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

TECHNICAL PROGRESS REPORT

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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 is being demonstrated under joint sponsorship from the U.S. Department of Energy and Otter Tail Power Company.

The project objective is 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 will be conducted 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 will conclude in November 2004.

The following Technical Progress 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.

POINT OF CONTACT

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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 Intrumentation 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 this project under 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.

Significant changes have been implemented in this quarter. The two most significant changes have been an in-place bag washing of the bags in the system, and a complete bag replacement.

Results from in-place bag washing were mixed. Although the bag washing improved the performance of

the system slightly, it was felt that the higher A/C ratios that would be seen this summer would likely still result in derates to the plant. So the decision was made to replace the bags in the system with as many bags as possible that showed a reduction in resistance to flow.

Approximately 75% of the bags were replaced with a form of PPS bag that showed through pitot tube instrumentation to have less resistance to flow. The results of this change out have been dramatic, and performance of the system has been very good for the last two weeks in June.

Overall the system needs to operate during the summer months to get a better handle on where we are at with regards to the new system arrangement. It is too early to say whether or not we are at a point of performance where we can feel confident that we are demonstrating the performance to acceptable commercial levels.

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 Hybrid™". 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 Hybrid™" 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.

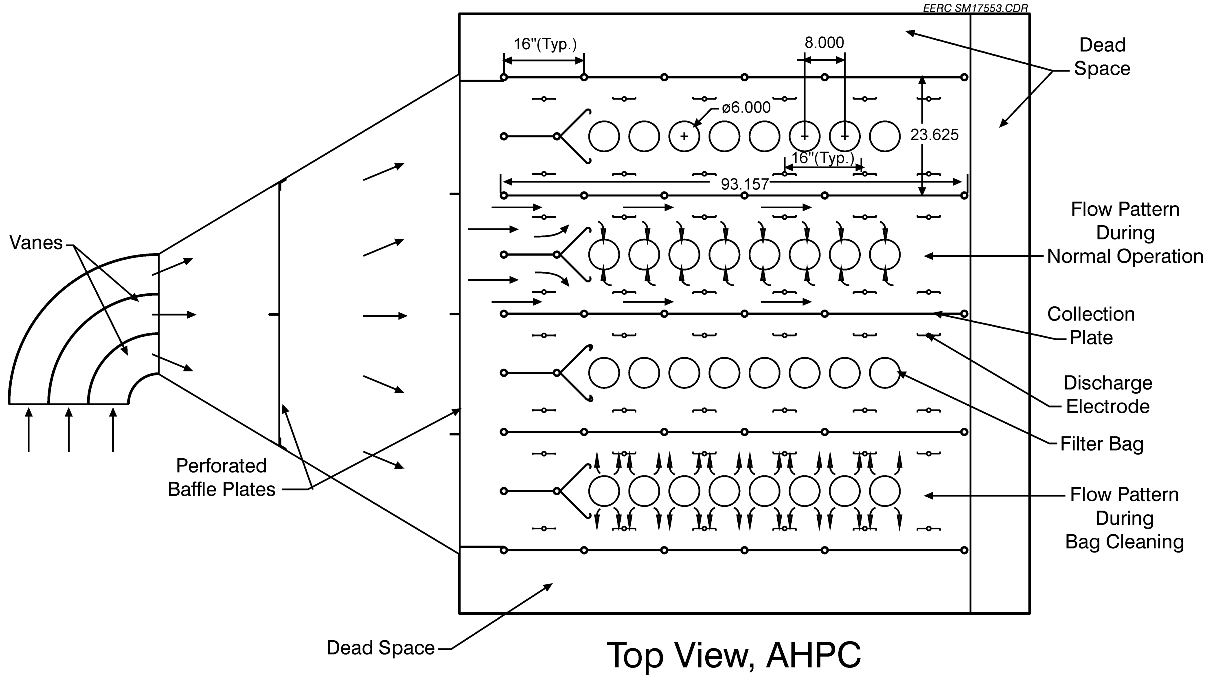


Figure 1. Top view of the old configuration for the 9000-acfm *Advanced Hybrid*™ filter at Big Stone.

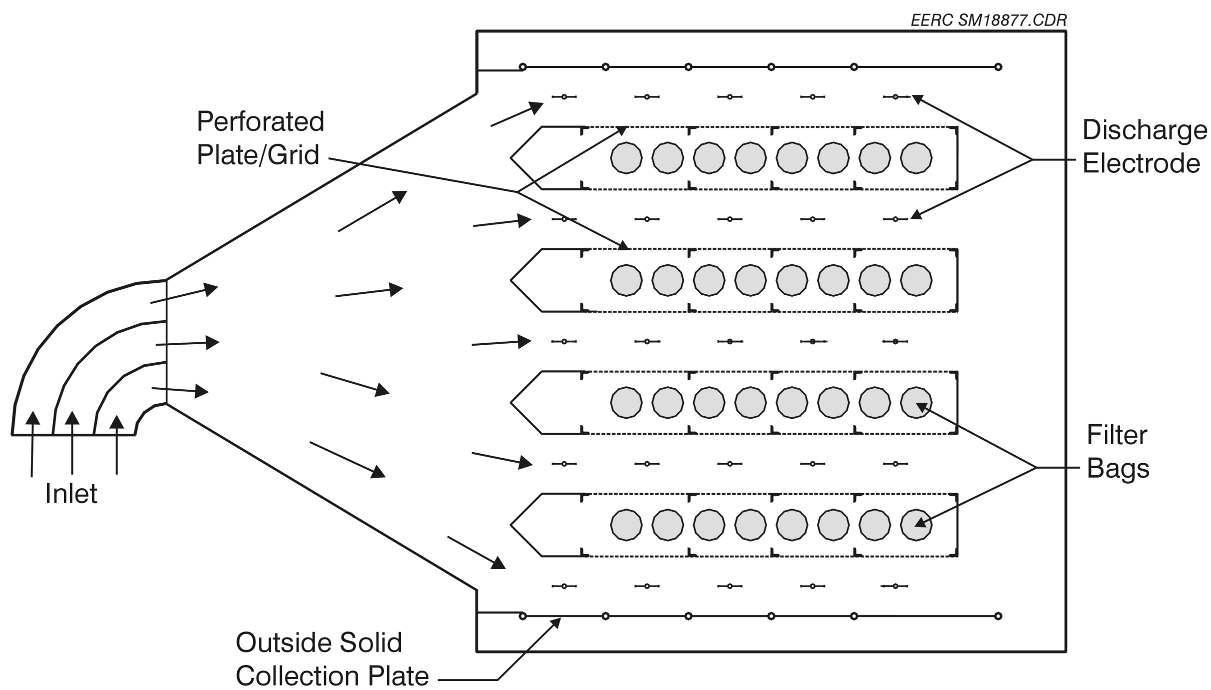


Figure 2. Top view of the perforated plate configuration for the 9000-acfm *Advanced Hybrid*™ filter.

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:

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

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/ft^2)
- 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*™ 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*™ filter performance, the K_2 and C_i can be considered together:

$$K_2C_i = \frac{(D_T - D_R)7000}{Vt} \quad \text{[Eq. 4]}$$

Evaluation of K_2C_i can help in assessing how well the ESP portion of the *Advanced Hybrid*™ filter is functioning, especially by comparing with the K_2C_i during short test periods in which the ESP power was shut off. For the Big Stone ash, the K_2C_i value has typically been about 20 without the ESP field. For the 9000-acfm pilot *Advanced Hybrid*™ filter, longer-term K_2C_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_2C_i value as possible; however, good *Advanced Hybrid*™ filter performance can be demonstrated with K_2C_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_2C_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_2C_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_2C_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.

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

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

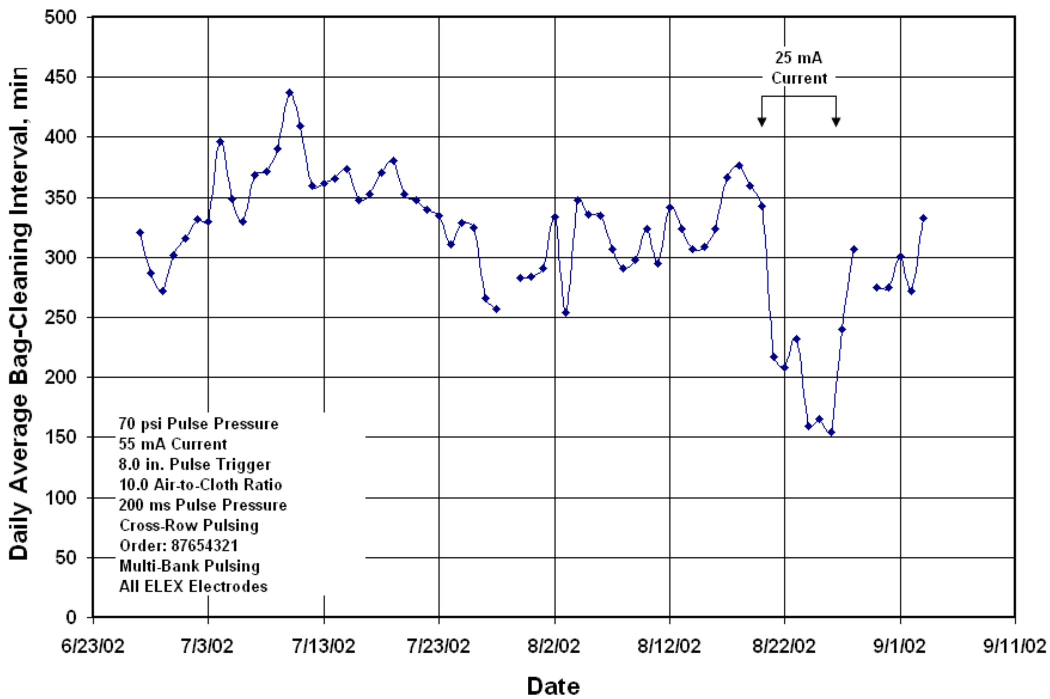


Figure 3. Daily average bag-cleaning interval for summer 2002 tests with the 9000-acfm *Advanced Hybrid*™ filter.

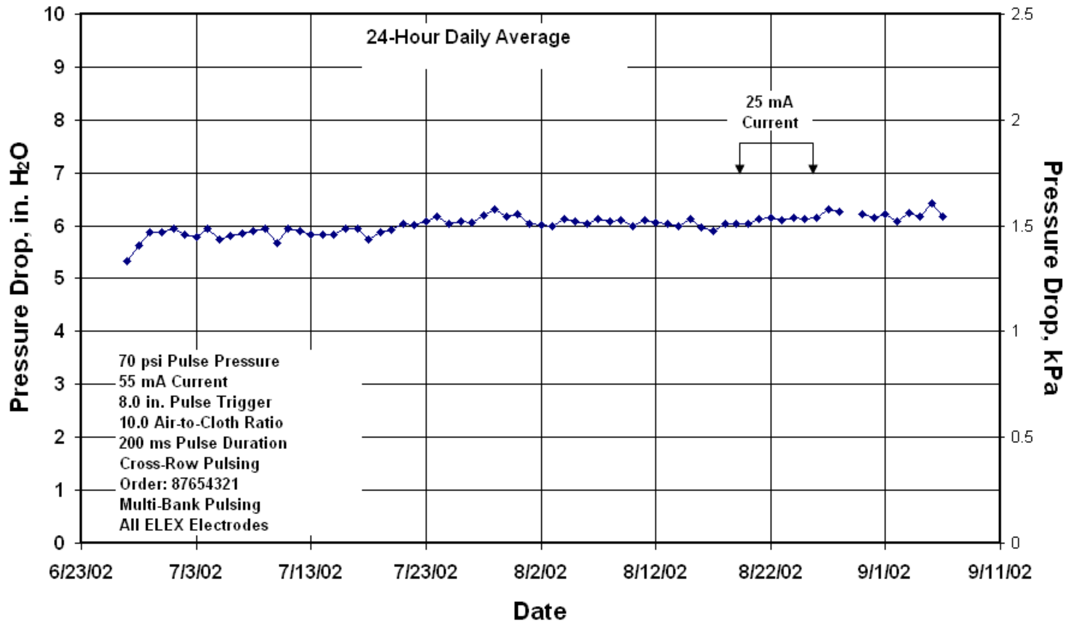


Figure 4. Daily average pressure drop for summer 2002 tests with the 9000-acfm *Advanced Hybrid*™ filter.

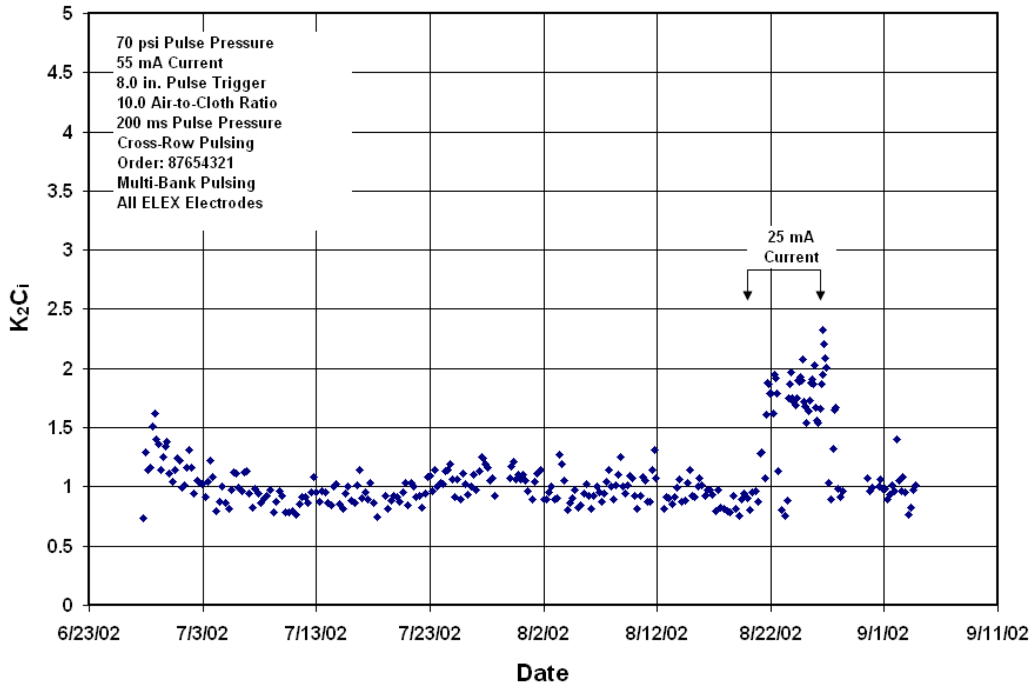


Figure 5. K_2C_i for summer 2002 tests with the 9000-acfm *Advanced Hybrid*™ filter.

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.

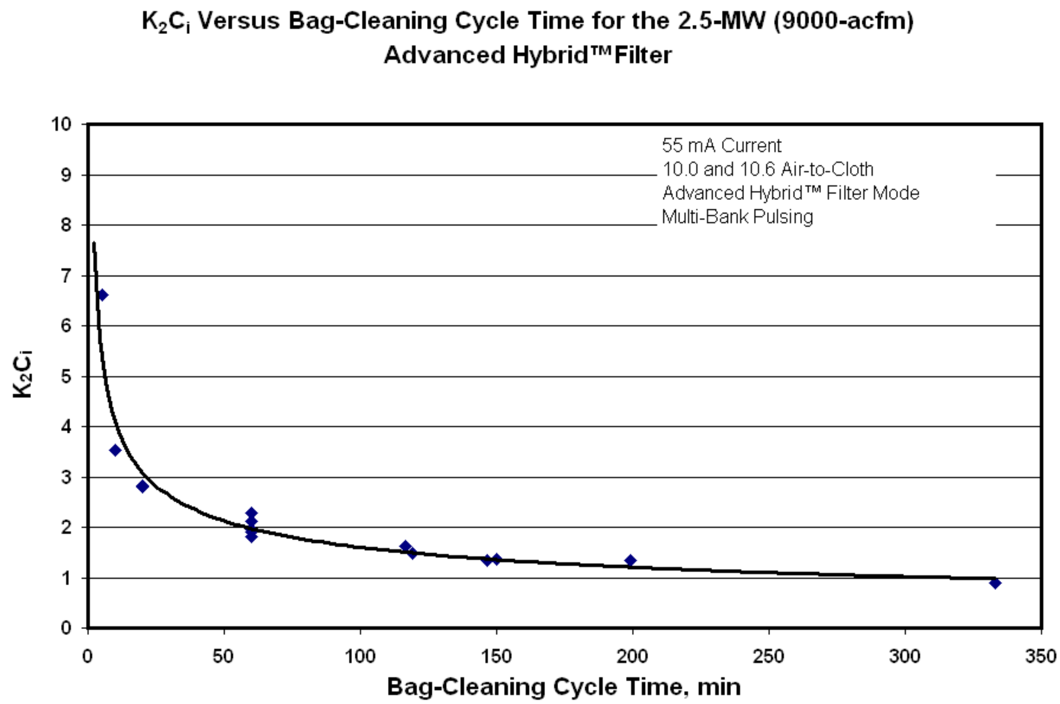


Figure 6. Effect of pulse interval on K_2C_i for 9000-acfm pilot *Advanced Hybrid*™ filter.

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 9).

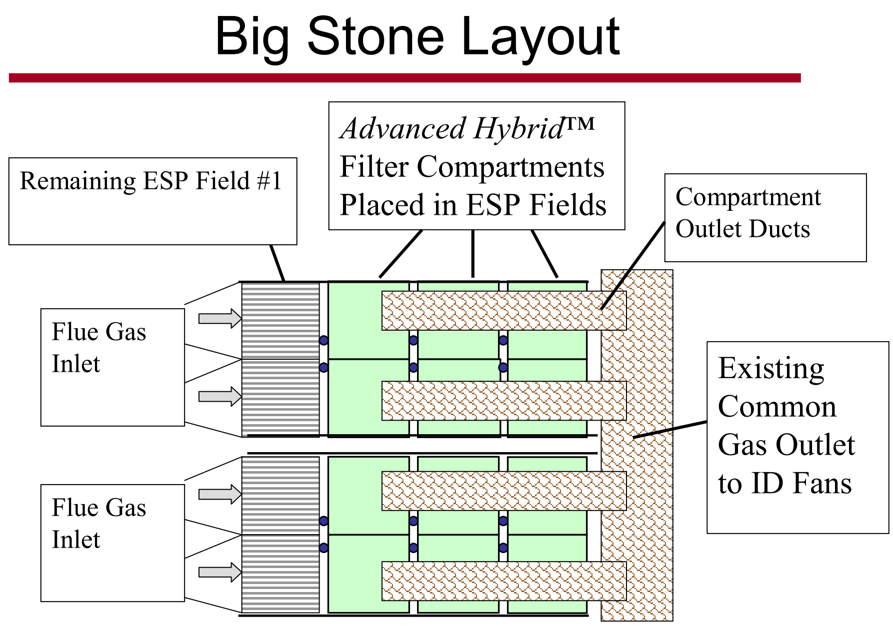


Figure 7. Top view of the *Advanced Hybrid*™ filter full-scale retrofit configuration at Big Stone.

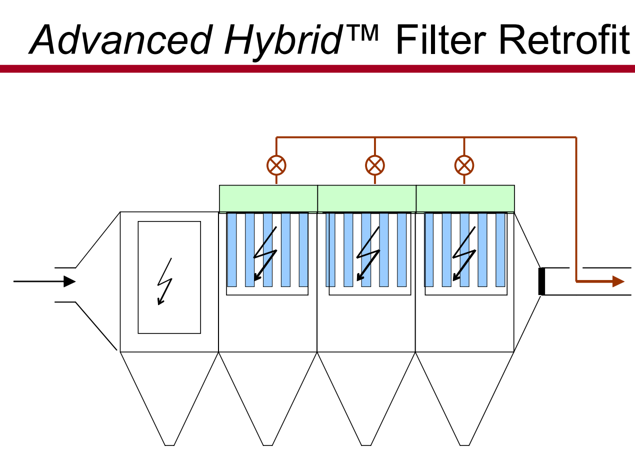


Figure 8. Side view of the *Advanced Hybrid*™ filter full-scale retrofit configuration at Big Stone.

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	Threshhold Cleaning	Unchanged
TR Rating of AH Field	1500 ma, 55 kV	Unchanged
TR Rating of Inlet ESP Field	2000 ma, 55 kV	Unchanged
Inlet ESP Field Data		
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

[1]The 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

The following is a description of the number and type of bags in the system. Some plugging of bags may occur, but in general, this should be an accurate description of the system with regards to filtration distribution. A diagram of the bag layout is included in Appendix B23.

Table 4 Bag Layout and Type Description

Compartment	Number of Bags	Bag Type
Chamber 1A Field 2	**413**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 1A Field 3	**413**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 1A Field 4	**413**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 1B Field 2	**392**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 1B Field 3	**392**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 1B Field 4	**393**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2A Field 2	**393**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2A Field 3	**393**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2A Field 4	**393**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2B Field 2	**413**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2B Field 3	**413**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2B Field 4	**413**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**

Table 5 Bag Layout and Type Description (After June outage)

Compartment	Number of Bags	Bag Type
Chamber 1A Field 2	**100/313**	**GORE-TEX™ Felt/GORE-TEX™ Membrane /Cond. PPS Felt/ GORE-TEX™ Membrane**
Chamber 1A Field 3	**413**	**PPS Felt/GORE-TEX™ Membrane**
Chamber 1A Field 4	**413**	**PPS Felt/GORE-TEX™ Membrane**
Chamber 1B Field 2	**392**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 1B Field 3	**392**	**PPS Felt/GORE-TEX™ Membrane[1]**
Chamber 1B Field 4	**393**	**PPS Felt/GORE-TEX™ Membrane**
Chamber 2A Field 2	**81/312**	**GORE-TEX™ Felt/GORE-TEX™ Membrane /Cond. PPS Felt/ GORE-TEX™ Membrane**
Chamber 2A Field 3	**393**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2A Field 4	**393**	**PPS Felt/GORE-TEX™ Membrane**
Chamber 2B Field 2	**413**	**GORE-TEX™ Felt/GORE-TEX™ Membrane**
Chamber 2B Field 3	**413**	**Cond. PPS Felt/ GORE-TEX™ Membrane**
Chamber 2B Field 4	**413**	**PPS Felt/GORE-TEX™ Membrane**

[1]Approximately 6 bags of different material were included in this compartment to gain operating time with more bag materials. These included, P-84 (basalt scrim-no membrane), PPS 7-denier (w/torcon scrim-no membrane), PPS non-conductive bag, conductive PPS, and an all GORE-TEX bag.

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^{o}F and 29.92 in HG as standard conditions. The flow is converted to kacfm using the following equation:

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

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.

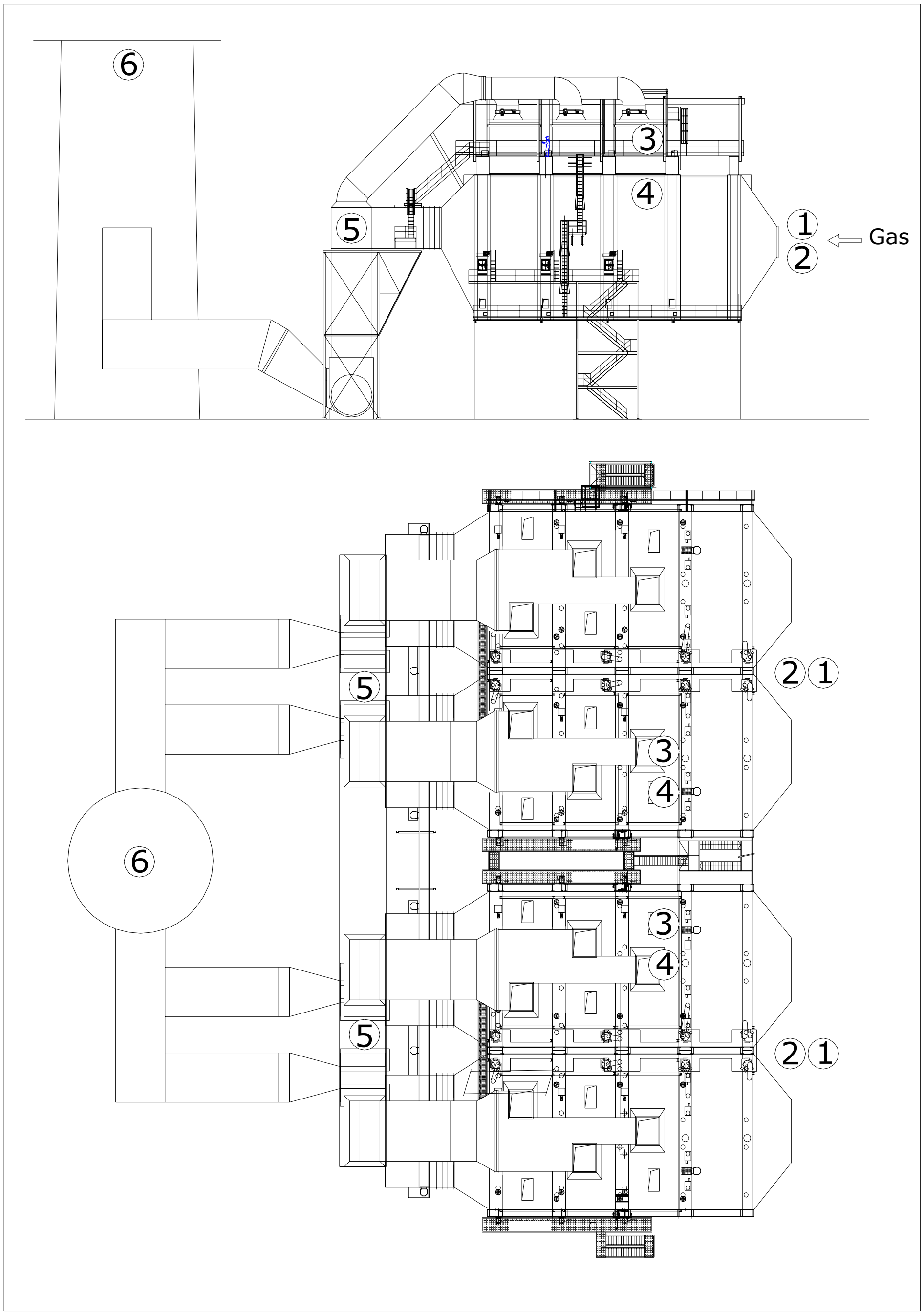
Compressed Air Flow: Continuously monitored using a Diamond II Annubar flow sensor equipped with a Honeywell 3000 Smart DP Transmitter. This ANNUBAR instrument is in the compressed air supply line after the compressors but before the desiccant dryer.

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 SO_2 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

<u>Quarter 1 (October 2002 – December 2002)</u>

System Startup	October 2002
Rapper Problems Realized	November 2002
Pulse Valve Problems Realized	November 2002
EERC Testing Completed	November 2002
Inlet Field Energized	December 2002

<u>Quarter 2 (January 2003 – March 2003)</u>

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

<u>Quarter 3 (April 2003 – June 2003)</u>

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

3.1.2 Discussion of Results of Significant Accomplishments

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.

<u>Mechanical Issues</u>

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.

<u>Performance Issues</u>

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 hesitance 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.

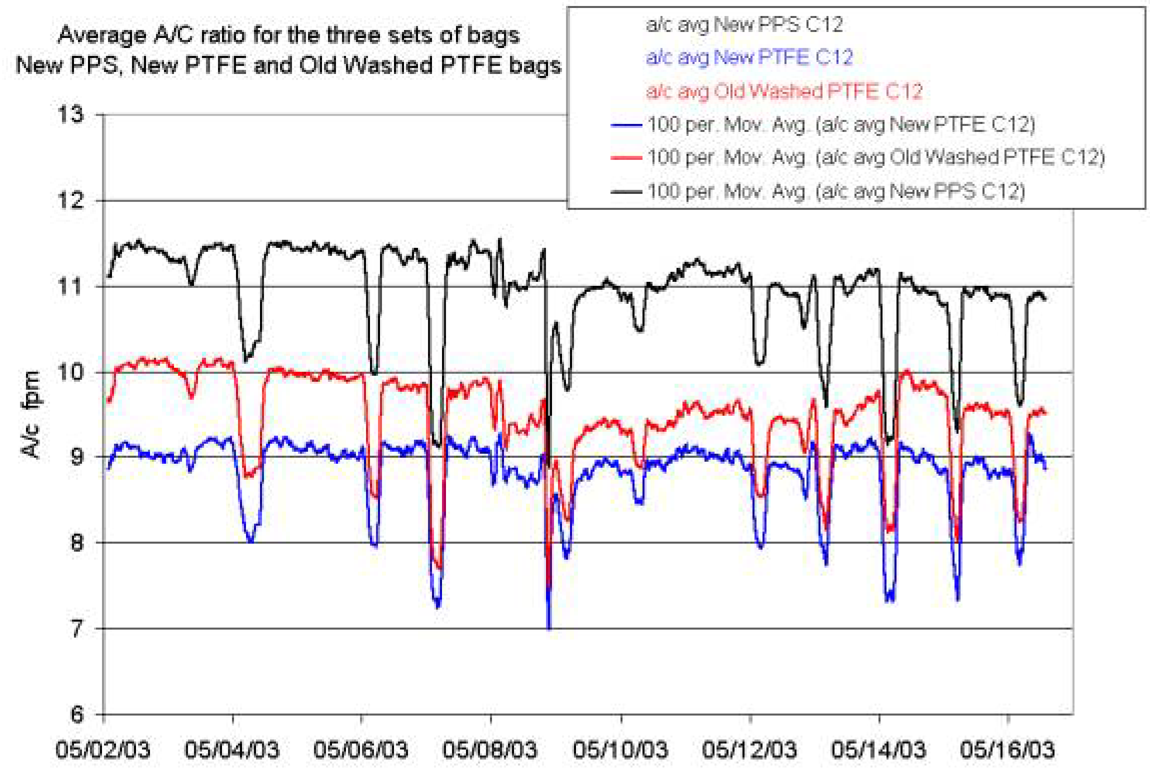
The second effort during the outage was to remove one of the filter bags from service and attempt a wash of the bag while it was not in the system. The bag wash appeared effective as the visual dust cake was removed and the black finish of the original bag was clearly seen. The decision was made to try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



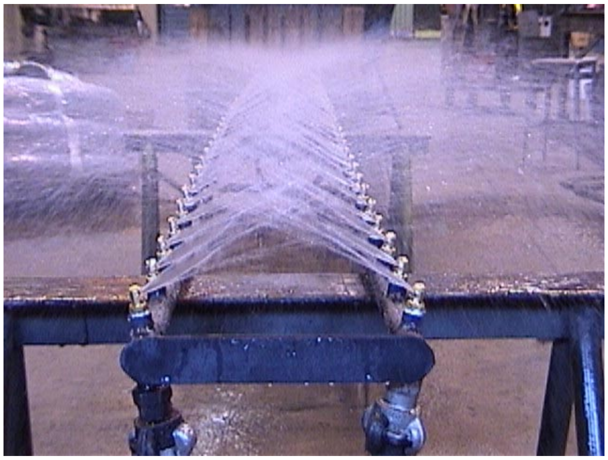
bags and the ptfe bags. The A/C ratio of the PPS bags is nearly 15 – 20% higher than the ptfe bags.

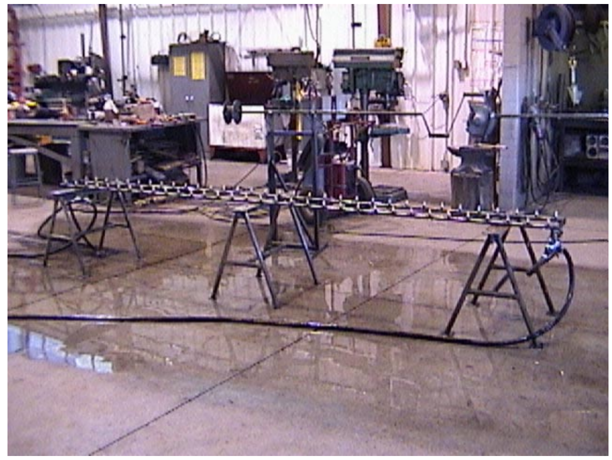
This result was very significant since it was the first evidence that a different bag type could result in a dramatic reduction in differential pressure or increased flow capabilities at the existing pressure drop.

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 B24. 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 either sections 2.1.2, or 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.

A recommendation was made by the EERC that the alignment of the nozzles to the bags might be checked as one possibility for performance improvement. A laser alignment system was developed at the plant to place the laser inside the pulse nozzle and place a concentric target on the top of the bag cage. This was completed in several compartments and the results were reviewed. In general, it was found that most of the pulse nozzles were less than 2 degrees out of alignment with the top of the cage. Anything within 3 degrees was considered acceptable. After a portion of the system was inspected, it was clear that any pulse nozzles greater than 3 degrees out of alignment were visually obvious, and the laser alignment tool was foregone for a simple visual inspection. We are confident in saying that 99% of the nozzles are within the 3-degree tolerance.

4.0 CONCLUSIONS

Several significant changes have taken place to the Advanced Hybrid system during the last quarter. A significant performance effort was undertaken. The specific items of improvement to be evaluated are included in the list below, and a short evaluation of each effort is below the list.

- Filter bag washing
- Pulse cleaning system modifications
- Flue gas conditioning
- Reduction of gas volume in-leakage
- Pressure relief dampers
- Removal of ID Fan outlet dampers
- Other bag types

Filter Bag Washing. One half of all of the original filter bags were washed in place. There was a definite improvement with washing, as the plant was able to regain approximately 10 MW per wash. Due to the high differential pressure that was seen from startup, we determined that it was unlikely this effort alone would restore full load to the power plant through the warm summer months of operation.

Pulse Cleaning System Modifications. A small effort was undertaken to install a single control system on one compartment of the system. Insignificant conclusions could be made through this effort.

Flue Gas Conditioning. The plant had an existing humidification system in place. This was not tested in this quarter. It is still possible that testing could take place in the next quarter.

Reduction of Air in-Leakage. The ductwork and system was walked down and inspected for areas where abnormal air in-leakage might be occurring. These areas would be easy to locate as air in-leakage would cause local areas of corrosion as the flue gas cools and the sulfur in the flue gas causes corrosion of the steel ductwork. No significant areas were found, but small areas around the old outlet ESP were seal welded.

Pressure Relief Dampers. Eight pressure relief dampers and ductwork were installed during the June outage. During the initial testing, the opacity was high enough to cause three 6-minute opacity exceedences. As a result, formal testing of the system was delayed until it was determined if these were needed. All of the dampers were left in the closed position until it is decided to do further testing.

Removal of ID Fan Outlet Dampers. Since the plant uses the ID fan inlet dampers for control, it was possible to remove the outlet dampers to reduce some of the existing flow restriction of the ductwork.

The ability of the fans to generate pressure has improved by approximately 0.5 INH2O.

Other Bag Types. Several different types of bags were evaluated using the pitot tubes. The largest performance improvement can be seen with a change in bag types. As a result, all of the bags in the system have been changed out and approximately 75% of the material is a new type of bag.

Performance

The previously stated four fundamental performance parameters of the system remain good starting points for performance evaluation. These are:

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

Opacity remained low right up to the June wash outage. After the June wash outage, opacity has been running in the 4-5% range. The stack looks just as clear as it did after the original startup, so some of this increase is probably attributable to the inability of the instrument to be calibrated to extremely accurate levels. However, the pressure relief dampers are now in the ductwork, clouding the issue. Further stack testing will be delayed until the final plan for these dampers is decided.

The A/C ratio has been running at approximately 11:1 in late June. With the rising temperatures this summer, it is likely that we will be running at 12:1.

Dramatic improvements in tubesheet dP were accomplished this quarter. Analyzing the graph in Appendix B5, the tubesheet dP has decreased from approximately 9.5 to about 7 INH2O. At the same time, the A/C ratio has increased from 10 to 11 fpm. This was the step change in performance needed to get the system under control. This improvement can almost wholly be attributed to the different bag type installed in 75% of the system.

The compressed air flow needed to clean the bags has dramatically decreased. During periods of constant pulsing prior to the outage in June the compressed air usage was around 2200 acfm. After the new bags were installed, the full load compressed air usage has been around 700 acfm. This means the new bags are less resistant to gas flow, and the compressed air needed to maintain this resistance is only one-third the level needed with the old bags.

<u>Summary</u>

All of these efforts and changes have resulted in the return of full load capability to the Big Stone Plant. Long-term performance results will need to be documented to determine if the changes made are enough to bring the Advanced Hybrid system up to acceptable standards. The focus during the next quarter is fairly simple:

- Document high A/C ratio results
- Continue any performance improvement efforts deemed necessary

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

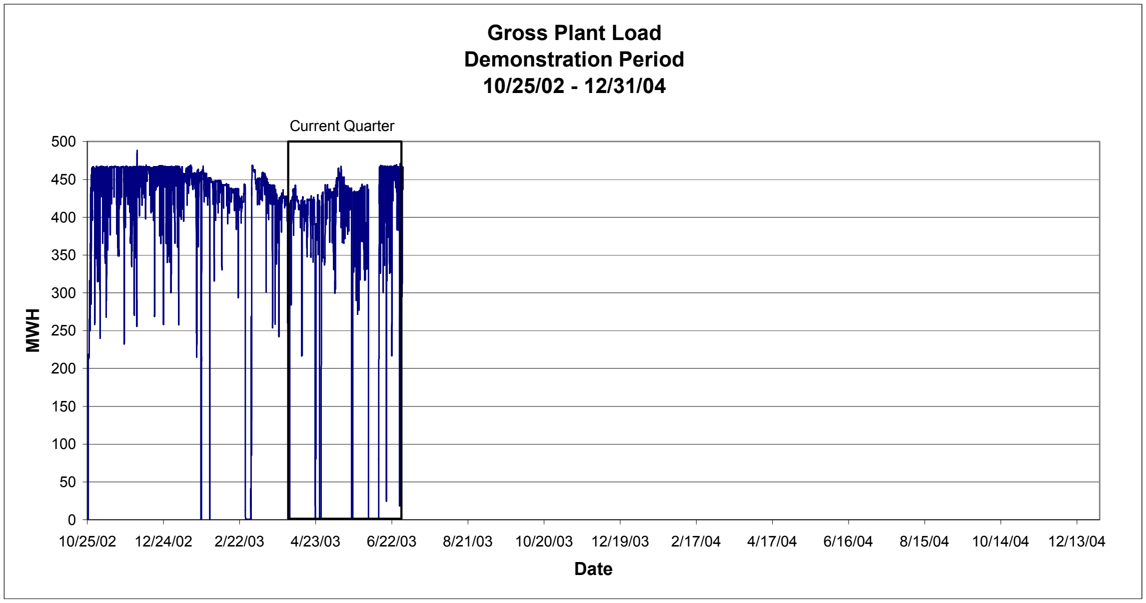
Appendix B14 & 15. The “adjustment” refers to an end of the month correction based on a comparison between visual levels and bookkeeping levels.

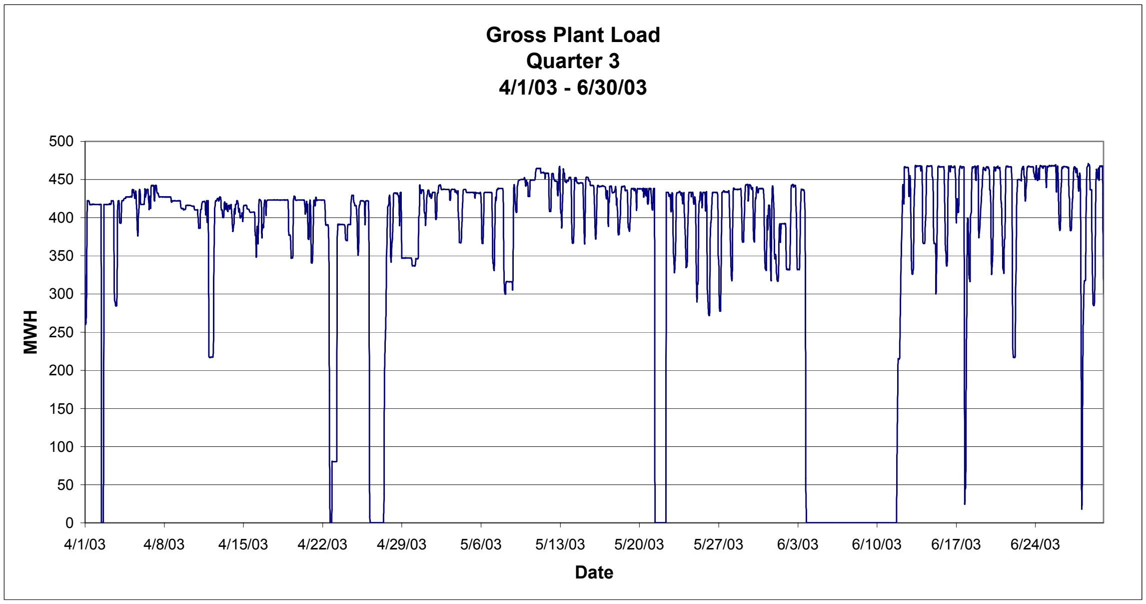
Appendix B8. Opacity graph shows spikes around 6/10/2003. These are instrument difficulties, and not representative of actual opacity.

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.

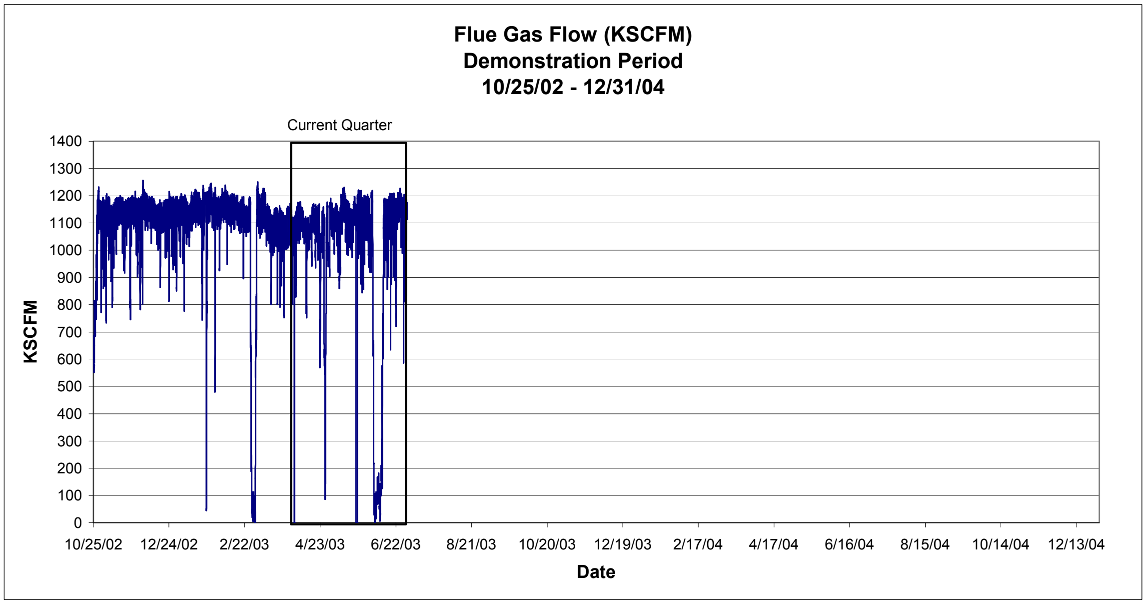
APPENDIX B – GRAPHICAL & TABULAR PERFORMANCE DATA

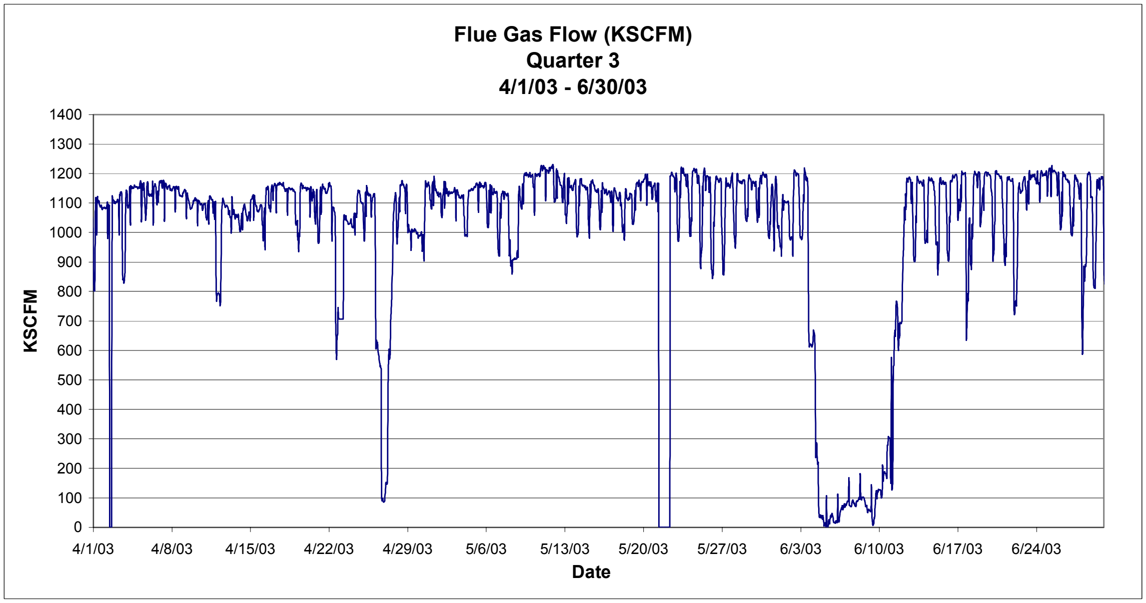
B1 Gross Plant Load



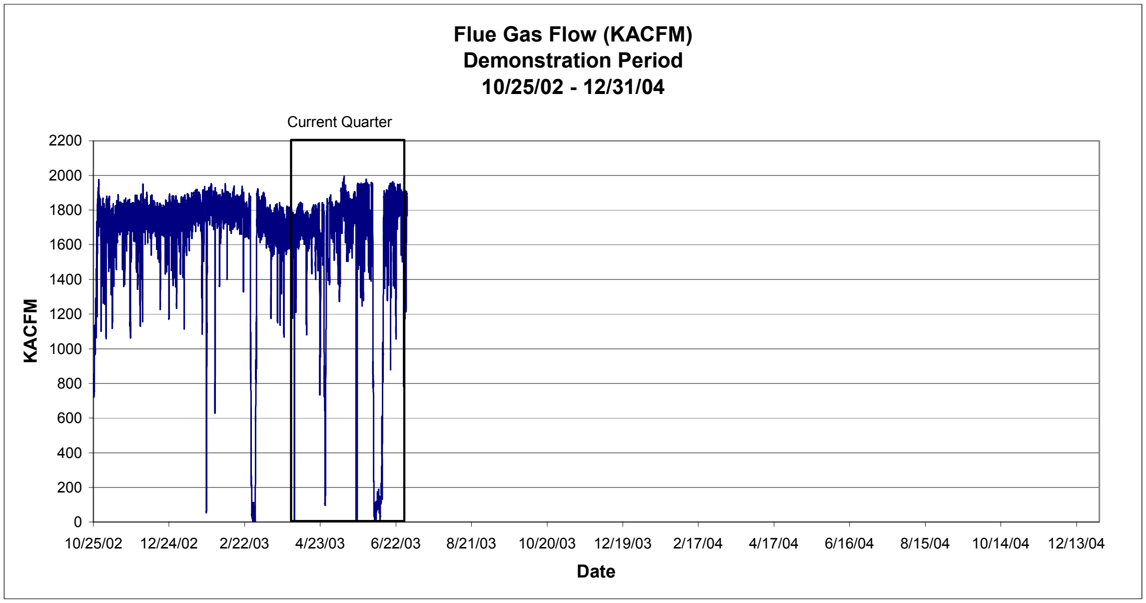


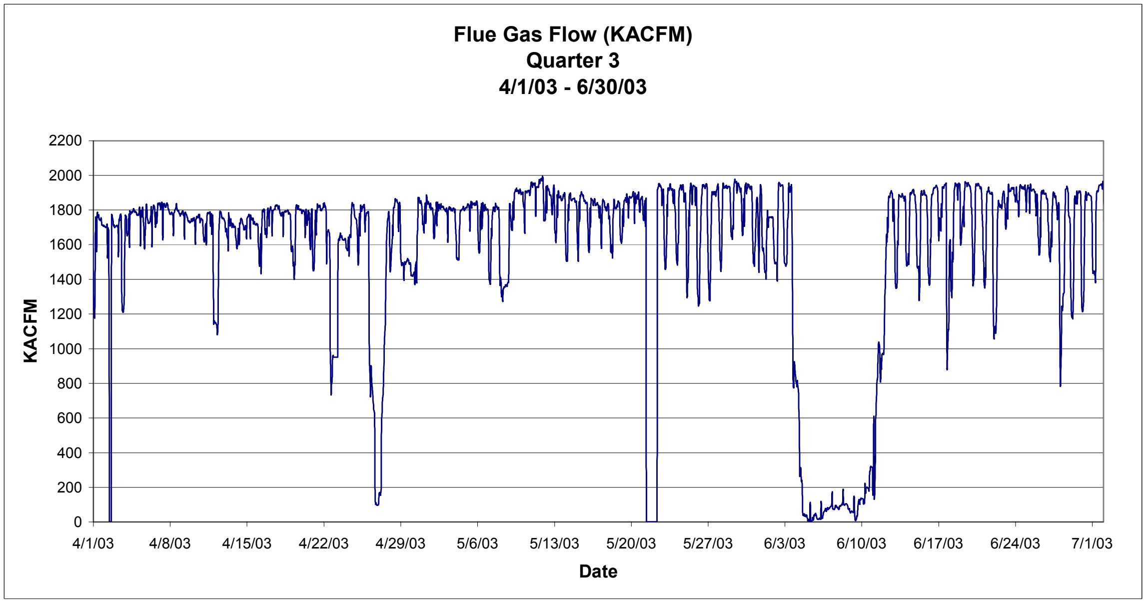
B2 Flue Gas Flow (KSCFM)



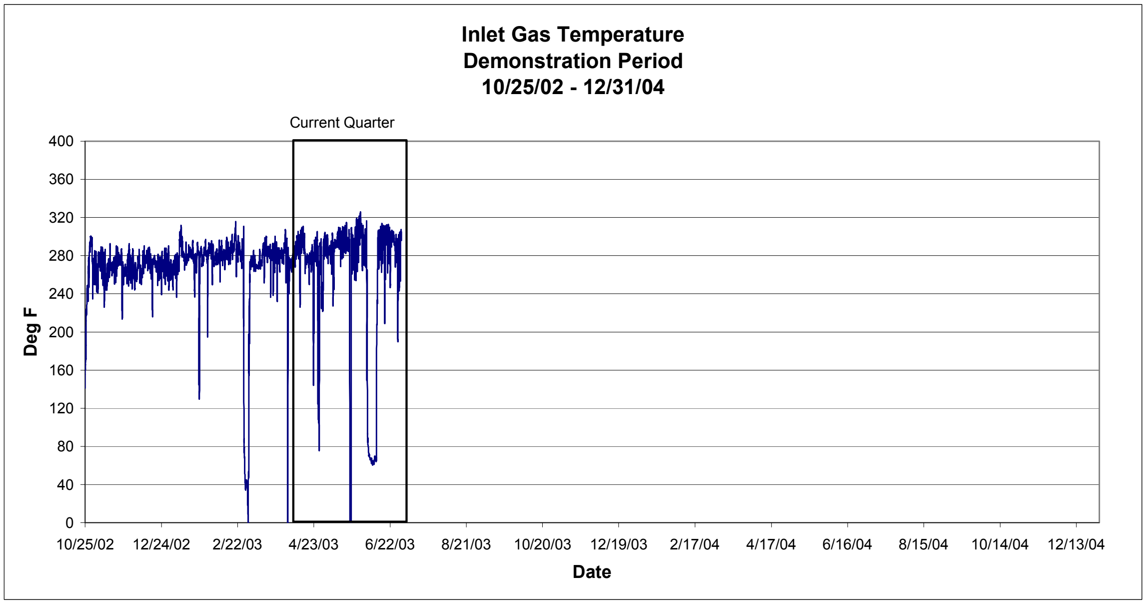


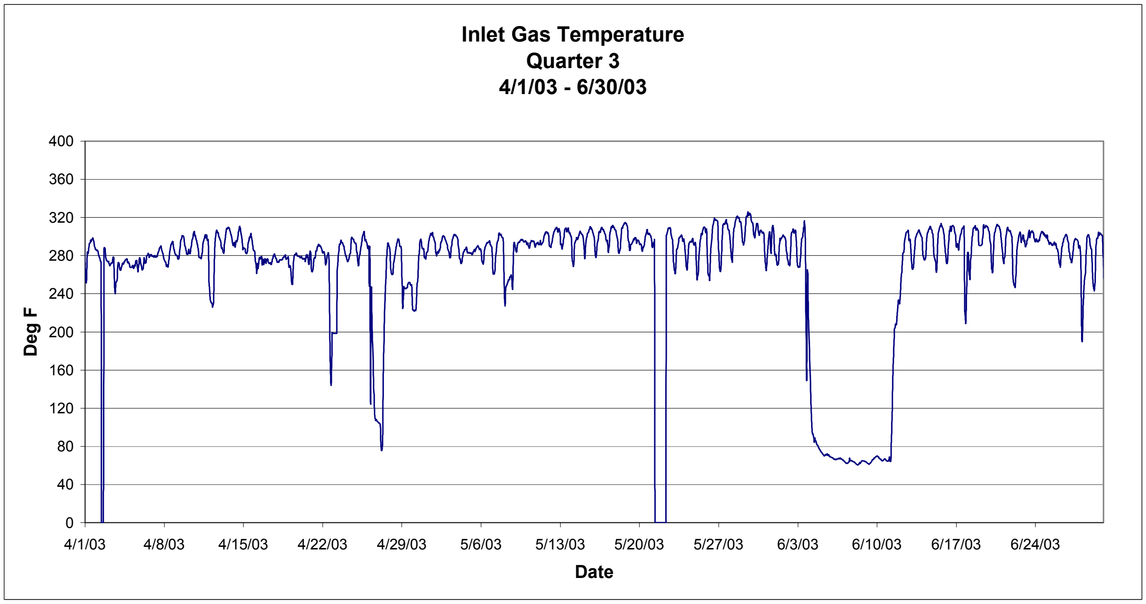
B3 Flue Gas Flow (KACFM)



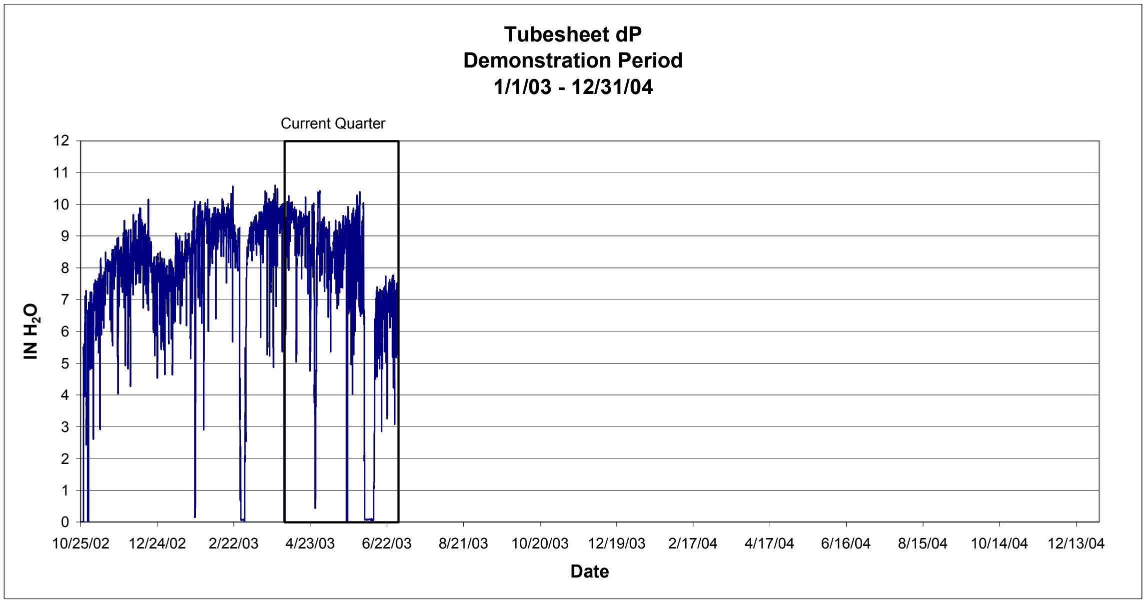


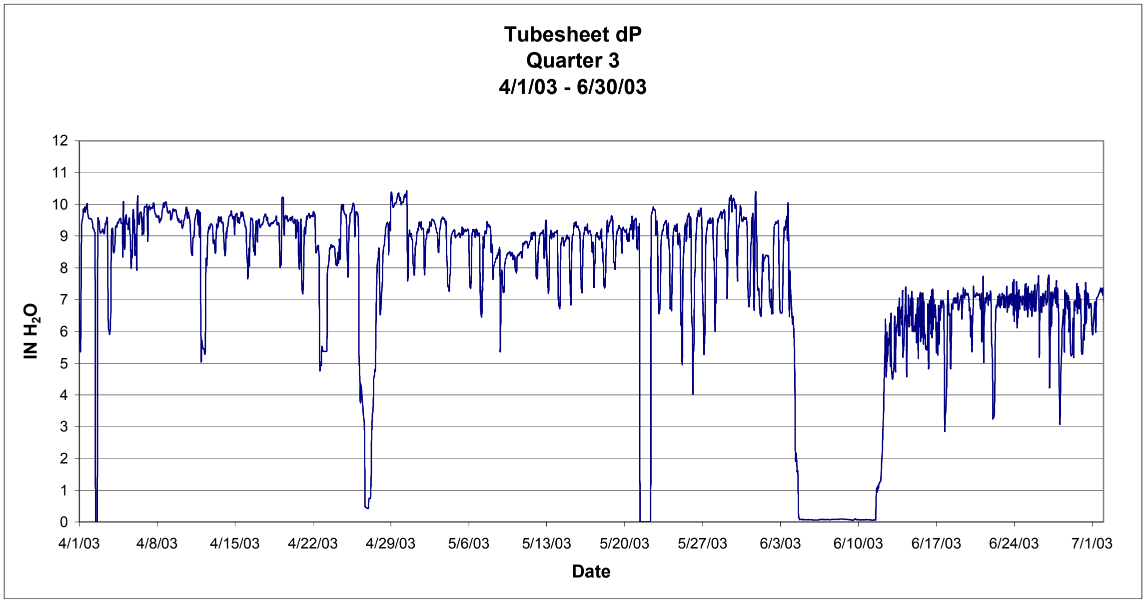
B4 Inlet Gas Temperature



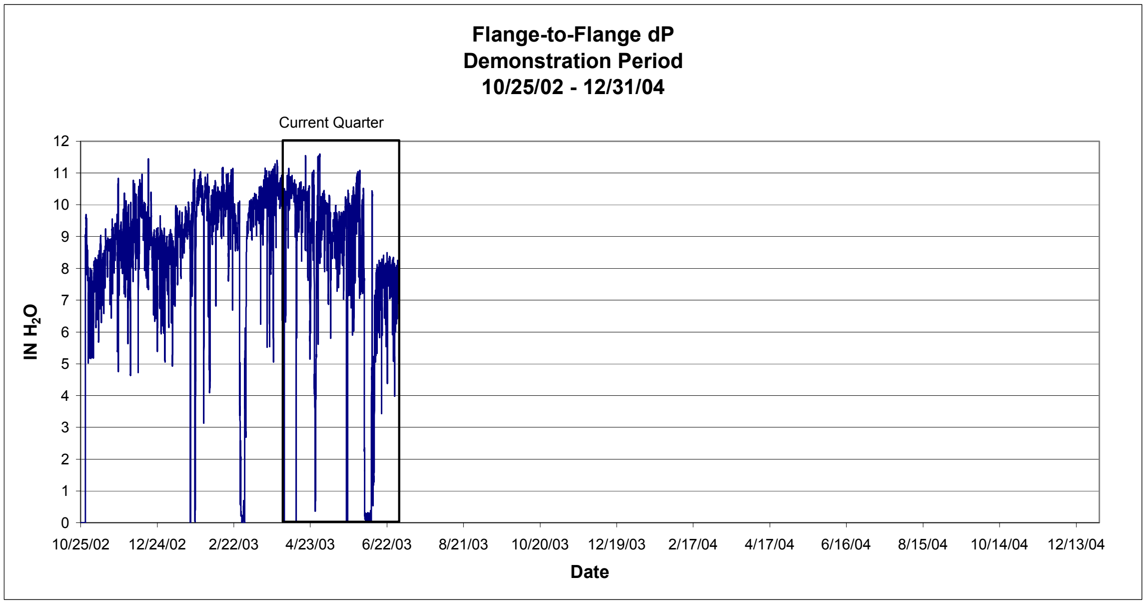


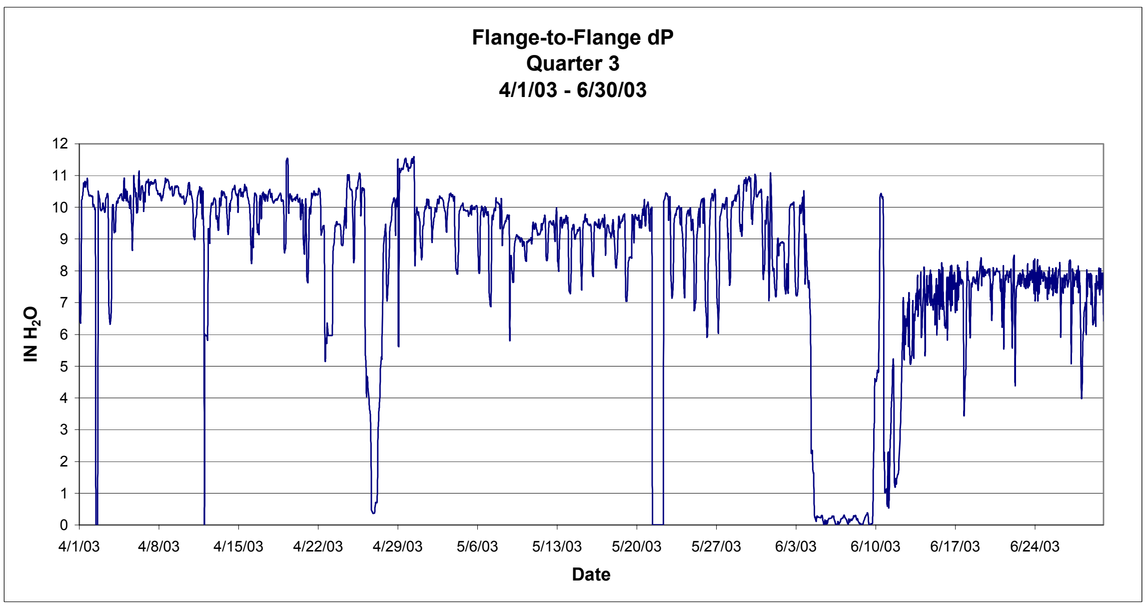
B5 Tubesheet dP



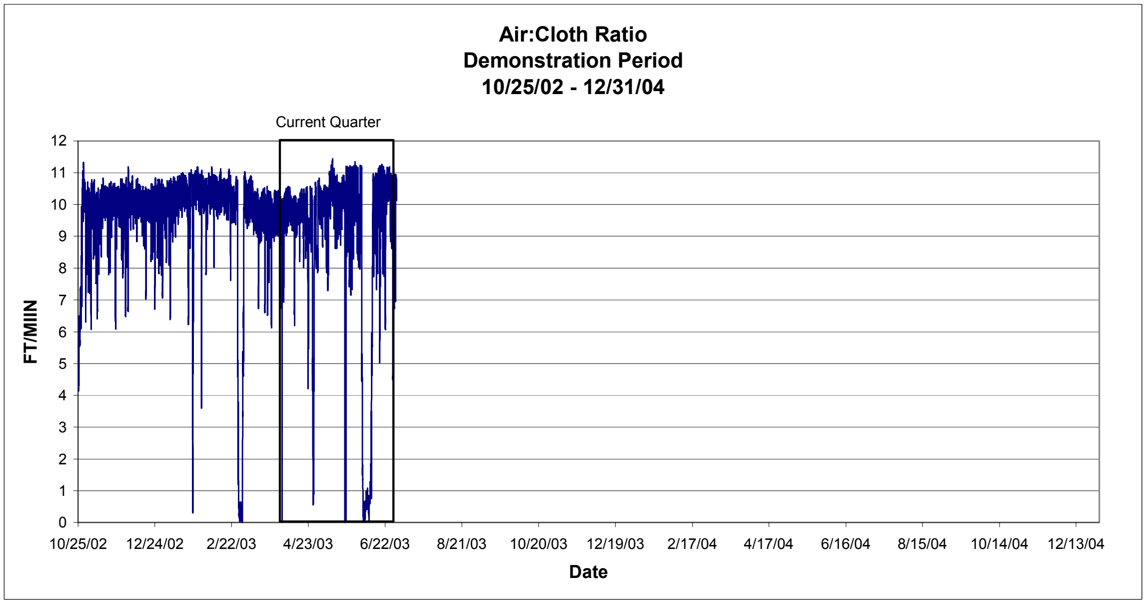


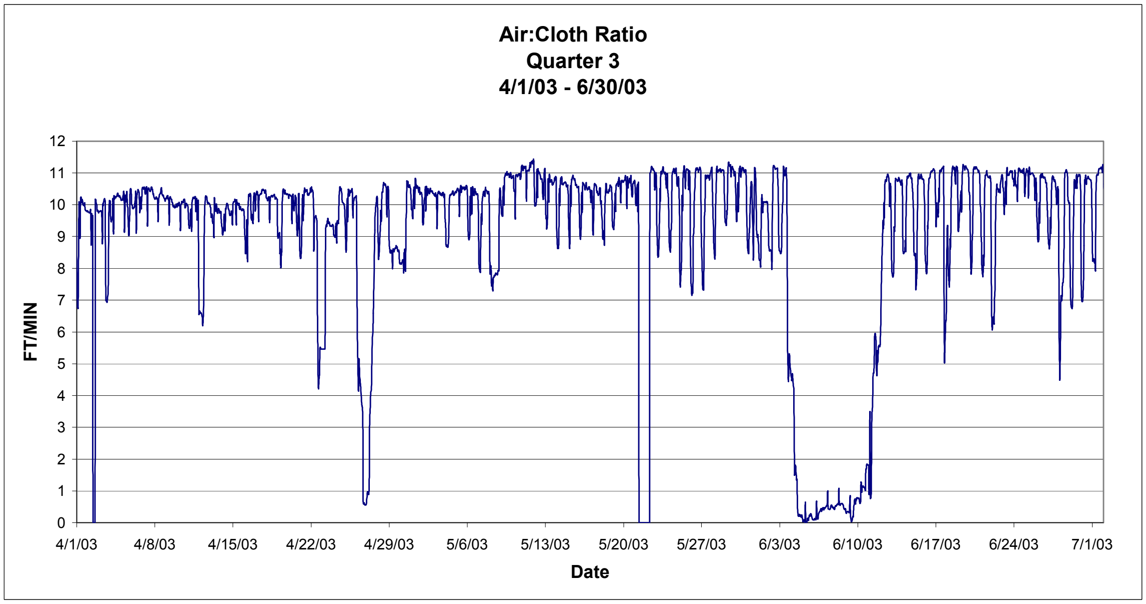
B6 Flange-to-Flange dP



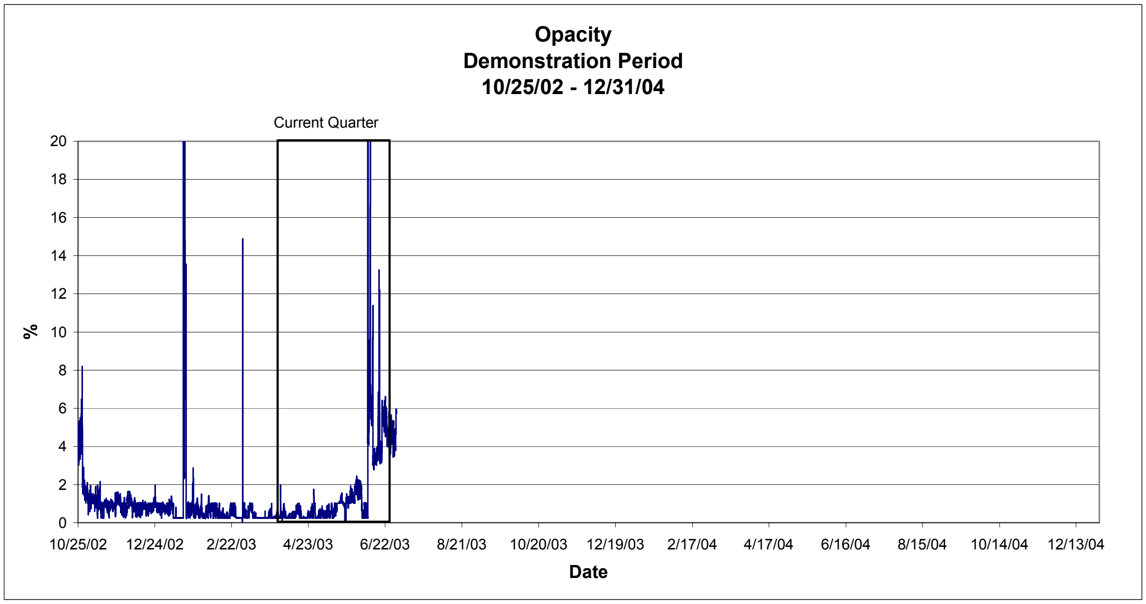


B7 Air-to-Cloth Ratio

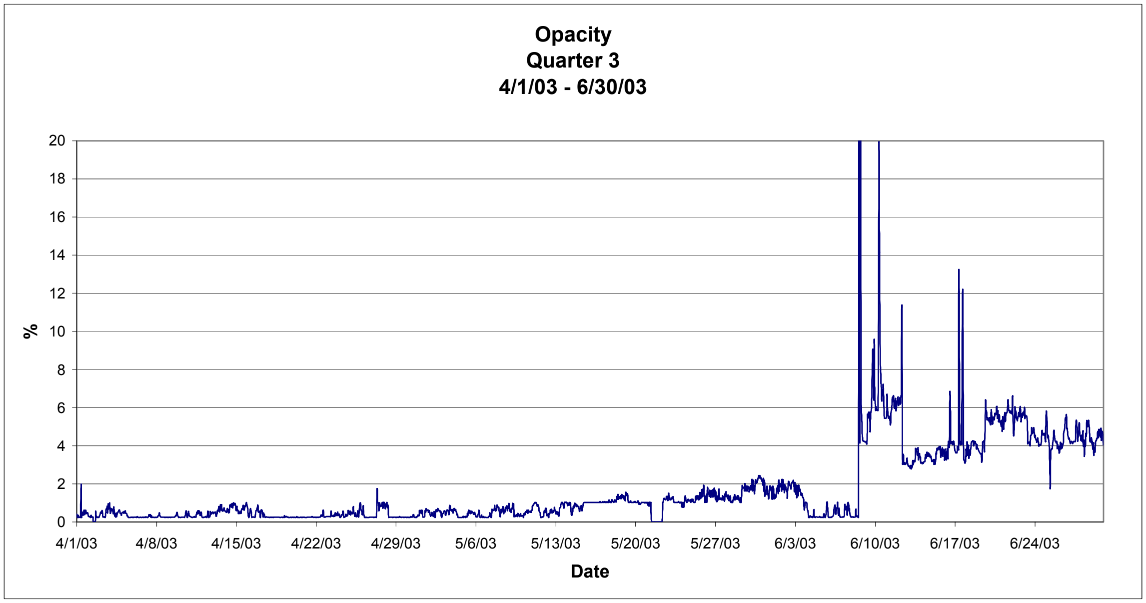




B8 Opacity

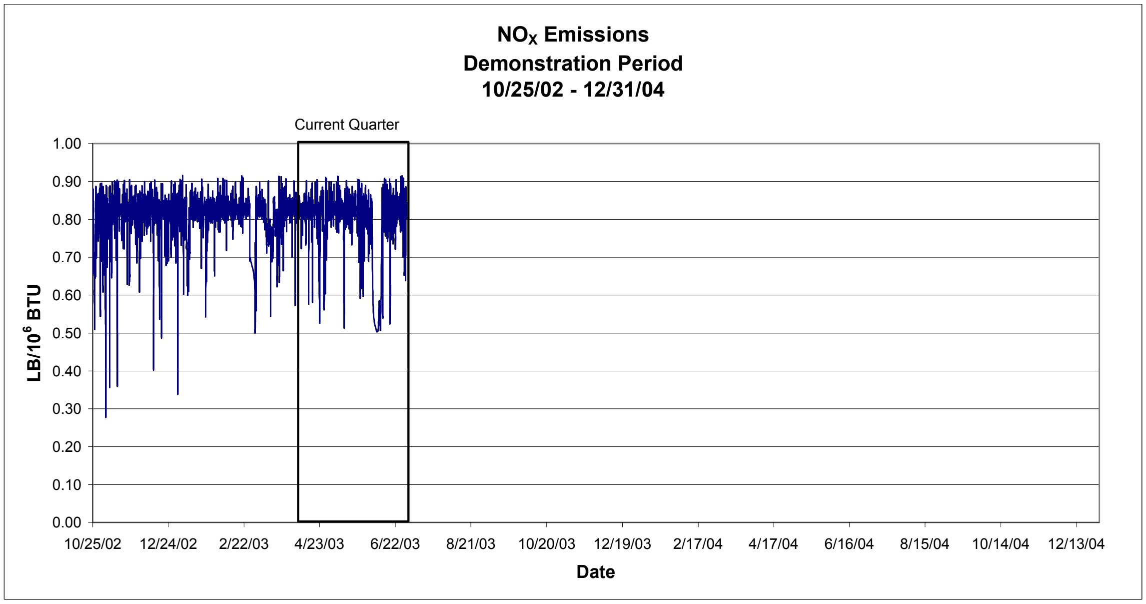


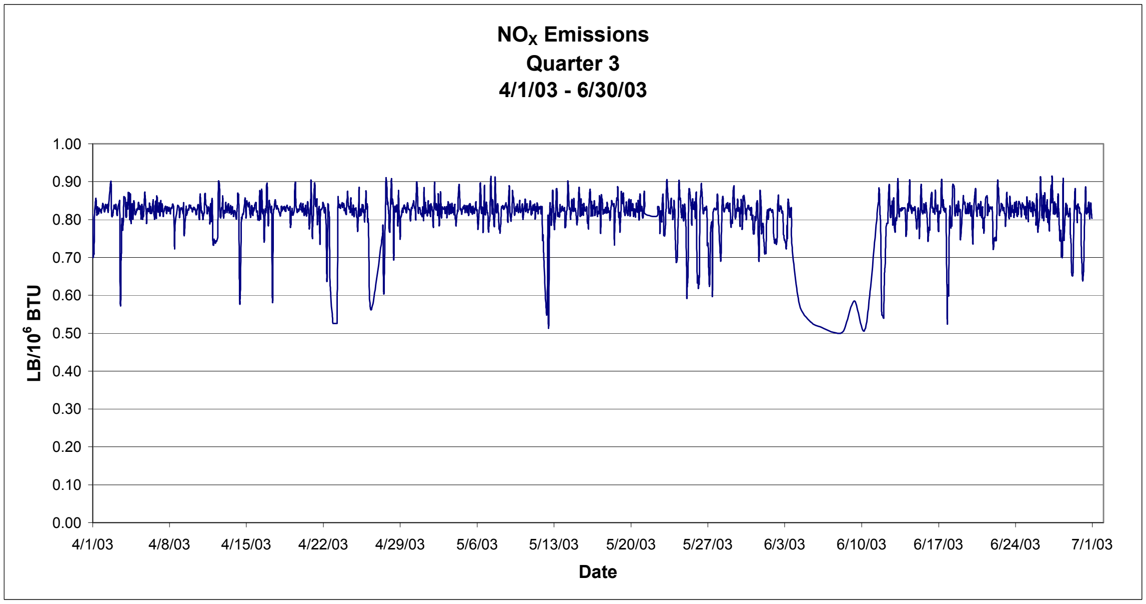
Opacity
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
20
18
16
14
12
10
8
6
4
2
0
%
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date



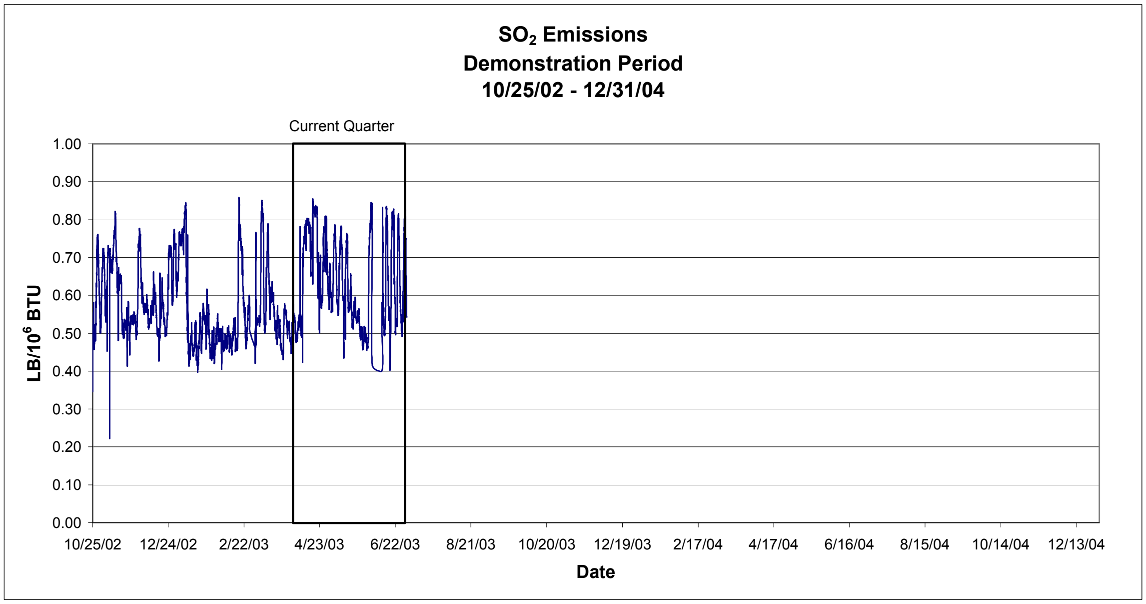
Opacity
Quarter 3
4/1/03 - 6/30/03
20
18
16
14
12
10
8
6
4
2
0
%
4/1/03
4/8/03
4/15/03
4/22/03
4/29/03
5/6/03
5/13/03
5/20/03
5/27/03
6/3/03
6/10/03
6/17/03
6/24/03
Date

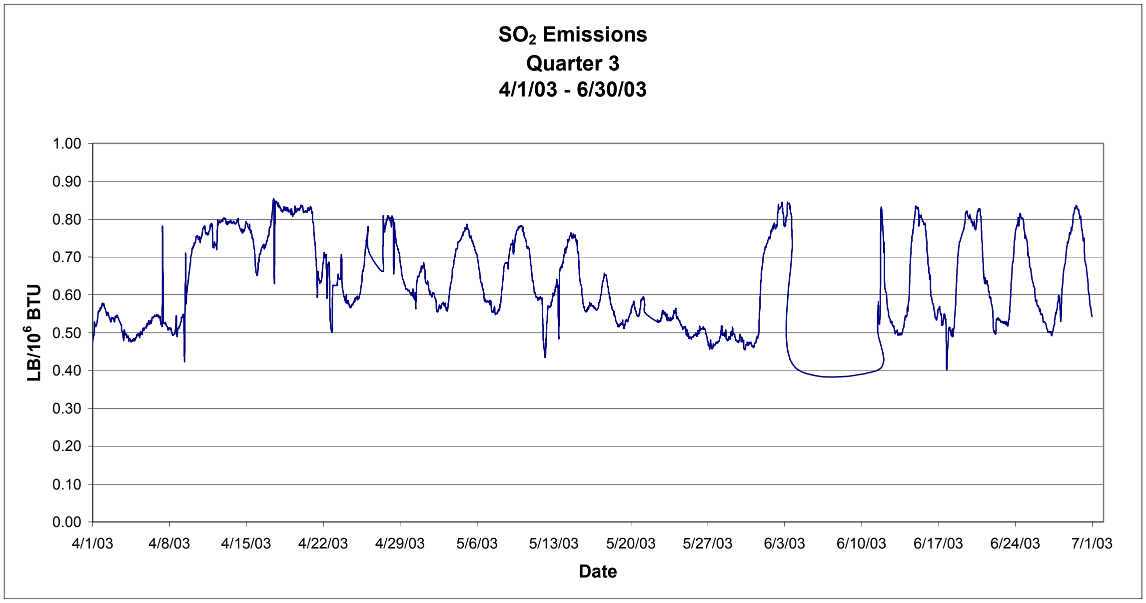
B9 NO_X Emissions



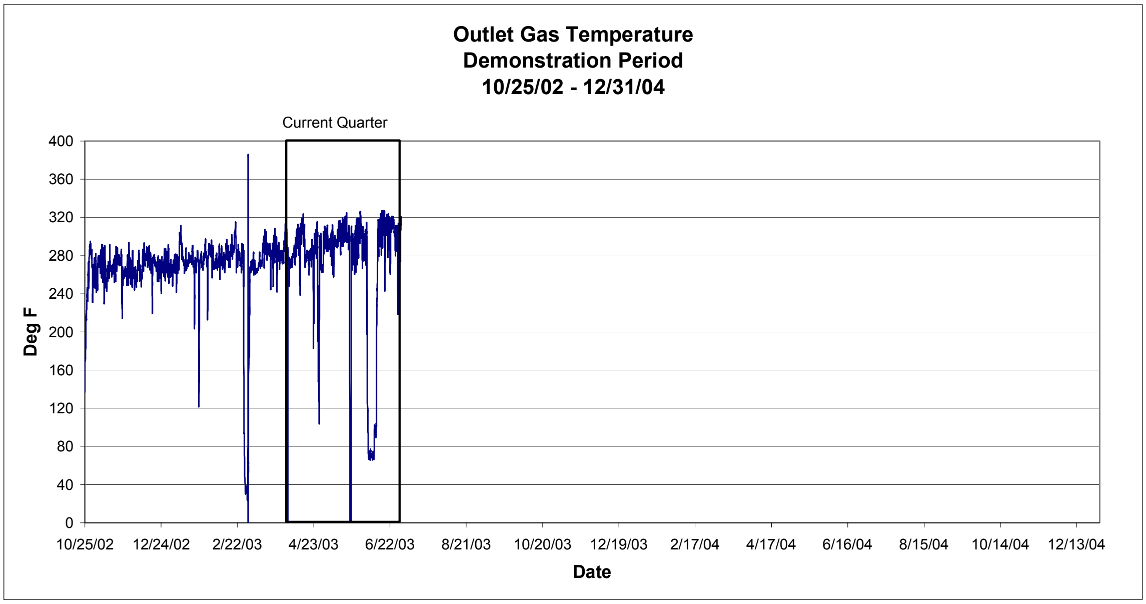


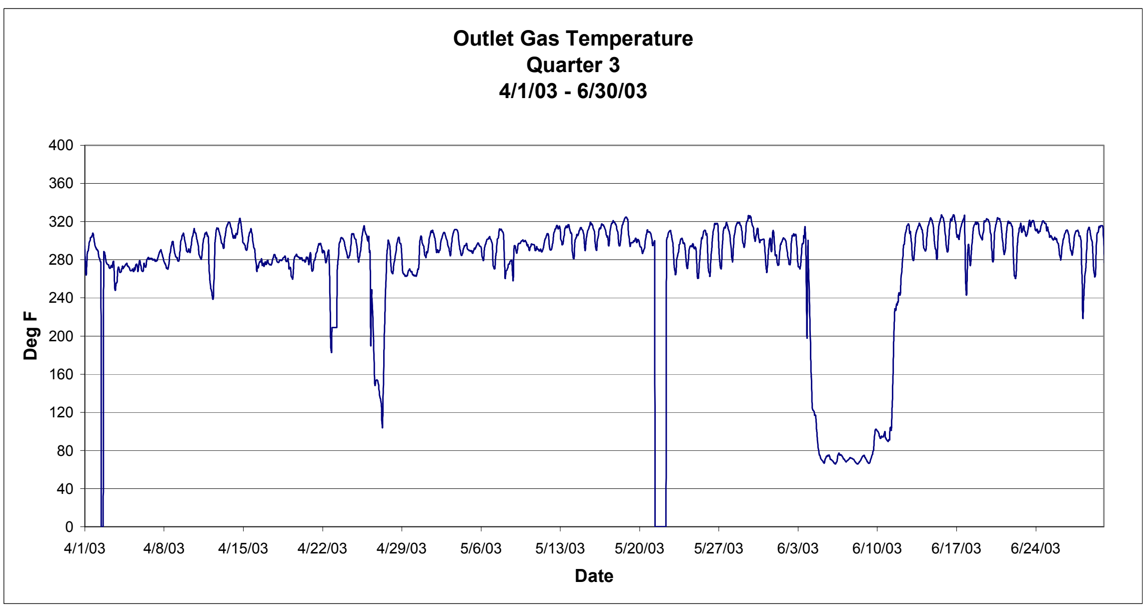
B10 SO_2 Emissions



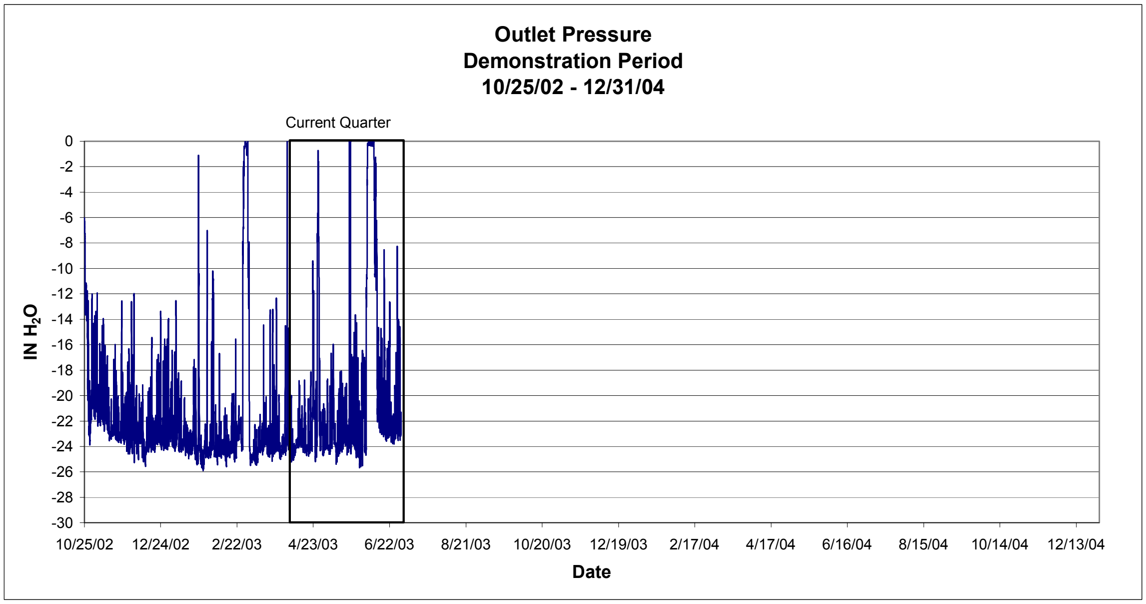


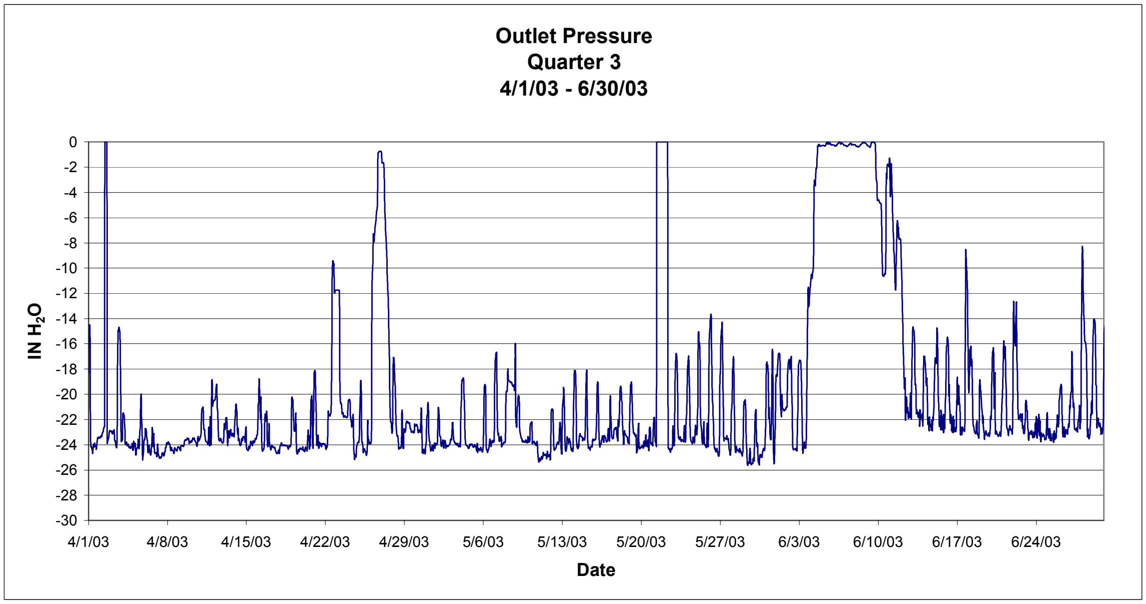
B11 Outlet Gas Temperature



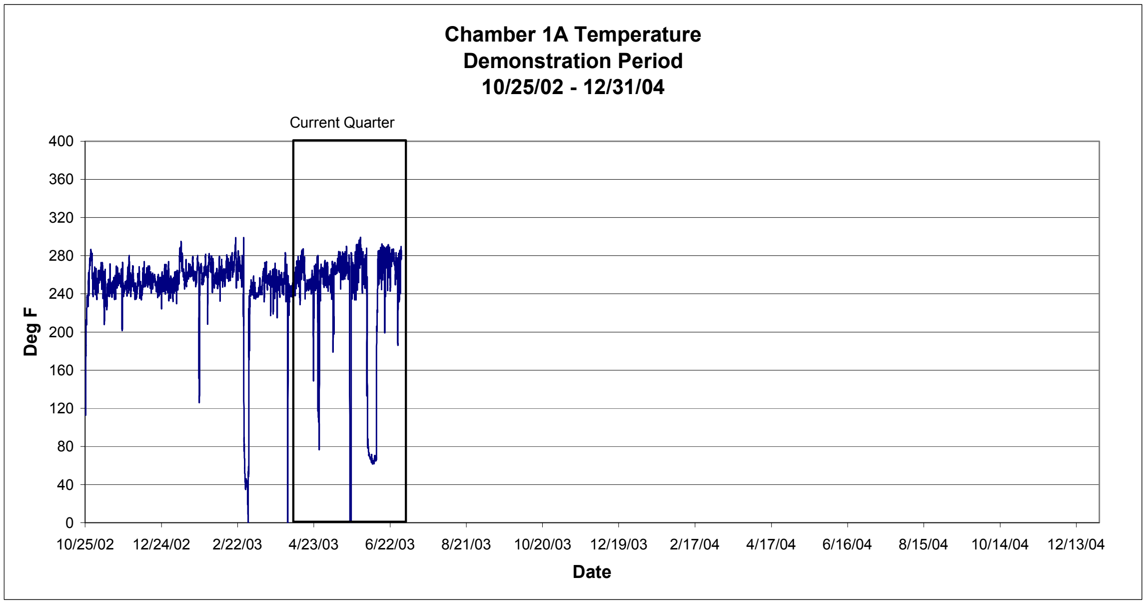


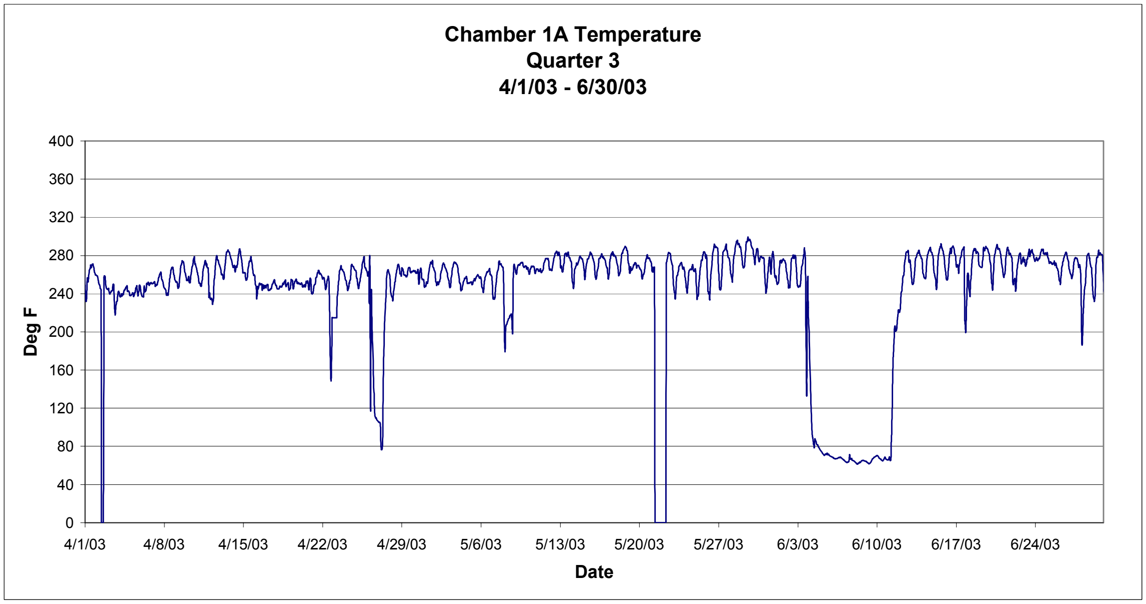
B12 Outlet Pressure

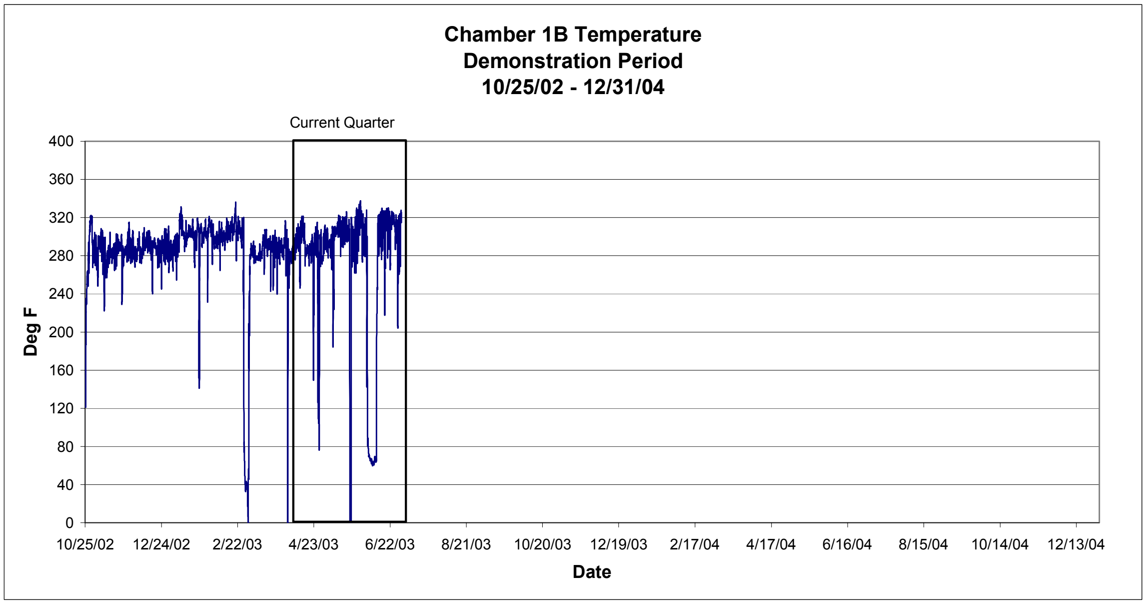


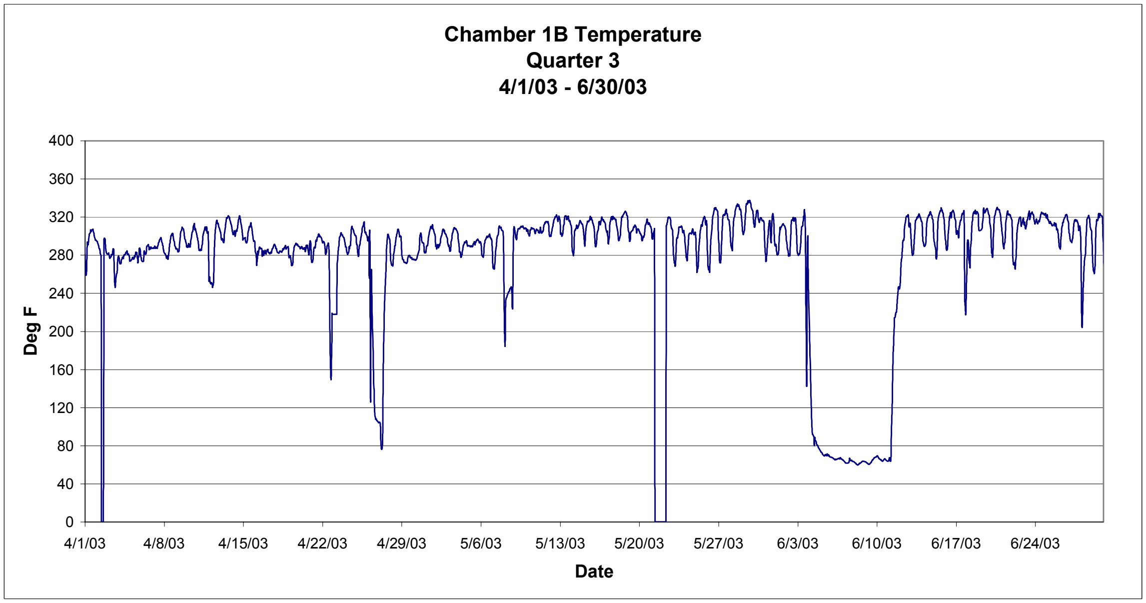


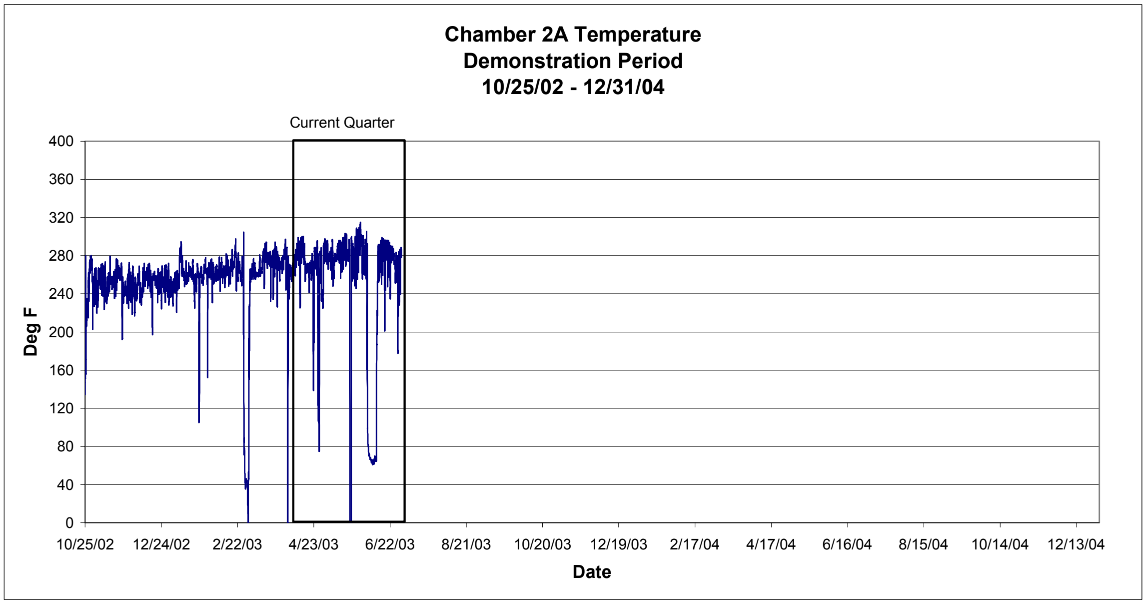
B13 Temperature per Chamber

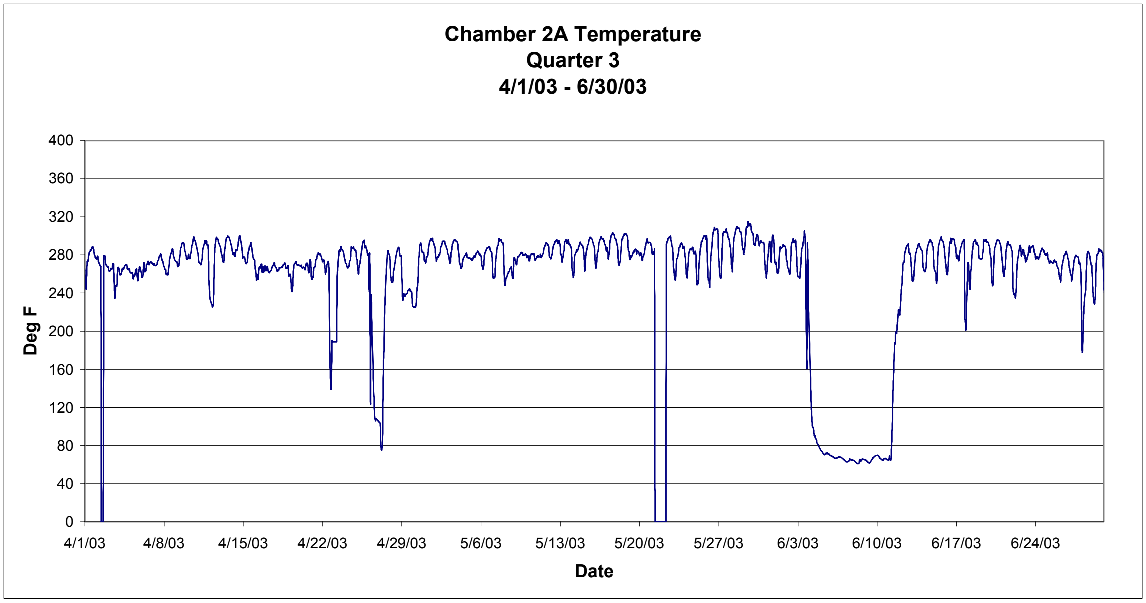


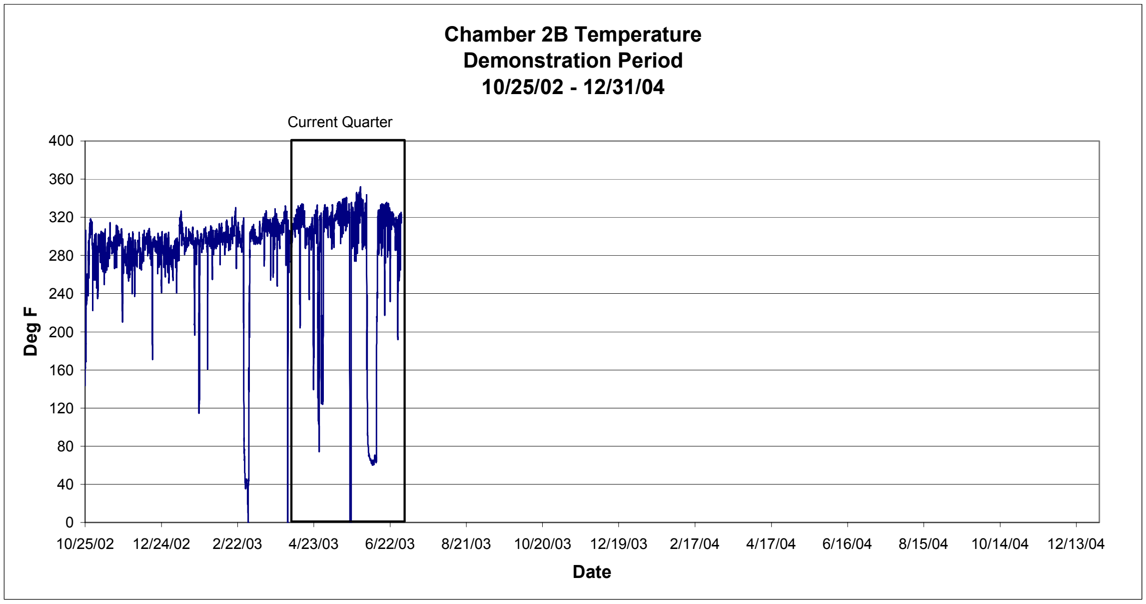


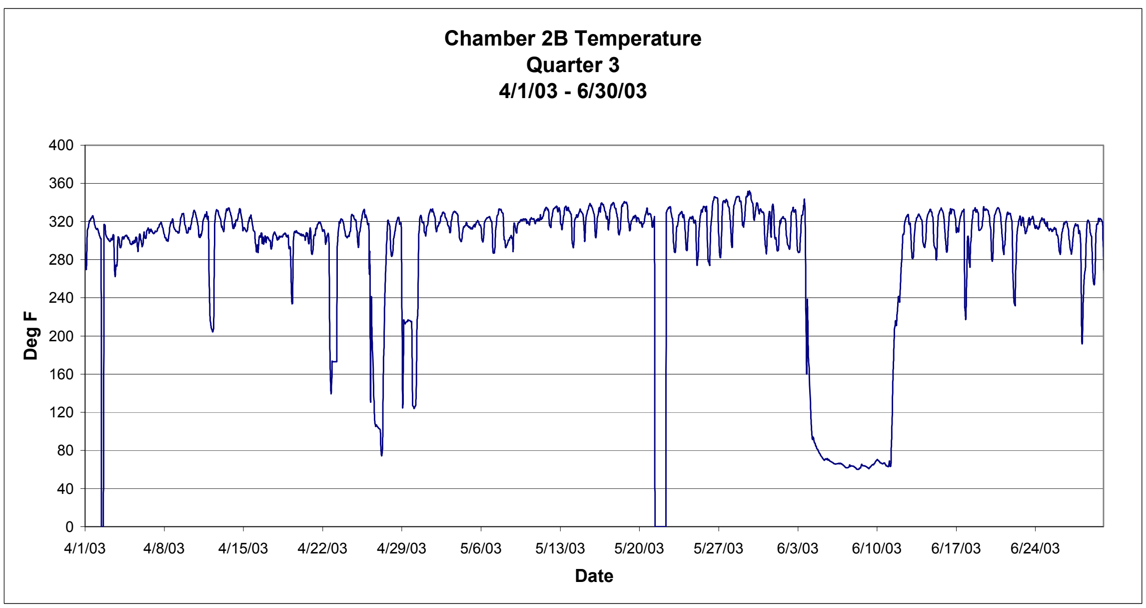

Chamber 1B Temperature
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
400
360
320
280
240
200
160
120
80
40
0
Deg F
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 1B Temperature
Quarter 3
4/1/03 - 6/30/03
400
360
320
280
240
200
160
120
80
40
0
Deg F
4/1/03
4/8/03
4/15/03
4/22/03
4/29/03
5/6/03
5/13/03
5/20/03
5/27/03
6/3/03
6/10/03
6/17/03
6/24/03
Date


Chamber 2A Temperature
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
Deg F
400
360
320
280
240
200
160
120
80
40
0
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 2A Temperature
Quarter 3
4/1/03 - 6/30/03
Deg F
400
360
320
280
240
200
160
120
80
40
0
4/1/03
4/8/03
4/15/03
4/22/03
4/29/03
5/6/03
5/13/03
5/20/03
5/27/03
6/3/03
6/10/03
6/17/03
6/24/03
Date


Chamber 2B Temperature
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
Deg F
400
360
320
280
240
200
160
120
80
40
0
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 2B Temperature
Quarter 3
4/1/03 - 6/30/03
Deg F
400
360
320
280
240
200
160
120
80
40
0
4/1/03
4/8/03
4/15/03
4/22/03
4/29/03
5/6/03
5/13/03
5/20/03
5/27/03
6/3/03
6/10/03
6/17/03
6/24/03
Date

B14 Fuel Burn Record

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	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(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	P. Coke	TDF	Waste Seeds	Toner	Gran. Insul.	Canvas Belting	Plastic Chips
	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(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

B15 Fuel Analysis Record

BIG STONE PLANT COAL ANALYSIS PER TRAIN
Apr-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. 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		30.11	4.65	8491	0.35	6.65	12148	0.50	1.67		Burn	164805.80

Monthly Mercury Analysis

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

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
	May-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	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
											Tons. OK	184842.830
Weighted Average		29.63	4.59	8560	0.31	6.53	12163	0.44	1.52		Burn	184842.830

Monthly Mercury Analysis

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

BIG STONE PLANT COAL ANALYSIS PER TRAIN

Jun-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. 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	0.00	
2-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
3-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
4-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
5-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
6-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
7-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
8-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
9-Jun-03	0	0	0	0	0	0	0	0	0	0	0.00	
10-Jun-03	0	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	0.00	
13-Jun-03	0	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	0.00	
17-Jun-03	0	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	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	0.00	
22-Jun-03	0	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	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	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	0.00	
ADJ.												127979.52
											Tons. OK	127979.52
Weighted Avg.		30.17	4.57	8482	0.36	6.54	12145	0.51	1.72		Burn	127979.52

Monthly Mercury Analysis

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

B16 Ash Analysis Record

None recorded this quarter

B17 Ultimate Coal Analysis

ULTIMATE ANALYSIS
AS RECEIVED

Sample Date	Moisture %	Ash %	Carbon %	Nitrogen %	Sulfur %	Hydrogen %	Oxygen %	HHV btu/lb	NaO %	Mercury 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										
13-Jul-03										
20-Jul-03										
27-Jul-03										
03-Aug-03										
10-Aug-03										
17-Aug-03										
24-Aug-03										
31-Aug-03										
07-Sep-03										
14-Sep-03										
21-Sep-03										
28-Sep-03										
05-Oct-03										
12-Oct-03										
19-Oct-03										
26-Oct-03										
02-Nov-03										
09-Nov-03										
16-Nov-03										
23-Nov-03										
30-Nov-03										
07-Dec-03										
14-Dec-03										
21-Dec-03										
28-Dec-03										

B18 Pictures from April 29 bag wash in Chamber 2B

April 29,2003

Big Stone Plant

AHPC Bag Wash

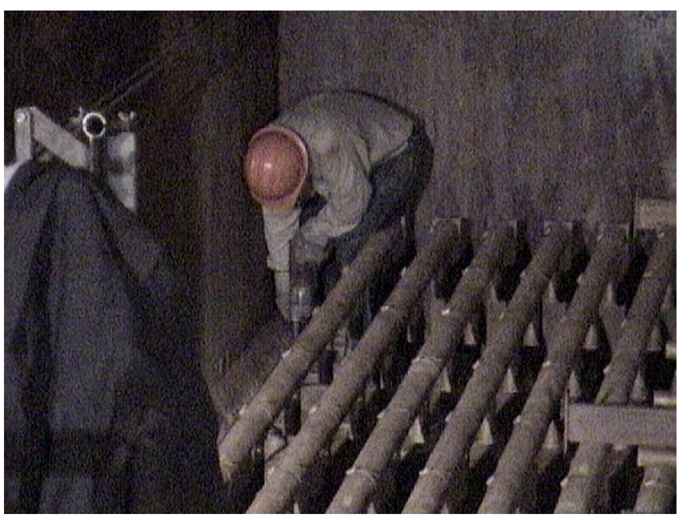
OK, these are Confined Spaces, everyone sign on the Permit

Work begins – Blowpipe removal

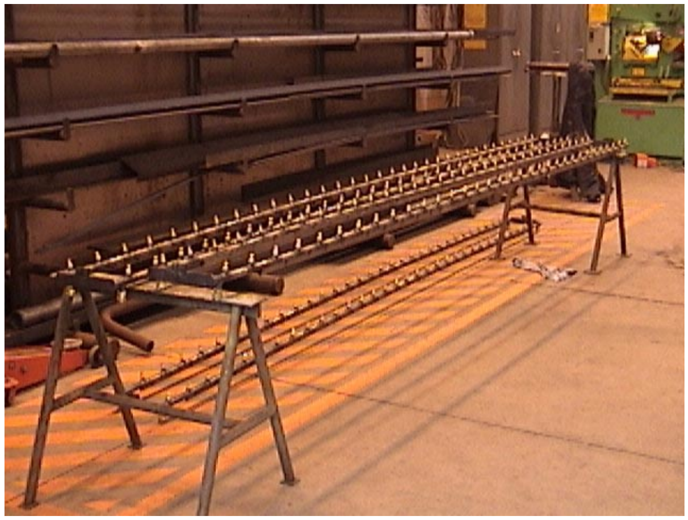
Safety – Make sure the TR Set is Grounded out

Blowpipe’s out

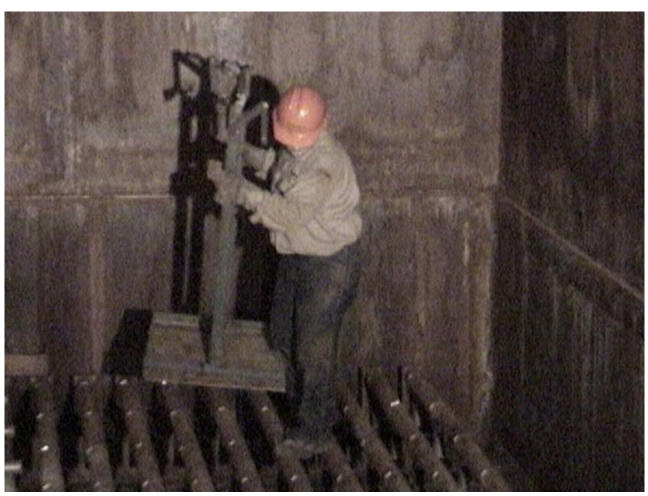
Drilling access holes for the wash (126 of em’)



The Wash headers standby - Ready for Service

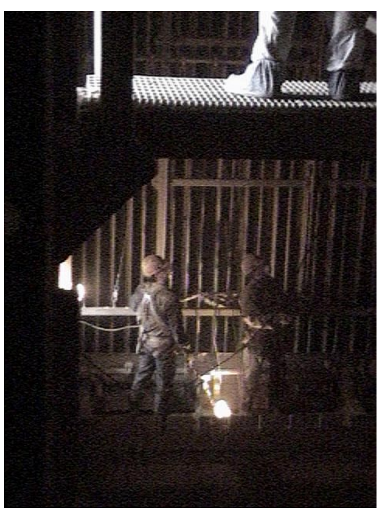


Getting ready to wash – Setting up the hoists



Crews preparing to enter the Gas path compartments

AHPC Wash

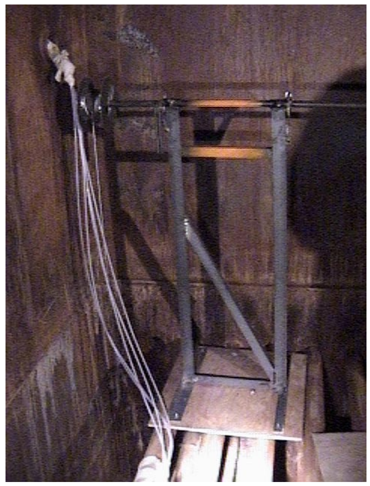


- Building staging in the first compartment.

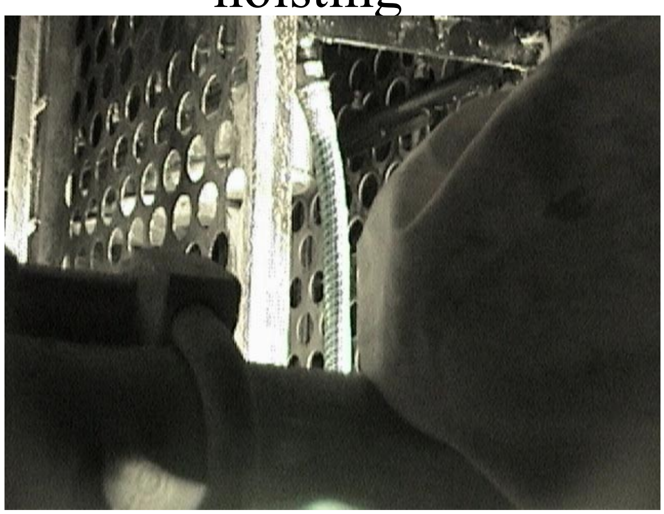
Looking straight up – staging built in compartment A

Guide bar removal

Winching system set for action

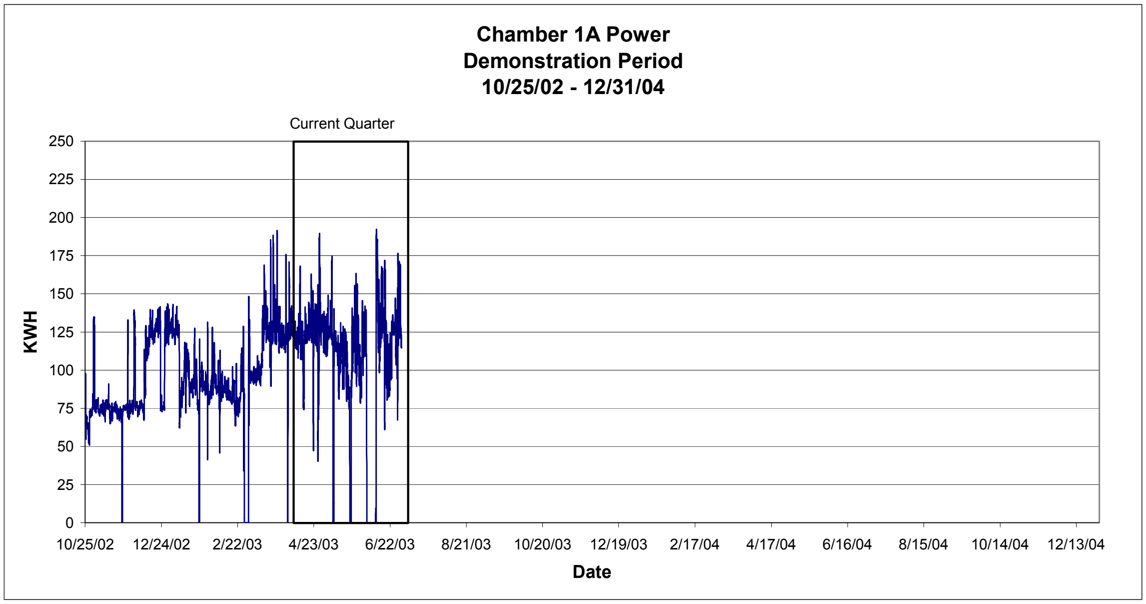


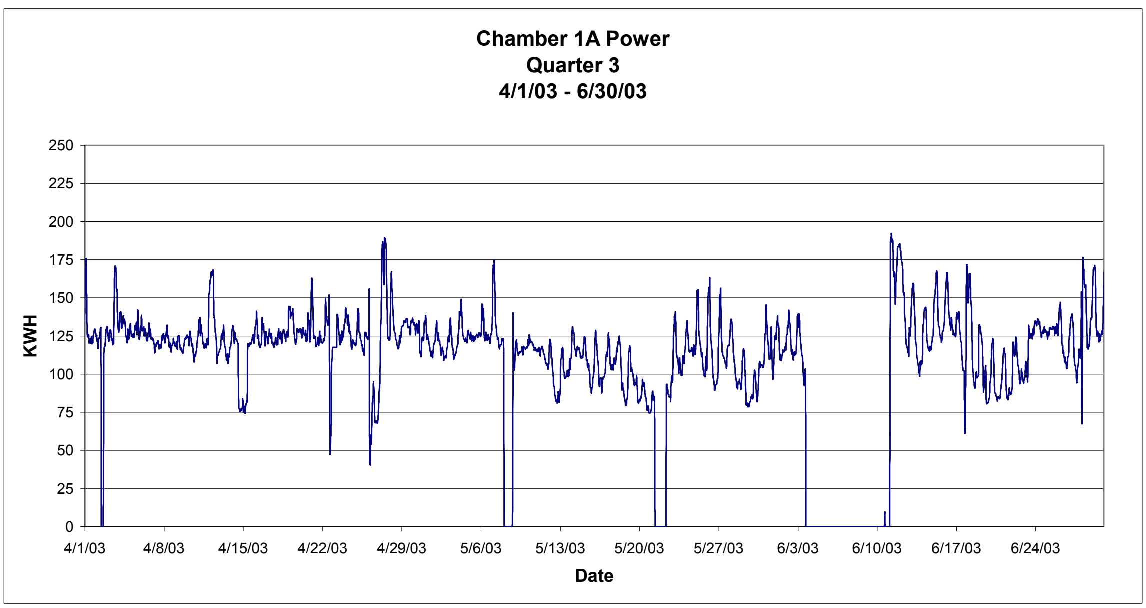
Wash header in place ready for hoisting

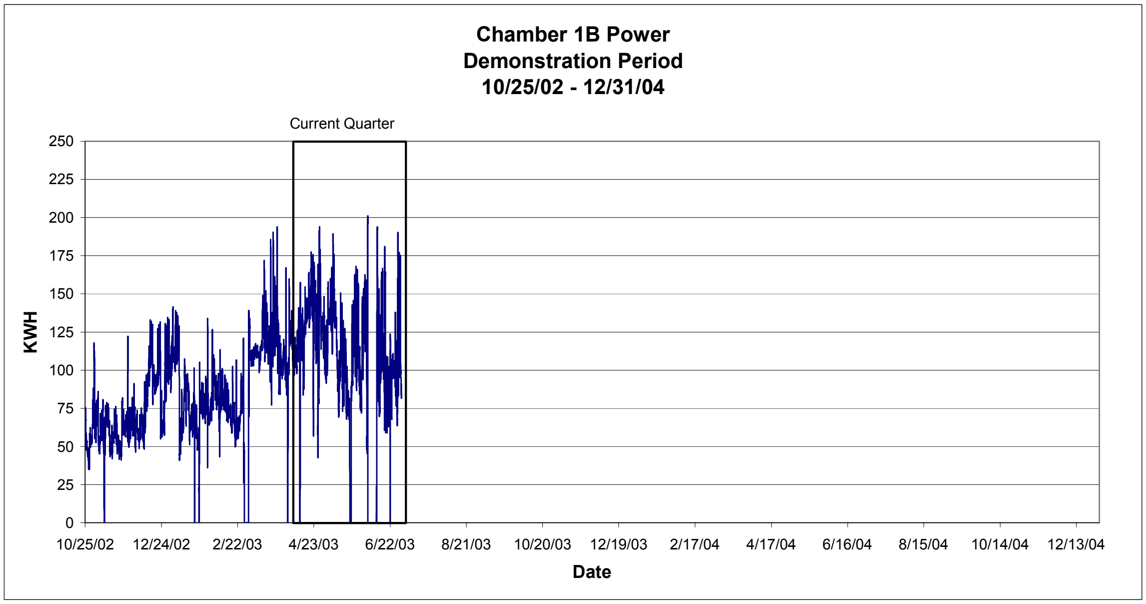


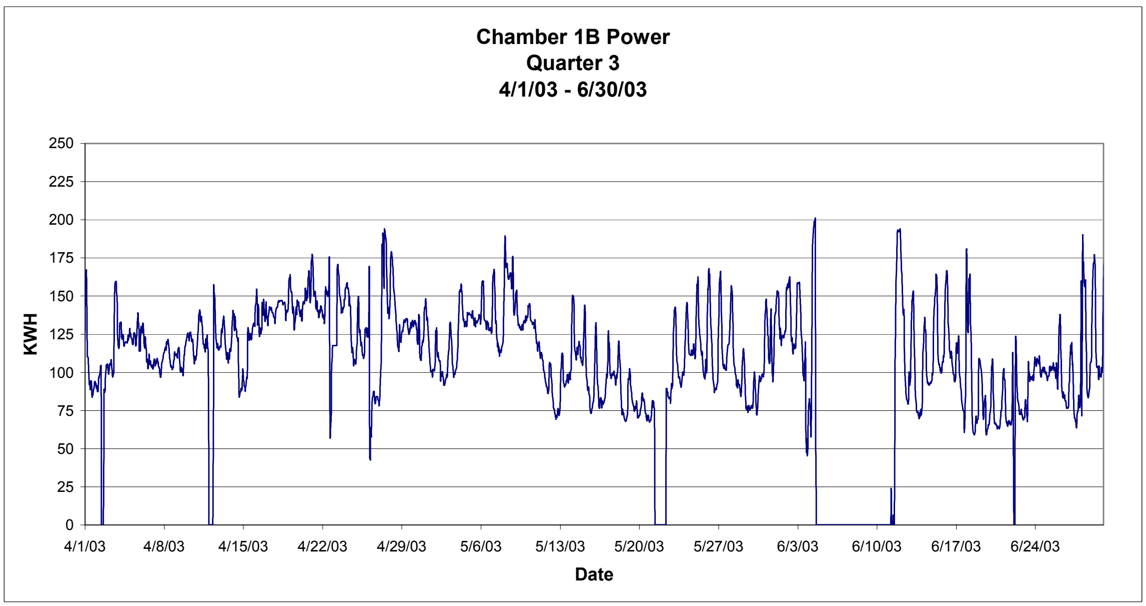
Hoisting the wash rack

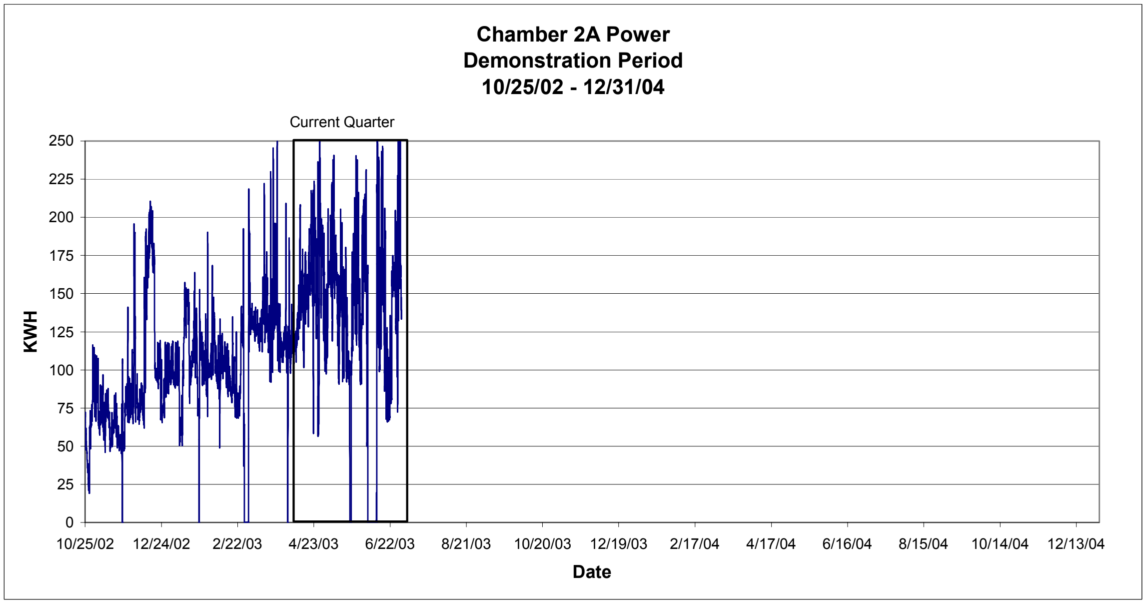
B19 ESP Power by Chamber

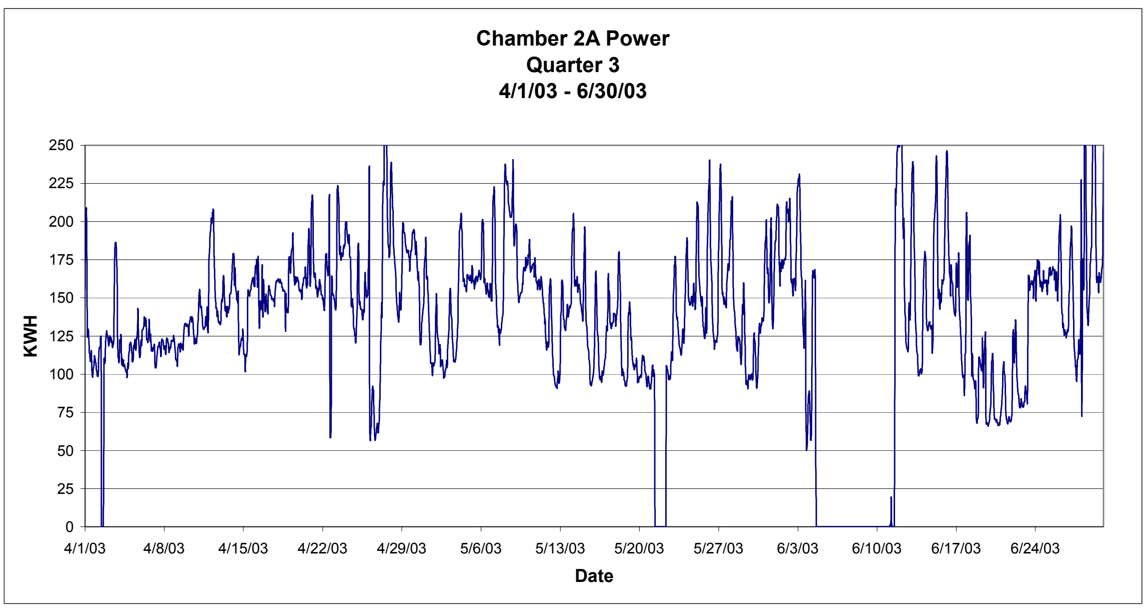


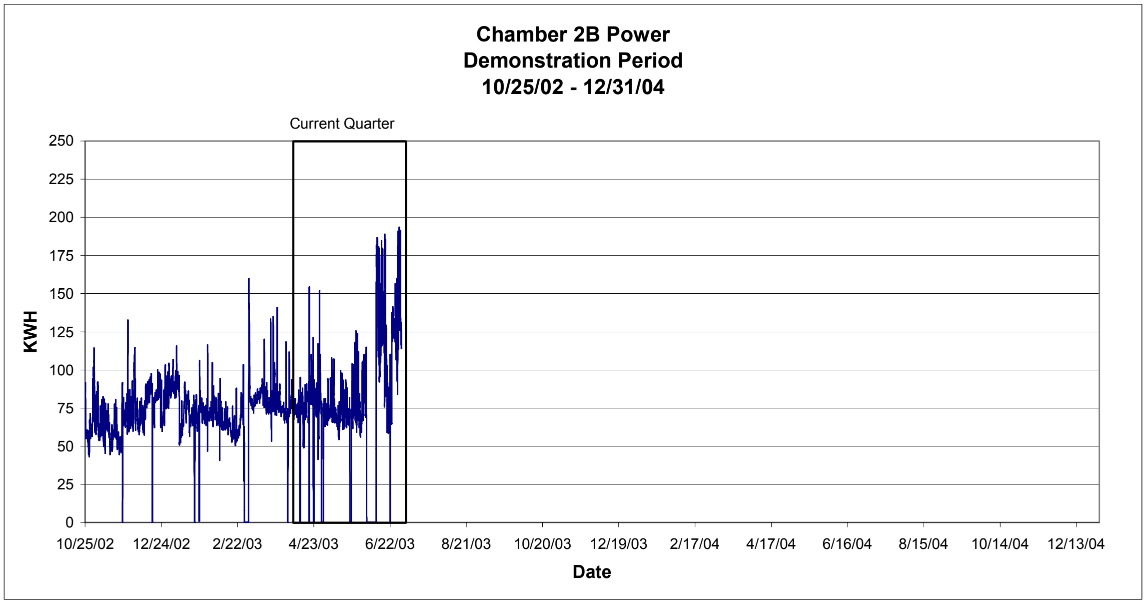


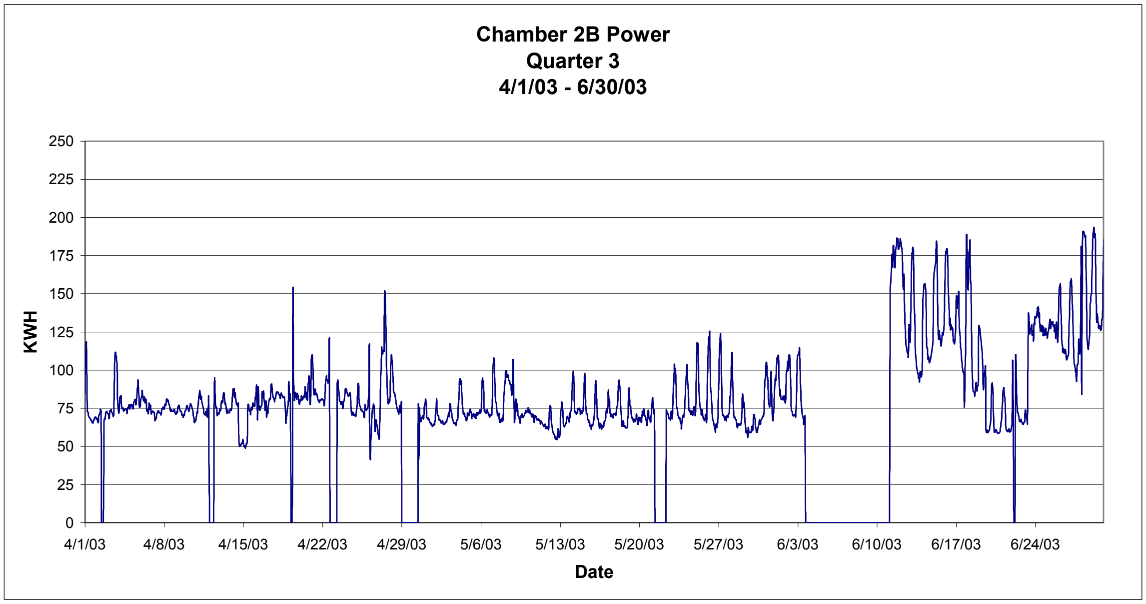

Chamber 1B Power
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
KWH
250
225
200
175
150
125
100
75
50
25
0
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 1B Power
Quarter 3
4/1/03 - 6/30/03
KWH
250
225
200
175
150
125
100
75
50
25
0
4/1/03
4/8/03
4/15/03
4/22/03
4/29/03
5/6/03
5/13/03
5/20/03
5/27/03
6/3/03
6/10/03
6/17/03
6/24/03
Date


Chamber 2A Power
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
KWH
250
225
200
175
150
125
100
75
50
25
0
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 2A Power
Quarter 3
4/1/03 - 6/30/03
KWH
250
225
200
175
150
125
100
75
50
25
0
4/1/03
4/8/03
4/15/03
4/22/03
4/29/03
5/6/03
5/13/03
5/20/03
5/27/03
6/3/03
6/10/03
6/17/03
6/24/03
Date


Chamber 2B Power
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
KWH
250
225
200
175
150
125
100
75
50
25
0
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 2B Power
Quarter 3
4/1/03 - 6/30/03
KWH
250
225
200
175
150
125
100
75
50
25
0
4/1/03
4/8/03
4/15/03
4/22/03
4/29/03
5/6/03
5/13/03
5/20/03
5/27/03
6/3/03
6/10/03
6/17/03
6/24/03
Date

B20 ESP Tabular Data

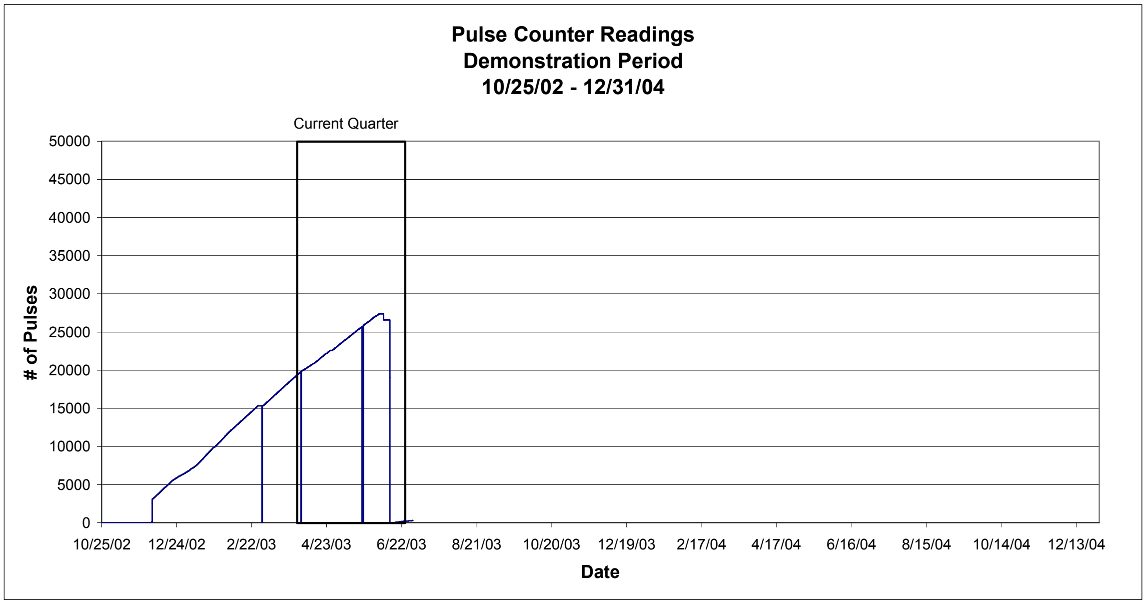
Transformer/Rectifier Performance Readings

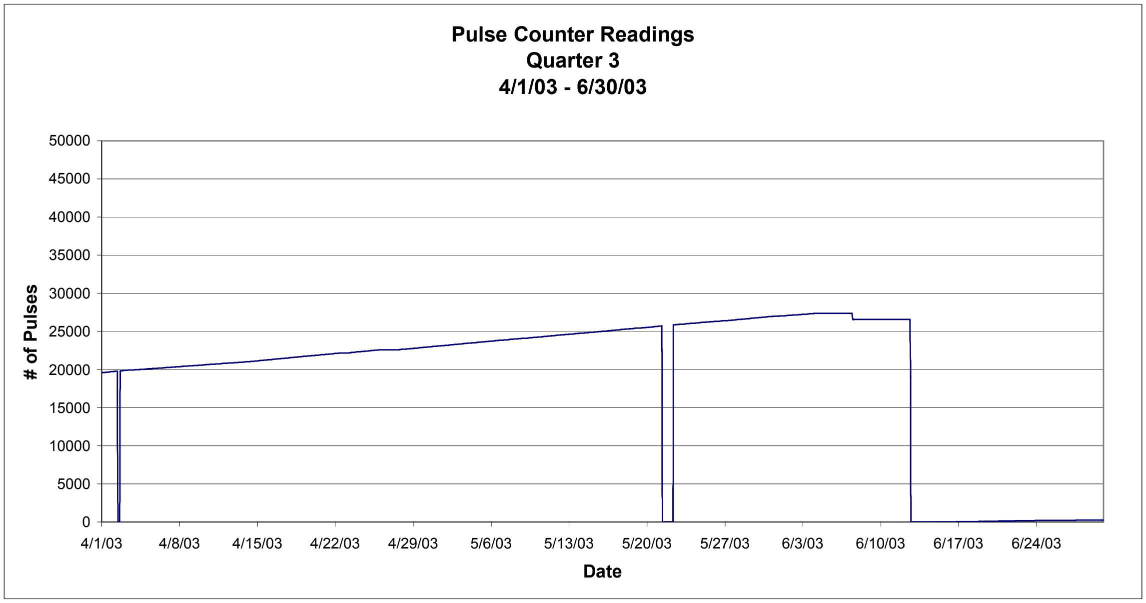
16-Apr-03	* Limiting factors highlighted											
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	192	58.8	98	535	44	19	997	50.1	3	1001	52.4	0
1B	464	61.4	97	661	48.9	19	818	48.5	19	1000	51.6	1
2A	600	64.8	6	774	50.3	19	494	46.8	19	995	50.3	3
2B	84	48	99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

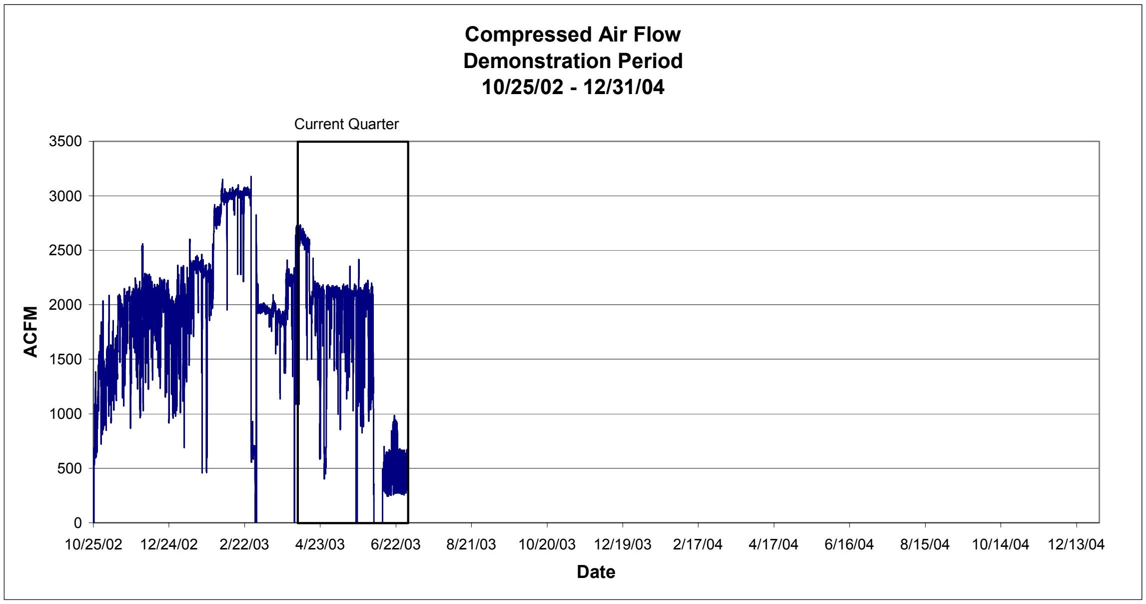
17-Jun-03	* Limiting factors highlighted											
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	128	64.4	33	664	47.3	19	979	49.3	11	997	54.7	3
1B	283	59.7	99	530	48.5	19	788	48.4	19	788	48.4	19
2A	497	63.4	46	770	52	19	645	50.4	19	953	50.1	10
2B	479	60.7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

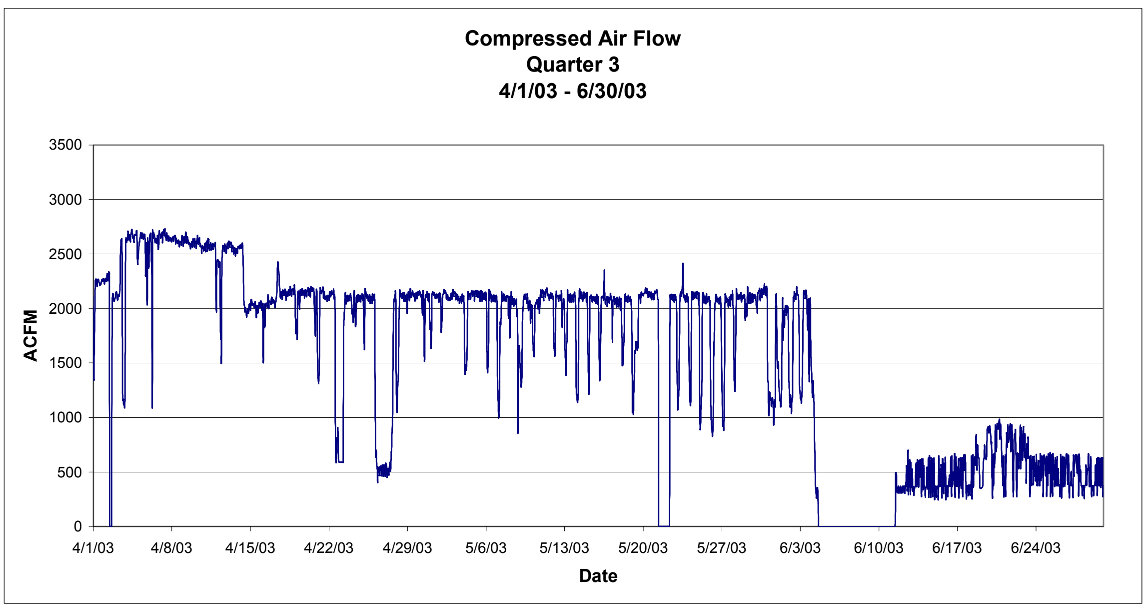
B21 Pulse Counter Readings





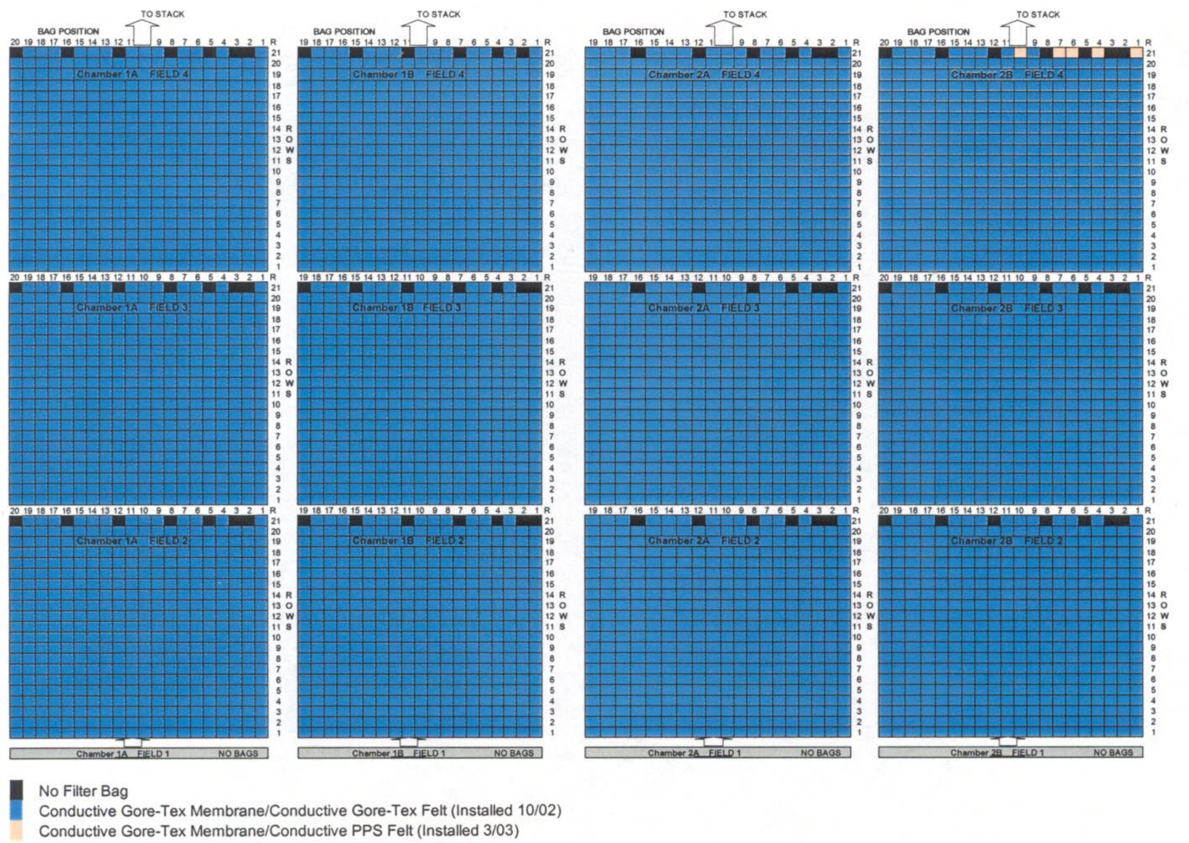
B22 Compressed Air Flow





B23 Bag Layout Diagram

Bag layout prior to June wash outage



Bag layout after June wash outage