure transmitters (Appendix B29) were set up near these compartment locations to record the velocity and static pressure data. There were a

limited number of transmitters available for velocity pressure readings, so the connection lines to the transmitters have to be moved frequently to show multiple compartment data.

Data from Pitot Tube Measurements

By the end of the quarter, only limited data was available for analysis. The following graphs are some examples of the data that was retrieved and reported by W.L. Gore and Associates personnel. There are three different types of information that could be garnered from the data; velocity pressure, air-to-cloth ratio, and filter bag drag. (These are represented in the first three graphs below). The fourth graph represents an example of the actual data as it is read from the PLC recording the data from the instruments. No substantial conclusions could be made as to the overall performance of the system by the end of the quarter. The limited data seemed to indicate there were fairly significant flow differences between compartments and between bag locations within compartments. However, the team did feel this was going to be a valuable tool and would aid in the evaluation of the following two aspects in the next quarter;

- Flow differences before and after a bag wash
- Flow differences between bag materials

March 15, 2003 20:00 hrs A/C ratio of bag flow from Pitot tubes
 Using correction factor of (0.5) comparing Chambers 2A and 2B
 Data acquired in 2A by datalogger and 2B by hand manometer

General Discussion (Third Quarter 4/2003 – 6/2003)

Significant amounts of work, testing, evaluation, and many accomplishments have taken place during the third quarter of operation of the Advanced Hybrid system. Most of the efforts have taken the project in a new direction than was ever planned or possibly anticipated. In keeping with the format of previous quarterly reports, a quick description of the mechanical issues will precede a much longer description of system performance issues.

Mechanical Issues

The primary mechanical issue yet to be resolved was the functioning capability of the existing plate rapper system. As has been discussed in previous reports, there were two problems found with the plate rapper system. The first was a sizing problem with the first section of rapper shaft as it penetrates the wall of the Advanced Hybrid system. This was solved during a scheduled boiler wash outage in the first week of June by replacing all of the first section of rapper shafts with the proper diameter shaft. The second issue was the misalignment of the rapping components and the internal walkway that had fixed points at opposite ends. These systems were better aligned and adjusted so there would be no interference while in the hot condition. It appears that these fixes will resolve the remaining startup mechanical issues.

Performance Issues

The primary idea from the previous quarter was to instrument and study potential modifications to the system to improve the performance (specifically the high differential pressure) so the restricted ability of the power plant to produce electricity is removed.

The Advanced Hybrid team members met on April 8-9 to review the current status and set a course to improve the existing performance. We agreed to evaluate the following;

- Filter bag washing to reduce residual drag
- Pulse cleaning system modifications
- Flue gas conditioning
- Reduction of gas volume in-leakage
- Install pressure relief valves
- Removal of ID Fan outlet dampers
- Investigate other bag types

Filter Bag Washing

The first item considered was an in-place filter bag wash to remove the residual dust cake that could not be removed from the bags by pulsing. This was met with some hesitation on the part of the Big Stone Plant staff as the results of mixing water and flyash have been disastrous. Flyash will set up like cement in the right type of atmospheric conditions.

The power plant was derated to enter the Advanced Hybrid system for a couple of tasks. First, the inlet field was inspected by ELEX personnel to try to evaluate if the inlet field performance could be improved through normal maintenance during the scheduled June wash outage. The following issues were found during the inspection;

- Chamber 1B Field 1: No problems found
- Chamber 2B Field 1:
 - Four discharge electrode support insulators are cracked
 - One discharge electrode rapper is not functioning correctly
 - One discharge electrode support frame is out of alignment

This did not appear to be a great deal of work or potential improvement, but if even one section of the ESP portion is significantly out of alignment, it could affect the entire field. It was determined to be worth the effort to go into the system and make these repairs during the June wash outage.

The second effort during the outage was to remove one of the filter bags from service and attempt a wash of the bag while it was not in the system. The bag wash appeared effective as the visual dust cake was removed and the black finish of the original bag was clearly seen. The decision was made to try some type of mass bag washing.

Bag Comparison Test

Approximately ten days later, the boiler experienced another outage due to an unrelated equipment failure. At that time, several different bag options were installed and instrumented with pitot tubes to aid in the data gathering and decision making process for potential solutions. These bags were;

- A new original style all-ptfe bag
- An original all-ptfe bag was removed from the system, washed outside of the system, and then replaced
- A new conductive PPS bag with ptfe membrane

The location of these bags seemed to be of importance because a difference in flow and the corresponding bag position within a compartment seemed to vary if the bags were not in close proximity to each other. This effect was noted and the bags were placed to minimize this effect. The earliest graph of significance in this regard is included below. This graph shows a distinct difference in A/C ratio between the new PPS

bags and the ptfe bags. The A/C ratio of the PPS bags is nearly 15 – 20% higher than the ptfe bags.

This result was very significant since it was the first evidence that a different bag type could result in a dramatic reduction in differential pressure or increased flow capabilities at the existing pressure drop.

Bag Washing

During the month of April, we developed plans to wash the Advanced Hybrid filter bags while they were in place. Many problems had to be resolved such as; how to handle the wet ash slurry as it flowed down through the hoppers, how to get the water on to the bags in an even and consistent manner, how to assure that the ash washed down the bags with no patches of ash remaining that could damage or restrict the bags, and the logistics of getting the work done in as safe and timely a manner as possible.

Working with W.L. Gore and Associates personnel, a bag wash boom was developed and built at the plant by Big Stone Plant personnel. The picture below shows the boom during testing in the plant maintenance

shop. This boom was designed to completely wash one row of bags during a single lift and decent cycle. This would ensure the bags were washed fairly well on the way up, and then rinsed on the way down to lessen the risk of leaving material on the bags. Three booms were built allowing all three compartments in the same chamber to be washed at the same time, reducing the overall duration of the plant derate.

The first bag wash occurred on April 29. It required nearly all of the available plant personnel to complete in approximately 24 hours. Employees washed all of the bags in chamber 2B. A presentation was prepared with pictures of the wash and these are included in Appendix B30. This was an extremely difficult task to accomplish and a lot of credit goes to the Big Stone Plant employees for accomplishing this task under difficult circumstances.

Bag Wash Results

After the 100 MW derate for approximately 24 hours, the plant was able to regain approximately 10 MW of load. This was dependant on the temperature of flue gas into the Advanced Hybrid.

A second bag wash in chamber 1A was completed on May 8. This was similar to the previous bag wash although the total time required to complete the task was reduced to approximately 16 hours. The results were about the same, with the plant able to increase the load carrying capability by another 10 MW.

Conclusions from Bag Wash

Bag washing at the plant appeared to be beneficial to the system. Washing the bags for half of the system reduced the restriction of the bags by about 20 MW total. If the remainder of the bags were washed, the plant might have been able to recover approximately 40 MW of load, at least for the short-term.

However, the ambient temperatures were going to increase significantly during the summer months and as long as there was no operating margin at the time, load was going to continue to be restricted. This would

cause a significant problem at the plant as the high cost of power through the summer months would make the situation worse. More improvements needed to be found to improve the system through the summer months.

Bag Type Evaluation

W.L. Gore and Associates began evaluating several different bag types at the end of April. The results of these bag studies continued to show a reduced flow resistance when compared to the original all PTFE design. One option considered was a complete or partial bag replacement with PPS or some other style bag. The bags considered for replacement included;

- Original all PTFE design
- PTFE membrane with Conductive PPS backing (rastek scrim)
- PTFE membrane non-conductive PPS backing (PPS scrim)

This decision was not an easy one. We decided that every effort to bring the plant back to full load must be undertaken, and the bags would be completely replaced. This involved some risk, as non-conductive bags had not been tested in the pilot unit for a period of time. PPS bags had not been exposed to the flue gas conditions at Big Stone and their reliability to withstand these conditions was a relative unknown. A decision needed to be made in the first week of May so that the bags could be fabricated and delivered to the site in the first week of June

June Outage Activities

The Big Stone Plant had a scheduled wash outage and the following list of tasks was completed in the AHPC;

- All bags replaced
- Inlet fields inspected and repairs made
- Rapper shafts replaced
- Rappers aligned
- Pressure relief dampers installed

All of the existing bags were replaced during the boiler wash outage in June. Due to the very short time frame to get the bags to the site, W.L. Gore and Associates had to supply some of each of the bag styles to make the delivery date. All bags replaced had a PTFE membrane, the differences occurred in the backing and scrim material, and bag conductivity. Please refer to Appendix B23 for a more informative description of the location, type, and number of bags installed.

The inlet field was inspected and there was not a significant amount of work accomplished. This work mostly centered on replacement of some of the insulator crocks that support the electrodes. Some electrode frames were re-aligned and plate rapper hammers were repaired.

The Advanced Hybrid rappers were repaired as described in an earlier section.

The last significant accomplishment was the installation of pressure relief dampers that could possibly pass approximately 5-10% of the flue gas after ESP cleaning only. This would be used as a last resort in case the system improvements were not sufficient to lower the differential pressure.

Results After Startup

The Big Stone Plant was put back on-line on June 11. Early results were extremely positive, as the differential pressure was controllable.

Some tests with the inlet field on and off were conducted but these tests went on through the summer and will be covered in the next quarterly report.

The pressure relief dampers were tested for operation on June 17, and opacity was not acceptable during this short test (approximately 20 minutes). As a result, these dampers were never used to control the differential pressure and remained closed.

General Discussion (Fourth Quarter 7/2003 – 9/2003)

General Comments

In general the Advanced Hybrid system has performed significantly better this quarter than in previous quarters. The system is still not performing as is required to demonstrate it commercially. The excellent performance seen immediately after the outage in June has not been maintained, as the differential pressure has risen from 7 to 8.5 INH₂O at the highest A/C ratios seen so far. The inlet ESP field remains charged to reduce the ash loading to the Advanced Hybrid system.

The focus of this quarter is to maintain stable operation of the power plant and delve further into the available data and instrumentation tools to understand the root causes of the performance differences between the pilot unit and the full-scale unit demonstrations.

Performance Testing

A series of performance tests were conducted to measure current performance. These tests are:

- A/C ratio range testing with the inlet field not energized
- Power Off /Plate Rapper Testing (POPR)
- Humidification Testing
- Further pitot testing as a basis for Computational Fluid Dynamic Modeling

The A/C ratio range testing is documentation of existing performance with the inlet field on and off to determine performance over an A/C ratio range. These results are summarized in the following two tables;

Date	A/C	Inlet Temp	K2Ci	Drag	Pulse Interval
	ft/min	deg F		Residual	min
8/5/03	9.67	294.29	4.22	0.61	36.81
8/3/03	9.66	288.21	3.66	0.59	47.17
7/15/03	9.49	287.83	4.01	0.53	56.87
7/19/03	9.48	306.32	3.80	0.61	45.77
8/24/03	9.15	309.42	3.99	0.67	38.55
7/14/03	8.79	289.11	3.25	0.52	94.75
7/13/03	8.66	279.42	2.45	0.50	140.64
8/2/03	8.36	270.88	2.64	0.56	124.63
9/17/03	8.05	286.92	3.06	0.63	103.27
9/2/03	8.00	269.94	2.44	0.61	138.64
9/1/03	7.98	268.47	2.74	0.60	127.58

**Table 2 - Advanced Hybrid
Performance with inlet field OFF**

Date	A/C	Inlet Temp	K2Ci	Drag	Pulse Interval
	ft/min	deg F		Residual	min
8/6/03	10.17	296.20	1.81	0.61	68.76
9/28/03	10.15	289.03	1.91	0.63	57.00
10/22/03	9.77	295.33	2.06	0.62	69.23
8/7/03	9.60	287.57	0.82	0.57	234.36
8/12/03	9.49	288.73	0.76	0.58	252.96
9/12/03	8.84	282.05	1.11	0.61	211.54
9/10/03	8.69	290.25	0.66	0.66	322.00
10/5/03	8.57	274.37	0.82	0.64	288.75
9/16/03	8.17	280.08	0.35	0.64	839.79
9/4/03	7.71	270.58	0.38	0.67	869.04

**Table 3 - Advanced Hybrid performance
with inlet field ON**

The test periods were limited to times of reduced plant load in the evenings. During these periods either the inlet field was de-energized (Table 2) or the conditions were noted if the inlet field was left on (Table 3). The results are similar to those obtained in the second quarter of the demonstration period. When referring to the results from Table 2, there is a considerable difference in the K2Ci values of the system when compared to the pilot unit. It is estimated that the K2Ci valued for the pilot unit would be less than 1 at an A/C ratio of 9.0 fpm. The full-scale unit K2Ci at 9.0 fpm appears to be about 4.0. This is an ash loading rate to the bags of four times the rate when compared to the pilot unit. These results lead us to focus on performance improvement effort in the Advanced Hybrid ESP section. Contrarily, the residual drag portion of the system is now comparable with the results of the pilot unit at approximately 0.5 – 0.6 INH₂O/ft/min.

The Power Off Plate Rap tests were performed by turning off the power to the individual compartments and rapping the ESP components to try to improve the ash collection of the ESP section. A graph of these results is included in Appendix B32. In this specific test, as in almost all the power off rapping tests, the ESP power increased slightly, but had no significant effect in the K2Ci, Residual Drag, or differential pressure. This may indicate there is a portion of flue gas bypassing the ESP zones or another problem with flow distribution.

The humidification test was another short-term improvement test to determine if the existing plant flue gas conditioning system could be used to improve ESP performance. The humidification system was used to inject a minimum amount of water and proprietary chemical to determine if an improvement could be made. As can be seen in the graph in Appendix B25, very little improvement was seen during this test.

The last significant testing was the analysis of the existing pitot tube data. As was described by W.L. Gore and Associates, there appears to be a fairly significant K2Ci performance difference between the first, second, and third section of some individual compartments. Pitot testing indicated the K2Ci value of the bags in the middle section of Chamber 2A Field 3 was about 2.0, while the back section of Chamber 2A Field 3 was about 5.0. In another interesting comparison, the front section of Chamber 2A Field 4 was about 4.5, while the middle section of Chamber 2A Field 4 was about 1.5. This is described by the graph in Appendix B26. All of these test results point towards a gas flow distribution issue that may help explain the difference in loading rate between the pilot and full-scale unit.

Performance Improvement Effort

Now that the Big Stone Plant has returned to full load capability, an effort towards a long-term improvement is being made. This effort is focused on the gas flow dynamics of the system and how an understanding of these dynamics may aid us in improving the system. Fluent Inc. was brought on board to evaluate the system through Computational Fluid Dynamic (CFD) modeling of the existing system. A description of the effort by Fluent Inc. is included in Appendix B33. The most reasonable approach to improvement of the ESP portion of the system is the addition of baffles below the bag rows in each section. A proposal in the form of a presentation is included in Appendix B34 with further details on the principal theory of the baffles.

The results of the Fluent Inc. modeling should be completed in the next quarter of demonstration.

General Discussion (Fifth Quarter 10/2003 – 12/2003)

General Discussion

Problems have again developed with the Advanced Hybrid system. Significant bag failures have occurred in the PPS bags with the PPS scrim since installation three months prior. Indications and likely reasons for bag failure are included below. As a result, a competitive bidding effort has taken place with several different suppliers of various bag materials. This should allow us a greater flexibility of bag options, but also increase the amount of unknowns.

Other than the bag failures, performance has been maintained and even slightly improved as cooler gas temperatures into the Advanced Hybrid are realized. The cooler temperatures are due to lower ambient temperatures heading into the winter.

Some modeling results from Fluent Inc. are available and will be reviewed.

Bag Failures

In early October, it became apparent there were opacity spikes occurring during periods of pulsing. The graph below shows a two-hour time duration and the observed indications. During periods of pulsing (red), opacity (green) is increasing from around 8% to about 10-11%. These spikes contribute to an overall opacity rise, seen in Appendix B8.

Specific Bag Failures

An exact number of failed bags is not known. The failing bags were the PPS bags with the PPS scrim. The reasons for failures appear to be the weakening of the strength of the fibers and cleaning pulsing. The temperature is likely the primary factor in weakening the bag material. The compartments of PPS bags with the most failures to the least failures are ranked in this order

1. Chamber 1B Field 3 (most failures)
2. Chamber 1B Field 4
3. Chamber 2B Field 4
4. Chamber 2A Field 4

The PPS bags in Chamber 1A appear to have few, if any, failures. The all-ptfe bags had no failures, and the PPS bags with the rastek scrim show only a few failures occurring in chamber 2B. There is an operating temperature difference between the chambers due to the regenerative style air preheater used to transfer heat from the flue gas to incoming air. As a result, 1B & 2B chambers operate approximately 20 degrees higher average temperature than 1A & 2A. This would logically explain why the compartments in chambers 1B and 2B have the most failures of PPS bags. However, the failures that occurred in Chamber 2A don't seem to follow this same pattern. A likely contributing factor to these failures was a high temperature event experienced in July 2003. During a plant trip, a failure of the air heater system caused a short-term temperature excursion. The temperatures into Chambers 2A & 2B exceeded the 375 degrees rating of the

PPS bags for about fifteen minutes.

Bag Replacement Decisions

Some bag replacement was necessary during the scheduled boiler wash outage in December. A significant operational performance improvement was made with the decision to replace the original all-PTFE bags with PPS bags in June 2003. The original style bags would not likely be considered for replacement due to high differential pressure concerns. Only PTFE membrane bags were considered allowing the fundamental goal of 99.99% particulate removal to be maintained. We considered bags of the following materials for use in the Advanced Hybrid system:

- All PTFE (new)
- All PTFE (original bag washed outside the Advanced Hybrid system)
- P-84
- Nomex
- PPS with the rastek scrim
- Fiberglass
- Superflex™

The only bags with operational history were the all-PTFE bags and the PPS bags with the rastek scrim. Both of these options seemed questionable because of either high differential pressure issues (all-PTFE), or questionable reliability strength issues (PPS). We decided to install one compartment of P-84 bags into Chamber 2B field 4, one compartment of NOMEX bags into Chamber 1B field 4, and one compartment of original all-PTFE washed bags in Chamber 2A field 3. Approximately 1000 bags were washed in the Big Stone Plant turbine bay prior to the outage. Fortunately this was accomplished, because an unexpected outage extension of 7 days occurred (unrelated to the Advanced Hybrid system). The bags in a fourth compartment Chamber 2A field 4 were also replaced with original washed all-PTFE bags. Bags in four of the twelve compartments were replaced during the December boiler wash outage. For more description of the specific type and styles, see section 2.1.2 or Appendix B23.

Fluent Modeling Effort

During the previous quarter, an effort was undertaken by Fluent Inc. to model the gas flow dynamics of the system. This was attempted to gain a better understanding of where gas flow dynamics may be adversely affecting performance, and what could be done to improve performance. The most likely improvement was the installation of flow baffles to direct gas flow from the bottom more directly into the ESP zones of the Advanced Hybrid components. Preliminary results indicated approximately 15% of the flue gas flow could be entering the area directly

beneath the bag rows and bypassing the ESP zone. The significance of this is fairly strong. If the flue gas passing through the ESP portion of the Advanced Hybrid system is being cleaned at a rate of 90%, and if 15% of the flue gas is bypassing this ESP zone with 100% of the ash loading, this would result in an overall ESP efficiency of only 76.5%. This may be better understood by taking the example of a loading rate of 1 grain/acf, and working through the potential ESP efficiency calculations. First, assume a true 90% ESP efficiency rate;

$$\text{Ash loading to bags} = 1 \text{ gr./acf} * (100\% - 90\%) = 0.1 \text{ gr./acf}$$

However, if the actual case is a 15% gas bypass of untreated flue gas, the result is;

$$\text{Ash loading to bags} = 85\% * (1 \text{ gr/acf} * (100\%-90\%)) + 15\% * ((1\text{gr/acf} * (100\%))) = 0.235 \text{ gr/acf}$$

This would mean a loading rate to the bags nearly 2.4 times the estimated rate of an ESP efficiency of 90%. This level of change would be needed to approach the loading rate demonstrated in the pilot unit. The full-scale unit loading rate is nearly four times the loading rate of the pilot unit.

Unfortunately, final modeling results were not available at the time baffles needed to be ordered for installation during the December boiler wash outage. Otter Tail Power Company personnel decided to purchase and install 3 sets of these baffles to allow an operational evaluation. The only reliable information in this limited format would be issues associated with installation and with operation (specifically whether or not the baffles plugged with ash during operation).

Three sets of baffles were designed by and purchased from Southern Environmental Inc. Installation was accomplished with Big Stone plant personnel. Some difficulties during installation were noted and modifications will be made if more baffles are ordered. A picture of the baffles is included in the Appendix.

A section of pitot tubes was installed across the bags with these baffles, but limited data and analysis is expected due to such a small number of baffles.

Blowpipe Modifications

Big Stone plant personnel modified one of the existing blowpipes so a single pulse valve pulsed 19 bags instead of 10. This was accomplished in a forward-looking manner, as there may be reasons in the future

to modify the system to remove the stacked blowpipe arrangement. This arrangement has caused a definite increase in bag replacement costs when compared to a standard baghouse arrangement with no stacked blowpipes. If successful, this would lower the cost of the existing system by reducing the required headers, pulse valves, control system and pulse pipes by half. There may also be an improvement in performance, as all the valves could be cycled through in half the time. Assuming an equal cleaning efficiency per pulse, this could result in a lower residual drag. Lastly, there is evidence that we are still over-cleaning the bags, indicated by an increased rate of bag failure on the short blow tubes as compared to the long blow tubes. A picture of this blow tube is included in the Appendix B39. The Big Stone Plant pitot instrumentation will be placed on the bags on this tube and some analysis may be possible.

General Discussion (Sixth Quarter 1/2004 – 3/2004)

General Discussion

Operation of the Advanced Hybrid system has been stable since startup after the December boiler wash outage. The bags are still being aggressively cleaned. There have been no significant plant limitations due to the Advanced Hybrid system since prior to the June 2003 boiler wash outage. There have been four primary efforts this quarter. These are;

- Performance improvement investigation – Fluent/baffle effort
- Evaluation of changes made – baffles, blowpipe, bags
- Review of technology results and goals – Technology team
- Proposal and review of second phase of project

Performance Improvement Investigation

The CFD modeling with Fluent continued through this quarter of demonstration. Some very informative and good modeling data has been generated. The figure below is taken from a presentation of the CFD results from Fluent. The first is a description of the assumptions and a three dimensional view of the

model. The second is a graphical display of the vertical gas flow components between the individual compartments in one chamber. This work aided the team to better understand the gas dynamics of the system, suggesting areas of improvement through baffling. Since mid-February this work has been on hold as the team has evaluated the overall goals and methods of improvement.

Evaluation of Changes Made

Several changes have been made to the system. These are

- Three rows of baffles installed
- A single blow tube installed
- P-84 and NOMEX bags installed

Three sets of baffles were installed in Chamber 2B field 3 during the boiler wash outage in December. These were installed to evaluate the ease of installation and to find any areas of concern during operation. A short pitot tube analysis was also completed, but as anticipated, the results have minimal reliability because so few baffles were installed. In general, the baffles may be reducing the ash loading by about 10% to the bags. During a short load drop on February 28, the baffles were inspected and found to be in satisfactory condition. There was no ash plugging and only a slight buildup on the baffles. An effort is underway to fund and install one complete chamber of baffles during the scheduled boiler wash in June of 2004.

Another change made was the modification of one blowpipe. Currently, one blowpipe charged by one three-inch pulse valve, is assigned to clean 10 bags. There are 20 bags in a cleaning row, meaning that two valves per cleaning row are necessary. The blowpipes for the system must be stacked so the compressed air to the second ten bags in any row is supplied through a solid line that travels over the blowpipe for the first ten bags. This current arrangement has advantages and drawbacks.

Advantages

- Better/more aggressive cleaning of bags

Drawbacks

- Significantly more expensive system
- Difficult to change bags/more expensive bag replacement
- Stacked blowpipe creates hazardous walking conditions inside plenum
- Aggressive cleaning may contribute to premature bag failure
- Longer time needed to complete one pulse cycle

One blowpipe was changed and instrumented with pitot tubes to try to determine if 20 bags could be pulsed effectively by one three inch pulse valve. The graph below depicts some of the pitot data as recorded by the Power Plant data historian.

The above graph shows the changes in velocity pressure as the bags are pulsed using either a 1-piece or 2-piece blowpipe. The chart below summarizes these changes (VP_i = Initial Velocity Pressure, VP_f = Final velocity pressure):

	Blowpipe	Load GMWH	Inlet Temp °F	A/C ft/min	Pressure psig	Duration ms	VP_i inwg	VP_f inwg	Delta %
Pitot #1	1-Piece	468	283	11.2	80	200	0.196	0.517	164
Pitot #2	2-Piece						0.236	0.550	133
Pitot #3	1-Piece						0.333	0.654	96
Pitot #4	2-Piece						0.304	0.659	117
Pitot #5	1-Piece						0.236	0.566	140
Pitot #6	2-Piece						0.213	0.566	165

Further testing has been performed using various pulse pressures and pulse durations at different A/C ratios. All the data indicates that there is no significant change in pulse efficiency when comparing the 1-piece modified blowpipe to the 2-piece blowpipe.

The last significant change was the installation of a compartment of P-84 bags and a compartment of NOMEX bags. The P-84 bags in Chamber 2B field 4 were inspected during the February 28 derate and no holes were seen at that time. At the end of this quarter, no specific information is known on the NOMEX bags as no other inspections have taken place.

Review of Technology Results and Goals

A group effort was undertaken in February to try to review the current status, goals and path forward for the technology. The real impetus behind this effort is a scheduled major outage of the Big Stone Plant in

April and May of 2005. If major changes to the system need to occur this would be the only reasonable chance until a projected outage some time in 2010. OTP facilitated a review in an attempt to reach a consensus. The current active stakeholders in the project and the technology include;

- Otter Tail Power Company (responded)
- National Energy Technology Laboratory
- Energy and Environmental Research Center (responded)
- W.L. Gore and Associates (responded)
- ELEX AG (responded)
- Southern Environmental Inc.

Four of the stakeholders listed above responded to questions to determine project status and goals. The main questions that need to be answered are;

- What defines successful operation of the Advanced Hybrid system?
- What A/C ratio can we currently claim would meet successful operation?
- What A/C ratio is needed for the technology to compete commercially?
- Is there a reasonable chance, through improving the existing system while maintaining the current A/C ratio, to demonstrate successful operation?

A summary of responses is listed below.

What defines successful operation of the Advanced Hybrid system?

Certainly particulate control and bag life are important factors to consider for successful operation. At the heart of the question is operation on a routine, minute-to-minute basis. In general, the best and simplest way to define successful minute-to-minute operation is the pulse interval. This is the time required to clean the bags completely through one cleaning until the differential pressure rises high enough to initiate the next cleaning. Approximately 30 to 60 minutes was the range discussed. OTP is of the strong opinion the pulse interval should be no less than 60 minutes. After some general discussion, this was agreed upon.

What A/C ratio can we currently claim would meet successful operation?

The approximate value is 8.0 fpm. This depends on the acceptable pulse interval from the previous question. At 60 minutes, the best approximation at this time is 8.0 fpm with the inlet ESP field off (true Advanced Hybrid).

What A/C ratio is needed for the technology to compete commercially?

The current commercialization partner feels strongly that an A/C ratio of at least 10 fpm is needed to compete commercially. Using the data from Appendix B7, the A/C ratio at full load has been 10.5 to 11.5 fpm since startup. This means that the system is in a competitive commercial range, but could be sized larger to reduce the A/C ratio by a range of 5 – 15%.

Is there a reasonable chance, though improving the existing system while maintaining the current A/C ratio, to demonstrate successful operation?

It is generally felt it would be difficult to demonstrate acceptable minute-to-minute performance at the current A/C ratios.

Several broad conclusions can be drawn from the opinions of the group. First, there is a significant difference between the current successful A/C ratio (8 fpm), and the actual A/C ratio (11.5 fpm). Second, the system can be resized by about 15% and still remain competitive commercially. Third, it would be difficult, if not impossible, to maintain the same A/C ratio and demonstrate successful minute-to-minute operation through improvements to the system.

Taking this thought process forward, Otter Tail Power Company personnel are proposing to re-size the existing system.

Proposal and Review of Second Phase of Project

Otter Tail Power Company has proposed that a new phase of this project be entered into to advance the needs of the power plant and improve the chances of bringing the technology to the commercial marketplace.

The proposed next phase of this project would be the replacement of the existing inlet ESP field with improved Advanced Hybrid components and some small changes to the existing system to improve overall performance. Primarily, this effort would reduce the A/C ratio of the system from approximately 11.5 fpm, to 70% of the current level or 8.05 fpm. This would accomplish two primary objectives. First, it would drop the A/C ratio to a range that has been demonstrated as acceptable during short term testing. Second, several design improvements could be implemented that may improve performance to meet a new goal of 10 fpm. Third, by sizing the system conservatively large, we will have the flexibility to increase the A/C ratio if changes made to the system are very successful. Conversely, we will not need to

maintain minimum commercially acceptable A/C ratios to meet the full load needs of the power plant.

Improvement ideas being currently discussed are;

- Installation of bag row baffles
- Further baffling to improve gas flow distribution
- Closer plate-bag spacing
- 20% more cloth surface in the same footprint
- Enhanced ESP zones
- Blow tube modifications

General Discussion (Seventh Quarter 4/2004 – 6/2004)

General Discussion

Operation of the Advanced Hybrid has been fairly stable. There have been no significant derates of the power plant due to Advanced Hybrid system. The remaining PPS bags have begun to fail at an unacceptable rate, and it was a good decision to plan on replacing all of the PPS bags during the scheduled June shut down. The major activities of this quarter were;

- Work related to the boiler wash outage including;
 - Replacement of 1928 PPS filter bags with P-84/BHATex filter bags.
 - One complete chamber of Baffles installed
 - One compartment of blowpipes modified
 - 10 filter bags pulled and sent to independent laboratory for analysis
- Review of proposed design for installation of AH components in the inlet field
- Bag testing data reviewed

June Boiler Wash Outage

The plant was shut down from June 5th to June 12th for the scheduled boiler wash. During this period, Southern Environmental Inc. was contracted to come in and perform the tasks listed above. A complete report of these activities can be found in Appendix 24.

Overall, the work that was completed was done well and on-time. It appears that our choice of using the P-84 bag from BHA was a good one and will hopefully get us through the warm summer temperatures without premature bag failures.

Proposed Project for Installation of Advanced Hybrid components in inlet field

A meeting between OTP, EERC, and SEI was held at the Big Stone Plant on Friday, March 5, 2004. The purpose of the meeting was to discuss the bid requirements and design optimization for the following items:

- 1.Manufacture and install 1 Chamber of bag row baffles in June 2004
- 2.Modify one compartment of blowpipes in June 2004
- 3.Convert 4 inlet ESP fields into Advanced Hybrid compartments in April 2005
- 4.Include with item 3, installing ESP field below new AH compartments
- 5.Design and construct new AH chamber for construction in April 2005

An engineering review meeting was held at SEI headquarters on April 13-14. The bag row baffle design and blowpipe modifications for the June 2004 outage were finalized. SEI also presented their progress on the items 3-5 above. Main items of discussion were:

1. Changing the plate-to-plate spacing from 12 in. to 10 in.
 - This closer spacing allows for more rows of bags thus lowering the A:C
 - This will not degrade the ESP performance
2. Determining the maximum number of bags per compartment
 - Four additional rows of bags will be added in each compartment
 - Total of 1974 additional bags representing a 41% increase in filtration surface area
3. Extending the length and increasing the number of the electrodes and plates
 - Rigid electrodes and collecting plates will be lengthened from 25 feet to 37 feet creating an ESP collecting zone below the fabric filter components
 - Below the level of the bag row baffles, the collecting plates will be solid instead of perforated.
 - There will be no discharge electrodes in the gas passages below the filter bags
 - The area below the pulse headers will be filled from the hot roof to the top of the hoppers with new discharge electrodes and solid collecting plates
4. Rapping systems
 - Electromagnetic rappers will be used instead of tumbling hammers for the discharge electrodes
 - The drive from the existing collecting plate tumbling hammer rapper system will be relocated and reused.
5. Duct work tie in
 - Outlet ductwork from new inlet compartment will tie straight into the outlet duct from field two
6. Electrical & controls
 - Discussed cable splicing options and Hesche pulse controller capabilities to handle additional compartments
7. New compartments include bag row baffles and modified blowpipe design

A brief discussion was held concerning the design and construction of a new AH chamber. Few details were discussed as converting the inlet fields to Advanced Hybrid was agreed upon as the most economical performance improvement option.

Following this meeting, a purchase order was issued to SEI for bag row baffles in one chamber and modification of the blowpipes in one compartment. Both of which took place during the June 2004 outage. SEI has also submitted a firm bid to convert the inlet ESP fields into the Advanced Hybrid as discussed above. The quote for \$3,625,000, would not include, filter bags, taxes, baffles or blowpipe modifications for the remaining compartments, or any additional costs as a result of NETL participation (EERC testing and reporting). They have requested a letter of intent and partial purchase order from OTP to begin engineering no later than August 1, 2004 to ensure construction readiness in April 2005.

Bag Testing Data

A significant amount of bag testing data was reviewed this quarter. The entire report by W.L. Gore and Associates is included in the appendix. The summary table from that report is included below.

Otter Tail Power Company Big Stone Power Plant Improvement Initiative Demonstration Site Filter Bag analysis summary chart - All Frazier #s are reported as cfm/ft2@0.5 in.w.g. driving force											
Location	Service Time	Max. exposed temp (F)	Backing	As rec'd (F-n)	Mullen Burst (psi)	Mullen Burst % Strength Retention	Tensile strength - cross machine direction (psi)	%Tensile strength retention cmd	Tensile strength - machine direction (psi)	% Tensile strength retention - md	Comments
1BF3 R1B1	6/10/03 to 9/17/03	365	all PPS	2.9	249	72	113	39	83	61	membrane OK, tan felt color
1BF3 R1B3	"	365	all PPS	3.6	226	66					membrane cracking along some of the vertical cage wires
1BF3R1B4	"	365	all PPS	4	223	65					membrane cracking at vertical/horizontal cage wire junctures
1BF3 R1B6	"	365	all PPS	3.8	182	53			51	37	membrane delaminated during HEC cleaning
1BF3R1B7	"	365	all PPS	2.7	236	69	114	39	61	45	membrane cracking, tan felt color
2BF2 R3B5	"	500	all GT	1.9	717	100					membrane OK
2BF2 R3B8	"	500	all GT	1.5	735	100					membrane OK
2BF3 R19B6	"	500	cond PPS	2.3	481	96	181	54	243	100	membrane OK, chocolate brown felt color
2BF3 R19B7	"	500	cond PPS	2.2	473	94	180	54	200	83	bag turned inside out during removal
2BF4 R20B7	"	500	all PPS	2.8	208	60	90	31	73	53	membrane scraped during removal, dark tan felt color
1AF4 R11B11	6/10/03 to 9/27/03	322	all PPS	3.9	234	68	123	43	90	66	membrane cracking along vertical and horizontal cage wires
1AF4 R1B20	6/10/03 to 10/24/03	322	all PPS	3.6	368	78	104	36	42	31	membrane cracking in vertical direction between vertical cage wires
1AF4 R1B12	"	322	all PPS	4	229	67	73	25	24	17	membrane cracking at vertical/horizontal cage wire junctures, tan felt color
1BF3 R21B5	"	365	all PPS	6.9	203	59	48	16	10	8	holes formed through felt backer, choc. brown felt
1BF3 R21B6	"	365	all PPS	5	210	61	33	11	2	2	membrane delamination, holes in felt
2AF4 R21B14	"	450	cond PPS	2	463	92	115	34	197	82	tan discoloration, hole in felt
1AF2 R15B11	6/10/03 to 2/28/04	322	cond PPS	2.6	449	89	224	67	205	85	membrane OK
1AF3 R11B15	"	322	all PPS	3	214	59	125	43	78	57	holes formed at vertical/horizontal cage wire junctures
2AF4 R13B10	12/3/03 to 2/28/04	350	SUPERFLEX	3.5	870	100	483	100	405	100	membrane OK
2AF4 R13B9	"	350	Fiberglass	3.1	920	100	729	100	461	100	membrane OK, small areas scraped during removal
2BF4 R11B6	"	365	P-84	5.1	337		185		97		membrane delamination throughout entire length of bag
	new	80	NOMEX	5.4	513		408		160		brand new
			new all PPS		366		289		137		
			cond PPS		503		337		241		
			all GT		650						

The overall conclusions in the report from W.L. Gore and Associates are as follows:

Conclusions:

- GORE-NO STAT® filter bags continue to maintain excellent membrane integrity and physical strength.
- Laboratory analysis of the filter bags revealed no membrane damage caused by electrostatic discharge or sparking.
- After 10 weeks of service SUPERFLEX® and fiberglass backed filter bags exhibited no loss in physical strength and membrane integrity.
- The all PPS backed and conductive PPS backed GORE-TEX® membrane filter bags have shown they are sensitive to temperature upsets.
- Future physical strength analysis should include Tensile strength testing, preferably using the Instron instrument.

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As the power plant operator, we consider the information in this light, ‘What bag should be installed in the system to give a balance of low resistance to gas flow and strength retention in service for prolonged mechanical life?’. With the operation results of the all PPS bags unacceptable with regards to mechanical bag life, it seems that our options looking ahead for filter bag backing are as follows (each of these bags would likely include a PTFE membrane);

- PTFE
- Superflex
- Fiberglass
- P-84
- NOMEX

At this time, it has not been determined which bag is the most likely candidate to give a good balance of performance. Additional testing and operation time is needed. Factors such as the Frazier number, as well as percentage strength retention need to be taken into account.

General Discussion (Eighth Quarter 7/2004 – 9/2004)

General Discussion

Operation of the Advanced Hybrid system has been stable during the last quarter. There has been very little change in operation or significant operational accomplishments. The plant was loaded a little bit lighter this summer due to an unseasonably cool temperatures. However, we still saw some derates and uncontrollable pressure drop during the warmest period of the summer.

Some of the significant points of discussion are:

- Independent bag analysis from Environmental Consulting Company (ECC)
- Full chamber baffle installation and blowpipe modification
- Bag life concerns with NOMEX
- Decision to move ahead with the inlet field modification
- P-84 Failures discovered

Independent bag analysis from ECC

An independent bag analysis company was contracted to perform testing and analysis on a variety of bags in the Advanced Hybrid system. The report is included in Appendix B41. The major conclusions are included below:

- NOMEX has undergone sulfur trioxide degradation and under the 6 month exposure has suffered high deterioration. NOMEX Aramid is not recommended for service in this application.
- The life projections for the following candidates based on limited testing data is as follows
 - Fiberglass 4-5 years
 - P-84 5-6 years
 - PTFE felt 8-9 years
- Other conclusions can be found in the Appendix

It was apparent to us that the NOMEX bags were beginning to fail unacceptably during the bag inspection last June. The analysis from ECC backed up those conclusions. However, of some concern is the estimate of 5-6 years of bag life remaining for the P-84 bags when some bag failures were seen during an impromptu inspection during a boiler tube leak outage in the last days of September. This is discussed in the last bullet item of this section.

Full chamber baffle installation and blowpipe modification

During the scheduled boiler wash outage in June, a full chamber of flow baffles was installed. This represents ¼ of the entire Advanced Hybrid system. There has not been a clear measurable advantage with the flow baffles in the system. Undoubtedly, the baffles are working to divert some of the formerly untreated flue gas into the ESP zone, but this is very difficult to measure.

Likewise, two blowpipe sections were combined into one long blowpipe to determine if this could be done to improve the overall usability of the system and reduce the system costs. Further research and testing will need to be done to evaluate if this is an acceptable option.

Bag life concerns with NOMEX

As mentioned earlier, our independent lab analysis of the NOMEX bags revealed that the strength of these bags was deteriorating at an unacceptable rate. It will be necessary to change these bags out during the scheduled boiler wash outage in October. It was determined that the most logical choice for replacement was fiberglass bags. Two options exist currently, a straight fiberglass bag or a fiberglass/PTFE composite (both membrane bags). A couple of these bags have been in service since December 2003, and have not failed, but a large scale (full compartment) needs to be tested in a warmer chamber. A purchase order was issued to Midwesco Inc. for a full compartment of fiberglass bags.

Decision to move ahead with the inlet field modification

A letter of intent and purchase order were issued to Southern Environmental from Otter Tail Power Company to install additional Advanced Hybrid components. This was done to lower the air:cloth ratio of the existing system to levels that have been demonstrated as successful. Currently the system operates at up to 12 fpm. The planned installation of 4 more compartments will reduce this to approximately 75% of current levels, or 9 fpm. A separate project is being considered for this work and it will not be covered under the existing reporting or project arrangement. It is uncertain at this time whether or not additional NETL participation will occur.

P-84 Failures discovered

The last item of interest was the discovery of a significant number of failed P-84 bags in the last compartment of Chamber 2B. These were discovered by chance during an unscheduled bag inspection that occurred during a boiler tube leak on September 29th. Other than the NOMEX compartment, which had a very significant percentage of failed bags, the compartment with P-84 bags that were installed in December 2003 was the only other compartment to have visual evidence of a significant number of failed bags. An estimated 40 bags have holes in them and about 50% occurred in the 9th and 10th position of the

short blowpipe in that compartment. Also, 100% of the failed bags were under the short blowpipe in other positions. This is a significant concern as the P-84 bags were considered the best, reasonable cost bag option until this time. The fact that the ECC bag analysis predicted 5-6 years of life and significant failures occurred in approximately 9 months needs further evaluation. The fact that these bags were all on the short blowpipe would also lead us to believe that there is an imbalance in the blow pipe design, and further refinement in the design is needed. Further testing and explanation of the failed P-84 bags with ECC will be completed.

General Discussion (*Ninth Quarter 10/2004 – 12/2004*)

Although not intended to cover an additional two months of reporting on the operations of the Advanced Hybrid system, Otter Tail Power Company is including data from the last months of the year in this final report.

The final demonstration period for the Advanced Hybrid system has been fairly stable. The most significant accomplishments were;

- Replacement of 1 compartment of NOMEX bags with fiberglass bags (with membrane)
- Replacement of ½ compartment of P-84 Bags with Superflex™ bags
- Independent analysis of the failed P-84 bags
- Continued work towards installing Advanced Hybrid components in the inlet field

Replacement of 1 compartment of NOMEX bags with fiberglass bags (with membrane)

The last compartment of Chamber 1B (Field 4, compartment #6) was replaced with membrane-style fiberglass bags from Midwesco. The installation went well, and only time will tell how these fiberglass bags will hold up during operation.

Replacement of ½ compartment of P-84 Bags with Superflex™ bags

One half of the bags in the last compartment of Chamber 2B (Field 4, compartment #12), was replaced with Superflex™ bags from W.L. Gore and Associates. All of these bags were under the short blow-pipe section. Again, only time and operational experience will tell if this type of bag will stand up to actual operational conditions.

Independent analysis of the failed P-84 bags

EEC was again contracted to perform an analysis on the P-84 bags which failed since the last outage. The report focused on the failure of the P-84 bags in service. It appears that the primary factor for failure was acid attack on the bags from moisture in the pulse air system. The report can be found in Appendix B42.

Addenda: General Discussion (Major Activities 1/2005 – 12/2005)

During 2005, the major focus has been the design, fabrication, construction and operation of additional Advanced Hybrid Components in the existing inlet field. The existing inlet field of the original system was left as designed in 1975 as a standard ESP section. The main goals of this modification were the following;

- Lower the A/C ratios to levels where acceptable performance has been demonstrated
- Improved ESP design and performance
- Improved pulse cleaning design
- Optimize bag placement and space consideration
- Return the Big Stone Power Plant to full load and stable operation

Lower A/C Ratios

The fundamental change to the system is the addition of 4 more AHPC compartments to bring the total number of compartments of the Advanced Hybrid system from 12 compartments to 16 compartments. In general, the operating air:cloth ratios have been reduced from 12 fpm to 8 fpm. This has been the air:cloth ratio that had been demonstrated from the performance of the initial system to be acceptable (see Tables 2 & 3 from “General Discussions Fourth Quarter). Also, see the performance graphs included as B45 Addendum - Performance Graphs from 10/2002 through 12/2005

Improved ESP design and performance

After the initial design, a likely improvement option from the opinion of most working on the project included improving the ESP design. These design changes included extending the plates and electrodes longer than the original design. In the original design, the plates were only extended to cover the length of the installed bags. In the new design, approximately 10 feet of additional collecting surface was extended downward. This should have improved the pre-collection effect, as approximately 75% of the total gas stream will pass below the inlet field to the back three compartments of each chamber. Also, the area of open space beneath the current header design will be filled with ESP components. This should have improved the pre-collection of the flue gas that would normally bypass around the ESP components laterally with the old design.

Improved Pulse Cleaning Design

With the original design, the blowpipes were arranged in a two-piece system. The first half blowpipe

would pulse the first half of the bags closest to the pulse header and the second half blowpipe would pulse the second half farthest from the header. This design proved to be aggressive to the point of accelerating bag failures and very difficult from a maintenance perspective to replace bags. During extensive testing and a demonstration of the improved single blowpipe design in one of the original compartments, it was determined that a single blowpipe design was superior for long-term bag life and maintainability, without poorly effecting performance. As a result, both the four new inlet compartments and the existing twelve compartments were retrofitted for a single blowpipe design.

Optimize Bag Placement and Space Consideration

In order to maximize the new cloth surface of the system, the new design was implemented with 10” plate spacing rather than 12” plate spacing. This design will allow for three more rows of bags (21 bags per row) per compartment. Also, successful demonstration of this concept would shrink the footprint of the system by over 10%.

Return the Big Stone Power Plant to full load and stable operation

Although the effort at replacing the inlet field with Advanced Hybrid design took advantage of lessons learned during the initial effort, the primary reason was to return the Big Stone Power Plant to full load stable operation. The performance of the Big Stone Plant primary particulate collection device needed to improve. In particular, the differential pressure across the system needs to be brought below 8 INH₂O to allow the existing plant ID fans to function normally at full load. Any improvement efforts of the Advanced Hybrid system that did not lend themselves to this concept were not considered. Failure of the effort to improve system performance enough to bring Big Stone back to full load would result in abandoning the technology from Otter Tail Power Company’s opinion.

General Discussion in Conclusion

During a six-week outage at Big Stone in the spring of 2005, the inlet field of ESP components was replaced with improved Advanced Hybrid Design described in general above. The results of this effort are described in the next sections, but in general, the project failed to meet the primary goal of overall improved performance.

4.0 CONCLUSIONS

4.1 PERFORMANCE PARAMETERS

The four fundamental performance parameters of the Advanced Hybrid system are;

- Opacity (Appendix B8)
- Air-to-cloth ratio (Appendix B7)
- Tubesheet dP (Appendix B5)
- Compressed air flow (Appendix B22)

Particulate control is ultimate goal of the Advanced Hybrid system. Only one stack test was performed by the EERC during the demonstration, although the stack opacity readings were recorded during the entire demonstration and this graph can be found in Appendix B8. The results of that stack test met the ultimate goal of 99.99%. However, as the various bag types were tried in an effort to reduce the differential pressure across the system, significant bag failures resulted in particulate control that falls short of the goal. It is generally accepted that to reach the 99.99% collection efficiency goal, an generally low opacity reading would be measured. After the initial set of bags was removed, the opacity would rise above minimum values and we are quite confident that the system would not reach the 99.99% goal. Significant improvements in the existing system must be realized so that overall performance will be acceptable, and bag integrity maintained so that the 99.99% particulate capture goal is met in the short term.

The A/C ratio during the demonstration has been between 10.5 and 12 fpm during full load operation. Significant plant reductions in load (5 – 50 MW) have been taken at times as the plant ID Fans have begun to stall during operation. Although this range of A/C was the goal of the system, what was determined as acceptable performance was not reached for the vast majority of this A/C ratio range. In addition to this, there is a discrepancy with regards to the overall flue gas flow volume of about 10%. In other words, the flue gas volume that was predicted by the stoichiometric equations and the volume measured by the stack flow probe is different by about 10%. If the expected stoichiometric flow was used instead of the stack flow monitor, it would result in an A/C ratio of about 9.5 – 10.8.

The tubesheet dP goal for the demonstration was 8.0 INH₂O. At full load conditions during the two-year demonstration, the differential pressure exceeded this value up to maximum of 10.5 IN H₂O at full load

operation.

The compressed air usage for the system is a good representation of performance if the differential pressure is being maintained below 8 IN H₂O. If the differential pressure is above 8 IN H₂O, it can be assumed that the pulse system is working at maximum and the compressed air flow would be represented at around 2200 acfm. However, at times when the differential pressure is below 8 IN H₂O, the pulse system will automatically pull back to reduce the compressed air usage while maintaining the differential pressure at 8 IN H₂O. It can be seen in Appendix B22 that the compressed air flow was at 2000 acfm or greater at the beginning of the demonstration and at the end. While testing the various bag types, the compressed air flow varied greatly from as low as 500 acfm, to the level consistent with constant pulsing.

4.1.(addendum) PERFORMANCE PARAMETERS (June 2005 – December 2005)

The four fundamental performance parameters of the Advanced Hybrid system are;

- Opacity (Addendum Appendix B45)
- Air-to-cloth ratio (Addendum Appendix B45)
- Tubesheet dP (Addendum Appendix B45)
- Compressed air flow (Addendum Appendix B45)

Opacity during this period remains a challenge. Although after modification of the inlet fields, the opacity of the system was in the 5% range, in four to five months, the opacity had risen again to 10-12%.

The failed bags were replaced in December 2005. The primary bag type that had failed was the BHA fiberglass bags.

The A/C ratio after the installation of the Advanced Hybrid components dropped to 7-8 fpm as compared to the 10-12 fpm with the original design.

The tubesheet dP for the system has not decreased as anticipated. One clarification needs to be made with regards to the performance graph at the end of the report. The mode of control for the entire plant changed after the spring 2005 outage. Rather than being a base loaded plant, due to energy market fluctuations as part of the MISO market system, the unit has been cycling to lower loads during certain times. This has resulted in wider load swings than the system has seen in the past. This accounts for the

greater variation in the graphical data presentation in both the Tubesheet dP and Flange-to-flange dP in the addendum section.

The compressed air usage after the new inlet field system was installed shows an increase from 2000 acfm to approximately 2400 – 2750 acfm. This is consistent with the installation of additional bags and pulse valves associated with the inlet field upgrade. One other note is that the increase above 3000 acfm at the end of the graph was due to a modification in piping at the plant and not related to an increased demand to the Advanced Hybrid system.

4.2 BENEFITS ANALYSIS

4.2.1 Cost Baseline Analysis

The cost baseline analysis before and after installation of the system is based on three primary factors, electrical energy usage, ongoing maintenance costs, and bag replacement costs. The electrical energy comparison information is presented in the following table.

Table 3 Electrical Energy Comparison

		ESP Only		Advanced Hybrid™
Precipitator 1A	KW	188.8		110.1
Precipitator 1B	KW	190.4		93.4
Precipitator 2A	KW	172.3		130.4
Precipitator 2B	KW	133.0		98.3
Total ESP Usage	KW	684.5		432.2
ID Fan A	KW	1,552.0		1,888.5
ID Fan B	KW	1,567.6		1,835.7
ID Fan C	KW	1,541.7		1,835.0
ID Fan D	KW	1,573.9		1,851.1
Total ID Fan Power	KW	6,235.2		7,410.4
Air Compressor D	KW	105.5		173.6
Air Compressor E	KW	87.2		181.5
Air Compressor F	KW	127.9		174.9
Total	KW	320.6		529.9
Total Electrical Energy	KW	7,240.3		8,372.5
Difference	KW			+ 1,132.2

Table 4 Cost Comparison

		ESP Only		Advanced Hybrid™
Labor & Materials	\$/month	\$5,741		\$35,670
Humidification Chemical	\$/month	\$7,022		NA
Bag Replacement Cost	\$/month	NA		\$174,028
Average	\$/Month	\$12,762		\$209,698
Sum of Monthly Average	\$/Year	\$153,144		\$2,516,376
Difference	\$/Year			+ \$2,363,232

Notes on the table above:

The Advanced Hybrid™ costs are derived from the spreadsheet AHPC Work Plan. The labor and materials are taken from the operators and other union personnel time. The material cost is derived from the OTP costs with the bags removed.

Table 5 MWH - Derate Comparison

	ESP Opacity Derates	ESP Repair Derates		Advanced Hybrid™ Opacity Derates	Advanced Hybrid™ Repair & Operational Derates
1999	7,786	16,004			
2000	6,859	16,676			
Average MWH/Year	7,323	16,340			
2003				0	99,324
2004				706	29,108
Average MWH/Year				353	64,216
Difference by Category				-6,970	+47,876
Total Derate Difference					+40,906

4.2.2 Technical Baseline Analysis

The technical baseline information is a comparison of the last particulate loading test that was performed at Big Stone and the Stack test that was performed by the EERC in November 2002 after the installation of the Advanced Hybrid™ system.

Table 6 – Collection Efficiency Comparison

		ESP		Advanced Hybrid™
Particulate Matter ¹	gr/scf	.0068		.00004
Collection Efficiency ²	Gr/acf	99.29%		99.996%

1 acf converted to scf by measured value during demonstration

2 Inlet loading during previous stack test assumed to be the same as the inlet loading during the EERC stack test.

4.2.3 Comparison Summary

Table 7 Comparison Summary Table

		ESP Only		Advanced Hybrid™
Collection Efficiency	Gr/acf	99.29%		99.996%
Cost Difference	\$/Year			+ \$2,363,232
Electrical Energy Usage Difference	KW			+ 1,132.2
Opacity Derate Difference	MWH/year			-6,970
Operational & Repair Derate Difference	MWH/year			+47,876

4.2.4 Baseline Analysis (Addendum)

There were no significant changes to the performance after the inlet field upgrade. So no additional comparison was made. However, as a point of note, the cost for the inlet field upgrade was approximately, \$7,907,374.

4.3 Final Project Conclusions

4.3.1 Project Objectives

Demonstrate that the AHPC technology can be retrofitted into an existing ESP at the full-scale level

This objective was met. The overall installation of the Advanced Hybrid™ system into the existing Wheelabrator-Frye electrostatic precipitator box was a significant success. The installation of the equipment was accomplished during a 5.5-week outage in October 2002. There was no difficulty in making this installation timeline.

Demonstrate the ability of a retrofitted AHPC to meet performance specifications without derating the plant because of high opacity

This objective was not met, as the plant had to derate output in October of 2004 as the bags began failing.

Demonstrate the ability of the AHPC to provide >99.99% particulate collection efficiency for all particle sizes greater than 0.01 µm.

This objective was met as the results of the stack test performed in November 2002 showed. Although, in general, it may have been better to state this objective as meeting the particulate collection efficiency goal after a certain period of time that would be considered acceptable. A likely better objective would have been 99.99% collection efficiency after 3-5 years of operation. The Advanced Hybrid™ system would not have met the objective in this case due to the failure of the filter bags.

Demonstrate the reliability of the AHPC as defined by acceptable maintenance requirements that are the same or less than standard ESP's or Baghouses.

This is somewhat speculative to answer, although I would say that the spirit of this objective was met. Obviously, when comparing the benefits and cost comparisons in the previous section, the Advanced Hybrid system is significantly more expensive to maintain than the previous ESP system. However, there are two underlying components that need to be considered. First, there was some difficulty after startup with the plate rapping systems, and working the bugs out of the system. This occurred for about six months or until the next week-long outage. After this outage, these issues were resolved and the rapping system worked fairly well. The other, considerably larger, factor is the significant work with the bag changes. If we would remove these two factors, it is our opinion that this objective would have been met. Other than the ongoing bag concerns, the maintenance for operation is at acceptable levels.

Demonstrate the ability of the AHPC to achieve low-pressure (guaranteed) pressure drop at an air-cloth

ratio of 12 ft/min

This objective was not met. Although the system was operated at 10.5 – 12 fpm (using the stack flow meter), the tubesheet differential pressure ranged from 8 – 10 IN H₂O. Because of this, significant limitations of the plant output were realized. This is the primary objective that drives the view of success of this project, as well as the primary consideration looking ahead.

Demonstrate the long-term operability of the AHPC

This objective was not met, since the previous objective was not met.

Demonstrate the economic viability of the AHPC

This objective was not met. This judgment is based on the previous two objectives not being met, as well as the high cost of the replacement bags to date.

4.3.2 Overall Conclusions

When reviewing the project objectives, three of the seven objectives were met. Overall however, the system is not where the project team estimated it would be at the conclusion of this demonstration. This can be attributed to two primary factors, differential pressure and air:cloth ratio.

If the differential pressure had met the 8.0 IN H₂O goal, there would not have been any plant output restrictions. The original filtration bags installed in October 2002 would still be in the system, and the significant cost and problems associated with attempting the use of various bag materials would not have occurred. The reason the differential pressure goal was not met is likely a scale-up problem from the pilot unit to the full-scale unit.

The most significant test and information came from a one-time test in February 2003. The details of this test can be found in pages 36-39 of this report. After this test the performance levels of full-scale system when compared to the pilot system were known. With a residual drag nearly 30% greater than previously reported results, and 3-5 times the rate of ash loading to the bags, the full-scale system was simply too far outside the reasonable range of performance. The system as designed and built was simply not able to demonstrate acceptable performance. All attempts to improve performance failed over the long-term, and the decision to re-size the system to a lower air: cloth ratio was made.

4.3.3 Looking Ahead

The current plans for the system involve the installation of improved Advanced Hybrid™ components in the existing inlet field at Big Stone. This will result in operation at an air:cloth ratio of approximately 8-9 fpm, or 75% of current levels. Using the table of demonstrated performance on page 54, this should result in acceptable performance. However, as was seen in the first phase of this project, unforeseen difficulties may still arise and the system needs to be demonstrated prior to being considered a viable market technology.

There are also questions as to which bag material is appropriate for the system. This has not yet been resolved, and will take additional demonstration before it can be concluded.

4.3.4 Final Conclusions (addendum)

The inclusion of Advanced Hybrid components in the inlet field of the Big Stone ESP failed to significantly improve performance to satisfactory levels. In fact, as can be seen by the performance graphs in the addendum section at the end of this report, differential pressure across the system actually increased during periods of full load.

The goal of installing the Advanced Hybrid system in the inlet field was improved performance demonstrated at lower A/C ratios during the operation of the Advanced Hybrid system and reported on Tables 2 and 3 in the Fourth Quarter General Discussion section of this report. It is the professional opinion of the authors of this paper that the reasons for this lack of performance improvement are due to the inability of the AHPC to precollect any flyash on the perforated collecting plates prior to the fabric filters. Main reasons for the lack of ESP collection are (1) high gas velocities, (2) high ash resistivity, and (3) inability to maintain design clearances between the plates and electrodes. Without the benefit of ESP precollection on the perforated collecting plates, the AHPC operates just as a conventional PJFF does. In essence, we replaced a working inlet field ESP with a PJFF compartment operating at an A/C of 8:1.

As a result of the lack of performance improvement, Otter Tail Power Company has made the decision to abandon the Advanced Hybrid technology, and is looking at full-scale replacement of the primary particulate device.

5.0 APPENDICES

APPENDIX A - COMMENTS ON ANOMALIES OF GRAPHICAL DATA

Appendix B5 & B6. The initial dP data was not historized correctly, so the first couple of days of dP history do not exist in the Plant Historian.

Appendix B19. Significant increases in Chamber Power typically indicate periods where the initial inlet field was energized, although spikes also occur during periods of reduced loading on the unit.

Appendix B17. Right hand column of units is incorrect. The ug/g unit is correct, but this is not a direct percent.

Appendix B8. Opacity Graph shows two spikes in the opacity reading that were not real (1/15/2003 & 3/1/2003). These spikes were instrumentation failures and/or calibrations.

Appendix B8. Opacity graph shows spikes around 6/10/2003. These are instrument difficulties, and not representative of actual opacity.

Appendix B15. bam, ebm, etc. are Powder River Basin mine codes

Appendix B14 & 15. The “adjustment” refers to an end of the month correction based on a comparison between visual levels and bookkeeping levels.

Appendix B21. Pulse counter graph seems to indicate no pulsing after the June 12, 2003 startup until the end of June. However, the scale is so large and the pulse cycle frequency was so insignificant, that it cannot be seen as a clear increase until the next quarter. The number of pulse cycles by June 30, 2003 was 284.

Appendix B2, B3 & B7. Low stack flow readings around 7/21/2003 are instrument problems and not real readings. As can be seen in B1, the plant was on-line and operating during the indicated period of no flow.

Appendix B8. Opacity spikes around 7/21/2003 and 9/23/2003 are instrument problems and not representative of actual high opacity.

Appendix B8. During the plant outage, (the period represented approximately 12/4/2003 – 12/9/2003 on the graph), the opacity is out of scale because it was removed from the plant stack and a “clear stack” calibration was performed in a clean environment. So the data from that period is not valid.

Appendix B6. There is no clear reason for the high differential pressure reading around 3/3/2003.

Appendix B8. The Opacity spike around 3/25/2004 was due to a calibration, and not a real opacity event. The step change in opacity can be attributed to a calibration issue and not a real opacity event.

Appendix B6. Beginning around 9/23/2004, there was a plugged sensing line for the Flange-to-Flange dP and this reading is in error.

APPENDIX B – Graphical & Tabular Performance Data

B1 Gross Plant Load

B2 Flue Gas Flow (KSCFM)

B3 Flue Gas Flow (KACFM)

B4 Inlet Gas Temperature

B5 Tubesheet dP

B6 Flange-to-Flange dP

B7 Air-to-Cloth Ratio

B8 Opacity

B9 NO_x Emissions

B10 SO₂ Emissions

B11 Outlet Gas Temperature

B12 Outlet Pressure

B13 Temperature per Chamber

B14 Fuel Burn Record

BIG STONE PLANT
FUEL BURN RECORD - page 1
Oct-02

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Oct-02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Oct-02	24.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Oct-02	1,245.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Oct-02	3,534.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Oct-02	5,058.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Oct-02	5,969.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Oct-02	6,442.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Oct-02	6,363.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31-Oct-02	5,619.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	34,257.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Delivered	56,477.36	0.00	22.39	189.33	0.00	0.00	0.00	0.00
HHV	8538	0	15000	7187	0	0	0	0
% Ash	4.41%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	1,511.61	0.00	51.48	12.52	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Nov-02

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Nov-02	5,987.98	0.00	22.39	189.33	0.00	0.00	0.00	0.00
2-Nov-02	6,001.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Nov-02	5,640.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Nov-02	4,601.40	0.00	90.01	979.79	0.00	0.00	0.00	0.00
5-Nov-02	5,871.32	0.00	22.61	36.17	0.00	0.00	0.00	0.00
6-Nov-02	6,181.69	0.00	45.36	47.65	0.00	0.00	0.00	0.00
7-Nov-02	6,062.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Nov-02	5,518.75	0.00	249.68	98.17	0.00	0.00	0.00	0.00
9-Nov-02	5,418.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Nov-02	6,080.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Nov-02	6,315.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Nov-02	6,169.84	0.00	45.18	24.18	0.00	0.00	0.00	0.00
13-Nov-02	6,139.55	0.00	91.71	23.04	0.00	0.00	0.00	0.00
14-Nov-02	6,305.74	0.00	117.44	48.82	0.00	0.00	0.00	0.00
15-Nov-02	6,202.35	0.00	46.40	84.85	0.00	0.00	0.00	0.00
16-Nov-02	6,510.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Nov-02	6,185.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Nov-02	5,796.69	0.00	43.73	160.38	0.00	0.00	0.00	0.00
19-Nov-02	6,013.24	0.00	22.87	194.89	0.00	0.00	0.00	0.00
20-Nov-02	6,289.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Nov-02	6,364.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Nov-02	6,037.07	0.00	139.47	179.66	0.00	0.00	0.00	0.00
23-Nov-02	4,780.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Nov-02	6,275.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Nov-02	6,341.81	0.00	22.79	0.00	26.60	0.00	0.00	0.00
26-Nov-02	6,248.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Nov-02	6,151.53	0.00	0.00	78.47	0.00	0.00	0.00	0.00
28-Nov-02	5,913.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Nov-02	5,651.60	0.00	45.50	0.00	0.00	0.00	0.00	0.00
30-Nov-02	6,338.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	5,000.00							
Total Burned	184,394.76	0.00	1,005.14	2,145.40	26.60	0.00	0.00	0.00
Total Delivered	193,968.54	0.00	982.75	1,956.07	26.60	0.00	0.00	0.00
HHV	8534	0	15000	7187	16932	0		
% Ash	4.73%	0.00%	7.04%	1.10%	0.00%	0.00%		
Tons Ash	8,715.21	0.00	70.76	23.60	0.00	0.00	0.00	0.00

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FUEL BURN RECORD - page 1
Dec-02

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Dec-02	5,707.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Dec-02	6,179.46	0.00	46.14	0.00	0.00	0.00	0.00	0.00
3-Dec-02	5,916.85	0.00	43.80	97.85	0.00	0.00	0.00	0.00
4-Dec-02	6,348.34	0.00	22.26	0.00	0.00	0.00	0.00	0.00
5-Dec-02	6,340.69	0.00	20.11	0.00	0.00	0.00	0.00	0.00
6-Dec-02	6,484.34	0.00	46.06	0.00	0.00	0.00	0.00	0.00
7-Dec-02	6,378.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Dec-02	6,530.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Dec-02	6,317.27	0.00	43.53	0.00	0.00	0.00	0.00	0.00
10-Dec-02	6,267.33	0.00	45.67	26.00	0.00	0.00	0.00	0.00
11-Dec-02	6,394.00	0.00	94.30	0.00	0.00	0.00	0.00	0.00
12-Dec-02	6,523.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Dec-02	6,257.51	0.00	93.99	0.00	0.00	0.00	0.00	0.00
14-Dec-02	6,373.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Dec-02	6,351.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Dec-02	6,274.49	0.00	70.37	17.64	0.00	0.00	0.00	0.00
17-Dec-02	5,785.53	0.00	45.77	0.00	0.00	0.00	0.00	0.00
18-Dec-02	6,368.68	0.00	47.44	47.88	0.00	0.00	0.00	0.00
19-Dec-02	6,374.26	0.00	24.14	48.00	0.00	0.00	0.00	0.00
20-Dec-02	6,453.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Dec-02	6,289.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Dec-02	6,072.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Dec-02	6,171.47	0.00	64.61	71.82	0.00	0.00	0.00	0.00
24-Dec-02	6,183.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Dec-02	6,604.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Dec-02	6,236.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Dec-02	6,056.94	0.00	44.89	25.47	0.00	0.00	0.00	0.00
28-Dec-02	6,240.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Dec-02	6,168.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Dec-02	5,950.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31-Dec-02	5,951.26	0.00	116.11	75.03	0.00	0.00	0.00	0.00
Adjustment	3,000.00							
Total Burned	196,553.92	0.00	869.19	409.69	0.00	0.00	0.00	0.00
Total Delivered	195,368.84		869.19	409.69	0.00			0.00
HHV	8533		15000	7187	0	0		
% Ash	4.71%		7.04%	1.10%	0.00%	0.00%		
Tons Ash	9,254.39	0.00	70.76	23.60	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Jan-03

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Jan-03	6,184.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Jan-03	6,223.02	0.00	22.37	62.31	0.00	0.00	0.00	0.00
3-Jan-03	6,319.77	0.00	45.77	148.16	0.00	0.00	0.00	0.00
4-Jan-03	6,287.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Jan-03	6,049.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Jan-03	5,943.97	0.00	47.26	431.57	0.00	0.00	0.00	0.00
7-Jan-03	5,505.74	0.00	48.59	707.47	0.00	0.00	0.00	0.00
8-Jan-03	5,576.26	0.00	0.00	685.74	0.00	0.00	0.00	0.00
9-Jan-03	5,577.80	0.00	0.00	600.00	0.00	0.00	0.00	0.00
10-Jan-03	6,179.08	0.00	113.66	123.16	0.00	0.00	0.00	0.00
11-Jan-03	6,298.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Jan-03	6,378.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Jan-03	6,490.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Jan-03	5,816.07	0.00	85.58	649.45	0.00	0.00	0.00	0.00
15-Jan-03	5,903.21	0.00	22.25	501.34	0.00	0.00	0.00	0.00
16-Jan-03	5,714.59	0.00	22.39	607.02	0.00	0.00	0.00	0.00
17-Jan-03	5,764.70	0.00	21.32	650.88	0.00	0.00	0.00	0.00
18-Jan-03	6,306.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Jan-03	4,924.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Jan-03	5,896.70	0.00	89.30	430.20	0.00	0.00	0.00	0.00
21-Jan-03	6,340.98	0.00	0.00	76.42	0.00	0.00	0.00	0.00
22-Jan-03	3,694.64	0.00	85.16	0.00	0.00	0.00	0.00	0.00
23-Jan-03	5,248.81	0.00	0.00	267.79	0.00	0.00	0.00	0.00
24-Jan-03	6,305.73	0.00	22.79	258.18	0.00	0.00	0.00	0.00
25-Jan-03	6,292.92	0.00	0.00	258.18	0.00	0.00	0.00	0.00
26-Jan-03	6,222.60	0.00	0.00	258.20	0.00	0.00	0.00	0.00
27-Jan-03	5,989.95	0.00	0.00	269.15	0.00	0.00	0.00	0.00
28-Jan-03	5,962.19	0.00	66.12	211.39	0.00	0.00	0.00	0.00
29-Jan-03	5,537.96	0.00	45.82	293.22	0.00	0.00	0.00	0.00
30-Jan-03	6,049.60	0.00	60.00	200.00	0.00	0.00	0.00	0.00
31-Jan-03	5,930.53	0.00	77.47	220.00	0.00	0.00	0.00	0.00
Adjustment	3,500.00							
Total Burned	186,416.92	0.00	875.85	7,909.83	0.00	0.00	0.00	0.00
Total Delivered	177,149.11	0.00	875.85	8,352.78	0.00	0.00	0.00	0.00
HHV	8595	0	15000	9000	0	0	0	0
% Ash	4.49%	0.00	7.04%	4.00%	0.00%	0.00%	0.00%	0.00%
Tons Ash	8,377.48	0.00	61.66	316.39	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Feb-03

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Feb-03	5,984.90	0.00	0.00	220.00	0.00	0.00	0.00	0.00
2-Feb-03	5,587.95	0.00	0.00	222.95	0.00	0.00	0.00	0.00
3-Feb-03	6,017.17	0.00	45.99	159.24	0.00	0.00	0.00	0.00
4-Feb-03	5,920.68	0.00	45.07	417.35	0.00	0.00	0.00	0.00
5-Feb-03	6,006.06	0.00	0.00	261.54	0.00	0.00	0.00	0.00
6-Feb-03	6,188.40	0.00	0.00	260.00	0.00	0.00	0.00	0.00
7-Feb-03	6,038.76	0.00	85.34	317.00	0.00	0.00	0.00	0.00
8-Feb-03	5,878.50	0.00	0.00	317.00	0.00	0.00	0.00	0.00
9-Feb-03	6,067.20	0.00	0.00	315.00	0.00	0.00	0.00	0.00
10-Feb-03	6,066.62	0.00	21.19	288.99	0.00	0.00	0.00	0.00
11-Feb-03	6,050.17	0.00	0.00	186.63	0.00	0.00	0.00	0.00
12-Feb-03	5,829.92	0.00	43.13	377.75	0.00	0.00	0.00	0.00
13-Feb-03	5,933.10	0.00	0.00	300.00	0.00	0.00	0.00	0.00
14-Feb-03	5,666.96	0.00	113.84	465.00	0.00	0.00	0.00	0.00
15-Feb-03	5,849.10	0.00	0.00	465.00	0.00	0.00	0.00	0.00
16-Feb-03	5,875.29	0.00	0.00	465.11	0.00	0.00	0.00	0.00
17-Feb-03	6,093.09	0.00	0.00	235.81	0.00	0.00	0.00	0.00
18-Feb-03	5,753.45	0.00	43.27	568.28	0.00	0.00	0.00	0.00
19-Feb-03	5,749.92	0.00	90.18	450.00	0.00	0.00	0.00	0.00
20-Feb-03	5,925.30	0.00	25.00	475.00	0.00	0.00	0.00	0.00
21-Feb-03	5,237.62	0.00	91.58	847.00	0.00	0.00	0.00	0.00
22-Feb-03	5,307.10	0.00	0.00	847.00	0.00	0.00	0.00	0.00
23-Feb-03	5,211.31	0.00	0.00	849.29	0.00	0.00	0.00	0.00
24-Feb-03	6,015.68	0.00	45.43	72.19	0.00	0.00	0.00	0.00
25-Feb-03	6,154.61	0.00	86.29	1.60	0.00	0.00	0.00	0.00
26-Feb-03	4,497.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Feb-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Feb-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	3,500.00							
Total Burned	154,405.86	0.00	736.31	9,384.73	0.00	0.00	0.00	0.00
Total Delivered	158,173.51	0.00	736.31	8,960.31	0.00	0.00	0.00	0.00
HHV	8551		15000	7187	0	0	0	0
% Ash	4.58%		7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	7,074.24	0.00	51.91	103.23	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Mar-03

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Mar-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Mar-03	127.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Mar-03	3,960.94	0.00	0.00	66.66	0.00	0.00	0.00	0.00
4-Mar-03	6,652.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Mar-03	6,493.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Mar-03	6,344.91	0.00	22.49	0.00	0.00	0.00	0.00	0.00
7-Mar-03	6,362.77	0.00	22.40	24.93	0.00	0.00	0.00	0.00
8-Mar-03	6,451.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Mar-03	6,504.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Mar-03	6,307.69	0.00	64.94	71.57	0.00	0.00	0.00	0.00
11-Mar-03	6,365.86	0.00	0.00	24.04	0.00	0.00	0.00	0.00
12-Mar-03	6,457.50	0.00	45.90	0.00	0.00	0.00	0.00	0.00
13-Mar-03	6,327.30	0.00	21.64	24.46	0.00	0.00	0.00	0.00
14-Mar-03	6,138.03	0.00	46.65	70.22	0.00	0.00	0.00	0.00
15-Mar-03	5,959.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Mar-03	6,199.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Mar-03	6,167.22	0.00	44.96	96.12	0.00	0.00	0.00	0.00
18-Mar-03	5,862.80	0.00	22.59	417.11	0.00	0.00	0.00	0.00
19-Mar-03	6,370.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Mar-03	5,727.87	0.00	46.66	72.77	0.00	0.00	0.00	0.00
21-Mar-03	6,160.10	0.00	45.25	77.95	0.00	0.00	0.00	0.00
22-Mar-03	5,656.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Mar-03	5,468.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Mar-03	5,771.78	0.00	22.18	122.64	0.00	0.00	0.00	0.00
25-Mar-03	5,276.36	0.00	44.19	100.35	0.00	0.00	0.00	0.00
26-Mar-03	5,672.84	0.00	22.08	123.18	0.00	0.00	0.00	0.00
27-Mar-03	5,965.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Mar-03	5,931.49	0.00	90.03	147.28	0.00	0.00	0.00	0.00
29-Mar-03	6,182.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Mar-03	6,139.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31-Mar-03	5,827.97	0.00	0.00	70.93	0.00	0.00	0.00	0.00
Adjustment	2,800.00							
Total Burned	177,636.53	0.00	561.96	1,510.21	0.00	0.00	0.00	0.00
Total Delivered	163,580.34	0.00	561.96	1,565.08	0.00	0.00	0.00	0.00
HHV	8562	0	15000	7187	0	0	0	0
% Ash	4.45%	0.00%	7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	7,907.69	0.00	39.62	16.61	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Apr-03

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Apr-03	5,563.81	0.00	22.09	73.40	0.00	0.00	0.00	0.00
2-Apr-03	5,828.17	0.00	22.34	69.09	0.00	0.00	0.00	0.00
3-Apr-03	5,440.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Apr-03	5,785.41	0.00	22.24	171.15	0.00	0.00	0.00	0.00
5-Apr-03	6,027.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Apr-03	5,921.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Apr-03	6,107.43	0.00	19.79	96.28	0.00	0.00	0.00	0.00
8-Apr-03	6,021.43	0.00	22.25	72.12	0.00	0.00	0.00	0.00
9-Apr-03	5,992.65	0.00	0.00	23.05	0.00	0.00	0.00	0.00
10-Apr-03	6,040.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Apr-03	5,759.20	0.00	44.97	20.73	0.00	0.00	0.00	0.00
12-Apr-03	5,021.35	0.00	0.00	0.00	21.35	0.00	0.00	0.00
13-Apr-03	5,995.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Apr-03	5,846.61	0.00	21.87	23.42	0.00	0.00	0.00	0.00
15-Apr-03	6,072.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Apr-03	5,651.65	0.00	44.32	46.13	0.00	0.00	0.00	0.00
17-Apr-03	6,275.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Apr-03	6,208.24	0.00	22.40	23.46	0.00	0.00	0.00	0.00
19-Apr-03	5,907.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Apr-03	6,086.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Apr-03	5,906.60	0.00	46.60	0.00	0.00	0.00	0.00	0.00
22-Apr-03	3,986.91	0.00	22.79	0.00	0.00	0.00	0.00	0.00
23-Apr-03	5,485.18	0.00	23.22	0.00	0.00	0.00	0.00	0.00
24-Apr-03	5,787.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Apr-03	5,903.63	0.00	68.87	22.40	0.00	0.00	0.00	0.00
26-Apr-03	909.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Apr-03	2,884.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Apr-03	5,998.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Apr-03	5,001.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Apr-03	5,389.63	0.00	90.93	24.24	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	164,805.80	0.00	494.68	665.47	21.35	0.00	0.00	0.00
Total Delivered	182,856.19	0.00	494.68	665.47	21.35	0.00	0.00	0.00
HHV	8491	0	15000	7187	16932	0	0	0
% Ash	4.65%	0.00%	7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	7,657.92	0.00	34.87	7.32	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
May-03

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-May-03	6,018.26	0.00	24.09	23.35	0.00	0.00	0.00	0.00
2-May-03	5,927.28	0.00	44.56	46.66	0.00	0.00	0.00	0.00
3-May-03	6,080.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-May-03	5,982.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-May-03	6,266.11	0.00	26.89	0.00	0.00	0.00	0.00	0.00
6-May-03	5,945.43	0.00	46.37	0.00	0.00	0.00	0.00	0.00
7-May-03	5,759.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-May-03	4,741.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-May-03	6,216.94	0.00	48.64	46.02	0.00	0.00	0.00	0.00
10-May-03	6,429.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-May-03	6,585.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-May-03	6,301.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-May-03	6,073.81	0.00	22.39	180.00	0.00	0.00	0.00	0.00
14-May-03	6,003.37	0.00	46.04	182.69	0.00	0.00	0.00	0.00
15-May-03	6,222.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-May-03	5,882.91	0.00	26.53	140.16	0.00	0.00	0.00	0.00
17-May-03	6,158.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-May-03	6,133.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-May-03	6,011.02	0.00	69.35	71.33	0.00	0.00	0.00	0.00
20-May-03	6,156.23	0.00	69.86	73.01	0.00	0.00	0.00	0.00
21-May-03	6,109.67	0.00	0.00	93.83	0.00	0.00	0.00	0.00
22-May-03	5,943.65	0.00	22.29	47.96	0.00	0.00	0.00	0.00
23-May-03	5,777.39	0.00	45.17	24.04	0.00	0.00	0.00	0.00
24-May-03	5,838.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-May-03	5,751.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-May-03	5,543.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-May-03	5,637.15	0.00	22.39	24.06	0.00	0.00	0.00	0.00
28-May-03	5,847.93	0.00	45.07	0.00	0.00	0.00	0.00	0.00
29-May-03	6,051.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-May-03	5,865.58	0.00	67.36	116.26	0.00	0.00	0.00	0.00
31-May-03	5,579.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	184,842.83	0.00	627.00	1,069.37	0.00	0.00	0.00	0.00
Total Delivered	183,962.43	0.00	627.00	1,069.37	0.00	0.00	0.00	0.00
HHV	8560	0	15000	7187	0	0	0	0
% Ash	4.59%	0.00%	7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	8,486.63	0.00	44.20	11.76	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Jun-03

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Jun-03	5,439.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Jun-03	5,564.42	0.00	110.79	67.89	0.00	0.00	0.00	0.00
3-Jun-03	4,109.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Jun-03	1,062.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Jun-03	5,927.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Jun-03	5,769.17	0.00	22.39	264.44	0.00	0.00	0.00	0.00
14-Jun-03	6,184.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Jun-03	6,104.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Jun-03	5,980.04	0.00	166.09	23.97	0.00	0.00	0.00	0.00
17-Jun-03	5,115.89	0.00	67.18	120.33	0.00	0.00	0.00	0.00
18-Jun-03	5,903.29	0.00	65.80	174.41	0.00	0.00	0.00	0.00
19-Jun-03	6,263.74	0.00	22.79	195.97	0.00	0.00	0.00	0.00
20-Jun-03	5,968.70	0.00	73.28	319.12	0.00	0.00	0.00	0.00
21-Jun-03	5,994.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Jun-03	5,455.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Jun-03	6,339.77	0.00	25.69	167.34	0.00	0.00	0.00	0.00
24-Jun-03	6,446.21	0.00	46.45	176.04	0.00	0.00	0.00	0.00
25-Jun-03	6,148.46	0.00	72.23	445.61	0.00	0.00	0.00	0.00
26-Jun-03	5,846.29	0.00	45.47	388.54	0.00	0.00	0.00	0.00
27-Jun-03	6,209.24	0.00	46.04	158.02	0.00	0.00	0.00	0.00
28-Jun-03	5,261.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Jun-03	5,916.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Jun-03	5,968.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	-1,000.00							
Burned	127,979.52	0.00	764.20	2,501.68	0.00	0.00	0.00	0.00
Delivered	129,386.06	0.00	810.36	2,674.20	0.00	0.00	0.00	0.00
HHV	8482	0	15000	7187	0	0	0	0
% Ash	4.57%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	5,842.41	0.00	53.80	27.52	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Jul-03

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Jul-03	5,608.91	0.00	92.25	380.44	0.00	0.00	0.00	0.00
2-Jul-03	6,015.40	0.00	27.52	474.68	0.00	0.00	0.00	0.00
3-Jul-03	6,544.89	0.00	73.64	23.87	0.00	0.00	0.00	0.00
4-Jul-03	4,873.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Jul-03	5,833.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Jul-03	6,044.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Jul-03	5,899.67	0.00	71.91	71.12	0.00	0.00	0.00	0.00
8-Jul-03	6,241.19	0.00	25.32	94.59	0.00	0.00	0.00	0.00
9-Jul-03	6,305.42	0.00	96.76	91.92	0.00	0.00	0.00	0.00
10-Jul-03	5,807.50	0.00	100.00	75.00	0.00	0.00	0.00	0.00
11-Jul-03	5,939.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Jul-03	6,269.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Jul-03	6,282.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Jul-03	5,493.97	0.00	70.85	39.18	0.00	0.00	0.00	0.00
15-Jul-03	6,311.10	0.00	24.00	117.93	26.47	0.00	0.00	0.00
16-Jul-03	6,525.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Jul-03	6,477.53	0.00	74.24	113.33	0.00	0.00	0.00	0.00
18-Jul-03	6,706.77	0.00	22.62	48.41	0.00	0.00	0.00	0.00
19-Jul-03	6,507.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Jul-03	6,703.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Jul-03	6,560.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Jul-03	6,099.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Jul-03	6,304.46	0.00	162.95	95.89	0.00	0.00	0.00	0.00
24-Jul-03	6,202.95	0.00	72.30	141.55	0.00	0.00	0.00	0.00
25-Jul-03	5,521.04	0.00	46.39	92.57	0.00	0.00	0.00	0.00
26-Jul-03	5,869.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Jul-03	6,624.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Jul-03	6,418.90	0.00	93.00	72.50	0.00	0.00	0.00	0.00
29-Jul-03	6,652.26	0.00	24.17	48.67	0.00	0.00	0.00	0.00
30-Jul-03	6,493.44	0.00	70.91	94.55	0.00	0.00	0.00	0.00
31-Jul-03	6,868.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	192,005.80	0.00	1,148.83	2,076.20	26.47	0.00	0.00	0.00
Total Delivered	154,635.98	0.00	1,271.15	1,974.87	26.47	0.00	0.00	0.00
HHV	8561	0	15000	7187	16932	0	0	0
% Ash	4.61%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	8,860.09	0.00	80.88	22.84	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Aug-03

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Aug-03	6,743.00	0.00	133.00	50.00	0.00	0.00	0.00	0.00
2-Aug-03	6,317.90	0.00	133.00	46.00	0.00	0.00	0.00	0.00
3-Aug-03	6,319.74	0.00	131.88	45.98	0.00	0.00	0.00	0.00
4-Aug-03	6,600.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Aug-03	6,103.03	0.00	237.82	229.15	0.00	0.00	0.00	0.00
6-Aug-03	6,689.25	0.00	70.01	61.74	0.00	0.00	0.00	0.00
7-Aug-03	6,693.50	0.00	50.00	50.00	0.00	0.00	0.00	0.00
8-Aug-03	6,789.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Aug-03	6,780.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Aug-03	6,640.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Aug-03	6,610.40	0.00	100.00	100.00	0.00	0.00	0.00	0.00
12-Aug-03	6,517.90	0.00	47.40	0.00	0.00	0.00	0.00	0.00
13-Aug-03	6,741.74	0.00	73.02	4.04	0.00	0.00	0.00	0.00
14-Aug-03	6,556.76	0.00	95.61	42.73	0.00	0.00	0.00	0.00
15-Aug-03	6,450.81	0.00	141.44	146.75	0.00	0.00	0.00	0.00
16-Aug-03	6,755.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Aug-03	6,812.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Aug-03	6,816.46	0.00	91.94	0.00	0.00	0.00	0.00	0.00
19-Aug-03	6,597.90	0.00	100.00	75.00	0.00	0.00	0.00	0.00
20-Aug-03	6,597.61	0.00	69.93	81.46	0.00	0.00	0.00	0.00
21-Aug-03	6,665.60	0.00	50.00	50.00	0.00	0.00	0.00	0.00
22-Aug-03	5,870.40	0.00	119.63	440.07	0.00	0.00	0.00	0.00
23-Aug-03	5,911.43	0.00	0.00	440.07	0.00	0.00	0.00	0.00
24-Aug-03	5,922.23	0.00	0.00	440.07	0.00	0.00	0.00	0.00
25-Aug-03	5,927.41	0.00	300.00	294.19	0.00	0.00	0.00	0.00
26-Aug-03	6,611.26	0.00	0.00	70.04	0.00	0.00	0.00	0.00
27-Aug-03	6,262.98	0.00	0.00	241.62	0.00	0.00	0.00	0.00
28-Aug-03	6,548.60	0.00	10.14	24.16	0.00	0.00	0.00	0.00
29-Aug-03	6,496.20	0.00	75.00	100.00	0.00	0.00	0.00	0.00
30-Aug-03	6,021.40	0.00	50.00	100.00	0.00	0.00	0.00	0.00
31-Aug-03	5,848.66	0.00	68.17	54.77	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	200,219.47	0.00	2,147.99	3,187.84	0.00	0.00	0.00	0.00
Total Delivered	184,120.00	0.00	1,979.51	3,116.65	0.00	0.00	0.00	0.00
HHV	8575	0	15000	7187	0	0	0	0
% Ash	4.70%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,417.23	0.00	151.22	35.07	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Sep-03

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Sep-03	6,062.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Sep-03	6,086.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Sep-03	5,671.17	0.00	210.82	68.41	0.00	0.00	0.00	0.00
4-Sep-03	5,901.99	0.00	72.78	46.73	0.00	0.00	0.00	0.00
5-Sep-03	6,225.60	0.00	100.00	50.00	0.00	0.00	0.00	0.00
6-Sep-03	6,367.08	0.00	121.38	45.94	0.00	0.00	0.00	0.00
7-Sep-03	6,247.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Sep-03	6,102.54	0.00	118.94	45.62	0.00	0.00	0.00	0.00
9-Sep-03	6,146.21	0.00	93.05	23.64	0.00	0.00	0.00	0.00
10-Sep-03	6,064.33	0.00	73.44	22.13	0.00	0.00	0.00	0.00
11-Sep-03	6,289.50	0.00	50.00	25.00	0.00	0.00	0.00	0.00
12-Sep-03	6,321.90	0.00	120.00	75.00	0.00	0.00	0.00	0.00
13-Sep-03	6,091.00	0.00	120.00	75.00	0.00	0.00	0.00	0.00
14-Sep-03	5,974.33	0.00	122.40	61.67	0.00	0.00	0.00	0.00
15-Sep-03	6,299.81	0.00	46.85	76.14	0.00	0.00	0.00	0.00
16-Sep-03	5,977.12	0.00	50.40	97.98	0.00	0.00	0.00	0.00
17-Sep-03	5,232.80	0.00	50.00	100.00	0.00	0.00	0.00	0.00
18-Sep-03	5,167.98	0.00	72.67	23.15	0.00	0.00	0.00	0.00
19-Sep-03	5,666.01	0.00	42.13	57.86	0.00	0.00	0.00	0.00
20-Sep-03	6,506.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Sep-03	6,583.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Sep-03	6,181.04	0.00	94.33	274.73	0.00	0.00	0.00	0.00
23-Sep-03	5,796.03	0.00	72.63	25.94	0.00	0.00	0.00	0.00
24-Sep-03	6,275.00	0.00	25.47	13.83	0.00	0.00	0.00	0.00
25-Sep-03	6,363.60	0.00	25.00	25.00	0.00	0.00	0.00	0.00
26-Sep-03	6,267.41	0.00	66.80	107.39	0.00	0.00	0.00	0.00
27-Sep-03	5,787.30	0.00	0.00	100.00	0.00	0.00	0.00	0.00
28-Sep-03	6,336.90	0.00	0.00	100.00	0.00	0.00	0.00	0.00
29-Sep-03	6,446.52	0.00	95.13	46.25	0.00	0.00	0.00	0.00
30-Sep-03	6,170.55	0.00	125.33	23.02	0.00	0.00	0.00	0.00
Adjustment	3,000.00							
Total Burned	185,611.32	0.00	1,969.55	1,610.43	0.00	0.00	0.00	0.00
Total Delivered	194,770.48	0.00	1,969.55	1,610.43	0.00	0.00	0.00	0.00
HHV	8530	0	15000	7187	0	0	0	0
% Ash	4.59%	0.00	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	8,526.64	0.00	51.48	12.52	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Oct-03

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Oct-03	6,319.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Oct-03	6,536.17	0.00	45.23	0.00	0.00	0.00	0.00	0.00
3-Oct-03	6,161.23	0.00	296.40	86.67	0.00	0.00	0.00	0.00
4-Oct-03	6,153.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Oct-03	6,127.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Oct-03	4,974.05	0.00	147.85	0.00	0.00	0.00	0.00	0.00
7-Oct-03	5,985.37	0.00	119.23	0.00	0.00	0.00	0.00	0.00
8-Oct-03	5,818.22	0.00	122.59	23.79	0.00	0.00	0.00	0.00
9-Oct-03	5,941.70	0.00	100.00	25.00	0.00	0.00	0.00	0.00
10-Oct-03	6,004.76	0.00	95.84	125.00	0.00	0.00	0.00	0.00
11-Oct-03	6,554.80	0.00	0.00	125.00	0.00	0.00	0.00	0.00
12-Oct-03	6,555.37	0.00	0.00	103.33	0.00	0.00	0.00	0.00
13-Oct-03	6,034.57	0.00	96.92	68.61	0.00	0.00	0.00	0.00
14-Oct-03	6,098.22	0.00	92.88	0.00	0.00	0.00	0.00	0.00
15-Oct-03	5,814.86	0.00	120.71	220.33	0.00	0.00	0.00	0.00
16-Oct-03	6,119.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Oct-03	6,173.77	0.00	146.93	0.00	0.00	0.00	0.00	0.00
18-Oct-03	5,794.62	0.00	144.46	98.92	0.00	0.00	0.00	0.00
19-Oct-03	5,757.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Oct-03	5,855.49	0.00	120.98	41.93	0.00	0.00	0.00	0.00
21-Oct-03	6,047.70	0.00	69.50	16.10	0.00	0.00	0.00	0.00
22-Oct-03	6,050.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Oct-03	6,053.61	0.00	73.99	0.00	0.00	0.00	0.00	0.00
24-Oct-03	4,424.76	0.00	151.22	149.32	0.00	0.00	0.00	0.00
25-Oct-03	6,050.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Oct-03	6,437.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Oct-03	5,984.16	0.00	71.57	71.57	0.00	0.00	0.00	0.00
28-Oct-03	5,872.19	0.00	95.15	49.26	0.00	0.00	0.00	0.00
29-Oct-03	6,055.15	0.00	95.25	22.40	0.00	0.00	0.00	0.00
30-Oct-03	5,880.57	0.00	118.97	117.46	0.00	0.00	0.00	0.00
31-Oct-03	5,939.92	0.00	141.81	145.87	0.00	0.00	0.00	0.00
Adjustment	6,000.00							
Total Burned	191,576.46	0.00	2,467.48	1,490.56	0.00	0.00	0.00	0.00
Total Delivered	209,506.85	0.00	2,467.48	1,490.56	0.00	0.00	0.00	0.00
HHV	8630	0	15000	7187	0	0	0	0
% Ash	4.83%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,245.59	0.00	51.48	12.52	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Nov-03

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Coyote Lignite (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Nov-03	6,484.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Nov-03	6,474.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Nov-03	6,412.21	0.00	25.77	46.72	0.00	0.00	0.00	0.00
4-Nov-03	6,243.01	0.00	144.47	46.62	0.00	0.00	0.00	0.00
5-Nov-03	6,174.34	0.00	50.92	122.44	0.00	0.00	0.00	0.00
6-Nov-03	6,346.40	0.00	49.08	22.32	0.00	0.00	0.00	0.00
7-Nov-03	6,248.46	0.00	71.89	146.85	0.00	0.00	0.00	0.00
8-Nov-03	6,498.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Nov-03	6,083.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Nov-03	6,156.57	0.00	116.35	99.78	0.00	0.00	0.00	0.00
11-Nov-03	6,259.45	0.00	47.69	21.96	0.00	0.00	0.00	0.00
12-Nov-03	6,308.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Nov-03	6,683.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Nov-03	6,373.22	0.00	45.69	209.89	0.00	0.00	0.00	0.00
15-Nov-03	6,382.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Nov-03	6,384.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Nov-03	6,274.89	0.00	98.81	0.00	0.00	0.00	0.00	0.00
18-Nov-03	6,086.07	0.00	166.07	26.16	0.00	71.00	0.00	0.00
19-Nov-03	6,099.04	0.00	123.90	69.86	0.00	0.00	0.00	0.00
20-Nov-03	6,122.30	0.00	100.00	25.00	0.00	0.00	0.00	0.00
21-Nov-03	6,488.06	0.00	0.00	94.94	0.00	0.00	0.00	0.00
22-Nov-03	6,415.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Nov-03	6,336.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Nov-03	6,750.64	0.00	23.69	107.87	0.00	0.00	0.00	0.00
25-Nov-03	6,614.30	0.00	140.83	25.57	0.00	0.00	0.00	0.00
26-Nov-03	6,731.28	0.00	49.32	25.80	0.00	0.00	0.00	0.00
27-Nov-03	6,078.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Nov-03	6,769.58	0.00	22.22	0.00	0.00	0.00	0.00	0.00
29-Nov-03	6,704.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Nov-03	6,171.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	3,000.00							
Total Burned	194,155.92	0.00	1,276.70	1,091.78	0.00	71.00	0.00	0.00
Total Delivered	181,630.49	0.00	1,276.70	1,091.78	0.00	71.00	0.00	0.00
HHV	8521	0	15000	7187	16932	6500		
% Ash	4.77%	0.00%	7.04%	1.10%	0.00%	0.00%		
Tons Ash	9,263.57	0.00	89.88	12.01	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Dec-03

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Dec-03	6,499.83	0.00	97.26	26.21	0.00	0.00	0.00	0.00
2-Dec-03	6,494.57	0.00	22.17	24.39	27.17	0.00	0.00	0.00
3-Dec-03	6,512.82	0.00	22.21	22.57	0.00	0.00	0.00	0.00
4-Dec-03	6,367.76	0.00	0.00	99.74	0.00	0.00	0.00	0.00
5-Dec-03	4,476.77	0.00	50.83	0.00	0.00	0.00	0.00	0.00
6-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Dec-03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Dec-03	213.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Dec-03	3,794.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Dec-03	5,939.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Dec-03	6,188.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Dec-03	6,275.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Dec-03	4,964.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Dec-03	5,966.36	0.00	22.14	0.00	0.00	0.00	0.00	0.00
27-Dec-03	5,954.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Dec-03	6,021.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Dec-03	6,538.93	0.00	23.07	0.00	0.00	0.00	0.00	0.00
30-Dec-03	6,487.71	0.00	0.00	25.09	0.00	0.00	0.00	0.00
31-Dec-03	6,581.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	1,000.00							
Total Burned	96,277.15	0.00	237.68	198.00	27.17	0.00	0.00	0.00
Total Delivered	124,513.74	0.00	237.68	198.00	27.17	0.00	0.00	0.00
HHV	8492	0	15000	7187	0	0	0	0
% Ash	4.86%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	4,679.14	0.00	70.76	23.60	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Jan-04

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Jan-04	6,298.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Jan-04	6,031.73	0.00	22.42	93.55	0.00	0.00	0.00	0.00
3-Jan-04	6,490.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Jan-04	6,644.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Jan-04	6,604.40	0.00	0.00	35.70	0.00	0.00	0.00	0.00
6-Jan-04	6,618.66	0.00	26.00	25.64	0.00	0.00	0.00	0.00
7-Jan-04	6,569.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Jan-04	6,659.53	0.00	22.88	23.09	0.00	0.00	0.00	0.00
9-Jan-04	6,619.80	0.00	45.94	142.36	0.00	0.00	0.00	0.00
10-Jan-04	6,670.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Jan-04	5,849.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Jan-04	6,277.63	0.00	22.52	66.25	0.00	0.00	0.00	0.00
13-Jan-04	6,098.33	0.00	23.07	0.00	0.00	0.00	0.00	0.00
14-Jan-04	6,496.82	0.00	0.00	22.88	0.00	0.00	0.00	0.00
15-Jan-04	6,398.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Jan-04	6,395.40	0.00	46.31	73.99	0.00	0.00	0.00	0.00
17-Jan-04	6,236.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Jan-04	6,743.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Jan-04	6,715.15	0.00	0.00	73.45	0.00	0.00	0.00	0.00
20-Jan-04	6,685.50	0.00	22.47	25.43	0.00	0.00	0.00	0.00
21-Jan-04	6,479.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Jan-04	6,444.04	0.00	22.97	122.59	0.00	0.00	0.00	0.00
23-Jan-04	6,446.14	0.00	0.00	49.86	0.00	0.00	0.00	0.00
24-Jan-04	6,688.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Jan-04	6,613.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Jan-04	6,632.17	0.00	0.00	23.63	0.00	0.00	0.00	0.00
27-Jan-04	6,768.70	0.00	22.30	0.00	0.00	0.00	0.00	0.00
28-Jan-04	6,777.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Jan-04	6,738.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Jan-04	6,630.83	0.00	0.00	110.17	0.00	0.00	0.00	0.00
31-Jan-04	6,853.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	3,500.00							
Total Burned	205,677.43	0.00	276.88	888.59	0.00	0.00	0.00	0.00
Total Delivered	177,708.33	0.00	276.88	888.59	0.00	0.00	0.00	0.00
HHV	8540	0	15000	7187	1632	0	0	0
% Ash	4.71%	0.00	7.04%	4.00%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,692.63	0.00	19.49	35.54	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Feb-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Feb-04	6,271.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Feb-04	6,495.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Feb-04	6,676.34	0.00	0.00	74.26	0.00	0.00	0.00	0.00
4-Feb-04	6,867.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Feb-04	6,656.28	0.00	22.32	0.00	0.00	0.00	0.00	0.00
6-Feb-04	6,551.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Feb-04	6,694.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Feb-04	6,802.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Feb-04	6,555.50	0.00	0.00	67.50	0.00	0.00	0.00	0.00
10-Feb-04	6,428.92	0.00	0.00	50.28	0.00	0.00	0.00	0.00
11-Feb-04	6,508.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Feb-04	6,770.16	0.00	23.85	23.09	0.00	0.00	0.00	0.00
13-Feb-04	6,689.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Feb-04	6,731.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Feb-04	6,807.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Feb-04	6,763.00	0.00	22.60	0.00	0.00	0.00	0.00	0.00
17-Feb-04	6,641.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Feb-04	6,703.83	0.00	0.00	20.67	0.00	0.00	0.00	0.00
19-Feb-04	6,538.38	0.00	22.02	0.00	0.00	0.00	0.00	0.00
20-Feb-04	6,568.78	0.00	22.82	0.00	0.00	0.00	0.00	0.00
21-Feb-04	6,781.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Feb-04	6,488.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Feb-04	6,756.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Feb-04	6,797.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Feb-04	6,742.48	0.00	23.62	16.10	0.00	0.00	0.00	0.00
26-Feb-04	6,575.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Feb-04	6,791.38	0.00	22.42	0.00	0.00	0.00	0.00	0.00
28-Feb-04	5,821.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Feb-04	6,755.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	1,500.00							
Total Burned	193,730.75	0.00	159.65	251.90	0.00	0.00	0.00	0.00
Total Delivered	186,986.38	0.00	159.65	251.90	0.00	0.00	0.00	0.00
HHV	8508	0	15000	7187	16932	0	0	0
% Ash	4.76%	0.00%	7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,220.63	0.00	11.26	2.77	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Mar-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Mar-04	6,745.64	0.00	22.66	0.00	0.00	0.00	0.00	0.00
2-Mar-04	6,669.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Mar-04	6,712.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Mar-04	6,806.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Mar-04	6,755.47	0.00	22.33	0.00	0.00	0.00	0.00	0.00
6-Mar-04	6,639.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Mar-04	6,714.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Mar-04	6,753.55	0.00	0.00	19.25	0.00	0.00	0.00	0.00
9-Mar-04	6,859.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Mar-04	6,827.09	0.00	22.41	0.00	0.00	0.00	0.00	0.00
11-Mar-04	6,723.99	0.00	22.51	0.00	0.00	0.00	0.00	0.00
12-Mar-04	6,794.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Mar-04	6,824.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Mar-04	6,712.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Mar-04	6,816.55	0.00	65.57	21.88	0.00	0.00	0.00	0.00
16-Mar-04	6,908.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Mar-04	6,915.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Mar-04	6,906.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Mar-04	6,817.39	0.00	45.65	22.66	0.00	0.00	0.00	0.00
20-Mar-04	6,709.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Mar-04	6,830.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Mar-04	6,724.85	0.00	0.00	22.05	0.00	0.00	0.00	0.00
23-Mar-04	6,604.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Mar-04	6,460.41	0.00	22.21	72.28	0.00	0.00	0.00	0.00
25-Mar-04	6,577.85	0.00	22.39	21.56	0.00	0.00	0.00	0.00
26-Mar-04	6,724.83	0.00	0.00	50.37	0.00	0.00	0.00	0.00
27-Mar-04	6,725.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Mar-04	6,644.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Mar-04	6,832.19	0.00	0.00	48.61	0.00	0.00	0.00	0.00
30-Mar-04	6,659.98	0.00	22.37	74.65	0.00	0.00	0.00	0.00
31-Mar-04	6,440.37	0.00	0.00	98.93	0.00	0.00	0.00	0.00
Adjustment	1,200.00							
Total Burned	210,037.66	0.00	268.10	452.24	0.00	0.00	0.00	0.00
Total Delivered	208,077.89	0.00	268.10	452.24	0.00	0.00	0.00	0.00
HHV	8556	0	15000	7187	16932	0	0	0
% Ash	4.69%	0.00%	7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,840.55	0.00	18.90	4.97	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Apr-04

DATE	Coal (Tons)	P. Coke (Tons)	TDF (Tons)	Waste Seeds (Tons)	Toner (Tons)	Gran. Insul. (Tons)	Canvas Belting (Tons)	Plastic Chips (Tons)
1-Apr-04	6,572.48	0.00	22.84	98.88	0.00	0.00	0.00	0.00
2-Apr-04	6,711.45	0.00	22.17	46.78	0.00	0.00	0.00	0.00
3-Apr-04	5,523.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Apr-04	6,039.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Apr-04	6,139.72	0.00	0.00	98.68	0.00	0.00	0.00	0.00
6-Apr-04	6,472.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Apr-04	6,481.63	0.00	22.40	119.97	0.00	0.00	0.00	0.00
8-Apr-04	6,613.32	0.00	0.00	95.68	0.00	0.00	0.00	0.00
9-Apr-04	6,665.89	0.00	0.00	26.51	0.00	0.00	0.00	0.00
10-Apr-04	6,709.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Apr-04	6,726.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Apr-04	6,358.18	0.00	0.00	97.32	0.00	0.00	0.00	0.00
13-Apr-04	5,728.55	0.00	0.00	93.85	0.00	0.00	0.00	0.00
14-Apr-04	6,138.60	0.00	0.00	49.20	0.00	0.00	0.00	0.00
15-Apr-04	6,302.95	0.00	22.39	24.06	0.00	0.00	0.00	0.00
16-Apr-04	6,532.74	0.00	0.00	50.06	0.00	0.00	0.00	0.00
17-Apr-04	6,463.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Apr-04	6,499.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Apr-04	6,689.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Apr-04	6,659.43	0.00	22.27	0.00	0.00	0.00	0.00	0.00
21-Apr-04	6,591.09	0.00	0.00	21.81	0.00	0.00	0.00	0.00
22-Apr-04	6,803.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Apr-04	6,680.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Apr-04	323.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Apr-04	5,039.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Apr-04	6,479.74	0.00	67.77	70.49	0.00	0.00	0.00	0.00
27-Apr-04	6,604.44	0.00	22.79	47.97	0.00	0.00	0.00	0.00
28-Apr-04	6,163.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Apr-04	6,644.04	0.00	0.00	15.36	0.00	0.00	0.00	0.00
30-Apr-04	6,537.30	0.00	0.00	24.30	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	185,896.05	0.00	202.63	980.92	0.00	0.00	0.00	0.00
Total Delivered	196,186.76	0.00	202.63	980.92	0.00	0.00	0.00	0.00
HHV	8597	0	15000	7187	16932	0	0	0
% Ash	4.66%	0.00%	7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	8,658.66	0.00	14.29	10.79	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
May-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-May-04	6,511.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-May-04	6,541.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-May-04	6,625.78	0.00	22.32	0.00	0.00	0.00	0.00	0.00
4-May-04	6,576.44	0.00	0.00	12.36	0.00	0.00	0.00	0.00
5-May-04	6,465.51	0.00	47.67	25.02	0.00	0.00	0.00	0.00
6-May-04	6,430.19	0.00	91.98	42.23	0.00	0.00	0.00	0.00
7-May-04	6,415.21	0.00	140.49	0.00	0.00	0.00	0.00	0.00
8-May-04	6,550.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-May-04	6,401.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-May-04	6,421.90	0.00	120.00	20.00	0.00	0.00	0.00	0.00
11-May-04	6,416.10	0.00	80.00	40.00	0.00	0.00	0.00	0.00
12-May-04	6,307.01	0.00	160.00	63.99	0.00	0.00	0.00	0.00
13-May-04	6,222.38	0.00	193.12	0.00	0.00	0.00	0.00	0.00
14-May-04	6,285.18	0.00	173.71	24.51	0.00	0.00	0.00	0.00
15-May-04	6,443.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-May-04	6,479.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-May-04	6,494.54	0.00	0.00	90.46	0.00	0.00	0.00	0.00
18-May-04	6,658.36	0.00	73.93	47.71	0.00	0.00	0.00	0.00
19-May-04	6,398.58	0.00	71.60	23.52	0.00	0.00	0.00	0.00
20-May-04	6,723.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-May-04	6,680.82	0.00	49.89	44.49	0.00	0.00	0.00	0.00
22-May-04	6,840.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-May-04	6,770.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-May-04	6,602.04	0.00	122.04	63.12	0.00	0.00	0.00	0.00
25-May-04	6,529.43	0.00	71.65	98.32	0.00	0.00	0.00	0.00
26-May-04	6,681.67	0.00	49.55	71.88	0.00	0.00	0.00	0.00
27-May-04	6,939.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-May-04	6,406.92	0.00	47.13	69.95	0.00	0.00	0.00	0.00
29-May-04	6,233.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-May-04	6,376.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31-May-04	6,279.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	2,000.00							
Total Burned	203,708.26	0.00	1,515.08	737.56	0.00	0.00	0.00	0.00
Total Delivered	211,380.43	0.00	1,515.08	737.56	0.00	0.00	0.00	0.00
HHV	8545	0	15000	7187	16932	0	0	0
% Ash	4.54%	0.00%	7.05%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,256.53	0.00	106.81	8.11	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1
Jun-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Jun-04	6,214.61	0.00	52.18	70.31	0.00	0.00	0.00	0.00
2-Jun-04	6,324.20	0.00	47.41	94.19	0.00	0.00	0.00	0.00
3-Jun-04	6,255.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Jun-04	4,258.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Jun-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Jun-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Jun-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Jun-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Jun-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Jun-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Jun-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Jun-04	212.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Jun-04	5,015.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Jun-04	6,189.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Jun-04	6,332.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Jun-04	6,056.08	0.00	173.21	66.81	0.00	0.00	0.00	0.00
17-Jun-04	5,931.45	0.00	129.99	117.56	0.00	0.00	0.00	0.00
18-Jun-04	5,969.10	0.00	100.00	0.00	0.00	0.00	0.00	0.00
19-Jun-04	5,670.96	0.00	100.34	0.00	0.00	0.00	0.00	0.00
20-Jun-04	5,428.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Jun-04	5,776.89	0.00	93.49	22.22	0.00	0.00	0.00	0.00
22-Jun-04	5,786.29	0.00	73.01	23.10	0.00	0.00	0.00	0.00
23-Jun-04	6,311.23	0.00	155.07	0.00	0.00	0.00	0.00	0.00
24-Jun-04	6,567.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Jun-04	6,269.60	0.00	122.46	39.14	0.00	0.00	0.00	0.00
26-Jun-04	5,793.10	0.00	100.00	0.00	0.00	0.00	0.00	0.00
27-Jun-04	5,242.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
28-Jun-04	5,978.85	0.00	96.97	44.18	0.00	0.00	0.00	0.00
29-Jun-04	6,439.56	0.00	95.02	49.52	0.00	0.00	0.00	0.00
30-Jun-04	6,402.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment	6,000.00							
Burned	136,424.32	0.00	1,439.15	527.03	0.00	0.00	0.00	0.00
Delivered	126,893.93	0.00	1,439.15	527.03	0.00	0.00	0.00	0.00
HHV	8460	0	15000	7187	0	0	0	0
% Ash	4.85%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	6,611.92	0.00	101.32	5.80	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD
Jul-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Jul-04	6,323.90	0.00	100.00	50.00	0.00	0.00	0.00	0.00
2-Jul-04	6,323.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Jul-04	6,242.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-Jul-04	5,693.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Jul-04	5,543.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Jul-04	5,800.15	0.00	204.45	0.00	0.00	0.00	0.00	0.00
7-Jul-04	5,671.74	0.00	337.24	46.22	0.00	0.00	0.00	0.00
8-Jul-04	6,278.89	0.00	96.51	0.00	0.00	0.00	0.00	0.00
9-Jul-04	6,627.10	0.00	120.00	0.00	0.00	0.00	0.00	0.00
10-Jul-04	6,285.25	0.00	238.85	0.00	0.00	0.00	0.00	0.00
11-Jul-04	6,516.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Jul-04	6,353.47	0.00	178.48	23.85	0.00	0.00	0.00	0.00
13-Jul-04	6,485.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Jul-04	1,885.26	0.00	241.72	200.62	0.00	0.00	0.00	0.00
15-Jul-04	226.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Jul-04	5,979.42	0.00	24.28	108.20	0.00	0.00	0.00	0.00
17-Jul-04	6,389.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Jul-04	6,355.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Jul-04	6,668.89	0.00	0.00	1.41	0.00	0.00	0.00	0.00
20-Jul-04	1,182.08	0.00	283.22	0.00	0.00	0.00	0.00	0.00
21-Jul-04	4,228.47	0.00	46.03	0.00	0.00	0.00	0.00	0.00
22-Jul-04	4,591.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Jul-04	3,457.68	0.00	67.66	28.96	0.00	0.00	0.00	0.00
24-Jul-04	5,654.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Jul-04	6,003.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Jul-04	6,478.26	0.00	114.84	0.00	0.00	0.00	0.00	0.00
27-Jul-04	5,665.82	0.00	167.56	22.62	0.00	0.00	0.00	0.00
28-Jul-04	5,909.31	0.00	192.29	0.00	0.00	0.00	0.00	0.00
29-Jul-04	5,944.37	0.00	167.73	0.00	0.00	0.00	0.00	0.00
30-Jul-04	5,799.51	0.00	167.09	0.00	0.00	0.00	0.00	0.00
31-Jul-04	5,802.20	0.00	200.00	0.00	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	168,366.77	0.00	2,947.95	481.88	0.00	0.00	0.00	0.00
Total Delivered	169,731.25	0.00	2,947.95	481.88	0.00	0.00	0.00	0.00
HHV	8485	0	15000	7187	16932	0	0	0
% Ash	4.69%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	7,891.06	0.00	207.54	5.30	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD
Aug-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Aug-04	6,220.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-Aug-04	6,231.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Aug-04	5,820.97	0.00	390.29	136.84	0.00	0.00	0.00	0.00
4-Aug-04	6,242.70	0.00	0.00	25.70	0.00	0.00	0.00	0.00
5-Aug-04	6,234.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Aug-04	5,599.51	0.00	339.47	118.52	0.00	0.00	0.00	0.00
7-Aug-04	5,872.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Aug-04	5,721.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Aug-04	5,845.91	0.00	72.77	25.52	0.00	0.00	0.00	0.00
10-Aug-04	5,937.55	0.00	22.74	40.11	0.00	0.00	0.00	0.00
11-Aug-04	6,328.43	0.00	47.17	25.60	0.00	0.00	0.00	0.00
12-Aug-04	5,994.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Aug-04	5,787.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Aug-04	6,140.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Aug-04	5,627.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Aug-04	5,906.56	0.00	385.16	46.98	0.00	0.00	0.00	0.00
17-Aug-04	6,298.44	0.00	95.76	23.30	0.00	0.00	0.00	0.00
18-Aug-04	5,785.59	0.00	267.51	0.00	0.00	0.00	0.00	0.00
19-Aug-04	6,209.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Aug-04	2,457.97	0.00	338.43	43.70	0.00	0.00	0.00	0.00
21-Aug-04	3,093.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Aug-04	4,551.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Aug-04	6,236.43	0.00	23.07	0.00	0.00	0.00	0.00	0.00
24-Aug-04	6,099.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Aug-04	6,431.44	0.00	290.16	0.00	0.00	0.00	0.00	0.00
26-Aug-04	6,665.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Aug-04	6,543.40	0.00	100.00	0.00	0.00	0.00	0.00	0.00
28-Aug-04	6,302.70	0.00	100.00	0.00	0.00	0.00	0.00	0.00
29-Aug-04	4,930.14	0.00	85.86	0.00	0.00	0.00	0.00	0.00
30-Aug-04	5,939.43	0.00	46.97	0.00	0.00	0.00	0.00	0.00
31-Aug-04	6,046.79	0.00	22.41	0.00	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	179,102.36	0.00	2,627.77	486.27	0.00	0.00	0.00	0.00
Total Delivered	180,630.08	0.00	2,627.77	486.27	0.00	0.00	0.00	0.00
HHV	8474	0	15000	7187	0	0	0	0
% Ash	5.13%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,195.57	0.00	185.00	5.35	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD
Sep-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Sep-04	6,415.74	0.00	49.66	0.00	0.00	0.00	0.00	0.00
2-Sep-04	6,272.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Sep-04	6,031.55	0.00	271.96	47.39	0.00	0.00	0.00	0.00
4-Sep-04	6,516.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Sep-04	6,409.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Sep-04	5,961.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-Sep-04	5,785.95	0.00	240.93	45.12	0.00	0.00	0.00	0.00
8-Sep-04	5,927.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9-Sep-04	6,066.87	0.00	192.03	0.00	0.00	0.00	0.00	0.00
10-Sep-04	6,162.54	0.00	191.46	0.00	0.00	0.00	0.00	0.00
11-Sep-04	6,462.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Sep-04	6,045.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Sep-04	5,949.24	0.00	187.26	0.00	0.00	0.00	0.00	0.00
14-Sep-04	6,353.24	0.00	172.26	0.00	0.00	0.00	0.00	0.00
15-Sep-04	6,226.68	0.00	299.12	0.00	0.00	0.00	0.00	0.00
16-Sep-04	6,022.77	0.00	122.53	0.00	0.00	0.00	0.00	0.00
17-Sep-04	6,325.42	0.00	140.45	46.43	0.00	0.00	0.00	0.00
18-Sep-04	6,686.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19-Sep-04	6,205.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-Sep-04	6,315.21	0.00	158.07	26.12	0.00	0.00	0.00	0.00
21-Sep-04	6,352.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Sep-04	6,701.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Sep-04	6,808.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Sep-04	6,453.00	0.00	146.90	0.00	0.00	0.00	0.00	0.00
25-Sep-04	6,275.80	0.00	100.00	0.00	0.00	0.00	0.00	0.00
26-Sep-04	5,974.60	0.00	100.00	0.00	0.00	0.00	0.00	0.00
27-Sep-04	3,991.58	0.00	45.42	0.00	0.00	0.00	0.00	0.00
28-Sep-04	443.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Sep-04	6,174.22	0.00	94.58	0.00	0.00	0.00	0.00	0.00
30-Sep-04	6,337.12	0.00	95.08	0.00	0.00	0.00	0.00	0.00
Adjustment	-1,500.00							
Total Burned	178,154.23	0.00	2,607.71	165.06	0.00	0.00	0.00	0.00
Total Delivered	181,803.11	0.00	2,607.71	165.06	0.00	0.00	0.00	0.00
HHV	8506	0	15000	7187	0	0	0	0
% Ash	4.66%	0.00	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	8,302.79	0.00	51.48	12.52	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD
Oct-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Oct-04	6,130.30	0.00	200.00	0.00	0.00	0.00	0.00	0.00
2-Oct-04	6,031.00	0.00	200.00	0.00	0.00	0.00	0.00	0.00
3-Oct-04	6,217.15	0.00	143.65	0.00	0.00	0.00	0.00	0.00
4-Oct-04	6,171.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Oct-04	6,385.43	0.00	166.07	0.00	0.00	0.00	0.00	0.00
6-Oct-04	6,571.88	0.00	47.42	0.00	0.00	0.00	0.00	0.00
7-Oct-04	6,634.81	0.00	45.69	0.00	0.00	0.00	0.00	0.00
8-Oct-04	6,408.54	0.00	193.26	0.00	0.00	0.00	0.00	0.00
9-Oct-04	6,794.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Oct-04	6,057.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Oct-04	6,502.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Oct-04	6,675.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Oct-04	6,585.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14-Oct-04	6,638.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-Oct-04	5,361.65	0.00	789.23	70.52	0.00	0.00	0.00	0.00
16-Oct-04	6,483.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17-Oct-04	6,468.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-Oct-04	6,409.92	0.00	23.38	0.00	0.00	0.00	0.00	0.00
19-Oct-04	6,596.53	0.00	44.87	0.00	0.00	0.00	0.00	0.00
20-Oct-04	6,507.18	0.00	68.82	0.00	0.00	0.00	0.00	0.00
21-Oct-04	6,512.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Oct-04	5,183.16	0.00	46.24	0.00	0.00	0.00	0.00	0.00
23-Oct-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Oct-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Oct-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Oct-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Oct-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Oct-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Oct-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Oct-04	2,415.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31-Oct-04	4,298.53	0.00	0.00	45.37	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	146,040.98	0.00	1,968.63	115.89	0.00	0.00	0.00	0.00
Total Delivered	139,115.98	0.00	1,968.63	115.89	0.00	0.00	0.00	0.00
HHV	8453	0	15000	7187	0	0	0	0
% Ash	4.77%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	6,963.15	0.00	51.48	12.52	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD
Nov-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Nov-04	6,456.19	0.00	0.00	23.11	0.00	0.00	0.00	0.00
2-Nov-04	6,847.50	0.00	27.60	0.00	0.00	0.00	0.00	0.00
3-Nov-04	6,708.27	0.00	121.74	24.79	0.00	0.00	0.00	0.00
4-Nov-04	6,370.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Nov-04	6,521.10	0.00	100.00	50.00	0.00	0.00	0.00	0.00
6-Nov-04	6,009.25	0.00	100.00	22.95	0.00	0.00	0.00	0.00
7-Nov-04	6,376.55	0.00	91.75	0.00	0.00	0.00	0.00	0.00
8-Nov-04	6,417.37	0.00	215.61	22.82	0.00	0.00	0.00	0.00
9-Nov-04	6,218.32	0.00	22.59	47.99	0.00	0.00	0.00	0.00
10-Nov-04	6,489.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11-Nov-04	6,474.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12-Nov-04	6,045.24	0.00	214.64	72.92	0.00	0.00	0.00	0.00
13-Nov-04	6,169.70	0.00	200.00	65.00	0.00	0.00	0.00	0.00
14-Nov-04	5,955.90	0.00	200.00	65.00	0.00	0.00	0.00	0.00
15-Nov-04	6,288.28	0.00	190.31	165.61	0.00	0.00	0.00	0.00
16-Nov-04	6,417.52	0.00	48.24	120.64	0.00	0.00	0.00	0.00
17-Nov-04	6,650.68	0.00	47.43	25.39	0.00	0.00	0.00	0.00
18-Nov-04	6,640.60	0.00	50.00	25.00	0.00	0.00	0.00	0.00
19-Nov-04	6,235.15	0.00	324.85	204.40	0.00	0.00	0.00	0.00
20-Nov-04	6,092.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Nov-04	6,340.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22-Nov-04	6,398.38	0.00	161.30	25.02	0.00	0.00	0.00	0.00
23-Nov-04	6,683.58	0.00	93.60	77.32	0.00	0.00	0.00	0.00
24-Nov-04	6,736.00	0.00	210.00	0.00	0.00	0.00	0.00	0.00
25-Nov-04	6,029.40	0.00	30.00	0.00	0.00	0.00	0.00	0.00
26-Nov-04	6,286.24	0.00	0.00	25.16	0.00	0.00	0.00	0.00
27-Nov-04	6,447.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-Nov-04	6,711.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-Nov-04	6,674.38	0.00	134.27	24.95	0.00	0.00	0.00	0.00
30-Nov-04	6,533.88	0.00	118.67	49.55	0.00	0.00	0.00	0.00
Adjustment	0.00							
Total Burned	192,225.48	0.00	2,702.60	1,137.62	0.00	0.00	0.00	0.00
Total Delivered	179,452.91	0.00	2,702.60	1,137.62	0.00	0.00	0.00	0.00
HHV	8535	0	15000	7187	16932	6500		
% Ash	4.63%	0.00%	7.04%	1.10%	0.00%	0.00%		
Tons Ash	8,899.99	0.00	190.26	12.51	0.00	0.00	0.00	0.00

BIG STONE PLANT
FUEL BURN RECORD - page 1 of 3
Dec-04

DATE	Coal	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)
1-Dec-04	6,677.28	0.00	126.45	73.87	0.00	0.00	0.00	0.00
2-Dec-04	7,045.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-Dec-04	6,664.19	0.00	147.63	100.08	0.00	0.00	0.00	0.00
4-Dec-04	6,638.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-Dec-04	6,724.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-Dec-04	6,484.83	0.00	141.25	26.02	0.00	0.00	0.00	0.00
7-Dec-04	6,873.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8-Dec-04	6,631.28	0.00	190.00	50.22	0.00	0.00	0.00	0.00
9-Dec-04	6,765.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-Dec-04	6,351.80	0.00	228.32	22.88	0.00	0.00	0.00	0.00
11-Dec-04	6,512.10	0.00	125.00	0.00	0.00	0.00	0.00	0.00
12-Dec-04	6,737.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-Dec-04	6,769.40	0.00	165.91	23.09	0.00	0.00	0.00	0.00
14-Dec-04	6,785.82	0.00	95.48	0.00	0.00	0.00	0.00	0.00
15-Dec-04	6,783.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16-Dec-04	6,761.13	0.00	74.93	23.74	0.00	0.00	0.00	0.00
17-Dec-04	6,611.05	0.00	254.18	24.37	0.00	0.00	0.00	0.00
18-Dec-04	6,890.00	0.00	200.00	0.00	0.00	0.00	0.00	0.00
19-Dec-04	6,831.30	0.00	200.00	0.00	0.00	0.00	0.00	0.00
20-Dec-04	6,657.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21-Dec-04	6,718.65	0.00	117.58	22.07	0.00	0.00	0.00	0.00
22-Dec-04	6,911.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23-Dec-04	6,918.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24-Dec-04	6,886.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-Dec-04	6,979.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26-Dec-04	6,927.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27-Dec-04	6,692.44	0.00	267.76	0.00	0.00	0.00	0.00	0.00
28-Dec-04	5,440.52	0.00	181.78	0.00	0.00	0.00	0.00	0.00
29-Dec-04	6,224.12	0.00	254.10	87.68	0.00	0.00	0.00	0.00
30-Dec-04	6,573.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31-Dec-04	6,559.53	0.00	50.27	0.00	0.00	0.00	0.00	0.00
Adjustment	-5,500.00							
Total Burned	201,529.44	0.00	2,820.64	454.02	0.00	0.00	0.00	0.00
Total Delivered	207,087.84	0.00	2,820.64	454.02	0.00	0.00	0.00	0.00
HHV	8532	0	15000	7187	0	0	0	0
% Ash	4.66%	0.00%	7.04%	1.10%	0.00%	0.00%	0.00%	0.00%
Tons Ash	9,388.17	0.00	70.76	23.60	0.00	0.00	0.00	0.00

B15 Fuel Analysis Record

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Oct-02	PAGE 1

DATE	TR #	MOIS. %	% ASH DRY	HHV DRY	S, %	% ASH DRY	HHV DRY	S, %	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.												
1-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
2-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
3-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
4-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
5-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
6-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
7-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
8-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
9-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
10-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
11-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
12-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
13-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
14-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
15-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
16-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
17-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
18-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
19-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
20-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
21-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
22-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
23-Oct-02		0	0	0	0	0	0	0	0	0	0	0.000
24-Oct-02	bam75	29.59	4.15	8639	0.27	5.9	12269	0.39	1.49	13038	13008.930	13008.930
25-Oct-02	0	0	0	0	0	0	0	0	0	0	0	0.000
26-Oct-02	ebm33	30.44	4.79	8404	0.38	6.89	12081	0.55	1.9	12975	14158.850	14158.850
27-Oct-02	0	0	0	0	0	0	0	0	0	0	0	0.000
28-Oct-02	bam76	29.63	4.14	8618	0.26	5.88	12247	0.37	1.42	13012	14061.250	7090.020
29-Oct-02	0	0	0	0	0	0	0	0	0	0	0	0.000
30-Oct-02	0	0	0	0	0	0	0	0	0	0	0	0.000
31-Oct-02	ebm34	29.98	4.87	8462	0.41	6.96	12085	0.59	1.86	12989	12962.025	
ADJ.												34257.800
Weighted Average		29.95	4.41	8538	0.31	6.31	12187	0.45	1.64		Tons. OK	34257.800
											Burn	34257.800

Monthly Mercury Analysis

Train #	Sample #	% Moist.	Mercury ug/g dry basis	Chlor. ug/g

BIG STONE PLANT

COAL ANALYSIS PER TRAIN

Nov-02

PAGE 1

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF %	COAL TONS	TONS OK
PREV. MON	bam76	29.63	4.14	8618	0.26	5.88	12247	0.37	1.4	13012	14061.25	10256.72
PREV. MON	ebm34	29.98	4.87	8462	0.41	6.96	12085	0.59	1.86	12989	12962.03	12962.03
1-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	
2-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	
3-Nov-02	crm01	30.09	5.03	8464	0.32	5.03	12106	0.46	1.1	13045	14143.18	14143.18
4-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
5-Nov-02	ebm35	30.36	4.75	8429	0.38	6.82	12103	0.54	1.9	12989	12205.48	12205.48
6-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
7-Nov-02	cdm01	28.79	5.93	8501	0.34	8.32	11939	0.41	1.3	13023	12960.60	12960.60
8-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
9-Nov-02	ebm36	29.86	4.83	8479	0.39	6.88	12088	0.56	1.8	12981	14098.98	14098.98
10-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
11-Nov-02	bam 77	29.51	4.88	8512	0.3	6.93	12076	0.42	1.4	12975	12795.68	12795.68
12-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
13-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
14-Nov-02	bam78	29.8	4.75	8589	0.31	6.76	12235	0.44	1.4	13122	14128.18	14128.18
15-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
16-Nov-02	bam79	29.86	4.1	8601	0.27	5.85	12262	0.38	1.6	13024	14043.63	14043.63
17-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
18-Nov-02	bam80	29.36	4.53	8629	0.29	6.41	12215	0.41	1.5	13052	13470.35	13470.35
19-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
20-Nov-02	bam81	29.53	4.64	8549	0.28	6.58	12132	0.4	1.4	12987	13204.80	13204.80
21-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
22-Nov-02	bam82	29.85	4.74	8466	0.29	6.75	12069	0.41	1.4	12943	14150.85	14150.85
23-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	0.00
24-Nov-02	bam83	29.29	4.46	8641	0.3	6.31	12221	0.42	1.5	13044	12727.63	12727.63
25-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	
26-Nov-02	bam84	29.72	4.41	8560	0.25	6.27	12180	0.36	1.5	12995	12724.88	12724.88
27-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	
28-Nov-02	ebm037	30.13	4.76	8456	0.42	6.81	12102	0.6	1.9	12986	13889.23	521.79
29-Nov-02	0	0	0	0	0	0	0	0	0	0	0.00	
30-Nov-02	crm02	29.37	5.62	8464	0.3	7.96	11982	0.42	1.2	13019	13825.90	
ADJ.												184394.76
Weighted Average											Tons. OK	184394.76
											Burn	184394.76

Monthly Mercury Analysis

Train #	Sample #	Mercury Chlor.		
		% Moist.	ug/g dry basis	ug/g
	C2489	30.15	0.11	<0.01

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Dec-02	PAGE 1

DATE	TR #	MOIS %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON	ebm037	30.13	4.76	8456	0.42	6.81	12102	0.60	1.92	12986	13889.23	13367.44
PREV. MON	crm02	29.37	5.62	8464	0.30	7.96	11982	0.42	1.17	13019	13825.90	13825.90
1-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
2-Dec-02	bam85	30.3	4.26	8530	0.29	6.11	12234	0.42	1.49	13030	10461.98	10461.98
3-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
4-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
5-Dec-02	crm03	30.8	5.21	8348	0.28	7.53	12055	0.4	1.21	13037	11797.38	11797.38
6-Dec-02	bam86	29.3	4.37	8658	0.25	6.18	12253	0.35	1.56	13060	14086.78	14086.78
7-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
8-Dec-02	bam87	29.9	4.53	8554	0.33	6.47	12205	0.47	1.43	13049	13267.00	13267.00
9-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
10-Dec-02	bam88	29.9	4.6	8565	0.29	6.57	12220	0.42	1.45	13079	14101.13	14101.13
11-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
12-Dec-02	bam89	29.4	4.32	8653	0.27	6.12	12255	0.38	1.49	13054	13264.00	13264.00
13-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
14-Dec-02	bam90	30.3	4.23	8537	0.26	6.07	12247	0.38	1.42	13038	14113.73	14113.73
15-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
16-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
17-Dec-02	bam91	29.1	4.56	8672	0.33	6.43	12225	0.46	1.44	13065	13722.10	13722.10
18-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
19-Dec-02	bam92	28.7	4.28	8729	0.26	6	12238	0.36	1.4	13019	14141.13	14141.13
20-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
21-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
22-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
23-Dec-02	ebm38	30.2	5	8396	0.37	7.17	12028	0.53	1.71	12957	14159.77	14159.77
24-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
25-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
26-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
27-Dec-02	ebm39	30.4	4.85	8381	0.4	6.97	12043	0.57	1.81	12945	13929.20	13929.20
28-Dec-02		0	0	0	0	0	0	0	0	0	0.00	
29-Dec-02	bam93	28.6	4.45	8712	0.31	6.24	12208	0.44	1.29	13020	14053.55	9182.78
30-Dec-02	ebm40	30	4.76	8457	0.42	6.79	12073	0.6	1.93	12952	13881.20	0.00
31-Dec-02		0	0	0	0	0	0	0	0	0	14145.23	
ADJ.												183420.32
Weighted Average											Tons. OK	196553.92
											Burn	196553.92

Monthly Mercury Analysis

Train #	Sample #	% Moist.	Mercury ug/g dry basis	Chlor. ug/g

BIG STONE PLANT COAL ANALYSIS PER TRAIN

Jan-03

PAGE 1

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MO	bam93	28.64	4.45	8712	0.31	6.24	12208	0.44	1.29	13020	14,053.55	4,870.77
PREV. MO	ebm40	29.95	4.76	8457	0.42	6.79	12073	0.60	1.93	12952	13,881.20	13,881.20
1-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
2-Jan-03	ebm41	30.52	4.72	8364	0.41	6.79	12038	0.59	1.85	12915	14,145.23	14,145.23
3-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
4-Jan-03	ebm01	29.97	4.85	8453	0.44	6.92	12071	0.63	1.8	12968	13,092.48	13,092.48
5-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
6-Jan-03	bam01	29.52	4.24	8614	0.27	6.02	12222	0.38	1.52	13005	14,090.35	14,090.35
7-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
8-Jan-03	bam02	29.26	4.37	8658	0.28	6.18	12239	0.4	1.35	13045	13,033.90	13,033.90
9-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
10-Jan-03	bam03	29.42	4.26	8688	0.25	6.03	12310	0.35	1.52	13100	11,730.45	11,730.45
11-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
12-Jan-03	bam04	29.5	4.39	8616	0.3	6.23	12221	0.42	1.48	13033	14,159.78	14,159.78
13-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
14-Jan-03	bam05	29.01	4.64	8640	0.29	6.53	12171	0.41	1.42	13021	9,762.10	9,762.10
15-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
16-Jan-03	bam06	29.01	4.64	8640	0.29	6.53	12171	0.41	1.42	13021	12,282.20	12,282.20
17-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
18-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
19-Jan-03	bam07	29.13	4.69	8678	0.3	6.62	12245	0.43	1.33	13113	13,522.30	13,522.30
20-Jan-03	bam08	29.62	4.44	8621	0.27	6.31	12249	0.38	1.46	13074	12,037.80	12,037.80
21-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
22-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
23-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
24-Jan-03	bam09	29.83	4.24	8629	0.26	6.04	12297	0.37	1.56	13087	13,318.28	13,318.28
25-Jan-03	bam10	29.95	4.43	8569	0.27	6.32	12233	0.39	1.5	13058	13,531.75	13,531.75
26-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
27-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
28-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
29-Jan-03	bam11	29.28	4.27	8704	0.28	6.04	12308	0.39	1.38	13099	13,322.95	12,958.34
30-Jan-03	bam12	29.85	4.42	8593	0.27	6.3	12250	0.39	1.42	13074	13,171.28	0.00
31-Jan-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
ADJ.												186,416.92
Weighted Average		29.57	4.49	8595	0.31	6.38	12202	0.44	1.54		Tons. OK	186,416.92
											Burn	186,416.92

Monthly Mercury Analysis

		Mercury Chloride	
Train Sample #	% Moist.	ug/g dry basis	ug/g

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Feb-03	PAGE 1

DATE	TR #	MOIS %	% ASI	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MO	bam11	29.3	4.27	8704	0.28	6.04	12308	0.39	1.38	13099	13,322.95	364.61
PREV. MO	bam12	29.9	4.42	8593	0.27	6.3	12250	0.39	1.42	13074	13,171.28	13171.28
1-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
2-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
3-Feb-03	bam13	30.2	4.24	8571	0.24	6.08	12285	0.35	1.63	13080	13082.78	13082.78
4-Feb-03	bam14	30.2	4.48	8530	0.25	6.42	12213	0.36	1.47	13051	13160.30	13160.30
5-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
6-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
7-Feb-03	bam15	30.1	4.29	8494	0.28	6.14	12158	0.4	1.66	12953	13275.88	13275.88
8-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
9-Feb-03	bam16	29.4	4.12	8681	0.28	5.84	12299	0.39	1.67	13062	12953.88	12953.88
10-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
11-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
12-Feb-03	bam17	29.2	4.5	8669	0.28	6.36	12244	0.4	1.43	13076	13273.08	13273.08
13-Feb-03	bam18	29.3	4.31	8651	0.27	6.09	12229	0.38	1.46	13022	12419.18	12419.18
14-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
15-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
16-Feb-03	ebm02	30.4	5.02	8413	0.45	7.21	12090	0.64	1.76	13029	12751.52	12751.52
17-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
18-Feb-03	ebm03	30.8	5.24	8316	0.39	7.57	12010	0.56	1.73	12994	13309.73	13309.73
19-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
20-Feb-03	bam19	29.2	4.51	8656	0.3	6.37	12218	0.43	1.51	13049	13185.42	13185.42
21-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
22-Feb-03	bam20	28.9	4.51	8639	0.28	6.35	12158	0.4	1.47	12982	13672.10	12727.61
23-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
24-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
25-Feb-03	bam21	30.4	4.3	8520	0.26	6.18	12234	0.37	1.53	13040	13671.40	0.00
26-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
27-Feb-03	bam22	29.2	4.46	8656	0.28	6.3	12230	0.39	1.47	13052	10746.15	0.00
28-Feb-03		0	0	0	0	0	0	0	0	0	0.00	0.00
ADJ.												143675.26
Weighted Average											Tons. OK	154405.86
											Burn	154405.86

Monthly Mercury Analysis

Train #	Sample #	% Moist.	Mercury Chloride	
			ug/g dry basis	ug/g
	C303	30.26	0.103	<0.01

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Mar-03	PAGE 1

DATE	TR #	MOIS %	% ASI	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF %	COAL TONS	TONS OK
PREV.	bam20	28.9	4.51	8639	0.28	6.35	12158	0.4	1.5	12982	13672.10	944.49
PREV.	bam21	30.36	4.30	8520	0.26	6.18	12234	0.37	1.53	13040	13671.40	13671.40
1-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
2-Mar-03	0	29.2	4.46	8656	0.28	6.3	12230	0.39	1.5	13052	0.00	0.00
3-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
4-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
5-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
6-Mar-03	ebm04	30.4	4.71	8455	0.41	6.76	12143	0.59	1.8	13023	13682.43	13682.43
7-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
8-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
9-Mar-03	bam23	30.8	4.27	8457	0.25	6.17	12221	0.36	1.4	13025	13360.65	13360.65
10-Mar-03	ebm05	30.6	4.37	8466	0.36	6.3	12195	0.52	1.9	13015	13486.15	13486.15
11-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
12-Mar-03	bam24	29.3	4.48	8658	0.28	6.34	12239	0.39	1.5	13067	13064.15	13064.15
13-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
14-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
15-Mar-03	bam25	29.1	4.69	8612	0.3	6.61	12147	0.42	1.6	13007	13310.88	13310.88
16-Mar-03	bam26	29.2	4.37	8645	0.25	6.17	12212	0.36	1.6	13015	13176.13	13176.13
17-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
18-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
19-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
20-Mar-03	bam27	30	4.3	8578	0.27	6.15	12256	0.38	1.5	13059	14006.18	14006.18
21-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
22-Mar-03	bam28	29.5	4.16	8648	0.24	5.9	12270	0.34	1.6	13039	13148.65	13148.65
23-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
24-Mar-03	bam29	29.7	4.85	8543	0.3	6.9	12143	0.42	1.3	13043	14094.48	14094.48
25-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
26-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
27-Mar-03	bam30	30.1	4.58	8485	0.26	6.55	12132	0.37	1.5	12982	14088.83	14088.83
28-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
29-Mar-03	bam31	29.5	4.23	8621	0.25	6	12221	0.35	1.5	13001	14033.93	15501.37
30-Mar-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
31-Mar-03	bam32	29.6	4.78	8594	0.29	6.79	12205	0.41	1.4	13094	14127.90	0.00
ADJ.												165535.78
Weighted Average											Tons. OK	177636.53
											Burn	177636.53

Monthly Mercury Analysis

Train #	Sample #	Mercury Chloride		
		% Moist.	ug/g dry basis	ug/g
	C550	29.23	0.116	<0.01

BIG STONE PLANT COAL ANALYSIS PER TRAIN

Apr-03

PAGE 1

DATE	TR #	MOIS %	ASI	HHV	S, %	% ASH	HHV	S, %	NaO	MAF	COAL	TONS
		%	AR	AR	AR	DRY	DRY	DRY	%	HHV	TONS	OK
PREV. MON.												
PREV. MO	bam32	29.6	4.78	8594	0.29	6.79	12205	0.41	1.4	13094	14127.90	12660.46
1-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
2-Apr-03	bam33	30	4.29	8551	0.27	6.12	12209	0.38	1.5	13005	13939.48	13939.48
3-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
4-Apr-03	bam34	29	4.7	8657	0.28	6.61	12184	0.39	1.4	13046	14163.38	14163.38
5-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
6-Apr-03	bam35	30	4.38	8562	0.27	6.26	12233	0.38	1.4	13050	12755.10	12755.10
7-Apr-03	ebm06	30.4	4.83	8392	0.43	6.94	12049	0.62	1.9	12948	10068.83	10068.83
8-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
9-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
10-Apr-03	ebm07	30.5	5.03	8401	0.43	7.23	12079	0.62	1.7	13020	7781.13	7781.13
11-Apr-03	ebm08	30.6	4.76	8404	0.43	6.86	12101	0.62	1.9	12992	14165.00	14165.00
12-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
13-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
14-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
15-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
16-Apr-03	ebm09	30.1	4.67	8435	0.44	6.68	12072	0.63	1.9	12936	14166.48	14166.48
17-Apr-03	ebm10	30.5	4.77	8410	0.42	6.86	12103	0.61	1.9	12994	14176.43	14176.43
18-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
19-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
20-Apr-03	ebm11	31.1	4.47	8375	0.33	6.49	12146	0.48	2	12989	14180.15	14180.15
21-Apr-03	bam36	29.9	4.39	8569	0.28	6.26	12221	0.4	1.6	13037	14148.50	14148.50
22-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
23-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
24-Apr-03	ebm12	31	4.87	8352	0.44	7.06	12098	0.64	1.8	13017	10432.75	10432.75
25-Apr-03	bam37	28.9	4.5	8689	0.3	6.33	12228	0.42	1.4	13054	12652.40	9165.71
26-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
27-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
28-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
29-Apr-03	0	0	0	0	0	0	0	0	0	0	0.00	
30-Apr-03	bam38	28.5	4.59	8716	0.28	6.42	12192	0.39	1.4	13028	14146.10	0.00
ADJ.												161803.40
											Tons. OK	164805.80
Weighted Average											Burn	164805.80

Monthly Mercury Analysis

		Mercury Chloride	
Train Sample	%	ug/g	ug/g
#	#	Moist.	dry basis
		0.116	<0.01

DATE	TR #	MOIS %	% ASH	HHV	S, %	% ASH	HHV	S, %	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MO	bam37	28.9	4.5	8689	0.3	6.33	12228	0.42	1.38	13054	12652.400	3486.690
PREV. MO	bam38	28.5	4.59	8716	0.28	6.42	12192	0.39	1.36	13028	14146.100	14146.100
1-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
2-May-03	ebm13	30.4	4.9	8415	0.42	7.03	12083	0.6	1.7	12997	14172.650	14172.650
3-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
4-May-03	bam39	29.4	4.26	8636	0.27	6.04	12237	0.38	1.48	13024	14135.200	14135.200
5-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
6-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
7-May-03	ebm14	30.4	4.69	8416	0.42	6.73	12087	0.6	1.89	12959	13846.500	13846.500
8-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
9-May-03	bam40	29.1	4.66	8626	0.3	6.57	12165	0.42	1.5	13020	14131.625	14131.625
10-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
11-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
12-May-03	ebm15	30.7	4.76	8354	0.38	6.87	12059	0.55	1.86	12949	14154.950	14154.950
13-May-03	bam41	29	4.53	8658	0.29	6.38	12189	0.41	1.36	13020	14059.200	14059.200
14-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
15-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
16-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
17-May-03	bam42	30.1	4.86	8488	0.27	6.96	12147	0.38	1.34	13056	14163.980	14163.980
18-May-03	bam43	30.1	4.9	8436	0.27	7.01	12076	0.39	1.31	12986	14176.330	14176.330
19-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
20-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
21-May-03	bam44	29	4.57	8692	0.3	6.44	12245	0.42	1.52	13088	14162.750	14162.750
22-May-03	bam45	29.1	4.42	8669	0.28	6.24	12232	0.4	1.52	13046	11741.200	11741.200
23-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
24-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
25-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
26-May-03	bam46	29.8	4.16	8576	0.25	5.92	12210	0.36	1.53	12978	14149.525	14149.525
27-May-03	bam47	29.6	4.38	8582	0.25	6.22	12194	0.36	1.49	13003	14181.670	14181.670
28-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
29-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
30-May-03	0	0	0	0	0	0	0	0	0	0	0.000	
31-May-03	ebm16	30.6	4.63	8390	0.43	6.67	12095	0.62	1.83	12959	14184.750	134.460
ADJ.												184842.830
Weighted Average		29.63	4.59	8560	0.31	6.53	12163	0.44	1.52		Tons. OK	184842.830
											Burn	184842.830

Monthly Mercury Analysis

		Mercury Chloride	
Train Sample #	% Moist.	ug/g dry basis	ug/g

BIG STONE PLANT COAL ANALYSIS PER TRAIN

Jun-03

PAGE 1

DATE	TR #	MOIS. %	% ASI	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MO	ebm16	30.63	4.63	8390	0.43	6.67	12095	0.62	1.8	12959	14184.75	14050.29
1-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
2-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
3-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
4-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
5-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
6-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
7-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
8-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
9-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
10-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
11-Jun-03	bam048	29.62	4.49	8611	0.28	6.38	12235	0.4	1.5	13069	14162.73	14162.73
12-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
13-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
14-Jun-03	ebm017	30.7	4.57	8378	0.42	6.59	12089	0.61	1.9	12942	14176.20	14176.20
15-Jun-03	bam049	29.98	4.46	8547	0.27	6.37	12207	0.39	1.5	13037	14161.78	14161.78
16-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
17-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
18-Jun-03	ebm18	30.78	4.67	8339	0.41	6.75	12047	0.59	1.9	12919	14180.70	14180.70
19-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
20-Jun-03	bam50	29.1	4.5	8698	0.28	6.35	12268	0.4	1.4	13100	14170.08	14170.08
21-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
22-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
23-Jun-03	ebm19	30.47	4.74	8410	0.42	6.82	12096	0.6	1.8	12981	14175.33	14175.33
24-Jun-03	bam51	29.47	4.27	8602	0.28	6.06	12196	0.39	1.8	12983	14161.33	14161.33
25-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
26-Jun-03	gregerso	30.47	4.74	8410	0.42	6.82	12096	0.6	1.8	12981	1871.60	1871.60
27-Jun-03	ebm20	30.76	4.75	8357	0.43	6.86	12069	0.62	1.8	12958	14166.25	12869.48
28-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
29-Jun-03	bam52	29.71	4.19	8605	0.23	5.96	12242	0.33	1.5	13018	14160.08	
30-Jun-03		0	0	0	0	0	0	0	0	0	0.00	
ADJ.												127979.52
Weighted Avg.											Tons. OK	127979.52
											Burn	127979.52

Monthly Mercury Analysis

Train Sample		Mercury Chloride	
#	#	% Moist.	ug/g dry basis

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Jul-03	PAGE 1

DATE	TR #	MOIS %	% ASI	HHV AR	S, % AR	% ASF DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MC	ebm20	30.8	4.75	8357	0.43	6.86	12069	0.62	1.83	12958	14166.25	1296.77
PREV. MC	bam52	29.7	4.19	8605	0.23	5.96	12242	0.33	1.52	13018	14160.08	14160.08
1-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
2-Jul-03	ebm21	31.2	4.85	8312	0.41	7.04	12075	0.6	1.76	12989	14166.88	14166.88
3-Jul-03	bam053	29.3	4.32	8606	0.25	6.12	12180	0.36	1.62	12974	14173.35	14173.35
4-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
5-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
6-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
7-Jul-03	bam054	29.3	4.47	8595	0.28	6.32	12161	0.39	1.56	12981	12952.58	12952.58
8-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
9-Jul-03	bam055	29.4	4.41	8585	0.26	6.24	12160	0.37	1.49	12969	14160.63	14160.63
10-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
11-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
12-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
13-Jul-03	bam056	28.8	4.73	8623	0.3	6.65	12114	0.42	1.34	12977	14178.45	14178.45
14-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
15-Jul-03	bam057	29.5	4.25	8610	0.26	6.03	12216	0.37	1.52	13000	14178.85	14178.85
16-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
17-Jul-03	bam58	29	4.38	8706	0.29	6.17	12265	0.41	1.51	13072	14178.40	14178.40
18-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
19-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
20-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
21-Jul-03	bam59	29.3	4.44	8634	0.31	6.28	12211	0.44	1.5	13029	14140.95	14140.95
22-Jul-03	ebm22	29.9	4.91	8472	0.49	7.01	12084	0.7	1.87	12995	14169.00	14169.00
23-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
24-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
25-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
26-Jul-03	bam60	28.4	4.85	8630	0.26	6.78	12056	0.37	1.36	12933	14154.60	14154.60
27-Jul-03	bam61	28.8	4.18	8671	0.28	5.87	12179	0.4	1.55	12938	14182.30	14182.30
28-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
29-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
30-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
31-Jul-03	0	0	0	0	0	0	0	0	0	0	0.00	
ADJ.												170092.84
Weighted Average		29.49	4.61	8561	0.30	6.55	12142	0.43	1.55		Tons. OK	192005.80
											Burn	192005.80

Monthly Mercury Analysis

Mercury Chloride				
Train #	Sample #	% Moist.	ug/g dry basis	ug/g
	C1364	30.39	0.105	<0.01

BIG STONE PLANT COAL ANALYSIS PER TRAIN

Aug-03

PAGE 1

DATE	TR #	MOIS %	% ASI	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.												
1-Aug-03	ebm23	30.2	4.77	8449	0.43	6.84	12105	0.61	1.89	12994	14170.08	14170.08
2-Aug-03	bam62	28.8	4.33	8708	0.3	6.08	12227	0.42	1.58	13019	14174.10	14174.10
3-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
4-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
5-Aug-03	ebm24	30.3	5.12	8366	0.43	7.34	11997	0.62	1.78	12947	14185.32	14185.32
6-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
7-Aug-03	bam63	29	4.36	8721	0.28	6.14	12274	0.4	1.48	13077	14180.18	14180.18
8-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
9-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
10-Aug-03	bam64	28.6	4.25	8714	0.29	5.95	12211	0.4	1.49	12984	14163.80	14163.80
11-Aug-03	bam65	28.5	4.49	8712	0.31	6.28	12191	0.44	1.53	13008	14179.73	14179.73
12-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
13-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
14-Aug-03	bam66	28.8	4.43	8645	0.29	6.23	12149	0.41	1.44	12956	14163.08	14163.08
15-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
16-Aug-03	bam67	28.7	4.71	8627	0.29	6.6	12099	0.41	1.46	12954	14179.60	14179.60
17-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
18-Aug-03	bam68	28.6	4.52	8663	0.29	6.33	12140	0.41	1.51	12960	14170.10	14170.10
19-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
20-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
21-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
22-Aug-03	bam69	29.3	4.79	8541	0.29	6.78	12083	0.41	1.63	12962	14042.45	14042.45
23-Aug-03	bam70	29.4	4.67	8541	0.3	6.61	12099	0.43	1.54	12955	14179.40	14179.40
24-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
25-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
26-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
27-Aug-03	bam71	29.4	4.6	8591	0.3	6.52	12168	0.43	1.49	13017	14164.35	14164.35
28-Aug-03	bam72	29.6	4.53	8590	0.27	6.43	12193	0.39	1.56	13031	14167.83	4375.44
29-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
30-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
31-Aug-03	0	0	0	0	0	0	0	0	0	0	0.00	
											174327.63	
Weighted Average											Tons. OK	200219.47
											Burn	200219.47

Monthly Mercury Analysis

Train Sample		Mercury Chlor.	
#	#	% Moist.	ug/g dry basis
C1719	28.75	0.081	<0.01

BIG STONE PLANT

COAL ANALYSIS PER TRAIN

Sep-03

PAGE 1

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.	bam72	29.55	4.53	8590	0.27	6.43	12193	0.39	1.6	13031	14167.83	9792.39
1-Sep-03	bam74	29.19	4.33	8623	0.28	6.11	12178	0.4	1.6	12970	14175.15	14175.15
2-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
3-Sep-03	bam73	29	4.25	8640	0.26	5.99	12169	0.36	1.5	12944	13314.88	13314.88
4-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
5-Sep-03	0	30.35	4.7	8423	0.42	6.75	12093	0.61	1.9	12968	597.50	597.50
6-Sep-03	ebm25	30.35	4.7	8423	0.42	6.75	12093	0.61	1.9	12968	14177.73	14177.73
7-Sep-03	bam75	28.72	4.66	8667	0.3	6.54	12159	0.42	1.4	13010	14133.38	14133.38
8-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
9-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
10-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
11-Sep-03	ebm26	30.46	4.76	8404	0.42	6.84	12085	0.61	1.8	12972	14174.25	14174.25
12-Sep-03	bam76	29.84	4.26	8573	0.25	6.07	12219	0.36	1.6	13009	12958.07	12958.07
13-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
14-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
15-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
16-Sep-03	bam77	29.81	4.23	8570	0.26	6.02	12210	0.37	1.6	12992	14189.58	14189.58
17-Sep-03	ebm27	30.98	4.42	8364	0.34	6.4	12118	0.49	2	12947	13756.80	13756.80
18-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
19-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
20-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
21-Sep-03	ebm28	30.61	4.84	8385	0.43	6.98	12084	0.62	1.8	12991	13204.48	13204.48
22-Sep-03	bam78	28.56	4.68	8662	0.29	6.55	12125	0.41	1.5	12975	14186.47	14186.47
23-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
24-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
25-Sep-03	bam079	28.94	4.58	8635	0.29	6.45	12152	0.41	1.4	12990	14189.03	14189.03
26-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
27-Sep-03	0	0	0	0	0	0	0	0	0	0	0.00	
28-Sep-03	bam80	29.84	4.61	8515	0.26	6.57	12137	0.37	1.5	12990	13928.00	10046.71
29-Sep-03	ebm29	30.12	4.87	8409	0.43	6.97	12034	0.61	1.7	12936	12972.78	
30-Sep-03	ebm30	30.4	4.91	8399	0.4	7.05	12068	0.58	1.8	12983	11613.50	
ADJ.												172896.42
Weighted Average											Tons. OK	185611.32
											Burn	185611.32

Monthly Mercury Analysis

Monthly Mercury Analysis				
Train #	Sample #	% Moist.	Mercury ug/g dry basis	Chlor. ug/g
	C2105	29.35	0.08	<0.01%

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Oct-03	PAGE 1

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.												
1-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
2-Oct-03	bam81	29.59	4.37	8580	0.24	6.2	12186	0.34	1.56	12991	9755.200	9755.200
3-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
4-Oct-03	ebm31	30.19	4.78	8446	0.42	6.84	12098	0.6	1.9	12986	8781.275	8781.275
5-Oct-03	bam82	29.05	4.42	8654	0.31	6.23	12197	0.43	1.49	13007	9557.500	9557.500
6-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
7-Oct-03	bam83	28.99	4.54	8696	0.3	6.4	12246	0.42	1.71	13083	8852.525	8852.525
8-Oct-03	ebm32	29.8	4.84	8515	0.41	6.9	12130	0.59	1.83	13029	13087.700	13087.700
9-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
10-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
11-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
12-Oct-03	bam84	28.72	4.63	8673	0.31	6.49	12168	0.44	1.4	13013	14172.250	14172.250
13-Oct-03	bam85	29.19	4.26	8664	0.28	6.01	12236	0.39	1.52	13018	12636.750	12636.750
14-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
15-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
16-Oct-03	ebm33	30.09	4.77	8454	0.34	6.82	12093	0.49	1.72	12978	14176.000	14176.000
17-Oct-03	bam86	29.41	4.45	8620	0.25	6.3	12212	0.36	1.54	13033	14023.050	14023.050
18-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
19-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
20-Oct-03	btm001	26.87	5.43	8818	0.31	7.43	12058	0.42	1.19	0	11990.200	11990.200
21-Oct-03	btm02	26.64	5.39	8864	0.25	7.35	12083	0.34	1.17	0	11620.100	11620.100
22-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
23-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
24-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
25-Oct-03	btm03	27.18	5.25	8809	0.26	7.21	12097	0.36	1.25	0	14197.450	14197.450
26-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
27-Oct-03	btm04	26.96	5.36	8835	0.25	7.34	12096	0.34	1.08	0	13716.600	13716.600
28-Oct-03		0	0	0	0	0	0	0	0	0	0.000	0.000
29-Oct-03	bam87	29.17	4.71	8647	0.31	6.65	12208	0.44	1.33	13078	14149.450	6542.450
30-Oct-03		0	0	0	0	0	0	0	0	0	0.000	
31-Oct-03	bam88	28.61	4.57	8693	0.31	6.4	12177	0.43	1.52	13010	14104.600	
ADJ.											184820.650	163109.050
Weighted Average		28.87	4.83	8630	0.31	6.78	12133	0.44	1.50		Tons. OK	191576.460
											Burn	191576.460

Monthly Mercury Analysis

Train #	Sample #	% Moist.	Mercury ug/g dry basis	Chlor. ug/g

BIG STONE PLANT

COAL ANALYSIS PER TRAIN

Nov-03

PAGE 1

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON	bam87	29.17	4.71	8647	0.31	6.65	12208	0.44	1.3	13078	14149.45	7607.00
PREV. MON	bam88	28.61	4.57	8693	0.31	6.4	12177	0.43	1.5	13010	14104.60	14104.60
1-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
2-Nov-03	bam89	29.21	4.24	8642	0.24	5.99	12208	0.34	1.5	12986	14255.77	14255.77
3-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
4-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
5-Nov-03	bam90	28.9	4.66	8661	0.28	6.55	12181	0.4	1.5	13035	14137.13	14137.13
6-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
7-Nov-03	ebm34	30.2	5.03	8442	0.42	7.2	12095	0.6	1.7	13033	14009.60	14009.60
8-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
9-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
10-Nov-03	ebm35	30.1	4.79	8445	0.41	6.85	12082	0.59	1.8	12970	13835.97	13835.97
11-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
12-Nov-03	ebm36	30.02	4.72	8468	0.41	6.75	12101	0.58	1.8	12977	13431.50	13431.50
13-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
14-Nov-03	ebm37	29.85	5.06	8504	0.43	7.22	12123	0.62	1.7	13066	14175.60	14175.60
15-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
16-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
17-Nov-03	bam91	29.35	4.57	8626	0.31	6.47	12210	0.44	1.5	13055	14132.80	14132.80
18-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
19-Nov-03	ebm38	30.5	4.76	8455	0.4	6.85	12165	0.58	1.9	13060	14168.75	14168.75
20-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
21-Nov-03	ebm39	30.26	4.7	8420	0.39	6.74	12073	0.56	1.9	12946	14172.00	14172.00
22-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
23-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
24-Nov-03	ebm40	30.45	4.74	8457	0.38	6.82	12159	0.55	1.8	13049	14152.15	14152.15
25-Nov-03	ebm41	29.95	4.98	8477	0.42	7.11	12101	0.6	1.8	13027	14096.00	14096.00
26-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
27-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
28-Nov-03	0	0	0	0	0	0	0	0	0	0	0.00	0.00
29-Nov-03	bam92	29.89	4.27	8584	0.26	6.09	12244	0.37	1.7	13038	12974.10	5244.85
30-Nov-03	ebm42	30.48	4.77	8454	0.43	6.86	12160	0.62	1.9	13056	14089.13	0.00
ADJ.												181523.72
Weighted Average											Tons. OK	194277.02
											Burn	194155.92

Monthly Mercury Analysis

Train #	Sample #	Mercury Chlor.		
		% Moist.	ug/g dry basis	ug/g
	C2557	29.51	0.07	<0.01

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Dec-03	PAGE 1

DATE	TR #	MOIS %	% ASI	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON	bam92	29.89	4.27	8584	0.26	6.09	12244	0.37	1.69	13038	12974.10	7729.25
PREV. MON	ebm42	30.48	4.77	8454	0.43	6.86	12160	0.62	1.86	13056	14089.13	14089.13
1-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
2-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
3-Dec-03	bam93	29.3	4.31	8652	0.27	6.1	12237	0.38	1.58	13032	6658.15	6658.15
4-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
5-Dec-03	ebm43	29.3	4.85	8575	0.42	6.86	12125	0.6	1.85	13018	14134.15	14134.15
6-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
7-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
8-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
9-Dec-03	ebm44	30	5.25	8419	0.43	7.5	12019	0.62	1.67	12994	11198.31	11198.31
10-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
11-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
12-Dec-03	ebm45	29.6	5.31	8463	0.44	7.55	12030	0.63	1.58	13012	0.00	
13-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
14-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
15-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
16-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
17-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
18-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
19-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
20-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
21-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
22-Dec-03	ebm46	30.4	4.87	8369	0.4	7	12025	0.57	1.8	12930	8801.65	8801.65
23-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
24-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
25-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
26-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
27-Dec-03	ebm47	29.7	4.94	8523	0.44	7.02	12120	0.63	1.89	13035	14139.83	14139.83
28-Dec-03	ebm48	29.9	4.9	8469	0.45	6.99	12087	0.64	1.83	12995	12957.55	12957.55
29-Dec-03		0	0	0	0	0	0	0	0	0	0.00	
30-Dec-03	ebm49	29.6	5	8524	0.42	7.11	12109	0.6	1.67	13036	14179.50	1341.83
31-Dec-03	ebm50	29.8	5.15	8470	0.43	7.34	12073	0.61	1.54	13029	12102.48	
ADJ.												91049.85
Weighted Average		29.89	4.86	8492	0.40	6.93	12113	0.57	1.78		Tons. OK	96277.15
											Burn	96277.15

Monthly Mercury Analysis

Train #	Sample #	% Moist	Mercury ug/g dry basis	Chlor. ug/g
	04-C19	29.76	0.06	<0.01

BIG STONE PLANT COAL ANALYSIS PER TRAIN

Jan-04

PAGE 1

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MO	ebm49	29.61	5.00	8524	0.42	7.11	12109	0.60	1.67	13036	14,179.50	12,837.67
PREV. MO	ebm50	29.84	5.15	8470	0.43	7.34	12073	0.61	1.54	13029	12,102.48	12,102.48
1-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
2-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
3-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
4-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
5-Jan-04	ebm01	30.62	4.84	8369	0.42	6.98	12063	0.61	1.79	12968	13,520.10	13,520.10
6-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
7-Jan-04	EBM02	30.44	4.72	8432	0.42	6.79	12122	0.6	1.81	13005	13,877.73	13,877.73
8-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
9-Jan-04	bam01	29.21	4.7	8608	0.31	6.64	12160	0.44	1.43	13025	13,617.45	13,617.45
10-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
11-Jan-04	BAM02	29.45	4.57	8586	0.29	6.48	12145	0.41	1.4	12987	14,168.10	14,168.10
12-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
13-Jan-04	bam03	29.39	4.82	8544	0.28	6.83	12100	0.4	1.47	12987	13,734.48	13,734.48
14-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
15-Jan-04	bam04	29.37	4.43	8641	0.31	6.27	12234	0.44	1.36	13052	13,762.80	13,762.80
16-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
17-Jan-04	ebm03	30.08	4.82	8474	0.43	6.89	12120	0.62	1.77	13017	13,697.98	13,697.98
18-Jan-04	bam05	29.41	4.51	8622	0.28	6.39	12214	0.39	1.73	13048	13,552.10	13,552.10
19-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
20-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
21-Jan-04	bam06	29.27	4.44	8609	0.3	6.28	12171	0.42	1.45	12987	11,728.30	11,728.30
22-Jan-04	bam07	29.45	4.3	8644	0.25	6.1	12252	0.36	1.65	13048	11,878.50	11,878.50
23-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
24-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
25-Jan-04	ebm04	29.94	4.95	8498	0.42	7.06	12130	0.6	1.69	13051	13,757.48	13,757.48
26-Jan-04	bam08	29.21	4.5	8650	0.31	6.35	12219	0.44	1.55	13048	13,257.18	13,257.18
27-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
28-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
29-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
30-Jan-04	ebm05	29.96	4.91	8439	0.43	7.01	12049	0.62	1.71	12957	13,733.30	13,733.30
31-Jan-04	0	0	0	0	0	0	0	0	0	0	0.00	
ADJ.												199,225.65
Weighted Average		29.69	4.71	8540	0.35	6.70	12143	0.50	1.60		Tons. OK	199,225.65
											Burn	205,677.43

Monthly Mercury Analysis

		Mercury Chloride	
Train Sample #	% Moist.	ug/g dry basis	ug/g
C53	29.33	0.093	<.01%

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Feb-04	PAGE 1

DATE	TR #	MOIS %	ASI %	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.												
1-Feb-04	bam09	29.4	4.26	8654	0.29	6.03	12260	0.41	1.51	13047	13227.65	13227.65
2-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
3-Feb-04	ebm06	29.9	4.92	8522	0.41	7.01	12148	0.59	1.77	13064	13432.30	13432.30
4-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
5-Feb-04	bam10	29.4	4.472	8617	0.3	6.26	12211	0.42	1.54	13026	13075.25	13075.25
6-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
7-Feb-04	bam11	30	4.33	8526	0.25	6.19	12176	0.36	1.61	12979	13381.70	13381.70
8-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
9-Feb-04	ebm07	30.1	5.05	8458	0.43	7.22	12093	0.62	1.66	13034	13135.92	13135.92
10-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
11-Feb-04	bam12	29.9	4.34	8575	0.26	6.19	12236	0.37	1.64	13043	13274.80	13274.80
12-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
13-Feb-04	bam13	30.7	4.37	8422	0.24	6.31	12149	0.35	1.64	12967	13331.43	13331.43
14-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
15-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
16-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
17-Feb-04	ebm08	30.3	4.88	8447	0.4	7	12117	0.57	1.73	13029	13021.83	13021.83
18-Feb-04	ebm09	29.9	5.02	8485	0.42	7.17	12110	0.6	1.6	13045	13279.58	13279.58
19-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
20-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
21-Feb-04	ebm10	29.8	4.52	8540	0.42	6.43	12159	0.6	1.99	12995	12493.23	12493.23
22-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
23-Feb-04	bam14	29.6	4.63	8560	0.28	6.58	12152	0.4	1.37	13008	13688.70	13688.70
24-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
25-Feb-04	ebm11	29.8	5.13	8474	0.39	7.3	12068	0.56	1.84	13018	13864.97	13864.97
26-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
27-Feb-04	ebm12	29.4	4.56	8599	0.4	6.46	12173	0.56	1.69	13014	13809.33	10702.49
28-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
29-Feb-04	bam15	28.9	4.41	8669	0.25	6.2	12199	0.35	1.58	13005	13969.70	0.00
ADJ.											169909.85	
Weighted Average											Tons. OK	193730.75
											Burn	193730.75

Monthly Mercury Analysis

Train #	Sample #	Mercury Chloride		
		% Moist.	ug/g dry basis	ug/g
	C282	29.27	0.035	<.01%

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Mar-04	PAGE 1

DATE	TR #	MOIS. %	% ASI AR	HHV AR	S, %	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF %	COAL TONS	TONS OK
PREV.	ebm12	29.4	4.56	8599	0.4	6.46	12173	0.56	1.7	13014	13809.33	5144.23
PREV.	bam15	28.9	4.41	8669	0.25	6.20	12199	0.35	1.58	13005	13969.70	13969.70
1-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
2-Mar-04	ebm13	29.76	5.11	8475	0.4	4.27	12066	0.57	1.7	13012	14105.25	14105.25
3-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
4-Mar-04	bam16	29.02	4.56	8630	0.29	6.43	12159	0.41	1.4	12995	14068.50	14068.50
5-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
6-Mar-04	ebm14	29.11	4.97	8561	0.4	7.01	12077	0.57	1.8	12987	12900.15	12900.15
7-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
8-Mar-04	ebm15	30.14	4.69	8477	0.41	6.72	12134	0.58	1.8	13008	13916.08	13916.08
9-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
10-Mar-04	ebm16	29.67	4.95	8514	0.4	7.04	12106	0.57	1.7	13023	14113.08	14113.08
11-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
12-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
13-Mar-04	ebm17	29.95	4.81	8474	0.41	6.87	12097	0.58	1.9	12989	14145.25	14145.25
14-Mar-04	ebm18	29.81	5.1	8488	0.44	7.26	12093	0.63	1.7	13040	12959.98	12959.98
15-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
16-Mar-04	ebm19	30.25	4.88	8445	0.4	7	12107	0.58	1.9	13018	14161.93	14161.93
17-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
18-Mar-04	bam17	29.51	4.52	8610	0.26	6.41	12215	0.37	1.5	13052	14164.38	14164.38
19-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
20-Mar-04	bam18	29.45	4.59	8598	0.27	6.51	12187	0.38	1.5	13036	14141.33	14141.33
21-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
22-Mar-04	bam19	29.52	4.25	8635	0.27	6.03	12251	0.39	1.6	13037	14167.70	14167.70
23-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
24-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
25-Mar-04	bam20	29.54	4.36	8590	0.29	6.19	12192	0.41	1.4	12996	14013.90	14013.90
26-Mar-04	ebm20	30.04	4.75	8462	0.39	6.79	12096	0.56	1.9	12977	14104.75	14104.75
27-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
28-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
29-Mar-04	bam021	28.73	4.32	8753	0.26	6.06	12281	0.36	1.5	13073	14160.13	9961.47
30-Mar-04	ebm021	29.8	4.83	8526	0.4	6.88	12145	0.57	1.9	13042	12955.50	
31-Mar-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
ADJ.												210037.66
Weighted Average		29.58	4.69	8556	0.34	6.45	12149	0.49	1.66		Tons. OK	210037.66
											Burn	210037.66

Monthly Mercury Analysis

Train #	Sample #	Mercury Chloride	
		% Moist.	ug/g dry basis

BIG STONE PLANT COAL ANALYSIS PER TRAIN
Apr-04

DATE	TR #	MOIS. %	% ASI AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.	bam021	28.73	4.32	8753	0.26	6.06	12281	0.36	1.5	13073	14160.13	4198.66
PREV. MON.	ebm021	29.8	4.83	8526	0.4	6.88	12145	0.57	1.9	13042	12955.50	12955.50
1-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
2-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
3-Apr-04	bam22	29.18	4.29	8626	0.27	6.06	12180	0.38	1.5	12966	14160.98	14160.98
4-Apr-04	bam23	28.84	4.64	8625	0.3	6.52	12121	0.42	1.4	12966	13350.00	13350.00
5-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
6-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
7-Apr-04	bam24	28.87	5.08	8607	0.29	7.14	12100	0.41	1.3	13030	9835.43	9835.43
8-Apr-04	bam25	28.87	4.87	8669	0.32	6.84	12187	0.45	1.4	13082	13773.15	13773.15
9-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
10-Apr-04	bam026	28.83	4.85	8651	0.3	6.82	12156	0.42	1.4	13046	14166.35	14166.35
11-Apr-04	bam27	28.89	4.71	8622	0.28	6.63	12125	0.4	1.5	12986	13800.53	13800.53
12-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
13-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
14-Apr-04	bam28	29.3	4.34	8628	0.27	6.14	12204	0.38	1.6	13002	14140.08	14140.08
15-Apr-04	bam29	28.83	4.36	8672	0.26	6.12	12185	0.37	1.5	12979	9536.70	9536.70
16-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
17-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
18-Apr-04	ebm22	29.72	4.99	8478	0.39	7.1	12063	0.56	1.7	12985	13080.60	13080.60
19-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
20-Apr-04	bam30	29.69	4.20	8618	0.26	5.98	12257	0.37	1.5	13037	12762.73	12762.73
21-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
22-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
23-Apr-04	ebm23	30.3	4.77	8474	0.39	6.84	12158	0.56	1.9	13051	14181.68	14181.68
24-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
25-Apr-04	bam31	29.12	4.66	8595	0.26	6.57	12126	0.37	1.5	12979	14163.73	14163.73
26-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
27-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
28-Apr-04	ebm24	29.83	4.77	8525	0.44	6.8	12149	0.62	2	13035	12989.30	11789.97
29-Apr-04	bam32	28.56	4.24	8684	0.27	5.94	12156	0.38	1.5	12924	14149.70	
30-Apr-04		0	0	0.00	0	0	0	0	0	0	0	0.00
ADJ.												185896.06
Weighted Average		29.29	4.66	8597	0.32	6.59	12157	0.45	1.58		Tons. OK Burn	185896.06 185896.05

Monthly Mercury Analysis

Train #	Sample #	Mercury Chloride		
		% Moist.	ug/g dry basis	ug/g
		30.14	0.116	<0.01

BIG STONE PLANT	COAL ANALYSIS PER TRAIN May-04
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DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON	ebm24	29.83	4.77	8525	0.44	6.8	12149	0.62	1.98	13035	12989.300	1199.330
PREV. MON	bam32	28.56	4.24	8684	0.27	5.94	12156	0.38	1.51	12924	14149.700	14149.700
1-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
2-May-04	ebm25	30.32	4.93	8396	0.4	7.07	12050	0.57	1.82	12967	14183.200	14183.200
3-May-04	bam33	29.16	4.28	8647	0.23	6.04	12207	0.33	1.48	12992	14158.475	14158.475
4-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
5-May-04	bam034	29.17	4.32	8693	0.28	6.1	12273	0.4	1.57	13070	12965.900	12965.900
6-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
7-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
8-May-04	bam35	29.4	4.38	8587	0.29	6.2	12163	0.41	1.55	12967	12720.880	12720.880
9-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
10-May-04	bam36	29.83	4.13	8578	0.27	5.89	12225	0.39	1.4	12990	14149.800	14149.800
11-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
12-May-04	bam37	29.88	4.53	8511	0.31	6.46	12138	0.44	1.46	12976	14167.225	14167.225
13-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
14-May-04	bam38	29.56	4.61	8594	0.3	6.55	12201	0.42	1.47	13056	14157.850	14157.850
15-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
16-May-04	bam39	29.55	4.35	8643	0.29	6.18	12268	0.41	1.54	13076	14156.550	14156.550
17-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
18-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
19-May-04	bam40	29.59	4.63	8563	0.3	6.57	12161	0.43	1.56	13016	14149.900	14149.900
20-May-04	ebm26	30.26	4.94	8406	0.38	7.09	12053	0.55	1.72	12973	14187.275	14187.275
21-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
22-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
23-May-04	bam041	29.12	4.69	8581	0.33	6.61	12107	0.46	1.4	12964	14151.225	14151.225
24-May-04	ebm027	30.78	4.81	8386	0.41	6.95	12115	0.59	1.8	13020	13105.525	13105.525
25-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
26-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
27-May-04	ebm028	30.36	4.68	8431	0.41	6.72	12106	0.59	1.76	12978	14151.046	14151.046
28-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
29-May-04	0	0	0	0	0	0	0	0	0	0	0.000	
30-May-04	ebm029	30.33	4.65	8445	0.41	6.68	12121	0.59	1.86	12989	14205.600	7954.379
31-May-04	ebm30	29.78	4.63	8500	0.39	6.6	12105	0.56	1.7	12960	14201.880	
ADJ.												203708.260
Weighted Average											Tons. OK Burn	203708.260

Monthly Mercury Analysis

Train Sample #	% Moist.	Mercury ug/g dry basis	Chloride ug/g
C817	29.19	0.086	<0.01

BIG STONE PLANT COAL ANALYSIS PER TRAIN
Jun-04

DATE	TR #	MOIS. %	% ASH	HHV	S, %	% ASH	HHV	S, %	NaO	MAF	COAL	TONS
		%	AR	AR	AR	DRY	DRY	DRY	%	HHV	TONS	OK
PREV. MO	ebm029	30.33	4.65	8445	0.41	6.68	12121	0.59	1.9	12989	14205.600	6251.221
PREV. MO	ebm30	29.78	4.63	8500	0.39	6.6	12105	0.56	1.7	12960	14201.880	
1-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
2-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
3-Jun-04	ebm031	30.21	4.76	8443	0.38	6.82	12098	0.55	1.7	12983	14154.15	14154.15
4-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
5-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
6-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
7-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
8-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
9-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
10-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
11-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
12-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
13-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
14-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
15-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
16-Jun-04	ebm32	29.94	4.84	8474	0.39	6.91	12096	0.56	1.7	12994	13927.43	13927.43
17-Jun-04	ebm33	29.35	4.87	8544	0.39	6.9	12094	0.55	1.9	12990	13905.63	13905.63
18-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
19-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
20-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
21-Jun-04	ebm34	30.22	4.58	8429	0.36	6.56	12079	0.52	1.8	12927	14156.00	14156.00
22-Jun-04	ebm35	30.23	4.84	8440	0.43	6.93	12097	0.62	1.8	12998	12427.50	12427.00
23-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
24-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
25-Jun-04	ebm36	30.08	4.59	8479	0.41	6.57	12127	0.58	1.8	12980	10909.80	10909.80
26-Jun-04	ebm37	30.21	4.63	8454	0.37	6.64	12113	0.53	1.8	12975	14144.95	14144.95
27-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
28-Jun-04	ebm38	29.61	4.86	8526	0.43	6.9	12112	0.61	1.7	13010	13080.90	13080.90
29-Jun-04		0	0	0	0	0	0	0	0	0	0.00	
30-Jun-04	ebm39	29.49	4.81	8523	0.38	6.82	12088	0.54	1.8	12973	9476.88	5174.24
ADJ.												118131.32
Weighted Avg.											Tons. OK	136424.42
											Burn	136424.32

Monthly Mercury Analysis

		Mercury Chloride		
Train Sample	%	ug/g	ug/g	
#	#	Moist.	dry basis	
C1045	28.75	0.154	<0.01	

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
	Jul-04

DATE	TR #	MOIS %	% AS	HHV AR	S, % AR	% AS	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MC	ebm39	29.5	4.81	8523	0.38	6.82	12088	0.54	1.75	12973	9476.88	4302.64
PREV. MON.												
1-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
2-Jul-04	ebm40	29.5	4.71	8490	0.39	6.67	12036	0.55	1.77	12896	14152.83	14152.83
3-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
4-Jul-04	ebm41	29.7	4.88	8526	0.43	6.94	12124	0.61	1.71	13028	13310.50	13310.50
5-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
6-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
7-Jul-04	bam42	28.8	4.49	8692	0.3	6.3	12203	0.42	1.49	13023	10669.50	10669.50
8-Jul-04	ebm42	30.3	4.61	8450	0.36	6.62	12127	0.52	1.77	12987	10166.70	10166.70
9-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
10-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
11-Jul-04	cdm01	30.6	4.68	8427	0.31	6.74	12136	0.44	1.72	13013	14199.90	14199.90
12-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
13-Jul-04	ebm43	29.9	4.63	8500	0.4	6.6	12118	0.57	1.82	12974	14179.18	14179.18
14-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
15-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
16-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
17-Jul-04	cdm02	29.4	5	8508	0.31	7.09	12052	0.45	1.18	12972	14174.55	14174.55
18-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
19-Jul-04	ebm44	30.4	4.66	8418	0.37	6.7	12098	0.53	1.89	12967	14167.80	14167.80
20-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
21-Jul-04	cdm03	30.3	4.83	8411	0.3	6.93	12072	0.43	1.19	12971	11770.80	11770.80
22-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
23-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
24-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
25-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
26-Jul-04	ebm45	30	4.44	8480	0.38	6.34	12116	0.55	1.82	12936	14159.33	14159.33
27-Jul-04	ebm46	29.9	4.52	8499	0.39	6.44	12115	0.56	1.94	12949	14174.38	14174.38
28-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
29-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
30-Jul-04	0	0	0	0	0	0	0	0	0	0	0.00	
31-Jul-04	ebm047	30.1	4.72	8436	0.42	6.75	12075	0.6	1.64	12949	14169.90	14169.90
ADJ.												163598.01
Weighted Average											Tons. OK	163598.01
											Burn	168366.77

Monthly Mercury Analysis

Train #	Sample #	Mercury Chloride		
		% Moist.	ug/g dry basis	ug/g
	C1192	29.54	0.111	<0.01

BIG STONE PLANT COAL ANALYSIS PER TRAIN
Aug-04

DATE	TR #	MOIS %	% ASH	HHV	S, %	% ASH	HHV	S, %	NaO	MAF	COAL	TONS
		%	AR	AR	AR	DRY	DRY	DRY	%	HHV	TONS	OK
PREV. MON.												
PREV. MON.												
1-Aug-04	cdm04	30.0	5.09	8460	0.36	7.28	12089	0.43	1.34	13038	14198.90	14198.90
2-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
3-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
4-Aug-04	ebm48	30.0	4.64	8506	0.4	6.63	12155	0.57	1.77	13018	14168.05	14168.05
5-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
6-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
7-Aug-04	cdm05	28.6	6.13	8486	0.28	8.57	11877	0.39	1.2	12990	14198.73	14198.73
8-Aug-04	ebm49	30.2	4.76	8451	0.44	6.82	12102	0.63	1.75	12988	14178.08	14178.08
9-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
10-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
11-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
12-Aug-04	cdm06	29.5	5.86	8381	0.32	8.32	11893	0.46	1.3	12972	11763.95	11763.95
13-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
14-Aug-04	ebm50	30.1	4.74	8435	0.42	6.78	12059	0.6	1.82	12936	14184.80	14184.80
15-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
16-Aug-04	cdm07	29.3	6.08	8425	0.29	8.59	11912	0.41	1.2	13032	14163.98	14163.98
17-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
18-Aug-04	ebm51	30.5	4.58	8391	0.37	6.59	12068	0.53	1.85	12919	14179.95	14179.95
19-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
20-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
21-Aug-04	crm01	28.6	5.56	8598	0.33	12.64	12038	0.46	1.17	13055	12998.88	12998.88
22-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
23-Aug-04	ebm52	30.6	4.71	8376	0.42	6.78	12065	0.6	1.74	12943	14198.60	14198.60
24-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
25-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
26-Aug-04	crm02	29.3	4.68	8601	0.27	6.61	12159	0.39	1.46	13020	14216.60	14216.60
27-Aug-04	bam43	29.3	4.53	8569	0.26	6.41	12122	0.37	1.59	12952	13139.60	13139.60
28-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
29-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
30-Aug-04	0	0.0	0	0	0	0	0	0	0	0	0.00	
31-Aug-04	crm03	29.6	5.61	8482	0.33	7.97	12056	0.47	1.33	13101	10940.73	10940.73
											176530.85	
											Tons. OK	176530.85
Weighted Average											Burn	179102.36

Monthly Mercury Analysis

		Mercury Chlor.	
Train Sample	%	ug/g	ug/g
#	#	Moist.	dry basis
C1446	29.01	0.144	<0.01

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.												
1-Sep-04	ebm53	30.58	4.56	8400	0.4	6.57	12100	0.58	1.69	12951	14172.68	14172.68
2-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
3-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
4-Sep-04	crm04	29.52	5.14	8530	0.31	7.29	12101	0.43	1.39	13053	12884.68	12884.68
5-Sep-04	bam44	29.61	4.52	8559	0.3	6.42	12159	0.42	1.44	12993	13963.63	13963.63
6-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
7-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
8-Sep-04	crm05	29.63	4.78	8581	0.26	6.79	12194	0.38	1.4	13082	14217.38	14217.38
9-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
10-Sep-04	ebm54	29.95	4.85	8499	0.42	6.92	12133	0.6	1.88	13035	13936.85	13936.85
11-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
12-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
13-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
14-Sep-04	bam45	29.18	4.76	8555	0.29	6.72	12080	0.41	1.44	12950	14152.68	14152.68
15-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
16-Sep-04	ebm55	30.64	4.81	8387	0.41	6.93	12092	0.59	1.79	12992	14181.33	14181.33
17-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
18-Sep-04	bam46	29.06	4.66	8632	0.31	6.57	12168	0.43	1.44	13024	13790.93	13790.93
19-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
20-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
21-Sep-04	ebm056	30.69	4.49	8356	0.28	6.48	12056	0.4	1.73	12891	14187.80	14187.80
22-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
23-Sep-04	bam47	29.44	4.35	8642	0.28	6.16	12248	0.39	1.64	13052	14158.50	14158.50
24-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
25-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
26-Sep-04	bam48	30.16	4.23	8534	0.23	6.05	12220	0.33	1.53	13007	14160.30	14160.30
27-Sep-04	ebm57	30.3	4.6	8455	0.42	6.6	12131	0.6	1.84	12988	14299.65	14299.65
28-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
29-Sep-04	0	0	0	0	0	0	0	0	0	0	0.00	
30-Sep-04	ebm58	30.16	4.62	8484	0.41	6.61	12148	0.58	1.7	13008	13696.73	6046.72
ADJ.												174153.13
Weighted Average											Tons. OK Burn	178154.23 178154.23

Monthly Mercury Analysis

Mercury			Chlor.
Train Sample	%	ug/g	ug/g
#	#	Moist. dry basis	

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Oct-04	PAGE 1 of 2

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.	ebm58	30.16	4.62	8484	0.41	6.61	12148	0.58	1.70	13008	13696.725	7650.005
1-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
2-Oct-04	ebm59	30.39	4.86	8412	0.43	6.98	12085	0.62	1.69	12992	13567.950	13567.950
3-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
4-Oct-04	bam49	29.72	4.67	8496	0.25	6.65	12089	0.36	1.51	12950	13918.450	13918.450
5-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
6-Oct-04	ebm60	30.49	4.68	8430	0.42	6.74	12128	0.61	1.77	13005	14173.825	14173.825
7-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
8-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
9-Oct-04	ebm61	30.2	4.78	8433	0.42	6.85	12082	0.6	1.75	12970	14191.575	14191.575
10-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
11-Oct-04	ebm62	30.1	4.73	8438	0.43	6.77	12071	0.62	1.81	12948	14184.350	14184.350
12-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
13-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
14-Oct-04	bam50	29.61	5.09	8514	0.28	7.23	12095	0.4	1.31	13038	14152.525	14152.525
15-Oct-04	ebm63	30.32	4.78	8443	0.42	6.86	12117	0.6	1.74	13009	14171.875	14171.875
16-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
17-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
18-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
19-Oct-04	bam51	29.03	4.72	8585	0.28	6.65	12096	0.39	1.36	12958	12922.100	12922.100
20-Oct-04	ebm64	30.95	4.76	8349	0.41	6.9	12091	0.6	1.68	12987	14183.500	14183.500
21-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
22-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
23-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
24-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
25-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
26-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
27-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
28-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
29-Oct-04	ebm65	30.4	4.68	8417	0.37	6.72	12093	0.53	1.72	12964	13649.830	12924.825
30-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
31-Oct-04	0	0	0	0	0	0	0	0	0	0	0.000	
ADJ.											139115.980	146040.980
Weighted Average											Tons. OK	146040.980
											Burn	146040.980

Monthly Mercury Analysis

Train #	Sample #	% Moist.	Mercury ug/g dry basis	Chlor. ug/g

BIG STONE PLANT

COAL ANALYSIS PER TRAIN

Nov-04

PAGE 1 of 2

DATE	TR #	MOIS. %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON	ebm65	30.4	4.68	8417	0.37	6.72	12093	0.53	1.7	12964	13649.83	725.01
1-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
2-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
3-Nov-04	ebm66	30.32	4.88	8449	0.4	7	12125	0.58	1.7	13038	13933.15	13933.15
4-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
5-Nov-04	bam52	29.68	4.2	8621	0.26	5.97	12260	0.37	1.6	13038	13423.35	13423.35
6-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
7-Nov-04	bam53	29.82	4.38	8584	0.27	6.24	12231	0.38	1.5	13045	14140.08	14140.08
8-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
9-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
10-Nov-04	bam54	28.96	4.38	8688	0.28	6.17	12230	0.4	1.5	13034	13916.23	13916.23
11-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
12-Nov-04	bam55	28.86	4.67	8684	0.28	6.57	12207	0.4	1.6	13065	13788.00	13788.00
13-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
14-Nov-04	bam56	29.03	4.66	8619	0.31	6.56	12145	0.44	1.4	12998	12956.32	12956.32
15-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
16-Nov-04	ebm67	30.21	4.59	8476	0.4	6.58	12145	0.57	1.9	13000	13781.35	13781.35
17-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
18-Nov-04	ebm68	30.14	5.07	8401	0.41	7.26	12025	0.58	1.6	12966	13174.40	13174.40
19-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
20-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
21-Nov-04	ebm69	30.33	4.75	8395	0.42	6.82	12050	0.61	1.8	12932	14172.05	14172.05
22-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
23-Nov-04	bam57	30.47	4.1	8508	0.24	5.9	12237	0.35	1.5	13004	14144.88	14144.88
24-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
25-Nov-04	bam58	29.42	4.52	8592	0.29	6.41	12174	0.41	1.5	13008	13937.98	13937.98
26-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
27-Nov-04	bam59	29.24	4.26	8614	0.25	6.02	12174	0.36	1.5	12954	14023.20	14023.20
28-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
29-Nov-04	0	0	0	0	0	0	0	0	0	0	0.00	
30-Nov-04	bam60	29.66	4.71	8552	0.27	6.86	12158	0.39	1.4	13030	14061.93	9015.08
ADJ.												175131.08
Weighted Average											Tons. OK	192225.48
											Burn	192225.48

Monthly Mercury Analysis

		Mercury Chlor.	
Train	Sample	%	ug/g
#	#	Moist.	dry basis

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
Dec-04	PAGE 1 of 2

DATE	TR #	MOIS %	% ASH AR	HHV AR	S, % AR	% ASH DRY	HHV DRY	S, % DRY	NaO %	MAF HHV	COAL TONS	TONS OK
PREV. MON.												
PREV. MON.												
1-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
2-Dec-04	bam61	29.1	4.85	8606	0.26	6.84	12145	0.36	1.21	13037	13904.43	13904.43
3-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
4-Dec-04	bam62	29.3	4.56	8598	0.26	6.45	12164	0.37	1.49	13003	13886.65	13886.65
5-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
6-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
7-Dec-04	bam63	29.8	4.23	8586	0.24	6.03	12227	0.34	1.58	13012	12743.53	12743.53
8-Dec-04	bam64	29.5	4.17	8652	0.25	5.92	12269	0.35	1.57	13041	14136.03	14136.03
9-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
10-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
11-Dec-04	ebm70	30.2	4.93	8401	0.43	7.06	12041	0.61	1.7	12956	14169.73	14169.73
12-Dec-04	bam65	29.5	4.63	8580	0.27	6.56	12168	0.38	1.44	13022	14133.78	14133.78
13-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
14-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
15-Dec-04	ebm71	30.4	5.12	8410	0.4	7.36	12088	0.57	1.6	13048	13872.93	13872.93
16-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
17-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
18-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
19-Dec-04	bam66	29.2	4.27	8644	0.27	6.03	12207	0.38	1.57	12990	14158.68	14158.68
20-Dec-04	bam67	29.1	4.65	8668	0.32	6.56	12227	0.45	1.43	13085	14117.58	14117.58
21-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
22-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
23-Dec-04	ebm72	30.6	5.01	8369	0.4	7.21	12056	0.58	1.61	12993	13567.68	13567.68
24-Dec-04	ebm73	30.2	4.78	8421	0.38	6.85	12061	0.55	1.69	12948	13703.60	13703.60
25-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
26-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
27-Dec-04	bam68	29.1	4.32	8703	0.26	6.09	12275	0.36	1.46	13071	13384.08	13384.08
28-Dec-04	ebm74	30.2	4.62	8437	0.42	6.62	12094	0.6	1.76	12951	13473.63	13473.63
29-Dec-04		0	0	0	0	0	0	0	0	0	0.00	
30-Dec-04	ebm75	30.2	4.38	8485	0.4	6.28	12159	0.57	1.86	12974	13891.23	11869.01
31-Dec-04	bam69	29.4	4.59	8595	0.25	6.5	12172	0.35	1.5	13018	12581.33	0.00
ADJ.												191121.34
Weighted Average		29.77	4.66	8532	0.32	6.63	12147	0.46	1.56		Tons. OK	201529.44
											Burn	201529.44

Monthly Mercury Analysis

Train #	Sample #	% Moist.	Mercury ug/g dry basis	Chlor. ug/g
	C2384	29.62	0.08	<0.01

B16 Ash and Alternative Fuel Analysis Records

JAN. 27. 2003 11:25AM CUMH/UPP

COMMERCIAL TESTING & ENGINEERING CO.

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www.comtjeco.com

January 10, 2003

RAG COAL WEST, INC.
EAGLE BUTTE MINE
P.O. BOX 3040
GILLETTE WY 82717

sample identification by
RAG Coal West, Inc.

SAMPLE ID: 36-114564
TRAIN #: BSB041
TOTAL TONNAGE: 14145.225
CUSTOMER: OTTERTAIL POWER
PLANT: BIG STONE
LOAD DATE: 12/31/2002

Kind of sample COAL
reported to us

Sample taken at Eagle Butte

Sample taken by Eagle Butte

Date sampled December 31, 2002.

Date received January 10, 2003

Analysis report no. 44-59398

ANALYSIS OF ASH	% Weight Ignited Basis
Silica, SiO ₂	29.92
Alumina, Al ₂ O ₃	16.85
Titania, TiO ₂	1.23
Ferric Oxide, Fe ₂ O ₃	5.33
Lime, CaO	26.82
Magnesia, MgO	6.49
Potassium Oxide, K ₂ O	0.23
Sodium Oxide, Na ₂ O	1.81
Sulfur Trioxide, SO ₃	11.00
Phosphorous Pentoxide, P ₂ O ₅	0.59
Strontium Oxide, SrO	0.63
Barium Oxide, BaO	0.64
Manganese Oxide, Mn ₂ O ₄	0.03
Undetermined	XXXXXX
Silica Value=	43.64
Base: Acid Ratio=	0.85
T250 Temperature=	2281 OF
Type of Ash=	LIGNITIC
Fouling Index=	1.81

*Done
by 1-24-03*

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Connie Christiansen
Gillette Laboratory

SINCE 1908*

COMMERCIAL TESTING & ENGINEERING CO.

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► January 10, 2003

RAG COAL WEST, INC.
EAGLE BUTTE MINE
P.O. BOX 3040
GILLETTE WY 82717

Sample identification by
RAG Coal West, Inc.

Kind of sample COAL
reported to us

SAMPLE ID: 36-104330
TRAIN #: BMBSB001
TOTAL TONNAGE: 14090.350
CUSTOMER: OTTERTAIL POWER
PLANT: BIG STONE
LOAD DATE: 01/04/2003

Sample taken at Belle Ayr

Sample taken by RAG Coal West, Inc.

Date sampled January 4, 2003

Date received January 10, 2003

Analysis report no. 44-59397

ANALYSIS OF ASH	% Weight Ignited Basis
Silica, SiO ₂	31.47
Alumina, Al ₂ O ₃	16.10
Titania, TiO ₂	1.39
Ferric Oxide, Fe ₂ O ₃	5.09
Lime, CaO	27.44
Magnesia, MgO	4.94
Potassium Oxide, K ₂ O	0.20
Sodium Oxide, Na ₂ O	1.52
Sulfur Trioxide, SO ₃	8.60
Phosphorous Pentoxide, P ₂ O ₅	1.31
Strontium Oxide, SrO	0.57
Barium Oxide, BaO	0.72
Manganese Oxide, Mn ₃ O ₄	0.03
Undetermined	0.62
Silica Value=	45.65
Base: Acid Ratio=	0.80
T250 Temperature=	2219 °F
Type of Ash=	LIGNITIC
Fouling Index=	1.52

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Kathy Boyan
Gillette Laboratory

MEMBER
ACIL

MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 N. Front St. - New Ulm, MN 56073 - 800-782-3557 - Fax 507-359-2890
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710 S. 14th St. - Grand Forks, ND 58201 - 800-272-7645 - Fax 701-772-0028
35 W. Lincoln Way - Nevada, IA 50201 - 800-362-0855 - Fax 515-382-3885

Sample Number: 03-C99

Report Date: 1/21/03

Tom Hrdlicka
Ottertail Power - Big Stone
PO Box 218
Big Stone City SD 57216-0218

Work Order #: 89-51
P.O. #: 7830

Sample Description: Soybeans
Sample Site: OTP Big Stone

* PROXIMATE *			
ANALYTE	AS RECEIVED	DRY BASIS	
Total Moisture	9.85 wt. %		
Ash	4.28 wt. %	4.75 wt. %	
BTU/lb	9338 BTU/lb	10359 BTU/lb	
Total Sulfur	0.31 wt. %	0.34 wt. %	

* ULTIMATE *			
ANALYTE	AS RECEIVED	DRY BASIS	
Total Moisture	9.85 wt. %		
Ash	4.28 wt. %	4.75 wt. %	
Carbon	48.97 wt. %	54.32 wt. %	
Hydrogen	7.50 wt. %	7.10 wt. %	
Nitrogen	5.71 wt. %	6.33 wt. %	
Total Sulfur	0.31 wt. %	0.34 wt. %	
Oxygen by Difference	33.23 wt. %	27.16 wt. %	

* SULFUR FORMS *			
ANALYTE	AS RECEIVED	DRY BASIS	
Total Sulfur	0.31 wt. %	0.34 wt. %	

* ASH FUSION *		
ANALYTE	REDUCING	OXIDIZING

* MINERAL ANALYSIS OF ASH *		
ANALYTE	DRY BASIS	
Potassium Oxide in Ash	43.39 wt. %	
Sodium Oxide	1.30 wt. %	

* MISCELLANEOUS *		
ANALYTE	AS RECEIVED	DRY BASIS
Hydrogen less H2O	6.40	
Oxygen Less H2O	24.48	

Approved By:

MVTL guarantees the accuracy of the analysis done on the sample submitted for testing. It is not possible for MVTL to guarantee that a test result obtained on a particular sample will be the same on any other sample unless all conditions affecting the sample are the same, including sampling by MVTL. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

AN EQUAL OPPORTUNITY EMPLOYER

MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 N. Front St. - New Ulm, MN 56073 - 800-782-3557 - Fax 507-359-2890
 1411 S. 12th St. - Bismarck, ND 58502 - 800-279-6885 - Fax 701-258-9724
 710 S. 14th St. - Grand Forks, ND 58201 - 800-272-7645 - Fax 701-772-0028
 35 W. Lincoln Way - Nevada, IA 50201 - 800-362-0855 - Fax 515-382-3885

Sample Number: 03-C98

Report Date: 1/21/03

Tom Hrdlicka
 Ottertail Power - Big Stone
 PO Box 218
 Big Stone City SD 57216-0218

Work Order #: 89-51
 P.O. #: 7830

Sample Description: Corn
 Sample Site: OTP Big Stone

* PROXIMATE *				* ULTIMATE *			
ANALYTE	AS RECEIVED	DRY BASIS		ANALYTE	AS RECEIVED	DRY BASIS	
Total Moisture	14.51 wt. %			Total Moisture	14.51 wt. %		
Ash	1.03 wt. %	1.20 wt. %		Ash	1.03 wt. %	1.20 wt. %	
				Carbon	40.12 wt. %	46.93 wt. %	
				Hydrogen	6.79 wt. %	6.04 wt. %	
BTU/lb	6925 BTU/lb	8100 BTU/lb		Nitrogen	1.14 wt. %	1.33 wt. %	
Total Sulfur	0.35 wt. %	0.41 wt. %		Total Sulfur	0.35 wt. %	0.41 wt. %	
				Oxygen by Difference	50.57 wt. %	44.08 wt. %	
* SULFUR FORMS *				* ASH FUSION *			
ANALYTE	AS RECEIVED	DRY BASIS		ANALYTE	REDUCING	OXIDIZING	
Total Sulfur	0.35 wt. %	0.41 wt. %					
* MINERAL ANALYSIS OF ASH *				* MISCELLANEOUS *			
ANALYTE	DRY BASIS			ANALYTE	AS RECEIVED	DRY BASIS	
				Hydrogen less H2O	5.17		
Potassium Oxide in Ash		29.39 wt. %		Oxygen Less H2O	37.68		
Sodium Oxide		0.50 wt. %					

Approved By:

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AN EQUAL OPPORTUNITY EMPLOYER

Sample Site: OTP Big Stone
Sample Description: OTP Fly Ash Sample
Sample Date: 23 Mar 2004

Analyte	Results	Units
SO3 in Ash	4.25	wt. %
Calcium Oxide in Ash	30.61	wt. %
Magnesium Oxide in Ash	6.88	wt. %
Sodium Oxide in Ash	2.81	wt. %
Potassium Oxide in Ash	0.51	wt. %
Aluminum Oxide in Ash	16.80	wt. %
Barium Oxide in Ash	0.87	wt. %
Iron Oxide in Ash	6.61	wt. %
Manganese Dioxide in Ash	0.06	wt. %
Silicon Dioxide in Ash	25.57	wt. %
Strontium Oxide in Ash	0.58	wt. %
Titanium Dioxide in Ash	1.38	wt. %
Phosphorus Pentoxide	1.22	wt. %
Arsenic	43.00	ug/g
Selenium	32.70	ug/g

Note: Unless otherwise indicated, results are on an As Received Basis.

B17 Ultimate Coal Analysis

ULTIMATE ANALYSIS

AS RECEIVED

Sample Date	Moisture %	Ash %	Carbon %	Nitrogen %	Sulfur %	Hydrogen %	Oxygen %	HHV btu/lb	NaO %	Merc % ug/g Dry
06-Jan-02	29.59	5.16	49.23	0.70	0.39	3.95	10.98	8469	1.50	
13-Jan-02	29.10	5.03	49.68	0.70	0.36	3.54	11.59	8656	1.00	0.169
20-Jan-02	30.11	5.00	49.25	0.70	0.37	3.77	10.80	8492	1.40	
28-Jan-02	29.61	4.59	49.60	0.71	0.39	3.74	11.36	8568	1.80	
03-Feb-02	29.80	4.98	48.68	0.66	0.40	3.80	11.68	8570	1.80	
10-Feb-02	28.86	4.81	49.03	0.64	0.39	3.76	12.51	8656	1.40	0.096
17-Feb-02	29.44	4.57	49.11	0.65	0.35	3.57	12.31	8690	1.70	
24-Feb-02	30.24	4.94	48.63	0.71	0.36	3.70	11.42	8172	1.60	
03-Mar-02	30.08	5.00	48.83	0.65	0.35	3.76	11.33	8399	1.50	
10-Mar-02	29.56	4.66	49.69	0.65	0.32	3.75	11.37	8559	1.50	0.058
17-Mar-02	30.39	4.68	48.93	0.65	0.40	3.96	10.99	8440	1.50	
24-Mar-02	30.22	5.00	48.86	0.65	0.44	5.09	9.74	8357	1.60	
31-Mar-02	29.69	5.49	48.97	0.66	0.37	3.64	11.18	8410	1.20	
07-Apr-02	29.39	4.61	49.58	0.64	0.35	3.52	11.91	8660	1.70	
14-Apr-02	29.44	4.72	48.80	0.74	0.42	3.16	12.72	8528	1.50	0.113
21-Apr-02	29.80	4.20	49.70	0.64	0.35	3.47	11.84	8582	1.40	
28-Apr-02	27.53	4.58	50.37	0.69	0.32	3.77	12.74	8653	1.40	
05-May-02	29.69	4.45	48.92	0.65	0.30	3.63	12.36	8550	1.40	
12-May-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
19-May-02	29.07	4.85	49.39	0.65	0.38	3.60	12.06	8627	1.60	0.087
26-May-02	29.88	4.27	49.32	0.67	0.30	3.69	11.87	8483	1.90	
02-Jun-02	28.53	4.80	48.88	0.76	0.27	3.97	12.79	8557	1.60	
09-Jun-02	30.24	4.69	48.26	0.63	0.37	3.56	12.25	8381	1.30	0.07
16-Jun-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	
23-Jun-02	26.23	5.18	51.01	0.67	0.36	3.81	12.74	8818	1.00	
30-Jun-02	29.28	4.67	48.65	0.70	0.32	3.74	12.64	8500	1.50	
07-Jul-02	29.29	4.89	49.15	0.72	0.24	3.74	11.97	8509	1.00	
14-Jul-02	29.60	4.79	48.44	0.69	0.28	3.95	12.25	8528	1.40	0.073
21-Jul-02	28.39	4.43	49.24	0.64	0.31	4.12	12.87	8636	1.20	
28-Jul-02	28.32	4.17	49.80	0.66	0.25	4.08	12.72	8629	1.50	
04-Aug-02	29.35	4.23	49.41	0.64	0.30	3.96	12.11	8644	1.40	
11-Aug-02	29.57	4.92	48.53	0.65	0.27	3.36	12.70	8487	1.00	0.078
18-Aug-02	30.00	4.67	48.33	0.67	0.37	3.66	12.30	8440	1.30	
25-Aug-02	30.01	5.08	47.26	0.66	0.39	3.53	13.07	8291	1.50	
01-Sep-02	29.07	4.17	49.39	0.63	0.31	3.65	12.78	8692	1.90	
08-Sep-02	29.16	4.62	48.90	0.69	0.34	3.58	12.71	8579	2.00	0.099
15-Sep-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
22-Sep-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
29-Sep-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
06-Oct-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
13-Oct-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
20-Oct-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
27-Oct-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
03-Nov-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
10-Nov-02	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	Outage	
17-Nov-02	29.90	4.16	49.30	0.65	0.30	3.41	12.28	8568	1.50	
24-Nov-02	30.15	5.06	48.38	0.66	0.28	3.22	12.25	8375	1.20	0.074
08-Dec-02	28.99	4.40	49.89	0.62	0.24	3.67	12.19	8649	1.30	
15-Dec-02	29.35	4.32	49.52	0.66	0.27	3.57	12.31	8699	1.40	0.249
22-Dec-02	29.21	4.23	49.77	0.63	0.26	3.44	12.46	8653	1.60	
29-Dec-02	29.61	5.21	48.48	0.63	0.40	3.50	12.17	8410	1.40	
Average	29.39	4.71	49.13	0.67	0.34	3.71	12.06	8539.15	1.46	0.11

ULTIMATE ANALYSIS

AS RECEIVED

Sample Date	Moisture %	Ash %	Carbon %	Nitrogen %	Sulfur %	Hydrogen %	Oxygen %	HHV btu/lb	NaO %	Merc % ug/g Dry
05-Jan-03	30.31	4.60	48.51	0.65	0.50	3.43	12.00	8415	1.90	
06-Jan-03	29.75	4.79	48.86	0.64	0.39	3.43	12.14	8465	1.30	
07-Jan-03	29.82	4.74	48.39	0.67	0.39	3.03	12.96	8431	1.70	
08-Jan-03	28.79	4.86	49.34	0.68	0.40	3.05	12.88	8593	1.60	
12-Jan-03	28.85	4.19	50.03	0.69	0.24	3.04	12.96	8692	1.30	0.093
19-Jan-03	28.91	4.75	49.71	0.66	0.29	3.59	12.09	8696	1.40	
26-Jan-03	29.09	4.23	49.73	0.85	0.24	3.55	12.31	8624	1.30	
02-Feb-03	21.42	4.44	54.26	1.05	0.28	4.19	14.36	9477	2.00	
09-Feb-03	30.26	4.23	49.20	0.69	0.25	3.48	11.89	8487	1.40	0.103
16-Feb-03	27.91	4.37	50.12	1.08	0.28	3.79	12.45	8672	1.30	
23-Feb-03	26.60	5.10	48.81	1.36	0.31	4.14	13.68	8618	0.31	
02-Mar-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	
09-Mar-03	29.99	4.48	49.46	0.63	0.26	4.21	10.97	8534	1.40	
16-Mar-03	29.23	4.53	49.32	0.66	0.26	3.74	12.26	8516	1.30	0.116
23-Mar-03	29.96	4.10	49.40	0.67	0.21	3.23	12.43	8581	1.10	
30-Mar-03	29.39	6.23	48.42	0.66	0.27	3.27	11.76	8402	1.80	
06-Apr-03	29.34	4.72	49.26	0.67	0.24	3.35	12.42	8514	1.20	
13-Apr-03	30.14	4.96	48.57	0.69	0.39	3.62	11.63	8474	1.60	0.116
20-Apr-03	30.16	4.87	48.65	0.68	0.49	3.70	11.45	8390	1.70	
27-Apr-03	30.74	4.33	48.77	0.67	0.35	3.54	11.60	8377	1.40	
04-May-03	30.57	4.81	48.95	0.66	0.30	3.59	11.12	8332	1.70	
11-May-03	29.97	4.56	50.35	0.68	0.35	3.73	10.36	8476	1.40	0.113
18-May-03	29.18	4.87	50.09	0.67	0.29	3.61	11.29	8572	1.10	
25-May-03	29.17	4.81	50.22	0.66	0.31	3.75	11.08	8557	1.40	
01-Jun-03	29.26	4.72	49.69	0.72	0.44	3.58	11.59	8501	1.80	
08-Jun-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	
15-Jun-03	29.96	4.43	49.24	0.70	0.45	3.63	11.59	8476	1.70	0.013
22-Jun-03	29.52	4.42	49.74	0.65	0.32	3.42	11.93	8564	1.40	
29-Jun-03	30.43	4.74	48.83	0.71	0.36	3.40	11.53	8404	1.70	
06-Jul-03	29.10	4.56	50.03	0.67	0.30	3.42	11.92	8539	1.00	
13-Jul-03	30.39	4.90	48.72	0.67	0.42	3.10	11.80	8415	1.30	0.105
20-Jul-03	29.36	4.28	50.07	0.69	0.31	3.51	11.78	8663	1.20	
27-Jul-03	28.14	5.06	49.96	0.68	0.60	3.70	11.86	8633	0.90	
03-Aug-03	29.70	4.61	49.24	0.70	0.40	3.83	11.52	8474	1.40	
10-Aug-03	28.75	4.28	50.44	0.74	0.29	4.06	11.44	8663	1.10	0.081
17-Aug-03	29.04	5.44	49.38	0.76	0.33	3.88	11.17	8415	1.30	
24-Aug-03	28.98	4.84	49.89	0.65	0.29	3.54	11.81	8584	1.20	
31-Aug-03	28.92	4.85	49.86	0.69	0.27	3.51	11.90	8500	0.80	
07-Sep-03	29.69	4.23	50.77	0.70	0.27	3.69	10.65	8656	1.40	
14-Sep-03	29.35	4.52	49.83	0.68	0.32	3.28	12.02	8489	1.40	0.084
21-Sep-03	30.82	4.88	48.81	0.72	0.26	3.56	11.35	8275	1.10	
28-Sep-03	29.26	4.74	50.11	0.75	0.35	3.65	11.14	8590	1.10	
05-Oct-03	29.17	4.26	50.42	0.68	0.23	3.35	11.89	8561	1.60	
12-Oct-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	
19-Oct-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	
26-Oct-03	27.13	5.07	51.78	0.67	0.28	3.30	11.77	8847	1.10	0.069
02-Nov-03	28.99	4.46	50.15	0.71	0.35	3.58	11.76	8636	1.10	
09-Nov-03	29.51	4.26	49.18	0.69	0.28	3.51	12.57	8545	1.20	0.071
16-Nov-03	29.93	4.86	47.98	0.71	0.43	3.64	12.45	8431	1.30	
23-Nov-03	30.26	4.75	47.73	0.66	0.44	3.42	12.74	8489	1.40	
30-Nov-03	30.33	4.35	48.75	0.71	0.36	3.36	12.14	8444	1.40	
07-Dec-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	
14-Dec-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	
21-Dec-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	
28-Dec-03	29.76	5.08	49.07	0.70	0.42	3.47	11.50	8557	1.30	0.057

ULTIMATE ANALYSIS **AS RECEIVED**

Sample Date	Moisture %	Ash %	Carbon %	Nitrogen %	Sulfur %	Hydrogen %	Oxygen %	HHV btu/lb	NaO %	Mercury ug/g Dry
04-Jan-04	29.76	5.09	48.59	0.70	0.44	3.44	11.98	8471	1.60	
11-Jan-04	29.33	4.62	49.57	0.69	0.33	3.38	12.08	8624	1.10	0.093
18-Jan-04	28.30	4.40	51.62	0.75	0.33	3.57	11.03	8602	1.70	
25-Jan-04	30.05	4.26	51.23	0.73	0.28	3.38	10.07	8548	1.70	
01-Feb-04	29.85	5.27	48.97	0.69	0.46	3.44	11.32	8503	1.80	
08-Feb-04	29.27	4.31	49.78	0.70	0.27	3.48	12.19	8604	1.40	0.035
15-Feb-04	30.58	4.38	49.39	0.68	0.26	3.34	11.37	8390	1.00	
22-Feb-04	29.67	4.99	49.05	0.70	0.44	3.59	11.56	8460	1.40	
29-Feb-04	28.68	4.83	50.30	0.73	0.43	3.36	11.67	8658	1.90	
07-Mar-04	29.65	4.70	50.04	0.69	0.34	3.43	11.15	8545	1.20	
14-Mar-04	28.54	4.87	50.47	0.72	0.40	3.49	11.51	8631	1.80	0.105
21-Mar-04	29.43	4.50	49.42	0.68	0.28	3.58	12.11	8543	1.70	
28-Mar-04	31.09	4.44	50.01	0.67	0.30	3.46	10.03	8428	1.50	
04-Apr-04	28.26	4.34	50.27	0.69	0.35	3.60	12.49	8712	1.80	
11-Apr-04	28.43	4.94	49.69	0.71	0.30	3.80	12.13	8622	1.50	0.089
18-Apr-04	28.75	4.22	50.96	0.67	0.26	3.36	11.78	8653	1.30	
25-Apr-04	29.68	4.72	49.54	0.68	0.38	3.36	11.64	8501	1.60	
02-May-04	28.11	4.51	51.45	0.66	0.41	3.47	11.39	8698	1.40	
09-May-04	29.19	4.46	50.73	0.62	0.30	3.50	11.20	8626	1.90	0.086
16-May-04	29.02	4.84	50.73	0.60	0.25	3.49	11.07	8581	1.30	
23-May-04	29.30	4.54	50.00	0.70	0.43	3.49	11.54	8528	1.60	
30-May-04	29.50	5.07	49.61	0.72	0.42	3.68	11.00	8449	1.40	
06-Jun-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	
13-Jun-04	29.93	5.07	49.93	0.76	0.43	3.65	10.23	8352	1.40	
20-Jun-04	28.75	5.06	51.16	0.78	0.38	3.74	10.13	8516	1.70	0.154
27-Jun-04	29.40	4.71	49.98	0.68	0.40	3.68	11.15	8449	1.70	
04-Jul-04	29.10	4.89	50.11	0.68	0.35	3.63	11.24	8519	1.60	
11-Jul-04	29.54	4.67	50.45	0.67	0.33	3.55	10.79	8503	1.30	0.111
18-Jul-04	29.47	4.87	50.59	0.70	0.38	3.55	10.44	8509	1.50	
25-Jul-04	30.43	5.26	49.63	0.73	0.33	3.65	9.97	8305	1.60	
01-Aug-04	30.66	4.60	49.96	0.67	0.37	3.68	10.06	8323	1.60	
08-Aug-04	29.01	5.68	50.50	0.69	0.33	3.69	10.10	8433	1.30	0.144
15-Aug-04	21.55	5.64	55.18	0.80	0.43	3.95	12.45	9223	1.50	
22-Aug-04	29.78	4.68	50.19	0.67	0.39	3.63	10.66	8437	1.70	
29-Aug-04	28.86	5.30	50.85	0.64	0.30	3.57	10.48	8518	1.10	
05-Sep-04	29.27	4.74	51.01	0.71	0.40	3.70	10.17	8606	1.60	
12-Sep-04	29.14	4.96	50.83	0.68	0.41	3.65	10.33	8500	2.10	0.08
19-Sep-04	14.38	5.96	60.86	0.86	0.43	4.32	13.19	10028	1.50	
26-Sep-04	29.37	4.35	51.85	0.67	0.25	3.69	9.82	8546	1.20	
03-Oct-04	29.32	4.63	50.39	0.81	0.37	3.61	10.87	8478	1.00	
10-Oct-04	29.79	4.61	50.68	0.71	0.39	3.71	10.11	8435	2.30	0.1
17-Oct-04	29.50	5.11	49.88	0.69	0.41	3.53	10.88	8410	1.50	
24-Oct-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	
31-Oct-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	
07-Nov-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	
14-Nov-04	30.14	4.72	50.46	0.67	0.34	3.54	10.13	8424	1.30	
21-Nov-04	29.84	5.14	49.95	0.66	0.41	3.48	10.52	8446	1.40	0.123
28-Nov-04	25.84	5.02	53.08	0.57	0.46	3.69	11.34	8782	1.40	
05-Dec-04	29.49	5.07	50.85	0.73	0.28	3.47	10.11	8530	0.90	
12-Dec-04	29.62	4.18	51.10	0.69	0.22	3.53	10.66	8575	1.20	0.082
19-Dec-04	30.61	5.00	48.84	0.69	0.38	3.41	11.07	8284	1.20	
26-Dec-04	28.62	4.92	50.40	0.74	0.39	3.56	11.37	8611.00	1.40	

B18 Photographs from January 19, 2003 inspection

Anvil – Front View

Anvil – Angle View

Missing Roller

Damaged Bolt & Nut

Rapper Shaft Coupler

Bent Support

New Thrust Support – End View

New Thrust Support – Side View

Missing Hammer

Broken Hammer Mount

Broken Mount – Close Up View

B19 ESP Power by Chamber

B20 ESP Tabular Data

Transformer/Rectifier Performance Readings

28-Oct-02 Limits: mA = 700, kV = 45, spm = 12												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	--	--	--	320	45.6	11	705	48.4	2	705	50.3	0
1B	--	--	--	254	46.9	11	711	45	11	711	45.6	2
2A	--	--	--	432	53.6	13	320	48.4	12	569	47.6	12
2B	--	--	--	361	47.2	12	645	42.2	11	592	44.8	10

29-Oct-02 Limits: mA = 700, kV = 45, spm = 12												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	--	--	--	296	45.4	12	705	47.2	0	705	50.5	0
1B	--	--	--	284	48.7	13	569	45.6	12	684	47	13
2A	--	--	--	409	54	11	284	50.2	12	699	50.7	11
2B	--	--	--	391	49.2	11	664	43.8	12	711	46.2	10

30-Oct-02 Limits: mA = 700, kV = 45, spm = 12												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	--	--	--	320	40.4	12	711	47.9	1	705	50.8	0
1B	--	--	--	260	49.2	11	652	47.3	11	703	47.3	10
2A	--	--	--	503	53.8	12	343	50.8	12	705	52	3
2B	--	--	--	260	48	14	592	45.7	11	675	48.6	12

22-Nov-02 Limits: mA = 700, kV = 65, spm = 50 for F2 and 12 for F3 and F4												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	--	--	--	332	46.7	49	664	48.1	11	705	54.1	3
1B	--	--	--	278	51.3	50	557	49.1	12	213	43.2	11
2A	--	--	--	361	51.8	50	284	44.7	12	592	50.9	12
2B	--	--	--	367	50.9	49	391	49.5	12	616	46.6	12

1B CHAMBER															
Date	Time	Inlet Temp (F)	1ST FIELD			2ND FIELD			3RD FIELD			4TH FIELD			ave mA for AH Chamber
			mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm	
11/22/2002	9:00 AM		off			190	51	12	480	49.4	12	379	47.7	12	349.7
	11:10 AM					278	51.3	50	557	49.1	12	213	43.2	11	349.3
11/23/2002	18:00 pm					346	53.5	50	705	52.1	2	705	53.3	0	585.3
1/6/2003			575			570			705			701			658.7
began burning soybeans at 600 to 700 tons/day															
1/9/2003		309.0	94	57.3		379	50.4		468	48.4		420	48.5		422.3
1/10/2003		303.0	112	62.4		400	53.4		509	52		569	53.6		492.7
stopped burning soybeans															
1/13/2003		297.0	302	58.4		581	50.8		717	50.2		711	51.4		669.7
1/13/2003			456	67.1	99	616	51.7	50	723	49.6	6	705	51.4	1	681.3
1/14/2003	07:30am	300.0	124	58.1	99	332	53.7	50	509	50.9	12	557	52.8	11	466.0
1/15/2003	07:30am	305.0	130	60.7	100	373	53.4	50	498	50.6	12	681	53.3	11	517.3
inspected and repaired compartments 4 and 11 collecting plate rapper shafts 1/19/2003															
Burning soybeans at lower rate 60-200 tons/day															
1/20/2003	07:30am	298.0	71	60.9	92	379	52.5	49	397	48.9	12	622	52.6	11	466.0
1/22/2003	plant tripped @ 14:40 CT back on line at midnight														
1/23/2003		296.0	94	57	99	343	48.7	52	486	47.6	12	640	50.2	8	489.7
1/26/2003		296.0	94	55.5	100	462	47.5	49	492	48.7	12	604	48.4	11	519.3
1/28/2003	7:30 AM	300.0	231	59.4	62.5	521	49.5	49	640	49.7	11	723	51.9	12	628.0
	15:30 pm	304.0	189	50.8	100	468	50.3	53	616	50.3	11	723	50.2	10	602.3
1/28/2003	spark limit setpoint increased in 2nd and 3rd fields to 99 spm														
1/29/2003	7:30 AM	303.0	130	58.1	99	498	49.8	101	735	50.1	95	622	48.2	4	618.3
1/30/2003	7:30 AM	312.0	106	52	101	337	41.1	102	575	46.9	101	652	49.2	9	521.3
2/3/2003	7:30 AM	300.0	343	60.5	99	521	43.6	98	711	49.8	1	705	51.3	1	645.7
2/4/2003	7:30 AM	290.0	189	58.9	99	403	48.4	100	687	49.3	100	735	51.6	5	608.3
2/5/2003	7:30 AM	302.0	177	54.7	99	468	46.4	101	634	49.3	100	711	53	83	604.3
2/6/2003	11:30 AM														
2/6/2003	15:20 pm	299.0	170	61	100	500	51	100	690	51	99	705	55	38	631.7
	17:00 pm	301.0	130	58	100	480	50	100	690	50	99	705	53	66	625.0
2/7/2003	8:15 AM	299.0	142	56	100	569	49	100	634	50	100	705	54	25	636.0
	12:05 PM														
	16:00 pm	313.0	83	56	100	355	43	100	569	45	101	598	48	54	507.3
2/8/2003	3:00	288.0	177	58	99	480	49	102	687	49	78	705	51	0	624.0
	4:42	256.0	527		3	705		0	707		0	707		0	706.3
	12:00	301.0	142	60	100	426	51	101	640	49	100	705	53	0	590.3
	19:00	308.0	284	61	98	474	50	100	711	50	13	705	52	0	630.0
2/9/2003	10:00	299.0	237	63	100	652	52	98	711	52	11	711	50	0	691.3
temporarily raised TR current limit setpoints when compartments were not at 100 spm - max was 1000 mA															
	13:00	313.0	130	54	100	430	49	100	570	49	100	806	51	100	602.0
	14:45	315.0	124	56	99	450	49	99	628	49	100	705	51	2	594.3
	17:00	308.0	106	60	99	533	50	99	509	44	100	705	52	0	582.3
2/10/2003	10:00	292.0	142	55	101	492	47	99	616	49	97	705	54	53	604.3
	19:10	300.0	201	63	89	438	50	101	699	50	86	711	53	1	616.0
2/11/2003	8:45	308.0	184	61	100	379	49	101	604	48	100	705	51	225	562.7
2/12/2003	7:30	293.0	118	58.2	100	361	44.8	101	675	49.7	100	705	51.5	0	580.3
2/12/2003	10:40	296.0	166	57	100	438	52	101	646	51	100	687	53	96	590.3
Each field was individually power off rapped starting with #2,#3,#4, and then 1st field															
Increased soybean burn rate to 500 ton/day on 13th															
	17:00	308.0	332	64	99	474	46	99	705	49	0	705	49	0	628.0
2/13/2003	7:30	302.0	142	53.7	100	397	48.7	100	616	49.8	100	634	49.5	100	549.0
2/16/2003	7:30	296.0	189	60.2	99	450	46.7	100	521	49.1	101	515	44.6	50	495.3
2/19/2003	7:30		118	55.7	99	320	46.9	99	616	49.7	99	640	49.5	99	525.3
2/21/2003	7:30		154	60.8	99	343	50.8	99	563	50.7	99	675	53.5	100	527.0
2/24/2003	7:30		189	63.5	100	361	53.1	100	592	52.7	101	711	54.7	8	554.7
Plant down for boiler wash, replaced first section of collecting plate rapper shafts and outboard bearing. Rapped all plates off															
3/3/2003	9:00		901	63	101	705	49	0	711	43.7	0	705	43	0	707.0
	14:31		824	65	6	705	49	0	705	44	0	705	43	0	705.0
	18:35		723	62	99	705	50	0	705	46	0	705	45	0	705.0
	20:12		474	63	93	705	52	1	705	47	0	705	47	0	705.0
	23:42		346	61	78	705	52	0	705	48	0	711	48	0	707.0
3/4/2003	7:20		296	64	7	681	51	1	705	50	0	705	49	0	697.0

2A CHAMBER															
Date	1ST FIELD			Inlet	2ND FIELD			3RD FIELD			4TH FIELD			ave mA AH chamber	
	mA	kV	spm	Temp (F)	mA	kV	spm	mA	kV	spm	mA	kV	spm		
11/22/2002	off				296	53.8	12	249	57.8	12	521	52	12	355.3	
11/22/2002					361	51.8	50	284	44.7	12	592	50.9	12	412.3	
11/23/2002					438	56.8	50	515	52.5	11	705	52.7	1	552.7	
1/6/2003	23				672			546			705			641.0	
1/9/2003	0	0			268	349	58.4	260	51.3		575	56.1		394.7	
1/10/2003	124	65			263	569	56.5	379	53		705	55.2		551.0	
1/13/2003	492	65			255	699	54.5	652	54.1		705	48.9		685.3	
1/13/2003	527	52.6	3		711	54.5	42	664	54.8	12	705	48.4	1	693.3	
1/14/2003	94	65.1	0		255	557	57.7	343	52.3	11	586	52.7	11	495.3	
1/15/2003	136	65	2		260	557	55.2	415	52	11	687	52.7	2	553.0	
1/19/2003															
1/20/2003	201	65.2	0		249	586	52	46	415	51.2	12	705	51.5	0	568.7
1/23/2003	249	65	1		253	699	57.7	34	403	50.5	13	705	51.3	0	602.3
1/26/2003	195	65.1	0		251	640	55.7	45	403	50.9	11	705	52	8	582.7
1/28/2003	201	65	0		264	723	58.1	27	403	51.3	12	705	52.5	0	610.3
1/28/2003	136	65.1	0		259	664	53.9	51	415	52.8	12	705	53.5	0	594.7
1/29/2003	183	65.1	4		255	705	59.2	11	438	59.2	100	705	52.3	0	616.0
1/30/2003	189	65	4		267	711	58.6	45	373	50.8	100	705	52	0	596.3
2/3/2003	367	65	3		255	723	54.5	8	563	52.7	100	705	49.8	0	663.7
2/4/2003	171	65	1		262	705	58.8	8	432	52.8	100	705	52.5	0	614.0
2/5/2003	94	65.2	2		265	581	54.8	102	343	50	101	675	51.7	52	533.0
2/6/2003	130	65	5		265	711	58	94	379	52	98	705	55	1	598.3
2/6/2003	140	65	0		264	699	59	99	380	52	100	711	55	0	596.7
2/7/2003	83	65	0		261	634	58	100	355	52	51	705	55	32	564.7
2/7/2003	142	65	1		275	610	54	100	332	48	100	711	52	4	551.0
2/8/2003	213	65	3		259	705	58	22	616	56	101	705	51	0	675.3
2/8/2003	496		0		238	705		0	705		0	706		0	705.3
2/8/2003	106	65	3		269	563	56	99	379	51	100	711	53	8	551.0
2/8/2003	177	65	1		264	705	58	11	426	51	100	705	52	0	612.0
2/9/2003	166	65	0		260	705	58	12	474	51	99	705	50	0	628.0
2/9/2003	189	65	0		278	680	55	87	379	49	100	800	53	1	619.7
2/9/2003	166	65	0		278	687	54	82	367	49	100	705	52	0	586.3
2/9/2003	124	65	6		273	640	56	100	349	50	100	711	52	1	566.7
2/10/2003	106	65	0		254	664	56	100	415	51	100	705	53	0	594.7
2/10/2003	130	65	0		257	705	60	40	391	49	101	705	52	0	600.3
2/11/2003	177	65	0		265	711	57	67	415	50	100	705	52	0	610.3
2/12/2003	166	65	15		252	634	55.9	98	373	49.4	99	711	52.4	69	572.7
2/12/2003	94	65	0		262	664	55	92	420	53	100	705	54	0	596.3
2/12/2003	177	65	28		267	705	57	1	533	52	100	705	49	0	647.7
2/13/2003	85	65.1	0		270	634	58.4	99	379	47.9	100	705	53.8	28	572.7
2/16/2003	189	65	0		251	652	56.5	29	462	53.2	100	711	52.2	0	608.3
2/19/2003	112	65	0			509	47.3	100	320	50.4	101	675	52.5	79	501.3
2/21/2003	94	65.1	3			432	50.3	97	290	52.5	100	669	47.7	98	463.7
2/24/2003	130	65.1	0			699	59.7	98	373	62	99	711	55.6	0	594.3
-line, pulsed bags at low load															
3/3/2003	1114	63	##		705	50	0	705	53	0	711	43	0	707.0	
	966	65	0		711	51	0	705	53	0	711	43	0	709.0	
	758	65	1		705	51	0	705	54	0	705	44	0	705.0	
	604	65	1		705	52	3	705	55	9	711	46	0	707.0	
	509	65	3		705	54	0	687	53	89	705	47	0	699.0	
3/4/2003	367	65	0		705	56	7	509	50	98	705	48	0	639.7	

2B CHAMBER															
Date	Time	Inlet Temp (F)	1ST FIELD			2ND FIELD			3RD FIELD			4TH FIELD			ave mA
			mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm	AH chamber
11/22/2002	9:00 AM		off			320	48.9	12	545	48.6	12	509	46.4	12	458
	11:10 AM					367	50.9	49	391	49.5	12	616	46.6	12	458
11/23/2002	18:00 pm					320	53.3	50	705	51.2	1	705	51.9	5	577
1/6/2003		85				491			708			705			635
began burning soybeans at 600 to 700 tons/day															
1/9/2003		303.0	35	47.1		296	52.7		533	50.5		521	51.6		450
1/10/2003		303.0	94	49		374	56.5		509	53.9		503	51.6		462
stopped burning soybeans															
1/13/2003		292.0	94	50		409	50.2		598	51.6		711	51.3		573
1/13/2003			94	52.6	99	486	51.3	51	610	52.9	12	634	50.5	12	577
1/14/2003	07:30am	295.0	106	48.6	101	320	50.4	48	462	53	11	486	50.4	11	423
1/15/2003	07:30am	298.0	88	49.3	99	420	55.3	51	557	53.9	12	581	48.3	12	519
inspected and repaired compartments 4 and 11 collecting plate rapper shafts 1/19/2003															
Burning soybeans at lower rate 60-200 tons/day															
1/20/2003	07:30am	285.0	59	46.9	99	355	52.7	50	616	49.7	12	669	52.7	12	547
1/22/2003	plant tripped @ 14:40 CT back on line at midnight														
1/23/2003		287.0	59	48.8	97	379	52	51	669	51.3	12	675	51.5	8	574
1/26/2003		296.0	71	49.1	98	385	50.1	49	592	48.2	12	521	49.8	10	499
1/28/2003	7:30 AM	303.0	53	49.1	98	401	53.2	50	581	52	10	634	52.8	10	539
	15:30 pm	291.0	83	49.9	100	415	54	51	616	50.9	12	575	52.7	10	535
1/28/2003	spark limit setpoint increased in 2nd and 3rd fields to 99 spm														
1/29/2003	7:30 AM	288.0	94	49	99	450	53	99	640	53.4	96	705	53.7	36	598
1/30/2003	7:30 AM	302.0	118	51.9	99	308	50.6	101	705	50.8	99	711	52	36	575
2/3/2003	7:30 AM	293.0	112	46.7	100	450	48.6	100	604	50.6	100	729	50.6	20	594
2/4/2003	7:30 AM	301.0	71	49.7	101	438	50.9	101	723	51.3	95	551	43.9	95	571
2/5/2003	7:30 AM	303.0	77	46.9	100	373	46.2	101	628	49.9	100	664	49.6	97	555
2/6/2003	11:30 AM														
2/6/2003	15:20 pm	300.0	70	50	99	280	50	101	695	49	100	604	51	65	526
	17:00 pm	302.0	40	54	100	390	52	100	581	51	100	580	53	92	517
2/7/2003	8:15 AM	299.0	106	48	99	391	54	99	640	51	100	735	52	61	589
	12:05 PM														
	16:00 pm	307.0	94	47	99	415	48	101	581	48	99	705	49	36	567
2/8/2003	3:00	293.0	77	51	98	486	54	96	699	51	88	711	51	1	632
	4:42	265.0	92		98	663		78	707		0	706		0	692
	12:00	307.0	94	50	101	379	52	99	652	50	101	711	51	4	581
	19:00	302.0	59	49	98	450	52	99	646	49	97	705	52	15	600
2/9/2003	10:00	296.0	65	49	98	426	77	100	515	50	100	705	50	21	549
temporarily raised TR current limit setpoints when compartments were not at 100 spm - max was 1000 mA															
	13:00	315.0	94	50	100	272	52	99	580	51	100	664	50	66	505
	14:45	315.0	59	49	100	373	53	100	498	48	100	640	48	86	504
	17:00	311.0	94	47	99	355	46	99	450	46	100	634	46	97	480
2/10/2003	10:00	294.0	96	51	100	379	54	98	577	51	100	604	43	100	520
	19:10	293.0	59	53	100	385	54	100	509	49	100	557	48	101	484
2/11/2003	8:45	301.0	59	54	99	355	52	99	557	51	100	551	47	93	488
2/12/2003	7:30	288.0	71	47.1	99	403	51.9	99	498	44.5	99	675	50.5	99	525
2/12/2003	10:40	299.0	71	50	99	385	52	101	486	51	100	569	49	98	480
Each field was individually power off rapped starting with #2,#3,#4, and then 1st field															#DIV/0!
Increased soybean burn rate to 500 ton/day on 13th															
	17:00	302.0	71	48	100	476	52	100	545	51	100	705	50	1	575
2/13/2003	7:30	308.0	94	43.3	99	391	53.8	100	563	52	100	652	50	99	535
2/16/2003	7:30	286.0	71	52.3	99	397	52.2	101	456	51	99	693	51.4	98	515
2/19/2003	7:30		130	54.2	99	367	49.8	99	391	50.1	101	521	50.4	99	426
2/21/2003	7:30		53	49.1	99	243	48.1	101	438	46.3	100	616	50.5	100	432
2/24/2003	7:30		59	53.4	100	355	54.1	99	450	53.8	101	581	50.4	39	462
Plant down for boiler wash, replaced first section of collecting plate rapper shafts and outboard bearing. Rapped all plates off-line, pulse															
3/3/2003	9:00		326	50	98	711	53	0	705	45	0	705	44	0	707
	14:31		166	57	99	705	54	5	705	46	0	711	45	0	707
	18:35		71	53	98	533	49	100	705	48	0	705	48	0	648
	20:12		71	50	101	480	51	101	711	49	1	705	49	2	632
	23:42		118	49	98	462	50	99	699	47	93	711	50	1	624
3/4/2003	7:20		47	57	100	468	48	99	717	50	84	711	51	0	632

Transformer/Rectifier Performance Readings

16-Apr-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	192	58.8	98	535	44	19	997	50.1	3	1001	52.4	0
1B	464	61.4	97	661	48.9	19	818	48.5	19	1000	51.6	1
2A	600	64.8	6	774	50.3	19	494	46.8	19	995	50.3	3
2B	84	48	99	433	49.3	19	619	46.4	19	591	40.6	18

18-May-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	138	61.5	91	425	44.3	19	919	49	18	970	54.1	15
1B	328	58.1	99	480	47.6	19	717	47.9	19	811	49.1	19
2A	596	62.8	86	584	49.1	19	587	49.7	19	814	48.5	19
2B	96	49.7	98	372	49	19	602	46	19	681	48.3	19

17-Jun-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	128	64.4	33	664	47.3	19	979	49.3	11	997	54.7	3
1B	283	59.7	99	530	48.5	19	788	48.4	19	788	48.4	19
2A	497	63.4	46	770	52	19	645	50.4	19	953	50.1	10
2B	479	60.7	98	620	48.7	19	949	48.7	14	552	36.3	18

Transformer/Rectifier Performance Readings

15-Jul-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	68	63.7	47	370	45.2	19	751	47.7	19	770	52.6	19
1B	172	55.5	99	319	47	19	537	46.1	19	601	48.2	19
2A	260	57.8	99	492	49	19	498	49.1	19	653	48.5	19
2B	262	57.3	99	434	48.5	19	720	47.2	19	620	47.5	19

15-Aug-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	116	62.3	87	413	44.9	19	758	47.2	19	806	52.1	19
1B	194	56.3	99	346	47.1	19	566	46.1	19	597	47.9	19
2A	324	59.3	99	541	49.6	19	546	49.5	19	665	48.2	19
2B	337	59	99	490	49.3	19	765	48	19	660	47.8	19

15-Sep-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	95	64.4	33	456	46	19	848	49.1	19	882	54.1	19
1B	195	57.1	99	359	47.6	19	567	46.5	19	632	48.9	19
2A	336	60.4	98	552	51.5	19	541	50.6	19	706	49.8	19
2B	317	59.4	99	473	49.7	19	738	48.5	19	681	47.9	19

Transformer/Rectifier Performance Readings

15-Oct-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	80	62.8	81	408	46.1	19	771	48.9	19	832	53.8	19
1B	123	55.9	99	330	48.6	19	534	47.5	19	598	48.6	19
2A	345	63.9	43	607	53.5	19	593	52.3	19	787	51	19
2B	273	60.5	98	457	50.2	19	743	49.5	19	688	48.7	19

15-Nov-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	113	64.6	24	538	46.1	19	927	49	16	970	52.7	8
1B	223	58.5	99	387	48.4	19	576	47.4	19	702	49.2	19
2A	485	64.1	42	753	49.1	19	750	49.7	18	962	48.8	9
2B	379	63.7	55	566	49.7	19	882	49.8	18	764	48.4	19

4-Dec-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	133	64.4	33	566	48	19	942	50.7	15	971	54.8	8
1B	215	60.2	99	435	50.5	19	627	49.2	18	718	50.7	19
2A	427	65	3	791	54	19	786	54.5	19	977	52	8
2B	301	64.2	29	567	51	18	903	51.6	18	688	44.7	18

Transformer/Rectifier Performance Readings

26-Feb-04 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	81	64.8	10	609	49.9	19	947	51.4	9	977	56.6	8
1B	219	60	98	443	50.2	19	731	50.6	19	780	53.1	19
2A	250	63.4	52	682	56.2	19	708	57.1	19	939	53.6	17
2B	281	62.3	77	505	51	19	839	50.9	19	767	49.9	19

15-Mar-03 * Limiting factors highlighted												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	Off	Off	Off	408	49.3	19	886	52.5	19	990	59.6	5
1B	229	61.6	97	549	52	19	807	52	19	892	54.4	19
2A	811	53	19	393	53.3	19	450	53.5	19	944	56.6	16
2B	263	64.7	12	615	52.5	19	918	52.7	18	689	41.5	18

Transformer/Rectifier Performance Readings

15-Apr-04 * Limiting factors highlighted												
Chamber	mA	Field 1		mA	kV	spm	mA	kV	spm	mA	kV	spm
		kV	spm									
1A	94	64.9	4	610	49.2	19	975	52.1	8	981	56.3	7
1B	230	59.6	99	455	50.7	19	723	50.3	19	816	52.9	19
2A	421	63.6	55	704	55.5	19	682	55.4	19	905	51.6	18
2B	313	62.8	68	509	51.3	19	835	51.1	19	778	49.9	19

15-May-04 * Limiting factors highlighted												
Chamber	mA	Field 1		mA	kV	spm	mA	kV	spm	mA	kV	spm
		kV	spm									
1A	425	64.4	30	481	47.3	19	870	49.7	19	881	54.4	19
1B	135	58.2	99	367	48.6	19	596	48.5	19	678	50.3	19
2A	445	64.4	38	646	53.3	19	592	52.7	19	814	50.1	19
2B	237	61.7	91	433	50.4	19	433	50.4	19	688	49.1	19

15-Jun-04 * Limiting factors highlighted												
Chamber	mA	Field 1		mA	kV	spm	mA	kV	spm	mA	kV	spm
		kV	spm									
1A	64	64.8	12	533	47.9	19	887	49.6	18	972	55.1	11
1B	291	60.1	99	563	49.1	19	823	48.9	19	862	51.5	19
2A	334	64.7	17	706	53.8	19	671	53.8	19	913	50.3	18
2B	194	63.3	62	496	50.8	19	705	48.7	19	626	44.2	19

Transformer/Rectifier Performance Readings

* Limiting factors in bold box, changes from previous quarter highlighted in red

17-Jul-04												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	98	64.8	16	572	47.8	19	967	50.2	13	1000	56.2	1
1B	299	57.6	99	536	48.3	19	806	47.8	19	801	49.1	19
2A	288	62.2	20	742	54.1	19	749	54.1	19	951	51.1	12
2B	308	61.4	93	594	50.5	19	790	47.8	19	666	43	18

13-Aug-04												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	91	61.7	82	369	44.6	19	738	46.3	19	841	49.1	19
1B	226	55.6	99	374	44.8	19	581	44.6	19	525	44	19
2A	235	58.6	99	517	45.9	19	499	47.6	19	621	46.1	19
2B	156	58.6	99	468	44.5	19	701	45.3	19	633	44.9	19

20-Sep-04												
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	88	59.5	99	115	32.5	19	795	48.7	19	903	54.1	19
1B	173	56.4	99	357	47.8	19	632	45.9	19	475	45.7	18
2A	308	60.9	98	591	52	19	643	52.6	19	824	50	19
2B	201	59.6	99	467	50.2	19	684	48.6	19	662	47.7	19

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Bag layout from Start-up until June 2003

Bag layout after June 2003 boiler wash outage

Advanced Hybrid Bag Map Big Stone Plant

Bag layout after the December 2003 boiler wash outage

Advanced Hybrid Bag Map Big Stone Plant

Bag layout after the June 2004 wash outage

Bag layout after the October 2004 boiler wash outage

B24 EERC Stack Test – November 19, 2002

Support in Demonstrating a Full-Scale Retrofit of the Advanced Hybrid™ Technology – TEST SERIES I

Test Series I Report

(For the period June 1, 2002 – January 22, 2003)

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SAMPLING SUPPORT TO DEMONSTRATE A FULL-SCALE RETROFIT OF THE ADVANCED HYBRID™ TECHNOLOGY – TEST SERIES I

INTRODUCTION

A new concept in particulate control, called the Advanced Hybrid™ Filter, was installed at the Big Stone Power Plant operated by Otter Tail Power Company. The Advanced Hybrid™ concept combines fabric filtration and electrostatic precipitation in the same housing, providing major synergism between the two methods, both in the particulate collection step and in the transfer of dust to the hopper. The Advanced Hybrid™ Filter is designed to provide ultrahigh collection efficiency for even fine particulate matter at air-to-cloth ratios significantly higher than those utilized for traditional fabric filters, 10–12 ft/min compared to 3.5–4 ft/min for a pulse-jet baghouse. This report presents the results of the first series of flue gas sampling designed to demonstrate the fine particulate collection efficiency of the Advanced Hybrid™ Filter. In addition to total particulate measurements, trace elements including mercury, were also measured.

APPROACH

The original proposal required testing three times during the first 2 years of operation. The results presented in this report were those obtained after about 600 hours of operation. The Advanced Hybrid™ Filter began operating on October 25, 2002, and sampling occurred during the week of November 18, 2002. Table 1 shows the test matrix for the sampling conducted during this period.

Table 1. Sampling Test Matrix for Big Stone Power Plant – Test Series I

Activity	Sampling Location	Nov. 18		Nov. 19		Nov. 20		Nov. 21		Nov. 22	
		AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Set-Up and Takedown		Setup									Takedown
APS/SMPS ¹	Stack	APS/SMPS									
EPA Method 29 ²	Advanced Hybrid™ Inlet			X		X	X				
EPA Method 29	Stack			X		X	X				
EPA Method 17	Stack		X			X		X			
Multicyclones	Advanced Hybrid™ Inlet				X			X	X		
Impactor	Stack					X					
Coal Samples and Hopper Ash				X		X		X		X	

¹ Aerodynamic particle sizer (APS)/scanning mobility particle sizer (SMPS).

² U.S. Environmental Protection Agency.

Figure 1. Schematic of the Big Stone Power Plant showing Advanced Hybrid™ System and sampling locations.

The Advanced Hybrid™ system has four chambers (1A, 1B, 2A, and 2B) with a separate duct going to each chamber. These ducts recombine at the outlet of the Advanced Hybrid™ Filter and exit a single stack. Figure 1 is a schematic of the system showing the flue gas sampling points. As can be seen in Figure 1, the Advanced Hybrid™ inlet sampling was done at two different ducts, 1B and 2A. The reason for this is that the first duct did not have a port large enough to use the multicyclone. Therefore, sampling location was changed from the second duct to the third duct. The sampling in the stack was done at a 288-ft level. There were four ports located in the stack. One port was used to do EPA Method 29 samples, and a different port was used to collect the EPA Method 17 samples. No traversing was done for these tests.

The fuel burned at the Big Stone Power Plant varies to some degree. The coal is a Powder River Basin (PRB) subbituminous coal from the Belle Ayr mine. However, periodically, the Big Stone Power Plant blends 10% or less of other combustible materials, including tire-derived fuel (TDF) and a waste seed biomass such as corn. Table 2 shows the fuel that was burned during the four days of testing.

The coal samples provided the Energy & Environmental Research Center (EERC) by plant personnel for the 4 days of testing were as follows (these samples were not taken directly at the mill, so they are different than those actually burned at the plant on any given day).

Table 2. Fuel Burned at the Big Stone Power Plant During Testing, by weight

Day	Coal, %	TDF, %	Waste Seed (Corn), %
Nov. 19	96.5	0.4	3.1
Nov. 20	100	0	0
Nov. 21	100	0	0
Nov. 22	95.0	2.2	2.8

11/18/2002 PRB–waste corn seed
 11/18/2002 TDF
 11/19/2002 PRB
 11/20/2002 PRB
 11/21/2002 PRB
 11/22/2002 PRB

The TDF sample was taken prior to mixing with the coal, but the waste corn seed was blended with the coal prior to the sample being taken. The sampling protocols used for the Test Series I sampling effort are presented in Table 3. The trace elements analyzed were as follows:

Antimony
 Arsenic
 Beryllium
 Cadmium
 Chromium
 Lead
 Nickel
 Mercury

At the Advanced Hybrid™ inlet sampling location, the EPA Method 29 and multicyclones were operated for about 2 hours. However, because of the very low emissions at the stack, the EPA Method 17 and impactor trains were operated for 12 hours to ensure enough dust was captured to accurately measure weight. To improve the detection of the trace elements at the stack, EPA Method 17 filters were analyzed, rather than the stack EPA Method 29 filters. To sample the required amount of flue gas isokinetically, EPA Method 29 can only be operated 2–3 hours compared to 12 hours for EPA Method 17.

RESULTS AND DISCUSSION

Coal Analysis

One coal–waste corn blend sample and three PRB coal samples were analyzed for this project for trace elements and chlorides. These results are shown in Table 4. With the exception of nickel, the addition of waste corn seed to the coal reduces all the trace elements.

Table 3. Sampling Protocols Used for Test Series I

Sample Method	Analysis
EPA Method 29	Trace elements and total dust loading at the Advanced Hybrid™ inlet (fly ash and flue gas)
EPA Method 17	Trace elements and total dust loading at the stack (fly ash)
Multicyclones	Particle-size distribution at the Advanced Hybrid™ inlet
Impactor	Particle-size distribution at the stack
APS/SMPS	Particle-size distribution at the stack (0.03–15 µm)
Sample	
Hopper Ash ¹	Trace elements, XRF ² analyses for major elements, and loss on ignition (LOI)
Coal ³	Trace elements, ultimate/proximate, heating value and chlorine

¹ Analyses were done on three hopper ash samples.

² X-ray fluorescence.

³ Analyses were done on four coal samples, 3 PRB only and 1 PRB plus waste corn seed.

Table 4. Analyses of Trace Elements in Fuel Fired at Big Stone Power Plant

Date	11/19/02	11/21/02	11/22/02	11/22/02
Trace Element	PRB Coal, µg/g	PRB Coal, µg/g	PRB Coal, µg/g	PRB and waste corn seed, µg/g
Antimony	<0.1	<0.1	<0.1	<0.1
Arsenic	0.56	1.1	0.60	0.49
Beryllium	0.21	0.27	0.26	0.15
Cadmium	0.064	0.10	0.060	<0.04
Chromium	3.5	4.3	4.3	2.84
Chloride	8.9	22.0	9.1	200
Lead	3.5	3.3	2.9	2.0
Mercury	0.087	0.0414	0.0586	0.0754
Nickel	5.3	5.8	4.2	14.8

Ultimate and proximate analyses for one PRB coal and the PRB-waste corn seed blend are shown in Table 5.

Total Dust Loadings and Particulate Collection Efficiency

The total particulate collection efficiency is shown in Table 6. As can be seen, the average collection efficiency is >99.995%. Based on the original proposal, the design specifications for the Advanced Hybrid™ Filter were <0.002 grains/scf and >99.99% collection efficiency. The results presented in Table 6 show that the Advanced Hybrid™ technology easily met these criteria.

Particle-Size Distributions

Near-real-time measurements were made for particles ranging from 0.5 to 15 µm with the APS. For the APS, rather than looking at emissions of several particle sizes, fine particle emissions are combined by calculating a value for respirable mass. The American Council of Governmental and

Table 5. Chemical Analysis of Coal, as received

Date	11/19/2002	11/22/2002
Description	100% PRB	PRB and waste corn seed
Proximate Analysis		
Moisture, %	29.50	21.60
Volatile Matter, %	33.24	37.97
Fixed Carbon, %	32.95	27.18
Ash, %	4.31	13.26
Ultimate Analysis		
Hydrogen, %*	6.66	6.15
Carbon, %	48.60	53.33
Nitrogen, %	0.86	0.92
Sulfur, %	0.31	0.35
Oxygen, % (by diff.)	39.26	26.00
Heating Value, Btu/lb	8520	9658
Fd, dscf/10 ⁶ Btu	9488	9562

*Includes hydrogen as water.

Table 6. Advanced Hybrid™ Particulate Collection Efficiency

Date	Sample Method	Advanced Hybrid™ Inlet Dust Loading, grains/scf	Advanced Hybrid™ Inlet ¹ Dust Loading, lb/10 ⁶ Btu	Stack Dust Loading, grains/scf	Stack ¹ Dust Loading, lb/10 ⁶ Btu	Particulate Collection Efficiency, %
11/18/2002	EPA Method 17			0.00002	0.00003	99.998
11/19/2002	EPA Method 29	1.02092	1.38378			
	Multicyclones	0.64099	0.86882			
11/20/2002	EPA Method 17			0.00006	0.00008	99.994
	EPA Method 29	0.85856	1.16372			
	EPA Method 29	0.92151	1.24904			
11/21/2002	EPA Method 17			0.00003	0.00004	99.997
	Multicyclones	0.66113	0.89611			
	Multicyclones	0.70044	0.94940			

¹ Values were calculated based on the Fd factors shown in Table 3 for 100% PRB.

Industrial Hygienists (ACGIH) definition of respirable mass is presented in Table 7. The ACGIH definition is extrapolated and interpolated to calculate the percentage at the midpoint of each channel for that particle size, as determined by the APS. The respirable mass from all the channels is added to obtain the total respirable mass. This provides a convenient and effective method of showing APS results for fine particle emissions. The results for the APS sampling are presented in Figures 2–4. The results show, with the exception of one spike, that the Advanced Hybrid™ respirable mass emissions are at or below those measured in the ambient air.

Table 7. ACGIH Respirable Mass Definition

Aerodynamic Diameter, μm	Respirable Mass Fraction, %
<2.0	100
2–2.5	90
2.5–3.5	75
3.5–5.0	50
5.0–10.0	25
>10	0

Particle-size distribution was measured at the Advanced Hybrid™ inlet using a 5-stage multicyclone and at the stack using an impactor. The Advanced Hybrid™ inlet multicyclone results are presented in Figure 5. As shown in Figure 5, the results for the three multicyclone samples at the inlet are similar and give a mass mean diameter of about 10 μm . The impactor results at the stack are shown in Figure 6. The results of the impactor are somewhat suspect because the total particulate loading, even after 12 hours of sampling, was so low that it was difficult to measure accurately. However, as shown in Figure 5, the mass loading measured at the stack was substantially finer. The D_{50} was <0.2 μm .

Flue Gas Analyses

The trace element analyses of the flue gas at the Advanced Hybrid™ inlet and the stack is shown in Tables 8 and 9. As would be expected based on the vapor pressure for the measured trace elements (with the exception of mercury), the vast majority of each of the trace elements is bound with the particulate matter. It should be noted that the vapor-phase lead values are somewhat suspect, as the field blanks indicated concentrations higher than would be expected. The field blank results are shown in Table 10. The field blank data shown in Table 8 are the total amount of each trace element in the impinger solutions of EPA Method 29. Table 9 represents the blanks for the gas-phase concentrations.

Comparing the Advanced Hybrid™ inlet and stack trace element analysis (Table 11) shows the Advanced Hybrid™ was extremely efficient, removing all the measured trace elements with the exception of the vapor-phase mercury. In an attempt to get a measurable quantity of trace elements, the filters from the EPA Method 17 samples were analyzed. The EPA Method 17 sample trains were operated for 12 hours, compared to only two for the EPA Method 29 trains. For all three samples taken at the stack, the trace elements, again with the exception of mercury, was at or below detection limits.

Mass Balances

In addition to the EPA Method 17 samples, fly ash samples were also taken from the hopper of the pilot-scale Advanced Hybrid™ that was running at the time. These samples were analyzed for major and trace elements as shown in Tables 12 and 13. The trace element analyses results from the ash samples compared quite well with those obtained from EPA Method 17 samples from the full-

Table 8. Analyses of Trace Elements in Flue Gas at the Advanced Hybrid™ Inlet^{1,2}

Day	11/19/02			11/20/02			11/20/02		
Time	10:50			09:30			13:37		
Fuel	PRB, TDF, and Corn Seed			100% PRB			100% PRB		
Trace Element	Part.-bound, $\mu\text{g}/\text{Nm}^3$	Vapor-Phase, $\mu\text{g}/\text{Nm}^3$	Total, $\mu\text{g}/\text{Nm}^3$	Part.-bound, $\mu\text{g}/\text{Nm}^3$	Vapor-Phase, $\mu\text{g}/\text{Nm}^3$	Total, $\mu\text{g}/\text{Nm}^3$	Part.-bound, $\mu\text{g}/\text{Nm}^3$	Vapor-Phase, $\mu\text{g}/\text{Nm}^3$	Total, $\mu\text{g}/\text{Nm}^3$
Antimony	26.7	0.5	26.7	17.6	0.7	17.6	15.0	0.6	15.0
Arsenic	53.5	2.0	53.5	48.0	2.6	48.0	51.5	2.5	51.5
Beryllium	2.9	0.5	2.9	6.4	0.7	6.4	2.7	0.6	2.7
Cadmium	7.5	0.2	7.5	5.3	0.2	5.3	4.9	0.2	4.9
Chromium	49.4	1.4	50.8	49.4	0.6	50.0	66.0	1.6	67.6
Lead	251.5	4.2	255.7	215.9	2.1	218.0	210.9	3.0	216.9
Mercury	3.2	4.5	7.7	2.3	7.4	9.7	6.8	7.7	14.5
Nickel	228.5	3.2	231.7	191.7	4.3	196.0	170.2	3.7	173.9

¹ Shaded results are below detection limits. The shown values are the detection limits. Those results that are below detection limits are not added to calculate the total concentrations.

² Particulate-bound trace elements were based on the filters of the EPA Method 17 samples.

Table 9. Analyses of Trace Elements in Flue Gas at the Stack¹

Day	11/19/02			11/20/02			11/20/02		
Time	11:08			09:25			13:25		
Fuel	PRB, TDF, and Corn Seed			100% PRB			100% PRB		
Trace Element	Part.-bound, $\mu\text{g}/\text{Nm}^3$	Vapor-Phase, $\mu\text{g}/\text{Nm}^3$	Total, $\mu\text{g}/\text{Nm}^3$	Part.-bound, $\mu\text{g}/\text{Nm}^3$	Vapor-Phase, $\mu\text{g}/\text{Nm}^3$	Total, $\mu\text{g}/\text{Nm}^3$	Part.-bound, $\mu\text{g}/\text{Nm}^3$	Vapor-Phase, $\mu\text{g}/\text{Nm}^3$	Total, $\mu\text{g}/\text{Nm}^3$
Antimony	<2.1	<0.5	ND ²	<2.2	0.5	ND	<2.2	0.5	ND
Arsenic	<1.4	<1.8	ND	<1.5	1.9	ND	<1.5	<1.9	ND
Beryllium	<0.7	<0.5	ND	<0.7	0.5	ND	<0.7	0.5	ND
Cadmium	<0.05	<0.1	ND	<0.05	0.1	ND	<0.05	0.1	ND
Chromium	<0.05	0.4	0.4	<0.05	0.5	0.5	<0.05	0.5	0.5
Lead	2.5	1.5	4.0	<1.5	1.4	1.5	<1.5	<1.0	ND
Mercury	<0.05	5.4	5.4	<0.05	6.1	6.1	<0.05	6.5	6.5
Nickel	<0.05	3.0	3.0	<0.05	1.7	1.7	<0.05	1.0	1.0

¹ Shaded results are below detection limits. The shown values are the detection limits. Those results that are below detection limits are not added to calculate the total concentrations.

² ND (not detected) is defined as those results where both forms of the trace element are below detection limits.

scale unit. Some of these trace elements such as beryllium and chromium are very refractory and a large percentage of the total amount measured in the coal is expected to be in the bottom slag which was not analyzed. This was the case as the percentage of beryllium and chromium found in the ash compared as a function of that predicted by the coals was, 13.1% and 6.3%, respectively. The one element that would be predicted to be almost all (>99%) vaporized is mercury. Based on the average coal concentration, F_d factor, and the heating value of the coal, the mercury in the flue gas is predicted to be $12.3 \mu\text{g}/\text{Nm}^3$ on a dry basis, the actual measured concentration is $9.7 \mu\text{g}/\text{Nm}^3$ or a balance of 78.8%. It is also interesting to note that the antimony concentration in the coal was below detection limits but was measured in the fly ash both for both the pilot-scale and full-scale units. Using the detection limit of $0.1 \mu\text{g}/\text{g}$ in the coal, the F_d factor, and the heating value of the coal the

Figure 2. Respirable mass measurements at the stack of the Big Stone Power Plant for November 19, 2002.

Figure 3. Respirable mass measurements at the stack of the Big Stone Power Plant for November 20, 2002.

Figure 4. Respirable mass measurements at the stack of the Big Stone Power Plant for November 21, 2002.

Figure 5. Particulate mass distribution at the Advanced Hybrid™ inlet based on mutlicyclone measurements.

Figure 6. Particulate mass distribution at the stack based on an impactor measurement.

Table 10. Field Blank Results for EPA Method 29 Samples

Trace Element	Day 1		Day 2	
	μg	$\mu\text{g}/\text{Nm}^3*$	μg	$\mu\text{g}/\text{Nm}^3*$
Antimony	<0.05	<0.04	<0.05	<0.04
Arsenic	<2	<2	<2	<2
Beryllium	<0.5	<0.4	<0.5	<0.4
Cadmium	<0.15	<0.12	<0.15	<0.12
Chromium	0.23	0.19	0.20	0.16
Lead	3.5	3.1	3.1	2.5
Mercury	0.16	0.13	0.10	0.08
Nickel	0.85	0.69	<0.5	<0.4

*The gas concentration is calculated on the average volume of gas sampled for all the EPA Method 29 samples (1.227 Nm^3).

maximum concentration of antimony to the Advanced Hybrid™ is $19.7 \mu\text{g}/\text{Nm}^3$. With the exception of one data point, all the measured concentrations in the ash for both the pilot- and full-scale units are just below the maximum value. Table 13 presents the major element analysis for one of the 100% PRB ashes. Also shown in Table 13 is the LOI for the three ashes.

Table 11. Comparison of the Concentration of Trace Elements at the Advanced Hybrid™ Inlet and Stack^{1,2}

Day	11/19/02		11/20/02		11/20/02	
Time	11:08		09:25		13:25	
Fuel	PRB, TRF, and Corn Seed		100% PRB		100% PRB	
	Advanced Hybrid™		Advanced Hybrid™		Advanced Hybrid™	
Trace Element	Inlet, lb/10 ¹² Btu	Stack, lb/10 ¹² Btu	Inlet, lb/10 ¹² Btu	Stack, lb/10 ¹² Btu	Inlet, lb/10 ¹² Btu	Stack, lb/10 ¹² Btu
Antimony	15.8	ND ³	10.4	ND	8.9	ND
Arsenic	31.7	ND	28.4	ND	30.5	ND
Beryllium	1.7	ND	3.8	ND	1.6	ND
Cadmium	4.4	ND	3.1	ND	2.9	ND
Chromium	30.1	0.2	29.6	0.3	40.0	0.3
Lead	151.3	2.4	129.0	0.9	128.4	ND
Mercury	4.6	3.2	5.7	3.6	8.6	3.8
Nickel	137.1	1.8	116.0	1.0	102.9	0.6

¹ All values shown are calculated based on Tables 8 and 9 and the Fd factor shown in Table 5 for 100% PRB.

² ND (not detected) is defined as those results where both the gas-phase and particulate bound forms of the trace elements are below detection limits.

Table 12. Trace Element Analyses of Pilot-Scale Advanced Hybrid™ Hopper Ash

Date	11/18/02		11/19/02		11/20/02	
Trace Element	µg/g	µg/Nm ³ *	µg/g	µg/Nm ³ *	µg/g	µg/Nm ³ *
Antimony	6.7	14	6.3	14	6.9	15
Arsenic	19	41	20	43	21	45
Beryllium	1.9	4.1	2.2	4.72	1.9	4.08
Cadmium	2.1	4.5	2.1	4.5	2.1	4.5
Chromium	20	43	24	51	28	60
Lead	78.7	169	77.5	166	84.0	180
Mercury	0.655	1.41	0.564	1.21	0.551	1.18
Nickel	95	204	93	199	84	180

* The gas concentration is calculated on an average dust loading of 0.93664 gr/scf to the Advanced Hybrid™ hopper (from EPA Method 17 samples on full-scale unit).

CONCLUSIONS

From the data, the primary conclusion was that the Advanced Hybrid™ technology is extremely efficient in removing particulate matter. The particulate efficiency is substantially better than the designed basis of 99.990%. The average particulate collection efficiency was 99.997%. The outlet dust loading was almost an order of magnitude lower than the proposed limit of 0.002 grain/scf. As would be expected from a concept that provides ultra-high collection efficiency for particulate matter, the Advanced Hybrid™ Filter removed those trace elements associated with the particulate matter at very high efficiencies as well. As measured at the stack, all trace elements, with the exception of mercury, were near or below detection limits.

Table 13. Elemental Analysis of Advanced Hybrid™ Pilot-Scale Hopper
Ash, 100% PRB Coal

Date Sampled	11/18/02	11/19/02	11/20/02
Oxide	%	%	%
SiO ₂		20.9	
Al ₂ O ₃		16.1	
Fe ₂ O ₃		7.30	
CaO		34.8	
MgO		5.93	
Na ₂ O		3.14	
K ₂ O		0.80	
P ₂ O ₅		2.87	
TiO ₂		1.58	
BaO		1.18	
MnO		0.07	
SrO		0.53	
SO ₃		4.83	
LOI	0.86	0.72	1.11
Cu, mg/kg		370	
V, mg/kg		300	
Zn, mg/kg		2170	

B25 E-mail from Stan Miller on soybean burn

Effect of Soy Bean Burning on AH performance

Page 1 of 1

Hrdlicka, Thomas

From: Miller, Stanley J. [smiller@undeerc.org]

Sent: Friday, April 11, 2003 11:07 AM

To: Swanson, William; Hrdlicka, Thomas; Rich Gebert (rgebert@wlgore.com); Dwight R. Davis (ddavis@wlgore.com); Craig Rinschler (P.E.) (crinschl@wlgore.com); Rick Bucher (rbucher@wlgore.com)

Cc: Jones, Michael L.; Olderbak, Michelle

Subject: Effect of Soy Bean Burning on AH performance

I received two samples from Rich of ash brushed from the bags removed in the full-scale Big Stone AH in November and March. Our first XRF analysis shows the November potassium level to be 0.4% compared to 3.2% for the March bag sample. Keep in mind that these samples would likely be a mixture of the entire dust cake going back to start up so at times the actual potassium level of additional ash on the surface may be much higher. The sulfate level was also much higher for the March sample. We are doing some additional scanning electron microscopy analysis of undisturbed ash from a bag sample which may provide further insight as to the effect of the high potassium levels.

I also looked at the pilot-scale data from February and saw an immediate increase in residual drag and decrease in bag cleaning interval on Feb 4, which is the day when there was a large increase in the amount of waste seeds being burned. The pilot unit was operated until Feb 11, but much of the operation was with single bank and a short pulse interval. However, before shutting down, we operated for about a day in baseline conditions again. By this time the residual drag and bag cleaning interval had deteriorated even more. The waste seed rate feed rate from Feb 5 to 11 was 260 to 315 tons per day. From Feb 12 until Feb 23 the seed feed rate was increased significantly and was over 800 tons per day from Feb 21 to 23.

All of this points to the waste seed burning as having a significant negative effect on the pressure drop.

It should also be noted that in the EERC small-scale pilot tests in January, we saw higher pressure drop when we increased the rate of TDF up to 10%. This is higher than the 5% that is occasionally burned at Big Stone, but it is another indication that alternative fuel burning can have a very negative effect on the pressure drop.

I suggest that all waste seed and TDF burning be stopped at the plant, at least until the pressure drop issues are solved. This is especially important for the time immediately after washing the bags. It may be shown in the future that a level of alternative fuels can be tolerated, but for the near term if we are looking for all ways to minimize pressure drop, it seems to be the way to go.

I will be out of the office on vacation from April 14 through 22, but can be reached if necessary.

Thanks,

Stan

B26 Photographs of pitot tube equipment

B27 Specific pitot tube information

Pitot Tube in a Filter Bag, Gas Flow Measurement Device Big Stone Application with 19 inch Spacing between Blowpipe and Tubesheet

Revised on May 28, 2003

Material List

Material	Size	Quantity
304 stainless steel tubing	ID 0.12 inch, OD 0.25 inch x 0.065 inch wall Length of each piece 40 inch	10
U bolt clamp steel	3.0 inch diameter steel pipe with 3.5" O.D. Bolt spacing 4.0 inch McMaster-Carr # 3042T21	10
Aluminum or steel angle for Plate Mount	1.5" x 2.0" x 12" x 0.25"	10
Aluminum or steel bar for Plate Clamp	1.5 " x 6" x 0.25"	10
Steel Bolts	5/16 x 18 x 1.25"	20
Steel locking nuts (optional)	5/16 x 18 steel locking	20
Flat steel washers	5/16	20
Flat steel washers	3/8	20
Steel locking nuts (for 500F), (optional)	3/8 steel locking	20

Instructions:

304 stainless steel tubing

- Cut to 40 inch length
- Create round nose on one end (radius of 0.100-0.125 inch) from center of tubing
- Make 2 bends in same plane ,45 degrees each, as per drawing .
- First bend 45 degrees 10 inches from Nose of tubing
- Second bend 45 degrees 10 inches from previous bend in opposite direction.
- With tubing cutter cut and trim end of tubing for compression fitting

Aluminum or steel angle for Plate Mount 1.5" x 2.0" x 12" x 0.25"

- Drill 2 through holes oversize for 3/8 inch diameter U bolt.
- Drill 2 through holes over size for 5/16 x 18 bolts
- Machine groove (0.125 inch radius) to (0.080 inch depth) for ¼ inch OD tubing

Aluminum or steel bar for Plate Clamp 1.5 " x 6" x 0.25"

- Drill 2 through holes over size for 5/16 x 18 bolts
- Machine groove (0.125 inch radius) to (0.080 inch depth) for ¼ inch OD tubing

Bag Flow Pitot Tube Measurement Device

Tubing – Pitot Tube

304 stainless steel tubing 40 inch length

- Create round nose on one end (radius of 0.100-0.125 inch) from center of tubing
- Make 2 bends in same plane ,45 degrees each, as per drawing .
- First bend 45 degrees 10 inches from Nose of tubing
- Second bend 45 degrees 10 inches from previous bend in opposite direction.
- Debur opposite end of tubing for compression fitting

Bag Flow Pitot Tube Measurement Device

Plate Mount

Aluminum or steel angle for Plate Mount
1.5" x 2.0" x 12" x 0.25"

1. Drill 2 through holes and oversize for 3/8 inch diameter U bolt.
2. Drill 2 through holes and over size for 5/16 x 18 bolts
3. Machine groove (0.125 inch radius) to (0.080 inch depth) for 1/4 inch OD tubing

Bag Flow Pitot Tube Measurement Device

Plate Clamp

Aluminum or steel bar for Plate Clamp 1.5" x 6" x 0.25"

4. Drill 2 through holes over size for 5/16 x 18 bolts
5. Machine 0.125 inch radius groove 0.080 inch depth for 1/4 inch tubing

B28 Specific Pitot Tube Placement on Bag Layout Diagram

Advanced Hybrid bag layout Big Stone Plant

B29 Photographs of pitot tube transmitters

April 29, 2003

Big Stone Plant
AHPC Bag Wash

OK, these are Confined Spaces,
everyone sign on the Permit

Work begins – Blowpipe removal

Safety – Make sure the TR Set is
Grounded out

Blowpipe's out

Drilling access holes for the wash (126 of em')

The Wash headers standby - Ready for Service

Getting ready to wash – Setting up the hoists

Crews preparing to enter the Gas path compartments

AHPC Wash

- Building staging in the first compartment.

Looking straight up – staging
built in compartment A

Guide bar removal

Winching system set for action

Wash header in place ready for
hoisting

Hoisting the wash rack

B31 POPR Test Results

POPR @ 12h 0m 0s

B32 Humidification Test Results

B33 Fluent Study

Background

The Advanced Hybrid Particulate Collector (AHPC) is a novel technology that combines the best features of electrostatic precipitators and fabric filters. Demonstration of a full-scale retro-fit of the AHPC technology is taking place at the $450MW_e$ coal-fired Big Stone power plant near Milbank, SD. The full-scale unit is demonstrating consistent high particulate collection efficiencies ($>99.99\%$) that far exceed that of a conventional electrostatic precipitator (ESP). However, the demonstration unit does experience problems with higher than expected pressure drops (Δp) and substantial variations in particle loading. These problems have lead to: (i) lowered power production due to limitations of the existing fan capacity and (ii) rapid cleaning frequency for the fabric filter bags.

The US Department of Energy (NETL), Otter Tail Power Company (who operates the Big Stone plant), and the parties involved in developing the AHPC technology are discussing several short and long term modifications to overcome the abovementioned problems. Since the uneven loading of fabric filter bags is believed to be largely a flow distribution problem, Fluent Inc. has been commissioned to propose a set of Computational Fluid Dynamics (CFD) studies to assist in the implementation of design modifications that ensure a better distribution of flow in the unit.

This technical memorandum is a project deliverable for this preliminary study. It presents a problem analysis and conclusions in the form of proposed CFD studies of the Big Stone AHPC unit.

Description of Big Stone AHPC Unit

The AHPC installation at Big stone consist of four parallel chambers retrofitted downstream of an existing ESP. Each chamber holds one existing ESP field and three AHPC filter compartments. Figure 1 gives a schematic representation of this arrangement. The AHPC compartments have 20 rows with 21 fabric filter bags each¹. Electrostatic charge electrodes are suspended between the rows of bags, with perforated collecting plates separating the fabric filter and ESP zones.

Figure 1: Big Stone AHPC unit. Arrows indicating assumed flow patterns.

¹ This translates to $3 \times 20 \times 21 = 1260$ bags per chamber.

As the old ESP unit is 40ft tall and the new AHPC compartments take up less height (24ft), flow may reach the compartments by way of the space below the retrofitted parts. From there, flow may either enter the ESP zones directly or via the spacing that separates the individual compartments. Thus, flow may enter the individual AHPC compartments from three directions: front, bottom, and back. To maximize the efficiency of the build-in ESP zones, it is desirable to have stratified flow (from one direction) with a reasonable residence time between the collecting plates. Furthermore, localized high velocities and turbulence levels should be avoided in order to prevent re-entrainment of fly ash.

Figure 2: Schematic bottom-view of filter sections. Pictured is an ESP section bounded by two bag rows and their guide rails.

An additional flow-related problem is that of potential *gas sneaking*, i.e. flue gas bypassing the ESP zone and entering the filter bag sections directly. This is an undesired phenomenon, made possible by the lack of a physical separation at the bottom of the filter bag sections.² Gas sneaking will lead to higher particle loading of the filter bags, and so may be a contributing factor to the quick dustcake build-up being observed.

Proposed CFD studies

In the following, an overview of the proposed flow modeling of the Big Stone AHPC unit is presented. It is suggested to split this work into three distinct tasks:

1. Modeling of overall flow distribution in the *existing* unit
2. Modeling of overall flow distribution in the *modified* unit
3. Detailed modeling of simplified filter compartment

Tasks 1 and 2 will aim at respectively understanding and correcting the overall flow in an entire chamber, while Task 3 will address the abovementioned phenomenon of gas sneaking by means of a detailed CFD model for part of an advanced hybrid compartment. In the following, the technical approach for each of these tasks will be explained in more detail. Finally, Section 4 summarizes work effort, deliverables, and a time schedule for the proposed tasks.

² Metal disks block the bottom of filter bags and there is a set of two guide rails per bag row. A simple analysis shows that this leaves approximately half the surrounding face open to up-coming flow.

TASK 1: Simulation of existing AHPC design

This task aims at predicting overall flow patterns in the existing Big Stone AHPC unit. The CFD simulation will provide information on the directional partitioning of flow entering the individual AHPC compartments, and will help spot regions with localized high velocities that may have a detrimental effect on ESP performance. The insight into flow patterns gained from this task, may serve in the development and refinement of flow correcting design modifications. The impact of these design modifications will subsequently be evaluated in Task 2.

While designing the AHPC retrofit for the Big Stone power plant, Elex AG conducted CFD simulations of a full chamber, similar to what is proposed as Task 1 here. At that time, the model size was severely limited by the available computer resources.³ However, the Computer Aided Design (CAD) model developed in that context will serve as a good starting point for the current effort. Section 1.1 outlines the CFD modeling approach, and explains the improvements over the Elex model that we intend to implement.

1.1 Modeling approach

The advanced hybrid filter is a complex system both in terms of geometry and involved physics, for which reason certain simplifications are necessary. As regards physical modeling, simulations will consider isothermal single-phase gas flow. That means, no attempt will be made to model the entrainment of fly ash particles in the flue gas. At the same time this relieves any need to include models for the electro-magnetic field and charge-carrying ability of ash particles. Most coal-derived flue gases are sufficiently dilute to warrant the assumption that the presence of particles does not influence the gas flow.

The pressure drop across the thin fabric filter membranes is modeled using a porous jump condition in the Fluent CFD code. The thin porous medium has a finite thickness over which the pressure change is defined by a combination of Darcy's Law and an additional inertial loss term.

$$\Delta p = - \left(\frac{\mu}{\alpha} v + C_2 \frac{1}{2} \rho v^2 \right) \Delta m \quad (1)$$

where μ is the molecular fluid viscosity, α is the medium permeability, C_2 is the pressure-jump coefficient, v is the velocity normal to the porous face, and Δm is the medium thickness. Parameters for the porous jump model will be assigned values based on existing measurements of filter bag pressure drops. For the purpose of overall flow modeling (Tasks 1 and 2), the pressure drop across the perforated collecting plates and the fabric filters are lumped. This means that a simple rectangular box represents one row of filter bags and the plates bounding it.⁴

1.1.1 Geometric modeling and meshing

The first step will consist in modifying the existing CAD-model so that it corresponds more accurately to the actual retrofit geometry. Here is a commented list of the geometry changes that will be implemented:

³ Simulations were carried out using Fluent 5.5 on a 500 MHz Pentium III processor with 1 Gb memory.

⁴ The slender rectangular boxes have porous sides (exception being the outermost bag rows in each compartment that have one solid side), a porous bottom, a solid front and back, and an open top face leading to the clean gas plenums.

- Add collecting plates for old ESP field

The original ESP remains in operation, but its collecting plates were not contained in the existing CFD model. However, these solid plates (spaced 1 ft apart), are poised to efficiently stratify the gas flow in its approach to the AHPC compartments. The plates will be modeled as solid walls of infinitesimal thickness.

- Remove girdles from two rear AHPC compartments

In the CFD model created by Elex, there is a 400 mm high rectangular plate placed perpendicular to the direction of the incoming flow just below the front of each AHPC field. This component (referred to as a girdle) is related to the rapping system that cleans dust of the collecting plates. However, in the actual Big Stone retrofit there is only one such girdle placed in connection with the first AHPC compartment.

- Include catwalk floor in model.

A further assesment is necessary to determine whether the model should be augmented with porous faces representing the floor of catwalks. There is one long grated walkway in the space behind each AHPC compartment. The actual flow blockage from these catwalks is most likely fairly modest, but they are placed in potentially critical spots and their presence may have localized effects in the corners of filter compartments.

Figure 3: Computational mesh from existing CFD model.

The Elex CFD model used a mesh discretization with approximately 1.5 million computational cells, see Figure 3. Approximately 2/3 of these cells were used to describe the three AHPC compartments. The computer resources available to Elex made it infeasible to further increase mesh resolution, although it remained relatively coarse inside the compartments.⁵ For the proposed work, use of parallel processing on the extensive computing clusters at NETL in Morgantown will enable an expansion of the model size by a factor of 2-3. Our preliminary investigations indicate that this would be sufficient to resolve the actual geometry of the individual filter bags, but it is our recommendation not to do so but rather to maintain the porous box approach with a finer mesh. The filter bag geometry will be considered in the proposed Task 3.

In contrast to the Elex mesh that consisted of 100% tetrahedral cells, we will be employing hexahedral meshing in as far as possible. Because of the spatial interpolation schemes involved in CFD this will achieve a higher solution accuracy. Moreover, a hexahedral mesh typically has significantly lower cell count than a comparable tetrahedral one.

1.1.2 Boundary conditions

Current theories on gas flow patterns inside a hybrid filter chamber, see Figure 1, were developed based on Pitôt tube data collected inside a chamber at the Big Stone power plant. These measurements, which may be correlated to the flue gas dust loading, were performed at three locations in each AHPC compartment: front, middle, and back. It is our intent to incorporate this measured data by implementing variations in the Δp characteristics (porous jump conditions) that model the pressure drop over filter bags.

All boundary conditions will be re-visited in cooperation with the power plant and technology developers to ensure consistency with the real operating conditions at Big Stone. In comparison with the Elex CFD model, the following changes in the handling of porous jump faces will be implemented.

- Lengthwise splitting of porous jump faces

Each of the large porous faces that separate the ESP zones from the filter bag zones will be sub-divided into three zones. Since a variation in Δp over one porous jump face cannot be assigned in Fluent, this sub-division is necessary to allow for variation. The resulting three zones may subsequently be assigned individual jump conditions based on the abovementioned Pitôt data from the front, middle, and back of that compartment. Other subdivisions are possible, but only make sense whenever matched by data.

- Define porous bottom of filter bag zones

Change the bottom of filter sections from a solid to a porous face. Notice the conditions for this face must also contain the (dominant) pressure drop across the fabric filters.

- Catwalk floor porosity

If it is chosen to include the grated walkways in the CFD model, empirical expressions for the induced pressure drop must be taken from literature and implemented.

⁵The ESP sections were described using only one cell across the width, while two cells were used inside the porous box that represents a row of bags.

1.1.3 Simulations

We propose to initially perform two different simulations: (a) with a uniform pressure drop across all filter bag sections (this corresponds to the Elex model with geometric modifications only), and (b) with a variation in pressure drop that reflects the measured data better. A comparison between these two simulations will reveal how sensitive the overall flow distribution is to perturbations in the prescribed pressure drop conditions. The filter membranes are by far the biggest source of frictional resistance in the entire unit, so logically one would expect these particular boundary conditions to have a significant impact on the distribution of flue gas flow.

After completing these initial CFD simulations, a comparison will be made between predicted and measured flow rates through the individual clean gas plenums. If the split of flow between compartments is predicted with reasonable accuracy, this helps build confidence in the simulations. Another option for model validation is to do additional velocity measurements, preferably by traversing the chamber-width at a position below or in between hybrid compartments. The recorded velocity profile may then be compared with simulation results.

A third simulation (c) will investigate the importance of the inlet velocity profile. In this simulation, an artificially skewed velocity profile will be assigned at the model inlet. This is in contrast to the uniform inlet profile applied in cases (a) and (b). Quite possibly the narrowly spaced collecting plates of the old ESP field may annul this perturbation in inlet velocities. However, should a significant change in flow distribution result there is reason to consider building a separate CFD model that considers the flow manifolding from the air preheater to the four AHPC chambers.⁶

1.1.4 Post-processing

Postprocessing of simulation data will produce a collection of plots that describe the chamber flow pattern. Moreover, the directional partitioning of flow *into* each AHPC compartment (from the front, back, and bottom respectively) will be quantified. This data will help confirm or modify the current hypothesis on flow distribution, which will briefly be outlined under Task 2. Due to the geometric simplifications in representing the filter bag rows, care should be exhibited in interpreting flow patterns *within* the AHPC compartments. The detailed model, proposed as Task 3 of this effort, will provide a much better basis for such interpretations.

⁶ Incidentally, such a study might help explain some of the variation that exists between the performance of the four parallel filter chambers. It is currently thought that this variation results from variations in chamber temperatures that impact the ESP performance.

1.2 Estimated work effort for Task 1

Table 1 gives an estimate of the work hours involved in Task 1. Sub-tasks correspond more or less to the previous sections.

TASK 1 : Modeling of *existing* unit

Sub-task	Task description	Work effort [h]	Comments
1.1	Geometric modeling and meshing	80	
1.2	Boundary condition setup	40	
1.3	Simulations	90	Simulations (a), (b), and (c)
1.4	Post-processing	30	
TOTAL		240 h	

Table 1: Estimated man-hours for carrying out the proposed Task 1

TASK 2: Simulation of design modifications

This task will determine the effect of two simple design modifications that both aim at improving the flow patterns in the Big Stone AHPC. Based on the already mentioned Pitôt tube measurements, the AHPC technology developers have formed a theory on the gas flow dynamics of this unit, see Figure 1. For the first AHPC compartment, it is believed that gas enters mostly from the front and flows towards the back while gradually effusing via the collecting plate perforations. In the two rear compartments, flow seems to enter the ESP zones from multiple directions (front, back, and bottom). The flow simulations of the existing unit will help confirm or refine this understanding, so that it is advisable to revisit the suggested design modifications after completion of the Task 1.

2.1 Suggested design modifications

As mentioned earlier, electrostatic precipitation will generally benefit from a uni-directional gas flow in the electro magnetic field between the collecting plates. For this reason, design modifications should first and foremost attempt to alter flow in the two rear compartments, where cross- and counter-flow is believed to be most prevalent. After consulting with the AHPC developers, it is proposed to investigate the following two design modifications:

A Installation of steel plates on the end of all AHPC compartments

The gas flow in this configuration can enter the ESP zone from the front or bottom of fields. This measure reduces the possible routes that the gas may travel. A simulation will reveal whether this results in a more uniform gas distribution or not.

B Installation of steel plates on both ends of the two rear AHPC compartments

In this configuration the first AHPC field remains unchanged, while gas flow can only enter the rear fields from the bottom. This should ensure similar pat-

terns in the two affected fields, but may increase problems with gas sneaking and may also cause significant lengthwise variations in the loading of the individual bags.

These two design modifications may have to be implemented in conjunction with a deflector system to limit gas sneaking from the bottom. This will be addressed by the detailed study of a compartment in Task 3. From a CFD perspective, the abovementioned design changes can be easily implemented in the model from Task 1; accomplished by a change in boundary conditions rather than geometry. In both cases it is also possible to investigate the use of perforated rather than solid plates. For both design studies, we will determine the directional re-partitioning of flow and also report any regions of high velocity or turbulence intensity.

2.2 Estimated work effort for Task 2

As this Task makes use of the CFD model developed under Task 1, a faster turn-around time can be expected for this second task. Estimates are given in Table 2.

TASK 2 : Modeling of *modified* unit

Sub-task	Task description	Work effort [h]	Comments
2.1	Model modification	25	Design studies A and B
2.2	Simulations	60	
2.3	Post-processing	20	
TOTAL		105 h	

Table 2: Estimated man-hours for carrying out the proposed Task 2

TASK 3: Detailed Modeling of Filter Compartment

With this task it is proposed to build a separate CFD model, which consider a portion of a filter compartment with a more refined geometry representation. This model is intended to predict flow details that cannot reasonably be described by the overall CFD model (Task 1). Most importantly, it will shed light on the sneaking ratio, i.e. the fraction of flow that bypasses the ESP section and instead enters the filter bag sections vertically. The model can also be used to assess deflector arrangements to reduce sneaking.

3.1 Modeling approach

The model will comprise a layer-wise arrangement of three full bag rows and four ESP zones, see Figure 4. Symmetry boundary conditions will be prescribed at the two model boundaries that cut through the center of an ESP zone. This configuration emulates a sub-domain inside a larger compartment, where the inclusion of several bag rows aims at limiting boundary effects. Flow will exit the model via an artificially defined plenum that receives gas from the bags.

Figure 4: Detailed model of hybrid compartment. Shown discharge electrodes not modeled.

The inlet flow condition will be prescribed in terms of a uniform velocity from the bottom, which may be either vertical or at an angle. The exact velocity magnitude and direction will be estimated based on the flow simulations for the overall chamber (Task 1 and 2). Variations in the approaching flow will exist depending on what part of a compartment you consider. The sensitivity in modeling results can be assessed by computing the sneaking ratio for a series of detailed model simulations with changes in the inlet velocity direction and/or magnitude.

The perforated collecting plates and the individual bags (3×21 in the model) will be modeled using different porous jump conditions, see section 1.1. The flow resistance of the perforated plates will be derived from an empirical relation, and should be significantly lower than the flow resistance of the bags.

3.2 Design studies

The second part of Task 3 will be a design study, considering the impact of equipping bag rows with a deflector arrangement to limit gas sneaking. An example of such a bag deflector can be seen for the right bag row in Figure 4. The exact deflector design will be provided later by the AHPC technology developers. Simulations will be performed for the same set of inlet conditions that was used in subtask 3.1. While it will be difficult to experimentally verify the predicted sneaking ratios, it is believed that the outlined CFD models (with and without deflectors) will predict trends with confidence.

3.3 Estimated work effort for Task 3

TASK 3 : Detailed Flow Simulation

Sub-task	Task description	Work effort [h]	Comments
3.1	Geometric modeling and meshing	60	From scratch
3.2	Boundary condition setup	20	
3.3	Simulations	50	Varying inlet conditions
3.4	Post-processing	20	
3.5	Design variation studies	60	Bottom deflector plate
TOTAL		210 h	

Table 3: Estimated man-hours for carrying out the proposed Task 3

4 Deliverables and Schedule

A strategy for the deployment of CFD modeling to assist in trouble-shooting of the AHPC unit at Big Stone power plant has been outlined. This section will summarize deliverables, estimated work effort, and present a time schedule for completion of the proposed tasks.

4.1 Project Deliverables

Project progress will be reported on a monthly basis in a short written status report. After successful completion of the project, **Fluent Inc.** will deliver the following items:

- Report summarizing CFD results from modeling of overall chamber flow (Tasks 1+2).
- Report summarizing results from detailed modeling of a filter compartment (Task 3).
- Fluent case/data files for all completed simulations.

4.2 Project time schedule

The specific breakdown into tasks and an estimate of the engineering hours have been compiled in Table 4.

Task	Task description	Work effort [h]
1	Modeling of overall flow distribution in the <i>existing</i> unit	240
2	Modeling of overall flow distribution in the <i>modified</i> unit	105
3	Detailed modeling of simplified filter compartment	210
TOTAL		555 h

Table 4: Summary of estimated man-hours for all tasks

Figure 5 shows the time schedule for completion of the specific subtasks. This chart has been based on work commencing October 1st 2003. As it appears, the total elapsed time

to complete the project is expected to be six months. While Tasks 1 and 2 are essentially sequential activities, the schedule for completion has been accelerated by working on Tasks 1 and 3 in parallel.

Figure 5: Projected timeline for completion of proposed tasks.

B34 Proposal for flow Baffles

Advanced Hybrid™ Filter

Proposed Filter Bag Bottom Flow Restriction Baffle Design

To:

John Caine SEI

Ulrich Leibacher ELEX

Peter Studer ELEX

From:

Rich Gebert W.L. Gore

September 30, 2003

Expanded end view of the bottom of the filter bag and the proposed flow deflector

Dimensions

- The drawings and information contained in this proposal are to be used as a guide for the design of the flow deflector plates.
- The bag guides or rectangular tubing dimensions based on the ELEX drawings are: 30 mm wide by 50 mm high by 4570 mm in length and are placed 15 mm from the bags and 26 mm from the collecting plates.
- The bag diameter is 155 mm and they are spaced 200 mm on center down the row with 21 bags per row creating a 4.2 meter length of bags.
- The proposed steel sheet deflector plates are designed to reduce the amount of gas flow that passes between the filter bags in the bag row and between the ESP collecting plates.
- The steel sheet 14 - 16 gauge can be spot welded, stick or mig welded to the bag guide rail.
- The downward angle is 60-70 degrees to allow the collected dust to fall into the hopper and the minimum clearance between the two plates must be 50 mm.
- Plate #1 at 60 degrees comprises 125mm of vertical section and a 220mm length at 60 degrees. The overall area is 1.4 sqmeter (51 sqft).
- Plate #2 at 70 degrees has 125 mm vertical section and 385 mm of sheet at 70 degrees at length of 4.2 meters. The overall area is 2.14 m2 (75 sqft).
- The area and weight of these plates for 16 gauge steel is 127 lbs and 187 lbs which may be in excess for the structural design limits.

B35 Photograph of Bag wash of original bags in Big Stone turbine bay

B36 Photograph of bag row baffles prior to installation on Advanced Hybrid walkway

B37 W.L. Gore Report on Bag Analysis

Full scale *Advanced Hybrid*TM Filter Big Stone Demonstration Operation Site Filter Bag Analysis

Date: September 4, 2003
Prepared By: Dwight Davis and Rich Gebert

Background:

Plant Location: Otter Tail Power Company, Big Stone City, South Dakota
Filter Bag Type: GORE-NO STAT[®] filter bags (GORE-TEX[®] membrane conductive/GORE-TEX[®] felt)
Bag Diameter: 6.0 inch
Length: 7 meter
Air/Cloth: 10 to 12 fpm
Dust Type: Fly Ash from Coal-Fired Boiler
Coal Type: Eagle Butte, Belle Ayr Mine; Western Sub-bituminous

GORE-NO STAT[®] filter bags were installed and pre-coated prior to the October 25, 2002 start-up of the full scale *Advanced Hybrid*TM Filter at Otter Tail Power Company's Big Stone Plant located in Big Stone City, SD. The unit remained in operation until the Big Stone Plant shutdown for a boiler wash on February 26, 2003. Operation resumed on March 2, 2003, with five conductive GORE-TEX[®] membrane on conductive polyphenylene sulfide (PPS) felt filter bags installed in Compartment 12. The PPS bags replaced the original filter bags in cross row 21, positions 1,4,6,7 & 10 (see bag locator chart in the appendix). During the February boiler wash 40 pitot tubes were also installed in compartments 7,8,9,10,11,and 12 for measuring air flow from individual filter bags. On April 26th and May 8th, chambers 2B and 1A respectively, filter bags were washed in place by Big Stone plant personnel while the Big Stone Plant operated at reduced load. The second boiler wash with a bag change out occurred on June 2, 2003.

As part of the Power Plant Improvement Initiative Big Stone Demonstration site DOE funding program, filter bags were removed for lab analysis when compartments or the entire *Advanced Hybrid*TM Filter were taken off line. Filter bag/s were removed November 9th after 2 weeks of operation, February 28th after 18 weeks of operation, April 12th after the PPS bags experienced 6 weeks of operation, and June 2nd after the PPS bags experienced 3 months of operation.

Filter Bag Evaluation:

A total of seven filter bags were removed over the eight month time period by W.L. Gore and Associates personnel for evaluation purposes. Various tests including; air permeability, felt strength, residual dust cake particle size and elemental analysis, along with visual observations including membrane microscopic

examination were undertaken.

Air Permeability Analysis

The air permeability analysis of the filter bag media was performed in the lab using the Frazierometer. Permeability is the volumetric flow rate of air, measured in cubic feet per minute (cfm) through a square foot of filter media at a pressure differential of 0.5 inches water gauge (w.g.). The unit of measure is cfm/ft² @ 0.5" w.g. and is called the Frazier Number (Fn). Samples of the *Advanced Hybrid*® filter bag media were cut from the top, middle, and bottom bag locations. The sample size was five inches in the vertical bag length direction along the entire circumference of the bag. Typically three measurements per bag sample were taken. An average value is then calculated from the nine measurements per bag. Each sample is tested for permeability in the condition it was received from the field and again in the identical location after lightly brushing the dust cake. See Table 1:

Otter Tail Power Company							
Big Stone Power Plant Improvement Initiative Demonstration Site							
Filter Bag analysis summary chart - All Frazier #s are reported as cfm/ft ² @ 0.5 in.w.g. driving force							
Date installed	Date removed	installed time	Laminate backing	As rec'd (Fn)	After light brushing (Fn)	Flat width ave.(cm)	Mullen Burst (psi)
10/25/2002	11/9/2002	2 wks.	GORE-TEX felt	2.1	4.2		
10/25/2002	3/1/2003	18	GORE-TEX felt	2	4.6		701
10/25/2002	3/1/2003	18	GORE-TEX felt	1.5	4.3		724
3/1/2003	4/12/2003	6	PPS felt	1.4	6.6	24.9	323
3/1/2003	6/2/2003	13	PPS felt	1.8	5.5	24.9	372
3/1/2003	6/2/2003	13	PPS felt	1.7	5	24.9	374
10/25/2002	6/4/2003	32	GORE-TEX felt			24.6	742

Table 1. Test Results Summary Chart

All the filter bags when removed contained a thin layer of dust similar to typical coal fired boiler fabric filter particulate collector applications. This residual filter cake and filter bag media air permeability measurement is shown in the "as received Frazier numbers" column. As the filter bags seasoned, whether the bags consisted of the conductive GORE-TEX felt or conductive PPS felt backing, the differences in the overall permeability of the two types of filter bags narrowed. After light brushing, all the filter bag perms returned to near new levels. It should be noted that when brushing the bags removed March 1st, extra effort was required to remove all the dust off the surface of the bag.

Felt Strength

Mullen burst tests were run on a portion of samples taken for the air permeability measurements. The test consists of applying pressure in the reverse direction of airflow on a three inch diameter filter bag sample, continuously increasing the pressure until the sample is ruptured. The physical strength of new GORE-TEX® felt backed filter bags averaged 650 psi while the PPS felt filter bags averaged 344 psi. As shown with the Mullen Burst test results, both types of filter bags' physical strength has not been weakened due to chemical or thermal attack of the flue gas environment inside the *Advanced Hybrid*™ Filter to date.

Visual and Microscope Analysis

As noted earlier, all the filter bags contained a thin layer of dust cake on the membrane surface, typical of most coal -fired boiler applications. The primary dust cake was easily brushed off the November sampled filter bag and the PPS bags removed in April and June, but required more effort on the bags removed in February. The filter bags were examined for membrane damage from electrostatic discharge or sparking using a microscope - no damage was observed. However, by the February inspection inside the *Advanced Hybrid™* Filter chambers, a portion of the filter bags exhibited wear in two general areas. One located at the center of the bottom disk of the bag, and the second area where the bag occasionally comes into contact with the bottom bag guide rails. The design of the filter bag took into account the expected wear at the bag guide rails incorporating a double layer of material in the bottom cuff.

Samples were taken from two of the filter bags for SEMS and an EDS analysis of the dust layer from the two filter bags removed in February. The results can be found in the APPENDIX. The SEMS indicate the residual flyash dust cake particle size falls in the range of 0.5 to 10 microns. Results from the EDS analyses indicate Potassium's presence in the flyash along with the other expected elements.

A single wrinkle formed on each of the PPS bags indicates some stretching occurred during the operation of the Advanced Hybrid™ Filter. The flat width measurements of these bags reaffirmed the visual observation showing the bags circumference increased roughly 0.9 cm.

Conclusions:

- Visual analysis of filter bags revealed excellent membrane integrity.
- Laboratory analysis of the filter bags revealed no membrane damage caused by electrostatic discharge or sparking.
- After 32 weeks of service the GORE-NO STAT® filter bags exhibited no loss in physical strength and the permeability looked good.
- After 13 weeks of service the PPS backed GORE-TEX® membrane filter bags also showed no loss in strength and retained their permeability.
- Future PPS bag manufacturing will incorporate a design change to reduce/eliminate the bag circumference growth.

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APPENDIX

Bag Locator Chart

OTPCO's Big Stone Plant *Advanced Hybrid* (TM) Filter TO STACK

The diagrams illustrate the bagging patterns for the Advanced Hybrid (TM) Filter TO STACK. The patterns are defined by the numbers 1, 2, and 3 in the grid cells, corresponding to the BAG POSITION and TO STACK labels.

Field 4 Patterns:

- Chamber 1A FIELD 4:** COMPARTMENT 3
- Chamber 1B FIELD 4:** COMPARTMENT 6
- Chamber 2A FIELD 4:** COMPARTMENT 9
- Chamber 2B FIELD 4:** COMPARTMENT 12

Field 3 Patterns:

- Chamber 1A FIELD 3:** COMPARTMENT 2
- Chamber 1B FIELD 3:** COMPARTMENT 6
- Chamber 2A FIELD 3:** COMPARTMENT 8
- Chamber 2B FIELD 3:** COMPARTMENT 11

Field 2 Patterns:

- Chamber 1A FIELD 2:** COMPARTMENT 1
- Chamber 1B FIELD 2:** COMPARTMENT 4
- Chamber 2A FIELD 2:** COMPARTMENT 7
- Chamber 2B FIELD 2:** COMPARTMENT 10

Field 1 Patterns:

- Chamber 1A FIELD 1:** NO BAGS
- Chamber 1B FIELD 1:** NO BAGS
- Chamber 2A FIELD 1:** NO BAGS
- Chamber 2B FIELD 1:** NO BAGS

Number Designations

1	6/1/2002	Bags eliminated due to Rapper Pinwheel Assembly in the way
2	10/12/2002	Bags eliminated due to Rapper Shaft bearing supports in the way

Oct. 25, 2002 rev

SEMS Photo

Surface comparison of 777013-Dust Cake and 777023-Dust Cake:

Fig1: 777013-Dustcake-SF01

Fig2: 777013-Dustcake-SF02

Fig3: 777023-Dustcake-SF01

Fig4: 777023-Dustcake-SF02

EDS results

Elemental comparison of 777013-Dust Cake and 777023-Dust Cake:

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B38 Photographs of baffles in place

View of exterior of flow baffles

View of interior of flow baffles

**Advanced Hybrid Outage Report
June 4, 2004 – June 12, 2004**

Prepared By:

**Tom Hrdlicka
Plant Engineer**

June 14, 2004

Summary of Work

- 1) Bag inspection
- 2) Bag replacement
- 3) Installed bag row baffles
- 4) Modified blowpipes
- 5) Moved pitot tubes to new locations and checked for proper orientation
- 6) Repair girder box and bus duct purge air supply line
- 7) Complete inspection of:
 - a. Clean gas plenums (leaks, cracks, corrosion, ash on tubesheet, etc.)
 - b. Discharge electrodes and plates for clearance issues and ash build-up
 - c. Rapper shafts, pinwheels, hammers and anvils
 - d. Girder boxes for leaks and insulator crock condition

Results and Discussion

1) Bag Inspection

- a. Expectedly found holes in many nonconductive PPS/Gore-Tex bags in 1AF3 and 1AF4 as well as a few holes in the conductive PPS/Gore-Tex bags in 1AF2, 2AF2 and 2BF3. All the bags in these compartments have been in service for one year and were scheduled to be replaced during this outage.
- b. Found two all Gore-Tex bags with holes in the bottom of the bag, one was installed new in June 2003 (1BF2) and the other was an original bag that was washed and reinstalled in Dec 2003 (1BF3).
- c. One Nomex bag was found with a hole in 1BF4.
- d. The following bags were pulled to be sent in for analysis:
 - i. 2 BHA-Tex/Nomex (one with a hole in it)
 - ii. 1 Gore-Tex/Gore-Tex
 - iii. 1 Gore-Tex/Fiberglass (installed with a 24 vertical wire cage)
 - iv. 1 Gore-Tex/Fiberglass (installed with a standard 16 vertical wire cage)
 - v. 1 Gore-Tex/Superflex
 - vi. 2 BHA-Tex/P84
 - vii. Two new BHA-Tex/P84 bags will also be sent in for analysis
 - viii. ECC will perform the bag analysis and issue a report in mid July.
- e. Ten missing nozzles were also discovered and new nozzles were installed.

2) Bag Replacement

- a. SEI was contracted to replace 1928 filter bags. The replacement bags, provided by BHA Group, Inc., are 14 oz. P84 felt with a BHA-Tex membrane. SEI also replaced 13 additional bags using new Gore-Tex felt with Gore-Tex membrane bags (see updated bag layout below).
- b. The blowpipes came apart relatively easy and there were no extra charges incurred during this bag change due to difficult bag or cage removal.

Advanced Hybrid Bag Map Big Stone Plant

3) Installed Bag Row Baffles (see Figure1-3 below)

- a. SEI was contracted to fabricate and install 57 sets of bag row baffles. The baffles were installed in all compartments of chamber 2B.
 - i. Half of the baffles had to be modified because of incorrect fabrication.
 - ii. Once the modifications were made, all three compartments were installed in only two days.
 - iii. The decision was made to tack weld the nuts on to support bracket bolts and also to tack weld the ends of the baffles near the bottom to maintain a 2-inch gap.
 - iv. There is some concern surrounding the clearance between the bag and the cut out portion of the end baffles.

Figure 1: Installed baffles viewed from below.

Figure 2: End baffle without tack weld

Figure 3: End baffle with tack weld

4) Modified Blowpipe

- a. One compartment of blowpipes was modified in 1BF3 (see Figure 4)
- b. Flat bar was used to seal off the holes for the top header (see Figure 5)

Figure 4: Modified blowpipes in 1BF3

Figure 5: Flat bar used to cover holes in plenum wall

5) Pitot Tubes

- a. Pitots were repositioned in 1BF3 to monitor the modified blowpipes and 2BF3 to help determine the effectiveness of the baffles.

6) Repair Purge Air Supply Lines

- a. SEI repaired four girder box and bus duct purge air supply lines. The PVC lines installed in Oct. 2002 were warped due to heat. Metal ducting was installed (see Figures 6-7).

Figure 6. New girder box purge line

Figure 7: Purge line interface to girder box

7) Complete Inspection

- a. Discharge electrodes and plates
 - i. Discharge electrodes have a thin layer of ash that is uniformly distributed. The ash brushes off with a soft bristle brush.
 - ii. The plates also had a thin layer of ash that is uniformly distributed. No buildup near the top of the plates was observed and no holes were plugged.
 - iii. No obvious clearance issues were reported.
- b. Rappers
 - i. The majority (95%) of the hammers are striking the anvils on center with the remainder within 1 cm.
 - ii. No broken hammers or rapper components were reported.
- c. Girder Boxes

- i. No ash buildup in the girder boxes.
 - ii. No cracked insulator crocs reported.
- d. Clean Gas Plenums
 - i. Amount of corrosion on ceilings has increased from last inspection (see Figure 8). Noted water dripping in around one top hatch (see Figure 9).

Figure 8. Corrosion on plenum ceiling

Figure 9. Plenum top hatch corrosion

Recommendations

- 10 filter bags will be sent in to ECC for analysis including 2 new P84 bags. The new bags will provide some baseline strength data that we do not have to date. Results will be available mid July.
- Standing water that is getting under the roof lagging is causing the corrosion. This problem needs further investigation to develop a solution.
- Pitots have been installed to monitor the modified blowpipes and chamber of baffles. They will have to be rotated on a regular basis to obtain data from different bags.
- The bags near the end baffles will have to be monitored closely. There is potential for abrasive wear and tearing for the bags in these positions.

B40 W.L. Gore and Associates Bag Report

Full scale *Advanced Hybrid™* Filter Big Stone Demonstration Operation Site Filter Bag Analysis

Date: June 11, 2004

Prepared By: Dwight Davis

Background:

Plant Location: Otter Tail Power Company, Big Stone City, South Dakota

Filter Bag Type: GORE-NO STAT® (GORE-TEX® membrane conductive/GORE-TEX® felt), GORE-TEX® membrane/PPS (polyphenylene sulfide) felt, GORE-TEX® membrane/conductive PPS felt, SUPERFLEX®, GORE-TEX® membrane/woven fiberglass filter bags, NOMEX® and P-84 backed filter bags

Bag Diameter: 6.0 inch

Length: 7 meter

Air/Cloth: 10 to 12 fpm

Dust Type: Fly Ash from Coal-Fired Boiler

Coal Type: Eagle Butte, Belle Ayr Mine; Western Sub-bituminous

GORE-NO STAT®, GORE-TEX® membrane/PPS felt, GORE-TEX® membrane/conductive PPS felt, SUPERFLEX®, GORE-TEX® membrane/woven fiberglass filter bags were installed and pre-coated prior to the June 11, 2003 start-up of the full scale *Advanced Hybrid™* Filter at Otter Tail Power Company's Big Stone Plant located in Big Stone City, SD. Refer to the June 11, 2003 bag locator guide found in the appendix. On July 14, 2003 a portion of the filter bags were exposed to a temperature excursion that exceeded their maximum temperature rating. Subsequently Big Stone took a derate to inspect and pull filter bags for analysis in two chambers on September 17th, and a third chamber on September 27th. On October 24th additional bags were pulled from three chambers for analysis. Big Stone remained in operation until the plant shutdown for a boiler wash on December 5, 2003. Operation resumed on December 20, 2003, with new bags replacing the all PPS filter bags in four of the compartments along with four trial SUPERFLEX® and six trial GORE-TEX® membrane/woven fiberglass filter bags. The filter bags pulled September 17th & 27th and October 24th for analysis, indicated the all PPS filter bags had been weakened in four of the compartments. This led to the four compartments' filter bags replacement during the December 2003 boiler wash shutdown. Two of the compartments were outfitted with previously used (Oct '02 to June '03) and washed off-line GORE-NO STAT® bags, the third compartment was outfitted with NOMEX membrane bags and the other with P-84 membrane bags. Refer to the December 2003 bag locator chart in the appendix for the replacement and trial filter bag location. On February 28th, 2004 the plant scheduled one last inspection and bag sampling derate prior to their June

2004 boiler wash outage.

As part of the Power Plant Improvement Initiative Big Stone Demonstration site DOE funding program, filter bags were removed for lab analysis when compartments or the entire *Advanced Hybrid*™ Filter were taken off line. Ten filter bags were removed on September 17th, one on September 27th, five on October 24th, and five additional filter bags on February 28th, 2004.

Filter Bag Evaluation:

A total of twenty-one filter bags were removed over the nine month time period by W.L. Gore and Otter Tail Power Company personnel for evaluation purposes by W.L. Gore and Associates. Various tests including air permeability, felt strength using both Mullen Burst and Instron tensile strength tests, along with visual observations including membrane microscopic examination were undertaken.

Air Permeability Analysis

The air permeability analysis of the filter bag media was performed in the lab using the Frazierometer.

Permeability is the volumetric flow rate of air, measured in cubic feet per minute (cfm) through a square foot of filter media at a pressure differential of 0.5 inches water gauge (w.g.). The unit of measure is cfm/ft² @ 0.5" w.g. and is called the Frazier Number (Fn). Samples of the *Advanced Hybrid*® filter bag media were cut from the top, middle, and bottom bag locations. The sample size was five inches in the vertical bag length direction along the entire circumference of the bag. Typically three measurements per bag sample were taken. An average value is then calculated from the nine measurements per bag.

Each sample is tested for permeability in the condition it was received from the field and again in the identical location after lightly brushing the dust cake. See Table 1:

Otter Tail Power Company											
Big Stone Power Plant Improvement Initiative Demonstration Site											
Filter Bag analysis summary chart - All Frazier #s are reported as cfm/ft ² @0.5 in.w.g. driving force											
Location	Service Time	Max. exposed temp (F)	Backing	As rec'd (F-n)	Mullen Burst (psi)	Mullen Burst % Strength Retention	Tensile strength - cross machine direction (psi)	%Tensile strength retention cmd	Tensile strength machine direction (psi)	% Tensile strength retention - md	Comments
1BF3 R1B1	6/10/03 to 9/17/03	365	all PPS	2.9	249	72	113	39	83	61	membrane OK, tan felt color
1BF3 R1B3	"	365	all PPS	3.6	226	66					membrane cracking along some of the vertical cage wires
1BF3R1B4	"	365	all PPS	4	223	65					membrane cracking at vertical/horizontal cage wire junctures
1BF3 R1B6	"	365	all PPS	3.8	182	53			51	37	membrane delaminated during HEC cleaning
1BF3R1B7	"	365	all PPS	2.7	236	69	114	39	61	45	membrane cracking, tan felt color
2BF2 R3B5	"	500	all GT	1.9	717	100					membrane OK
2BF2 R3B8	"	500	all GT	1.5	735	100					membrane OK
2BF3 R19B6	"	500	cond PPS	2.3	481	96	181	54	243	100	membrane OK, chocalat brown felt color
2BF3 R19B7	"	500	cond PPS	2.2	473	94	180	54	200	83	bag turned inside out during removal
2BF4 R20B7	"	500	all PPS	2.8	208	60	90	31	73	53	membrane scraped during removal, dark tan felt color
1AF4 R11B11	6/10/03 to 9/27/03	322	all PPS	3.9	234	68	123	43	90	66	membrane cracking along vertical and horizontal cage wires
1AF4 R1B20	6/10/03 to 10/24/03	322	all PPS	3.6	368	78	104	36	42	31	membrane cracking in vertical direction between vertical cage wires
1AF4 R1B12	"	322	all PPS	4	229	67	73	25	24	17	membrane cracking at vertical/horizontal cage wire junctures, tan felt color
1BF3 R21B5	"	365	all PPS	6.9	203	59	48	16	10	8	holes formed through felt backer, choc. brown felt
1BF3 R21B6	"	365	all PPS	5	210	61	33	11	2	2	membrane delamination, holes in felt
2AF4 R21B14	"	450	cond PPS	2	463	92	115	34	197	82	tan discoloration, hole in felt
1AF2 R15B11	6/10/03 to 2/28/04	322	cond PPS	2.6	449	89	224	67	205	85	membrane OK
1AF3 R11B15	"	322	all PPS	3	214	59	125	43	78	57	holes formed at vertical/horizontal cage wire junctures
2AF4 R13B10	12/3/03 to 2/28/04	350	SUPERFLEX	3.5	870	100	483	100	405	100	membrane OK
2AF4 R13B9	"	350	Fiberglass	3.1	920	100	729	100	461	100	membrane OK, small areas scraped during removal
2BF4 R11B6	"	365	P-84	5.1	337		185		97		membrane delamination throughout entire length of bag
	new	80	NOMEX	5.4	513		408		160		brand new
			new all PPS		366		289		137		
			cond PPS		503		337		241		
			all GT		650						

Table 1. Test Results Summary Chart

All the filter bags when removed contained a thin layer of dust similar to typical coal fired boiler fabric filter particulate collector applications. This residual filter cake and filter bag media air permeability measurement is shown in the "as received Frazier numbers" column. After light brushing, all the filter bag perms returned to near new levels. It should be noted that the higher Frazier number readings occurred when the membrane was scraped during removal, had cracked due to a weakened backer, or had become delaminated.

Felt Strength

Mullen burst tests were run on a portion of samples taken for the air permeability measurements.

The test consists of applying pressure in the reverse direction of airflow on a three inch diameter filter bag sample, continuously increasing the pressure until the sample is ruptured.

The September 2003 sampled filter bags' physical strength of the GORE-TEX® felt backed and conductive PPS felt backed filter bags maintained their strength while the all PPS felt backed filter bags began to show some minor weakening. Once we noticed the weakening of the all PPS felt backed filter bags, we began running a second type of physical strength test using an Instron test device. The Instron measures the tensile strength in both the machine and cross machine direction of the felt using two 2 inch by 5 inch samples. The sample cut with the long dimension in the vertical direction as the filter bag hangs represents the machine direction, the other sample cut with the long dimension cut in the horizontal (circumference) direction represents the cross machine direction. The Instron tests confirmed the all PPS felt backed filter bags had begun to weaken and the results indicated the higher the temperature exposure, the weaker the felt backer had become. A second set of filter bags was pulled in October 2003 and proved the all PPS felt filter bag continued to become weaker as shown in the appendix. By February 2004 the conductive PPS backed filter bags began to exhibit early signs of strength loss, even at the maximum exposed temperature of 322 (F).

Visual and Microscope Analysis

As noted earlier, all the filter bags contained a thin layer of dust cake on the membrane surface, typical of most coal -fired boiler applications. The primary dust cake was easily brushed off all the filter bags. The filter bags were examined for membrane damage from electrostatic discharge or sparking using a microscope - none was observed. However, membrane cracking began to occur with all PPS backed filter bags with the first set removed in September 2003. The conductive PPS backed and GORE-NO STAT® filter bags membrane integrity remained intact. The filter bags pulled February 2004, after two and a half months service, SUPERFLEX® and fiberglass backed filter bags show no membrane or backer wear. The P-84 backed filter bag had from top to bottom areas where the membrane had become delaminated in 1 to 3 inch diameter sections. The redesign of the filter bag incorporated in the June 2003 bag install utilizing a double layer of material in the bottom cuff apparently solved the wear previous seen with the October 2002 installed bags. .

Conclusions:

- GORE-NO STAT® filter bags continue to maintain excellent membrane integrity and physical strength.
- Laboratory analysis of the filter bags revealed no membrane damage caused by electrostatic discharge or sparking.
- After 10 weeks of service SUPERFLEX® and fiberglass backed filter bags exhibited no loss in physical strength and membrane integrity.
- The all PPS backed and conductive PPS backed GORE-TEX® membrane filter bags have shown they are sensitive to temperature upsets.
- Future physical strength analysis should include Tensile strength testing, preferably using the Instron instrument.

®GORE-TEX and GORE-NO STAT are registered trademarks of W. L. Gore & Associates, Inc.

APPENDIX

Physical strength retention of Conductive PPS backed filter bags vs temperature and service time

TO STACK

BAG POSITION

Chamber 1A FIELD 4
COMPARTMENT 3
GORE-TEX membrane/PPS felt bags
Part #51SF16915

Chamber 1B FIELD 4
COMPARTMENT 6
GORE-TEX membrane/PPS felt bags
Part #51SF16915

Chamber 2A FIELD 4
COMPARTMENT 9
GORE-TEX membrane/PPS felt bags
Part #51SF16915

Chamber 2B FIELD 4
COMPARTMENT 12
GORE-TEX membrane/PPS felt bags
Part #51SF16915

Chamber 1A FIELD 3
COMPARTMENT 2
GORE-TEX membrane/PPS felt bags
Part #51SF16915

Chamber 1B FIELD 3
COMPARTMENT 5
GORE-TEX membrane/PPS felt bags
Part #51SF16915

Chamber 2A FIELD 3
COMPARTMENT 8
Cond. GORE-TEX membrane/Cond. GORE-TEX felt bags
Part #51SF16915-YP2425

Chamber 2B FIELD 3
COMPARTMENT 11
Cond. GORE-TEX membrane/Cond. GORE-TEX felt bags
Part #51SF16915-YP2425

Chamber 1A FIELD 2
COMPARTMENT 1
Conductive PPS laminate bags
Part #51SF16915-YP2425

Chamber 1B FIELD 2
COMPARTMENT 4
Cond. GORE-TEX membrane/Cond. GORE-TEX felt bags
Part #51SF16915-YP2425

Chamber 2A FIELD 2
COMPARTMENT 7
Cond. GORE-TEX membrane/Cond. PPS felt bags
Part #51SF16915-YP2425

Chamber 2B FIELD 2
COMPARTMENT 10
Cond. GORE-TEX membrane/Cond. GORE-TEX felt bags
Part #51SF16915-YP2425

4833 Total Bags Installed

Chamber 1A FIELD 1 NO BAGS

Chamber 1B FIELD 1 NO BAGS

Chamber 2A FIELD 1 NO BAGS

Chamber 2B FIELD 1 NO BAGS

X - pilot tube installed

Bag locator guide for December 20, 2003

TO STACK																				
BAG POSITION																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 1A FIELD 4																				
COMPARTMENT 3																				
GORE-TEX membrane/PPS felt bags Part # 51SF16815																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 1B FIELD 4																				
COMPARTMENT 6																				
Nomex felt membrane filter bags																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 2A FIELD 4																				
COMPARTMENT 9																				
Washed Cond. GORE-TEX membrane/Cond GORE-TEX felt Part# 83SF84801																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 2B FIELD 4																				
COMPARTMENT 12																				
P64 felt membrane filter bags																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 1A FIELD 3																				
COMPARTMENT 2																				
GORE-TEX membrane/PPS felt bags Part # 51SF16815																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 1B FIELD 3																				
COMPARTMENT 5																				
Washed Cond. GORE-TEX membrane/Cond GORE-TEX felt Part# 83SF84801																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 2A FIELD 3																				
COMPARTMENT 8																				
Cond. GORE-TEX membrane/Cond GORE-TEX felt bag Part# 83SF84801																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 2B FIELD 3																				
COMPARTMENT 11																				
Cond. GORE-TEX membrane/Cond. PPS felt bags Part # 52SF16815-YP2425																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 1A FIELD 2																				
COMPARTMENT 1																				
Conductive PPS laminate bags Part # 52SF16815-YP2425																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 1B FIELD 2																				
COMPARTMENT 4																				
Cond. GORE-TEX membrane/Cond GORE-TEX felt bag Part# 83SF84801																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 2A FIELD 2																				
COMPARTMENT 7																				
Cond. GORE-TEX membrane/Cond. PPS felt bags Part # 52SF16815-YP2425																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 2B FIELD 2																				
COMPARTMENT 10																				
Cond. GORE-TEX membrane/Cond GORE-TEX felt bags Part# 83SF84801																				
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Chamber 1A FIELD 1																				
NO BAGS																				
Chamber 1B FIELD 1																				
NO BAGS																				
Chamber 2A FIELD 1																				
NO BAGS																				
Chamber 2B FIELD 1																				
NO BAGS																				

4834 Total Bags Installed

Number Designations

1

June 1st 2002

Bags eliminated due to Rapper Pinwheel Assembly in the way

2

Oct 12th 2002

Bags eliminated due to Rapper Shaft bearing supports in the way

Cond. GORE-TEX membrane/Cond GORE-TEX felt bags

Cond. GORE-TEX membrane/Cond. PPS felt bags

Washed GORE-TEX membrane/Cond GT felt bags

White box - no bag installed

Y Installed OTRCO pitot tube

X Installed Gore pitot tube

SUPERFLEX filter bag

83SF84801

52SF16815-YP2425

83SF84801

GORE-TEX membrane fiberglass filter bag

Nomex membrane filter bag

P64 membrane filter bag

B41 EEC Bag analysis report from July 22, 2004

Prepared for:

**OTTERTAIL POWER COMPANY
BIG STONE, SOUTH DAKOTA
JULY 22, 2004
TLN 402 J**

July 22, 2004
TLN 402 J

REPORT OTTERTAIL POWER COMPANY

Reference: Filter Bag Evaluations

Eleven filter bags (2 new and 9 used) were received for testing and evaluation. The bags were sampled from an Advanced Hybrid Filter baghouse collecting fly ash off a coal fired boiler operation.

The baghouse is a pulse jet cleaning unit operating at 320°F average to a maximum of 365°F. Pressure differentials are reported to be 8.0" w.c. with a maximum differential of 8.5" w.c.

The bags were identified as follows:

[1]	New Bag – P-84/Membrane BHA Tex
[2]	New Bag – P-84/Membrane BHA Tex
[3]	R1-B8 – installed 12/03 – out 4/04
[4]	R5-B13 – installed 10/02 washed (*) Washed reinstalled 12/03 out 6/04
[5]	R6-B8 – installed 12/03 out 6/04
[6]	R8-B19 – installed 12/03 out 6/04
[7]	R9-B12 – installed 12/03 out 6/04
[8]	R10-B8 – installed 12/03 out 6/04
[9]	R10-B12 – installed 12/03 out 6/04
[10]	R11-B17 – installed 12/03 out 6/04
[11]	R13-B19 – installed washed (*) Washed reinstalled 12/03 out 6/04

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The bags are of various generic class (see data sheets) and R5-B12 and R13-B19 were laundered and reinstalled in the unit.

Attached are the results of the testing data.

In general, the as received permeability of the bags yielded generally low throughput characteristics in full profile.

There is no significant differences between the candidates however both laundered candidates (R5-B13 and R13-B19) did generate a lower throughput average.

The following are the average Permeabilities as received of all candidates in order of decreasing

values:

CANDIDATES	AVERAGE PERMEABILITY
R6-B8	2.027
R8-B19	2.023
R11-B17	2.013
R1-B8	1.980
R9-B12	1.973
R10-B8	1.970
R10-B12	1.953
R5-B13	1.950
R13-B19	1.877

The differences are not that significant however, there is about an 8% gain in flows from the lowest to the highest candidate.

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All candidates exhibited a generally porous non-agglomerated cake structure.

Microscopic **Photo A and B** are views of this as received porous ash cake structure common to all bags.

Photo A

Photo B

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Impact generated this outer dust to discharge however directly on the membrane surface were densified ash agglomerations.

Microscopic **Photo C and D** are views of the impacted membrane surface.

Photo C

Photo D

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This densified thin layer of dust directly on the membrane has caused generally low regain characteristics in Permeabilities.

Again, no significant differences were present between the candidates flow characteristics.

The candidates generally followed the same rankings in regain as the as received conditions.

The following are the required Permeabilities of the candidates:

Candidate	Permeability
R6-B8	2.783
R8-B19	2.770
R11-B17	2.786
R1-B8	2.740
R9-B12	2.813
R10-B8	2.737
R5-B13	2.660
R10-B12	2.760
R13-B19	2.297

The permeability capacity characteristics of the candidates (except R13-B19) are not at any significant differences with very comparable flows.

R13-B19 yielded abnormal levels of regain.

Physical strengths of breaking tenacity and mullen burst strengths on R10-B8 revealed reductions in values uncommon to all other candidates.

Flex characteristics also revealed an uncommon decline in endurances of Bag R10-B8 exhibited by the other candidates.

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Considering the limited reported service use of 6 months the Nomex Aramid bag has undergone added degradation not experienced by the other candidates.

The Nomex candidate was extracted for soluble fraction analysis. Titration (Barium Chloride) resulted in positive sulphate salts within the Aramid Nomex polymer chemistry.

These sulphates result from the gaseous sulfur oxides (primarily sulfur trioxide) degrading the Aramid fiber Polymer.

With catalyst such as valadrum, sulfur trioxide is generated to 2-5% levels within the sulfur dioxide and will chemically degrade Nomex.

All other candidates did not exhibit any abnormal deterioration under this limited usage.

All losses from the candidates (except Nomex R10-B8) generated normal declines in physical values resulting from service use.

The extractions generated high levels of alkaline sulphates (calcium sulphate) indicative of

Powder River Basin coal with higher calcium oxide in the ash compared to the level of iron oxide.

This metallic oxide content generates an alkaline chemistry which is not detrimental to any of the candidates.

There is no thermal or chemical deterioration (except R10-B8 Nomex) on the bags with all losses attributed to physical service use fatigue and normal adjustments in values from service use.

All bags exhibited good snap band gasket to tube sheet sealing with no leakage demonstrated.

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Examination of the membrane surface revealed no failures/fractures with good bonding to the corresponding sub straight fabric.

Examination of the R5-B12 and R13-B19 (washed candidates) did not exhibit any membrane failures/fractures from the washing procedure.

Bags housed on the 24 wire cages (R18-B12 and R13-B19) did not generate any significant differences in Permeabilities/cleanable compared to the 16 wire candidates.

I would add that fiberglass would undergone reduced cage contact wear/flex with the higher 24 cage wire support and upon time would generally extend bag life on fiberglass.

Conclusions:

- Nomex has undergone sulfur trioxide degradation and under the 6 month exposure has suffered high deterioration. Nomex Aramid is not recommended for service in this application.
- Fiberglass candidates exhibited good retention in physical strengths and flex endurances. Fiberglass reductions have resulted from normal physical service use fatigue and normal adjustments in value from thermal baghouse exposures (normal for fiberglass).
- The PTFE needled felt candidate exhibited no loss in strength and flex fatigue at this current service use.
- P-84 media experienced normal losses in strength and flex endurances.
- The fiberglass, P-84 and PTFE needled felt are exhibited suitable characteristics for use in this application.
- **Life projections of the candidates based on this limited usage/data are as follows:**
Fiberglass – 4 to 4.5 years, P-84 - 5 to 6 years and PTFE felt – 8 to 9 years.
- The PTFE expanded membrane of the candidates are all rated at comparable performances.
- All membrane candidates generated good ash collection characteristics with no penetration beyond the membrane.
- **Photo E** is a cross sectional typical to all bags revealing the internal depths of the media void of any dust penetration.

Photo E

FABRIC	NEW	NEW
FIBER	P-84	P-84
TYPE	NEEDED	NEEDED
SCRIM SUPPORT	YES	YES
SCRIM WEAVE	PW	PW
SCRIM YARN	SPUN	SPUN
SCRIM COUNT (W X F)	24 X 23	24 X 24
WEIGHT (OZ/SQ YD)	18.74	17.61
THICKNESS (INCHES)	.084	.080
DENSITY (OZ/CUBIC INCH)	0.1721	0.1698
PERMEABILITY (CFM)	6.9	7.3
MULLEN BURST (LBS/SQ INCH)	611	604
TENSILE (LBS/INCH) WARP FILLING	198 317	203 305
FINISH	MEMBRANE	MEMBRANE
TYPE	PTFE	PTFE
MEMBRANE QUALITY	GOOD	GOOD

FABRICATION	NEW	NEW
FLAT WIDTH (INCHES)	9.75	9.78

DIAMETER (INCHES)	6.21	6.23
OAL	NO BAND TOP PRESENT	CUT OFF
BOTTOM CUFF (INCHES)	5.9	6.0
BOTTOM CUFF STITCH	LOCK	LOCK
BOTTOM CUFF STITCH ROWS	2	2
BOTTOM CUFF STITCH YARN	PTFE	PTFE
BOTTOM CUFF STITCHES PER INCH	5.2	5.3
SEAM TYPE	OVERLAP	OVERLAP
SEAM STITCH	CHAIN	CHAIN
SEAM STITCH ROWS	3	3
SEAM STITCH YARN	PTFE	PTFE
SEAM STITCHES PER INCH	6.8	6.5

B42 EEC Bag analysis report from December 3, 2004

Prepared For:

**OTTER TAIL POWER COMPANY
BIG STONE CITY, SOUTH DAKOTA
DECEMBER 3, 2004
TLN 618 J**

**REPORT
OTTER TAIL POWER COMPANY**

**Reference: Big Stone Plant
TLN 402J of 7/22/04**

Four filter bags were submitted for complete evaluations. The bags were labeled as “10-H Advanced Hybrid”, “8-G Advanced Hybrid”, “2AF3 Advanced Hybrid” and “None – Cole Unloading”.

Coal Unloading:

The bag is from a pulse jet unit collecting residual dust from the coal unloading area. The differential pressure levels are 7” w.c. and maintained by an ID damper system. As pressures elevate the flows are reduced to maintain the dp. Temperatures are ambient with current service use @ 3 years.

The submitted bag as received exhibited low permeability throughput acceptances in full profile. Examination of the dust cake revealed a non-agglomerated porous structure with no major obstructions to throughput present.

Cross sectional inspection revealed the cause for the low permeability characteristics.

Microscopic **Photo A and B** are cross sectional views revealing the presence of fine micron dust penetration into the media depths.

Photo A

Photo B

The filtration efficiency of this media is at questionable levels.

The use of Duo-density Polyester may be a more suitable replacement when change out is scheduled.

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TLN 618 J
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The current chemistry/temperature of the PRB coal unloading is not detrimental to Polyester with no hydrolysis potential present.

Physical strengths and flex endurances of the bag are at good retention levels in full profile.

All current losses are attributed to physical service use.

This bag is rated at a 35% maximum termination indicative of good continued service use potential. No abnormal wear was demonstrated on this bag.

Advanced Hybrid Filter – Fly Ash

All three bags exhibited a porous ash cake common to Powder River Basin Coal ash. This PRB ash contains higher levels of calcium oxide compared to Iron Oxide, hence, the predominant sulphate is the ALKALINE calcium sulphate.

The Permeabilities as received did exhibit a viable level of through. The following are the average permeability flows:

CANDIDATE	PERMEABILITIES
10-H	2.090
8-6	2.083
2AF3	1.753

The two P-84 membrane candidates (10-H and 8-G) exhibited very abnormal losses in all breaking strengths and mullen burst values in full profile.

Further the bags are at or very near full hole formations with H-10 already demonstrating vertical hole.

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Flex endurances on both bags also demonstrated severe losses in full profile with flex fatigue levels at 80%.

The added physical fatigue on the bag fold merely added sufficient stress/strain to generate the vertical failure.

The bag fold is the result of normal bag over sizing in circumference compared to the cage circumference.

This over sizing is necessary for cage insertion and the popping action off the bag under pulse for cleaning.

This does become the flex position common to all pulse jet bags hence, merely fails along the vertical fold first.

The high losses both on flex positions and off flex zones is indicative of all degradation sources beyond normal physical fatigue.

The fiberglass candidate did not exhibit any significant declines in strength and flex characteristics.

Extractions of the media less dust revealed the presence of sulphate (acidic) with the P-84 Imide chemistry.

Further nitrates were also present in the current chemistry of the P-84 fibers.

The fiberglass was negative of Nitrate involvement in the inorganic fiber chemistry with only Sulphates detected (slight) and they were acidic.

Power River Basin coal will always yield alkaline calcium sulphates in the ash chemistry. However sulfur gases passing through the membrane (ash does not) and condenses out will generate the acid condensate of sulfuric acid which will attack P-84 as well as Nomex.

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Also N0x condensate will do the same thing and condensate out as nitric acid which will attack the P-84 however, not the fiberglass.

The low deterioration on the 2AF3 bag and the high degradation on 10-H and 8-G strongly suggests that moisture condensate in contact with N0x occurred within the clean air side of the system generating the nitric acid and further degrading P-84 as demonstrated by the P-84 degradation and the nitrates within the fiber.

Evidence of clean side moisture corrosion was also demonstrated.

Photo C and D are views of the clean side of the 2AF3 revealing the staining that has occurred.

Photo C

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Photo D

The rust material tested positive for both metallic sulphates/nitrates further indicative of the acid generation on the clean air side.

It is evident that moisture has entered the clean air side (plenum) of the baghouse causing the exiting gases of sulfur oxides and nitrogen oxides to condense out as the acid.

This situation has occurred between the sampling of TLN 402J (7/22/04) and the failures being experienced. Clean side condensates are most commonly associated with inleakage of cool air/moisture or moisture condensates in the pulse air line. Further, these acids will also generate rust within the metal fractures such as the cages.

B43 Addendum - Startup report after the replacement of the inlet field.

STARTUP REPORT
FOR
OTTERTAIL POWER COMPANY
BIG STONE PLANT
MILBANK, SOUTH DAKOTA
JUNE 30, 2005
BY: BEN ABBOTT

This is a startup report for ESP's 1 and 2 after SEI's modification to the first fields and bag replacement.

Forry ERC 1001 Rapper Controller and Rappers:

Single impact rappers were installed on the high voltage frame of the first fields. All rappers were installed and adjusted properly. The Forry ERC 1001 rapper controller was set up and programmed. The rapper controller and all rappers are working properly. A copy of the rapper controller set up and program is included with this report. Five plant electricians were trained on the operation of the rapper controller.

Automatic Voltage Controls (AVC) and Transformer Rectifier (TR) Sets:

During construction some TR sets were relocated to different locations. The AVC's need to be edited to match the name plate ratings of the TR sets. Attached are the settings and operational parameters that are in the AVC's along with suggested settings and parameters. Also attached are the air load readings of the AVC's.

There is a close clearance at the bottom tadpole on the first field of all four chambers. Due to this close clearance the first fields were limited to 21 to 26 kV.

With the exception of some sparking, all other fields had good air load readings.

Air load readings are attached.

Support Insulator Heaters:

After drying out the girder boxes, all heaters worked properly.

First field Outlet Dampers:

All four dampers were operated and work properly. The limit switch on chamber 1A did not always indicate the full open position. The plant was to adjust the limit switch the next day.

Tumbling Hammers:

The rotation and operation of all tumbling hammers were checked and worked properly.

OPERATIONAL VALUES

AVC	PA	PV	SA	SV	SPARK QUENCH	ARC QUENCH	FAST RAMP	SET BACK	S/M	SCR
1A1	327	480	2000	25	1	3	6	20	99	30
*	327	480	2000	55	2	4	4	10	60	30
1A2	327	480	2000	55	1	3	6	5	20	30
*	327	480	2000	55	2	4	4	10	30	30
1A3	327	480	1000	55	1	3	6	5	20	30
*	245	480	1500	55	2	4	4	10	30	30
1A4	327	480	1000	55	1	3	6	5	20	30
*	245	480	1500	55	2	4	4	10	30	30
1B1	267	480	2000	25	1	3	6	20	99	30
*	245	480	1500	55	2	4	4	10	60	30
1B2	327	480	1000	55	1	3	6	5	20	30
*	327	480	2000	55	2	4	4	10	30	30
1B3	327	480	1000	55	1	3	6	5	20	30
*	245	480	1500	55	2	4	4	10	30	30
1B4	327	480	1000	55	1	3	6	5	20	30
*	245	480	1500	55	2	4	4	10	30	30
2A1	327	480	2000	21	1	3	6	20	99	30
*	327	480	2000	55	2	4	4	10	60	30
2A2	327	480	1000	55	1	3	6	5	20	30
*	327	480	2000	55	2	4	4	10	30	30
2A3	327	480	1000	55	1	3	6	5	20	30
*	245	480	1500	55	2	4	4	10	30	30
2A4	327	480	1000	55	1	3	6	5	20	30
*	327	480	2000	55	2	4	4	10	30	30
2B1	327	480	2000	55	1	3	3	10	99	30
*	327	480	2000	55	2	4	4	10	60	30
2B2	327	480	2000	50	1	3	6	5	20	30
*	327	480	2000	55	2	4	4	10	30	30
2B3	327	480	1000	55	1	3	6	5	20	30
*	245	480	1500	55	2	4	4	10	30	30
2B4	327	480	1000	55	1	3	6	5	20	30
*	245	480	1500	55	2	4	4	10	30	30

* SUGGESTED VALUES (NOTE: Due to time constraints during air load the suggested values were not implemented. It was discussed that after the boiler was brought back on line, some of the operating parameters would need to be changed. The plant said they could handle this if it is necessary to do so).

AIR LOAD READINGS

Chamber 1A

FIELD	PV	PA	SA	SV	SCR	KW	S/M
1	148	140	664	25	115	17	0
2	73	249	296	38	122	9	19
3	148	260	640	44	108	39	19
4	158	280	794	54	97	55	17

Field 1 limited at 25 kV due to excessive sparking at higher kV.

Chamber 1B

FIELD	PV	PA	SA	SV	SCR	KW	S/M
1	161	144	723	25	113	18	0
2	66	211	343	52	103	26	15
3	143	295	586	44	100	42	19
4	113	258	458	50	100	23	19

Field 1 limited at 25 kV due to excessive sparking at higher kV.

Chamber 2A

FIELD	PV	PA	SA	SV	SCR	KW	S/M
1	113	130	450	21	125	9	0
2	124	330	430	47	106	15	19
3	133	289	527	58	100	26	15
4	121	243	545	53	100	37	14

Field 1 limited at 21 kV due to excessive sparking at higher kV.

Chamber 2B

FIELD	PV	PA	SA	SV	SCR	KW	S/M
1	180	150	820	26	110	21	0
2	170	321	420	53	96	25	18
3	165	227	432	42	117	35	22
4	106	244	474	46	113	28	19

Field 1 limited at 26 kV due to excessive sparking at higher kV.

Note: If kV limit is raised on fields 1 the spark rate goes up to approximately 100 S/M.

B44 Addendum - Bag Layout map after installation of AH components in the inlet field

B45 Addendum - Performance Graphs from 10/2002 through 12/2005