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

TECHNICAL PROGRESS REPORT

January 2004 – March 2004

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Prepared for:

United States Department of Energy
National Energy Technology Laboratory
DOE Award No. DE-FC26-02NT41420

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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 EERC is the patent holder for the technology, and W.L. Gore & Associates is the exclusive licensee.

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 is installed on an electric power plant burning Powder River Basin (PRB) coal, Otter Tail Power Company's Big Stone Plant, in Big Stone City, South Dakota. The $13.4 million project was installed in October 2002. Project related testing 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 under a program entitled the Power Plant Improvement Initiative Program.

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

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

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

The results of operation during this quarter have been fairly stable. Some improvement efforts have taken place, but the focus of the efforts this quarter has been the evaluation of project and technology goals and expectations.

The current technology team has reviewed the present status to come to consensus on a path forward. Otter Tail Power Company is soliciting proposals for an improved and larger system to overcome current operational issues at the currently demonstrated A/C ratios.

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.

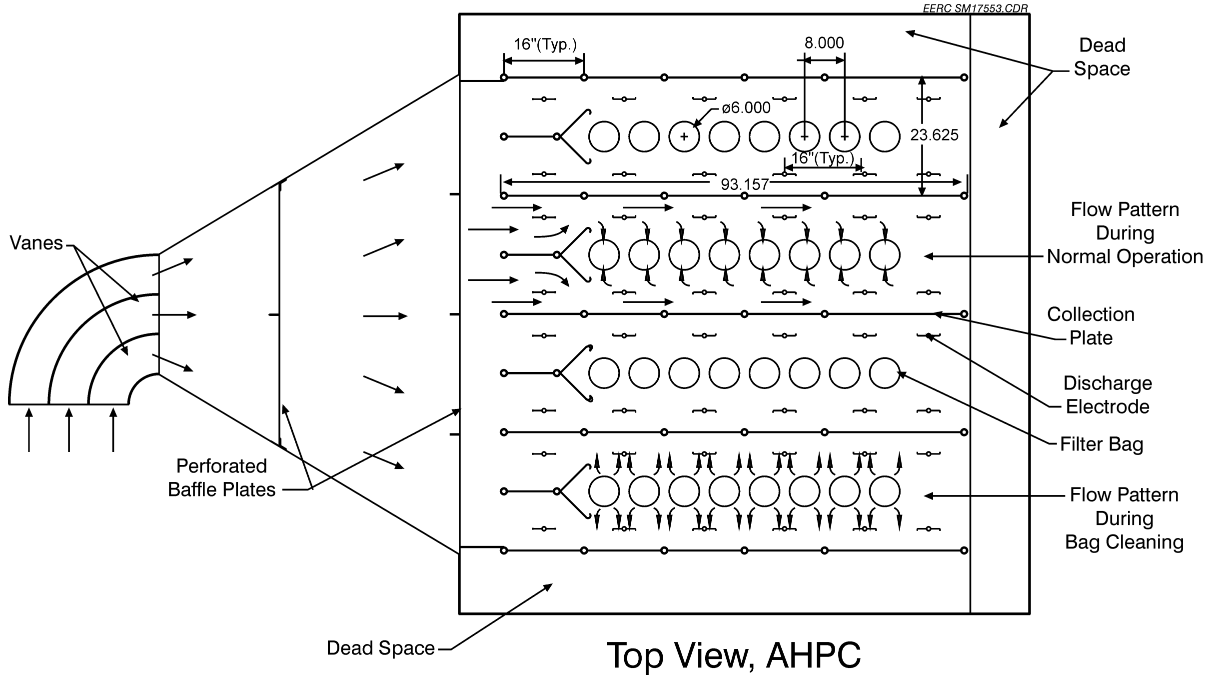


Figure 1. Top view of the old configuration for the 9000-acfm *Advanced Hybrid*™ filter at Big Stone.

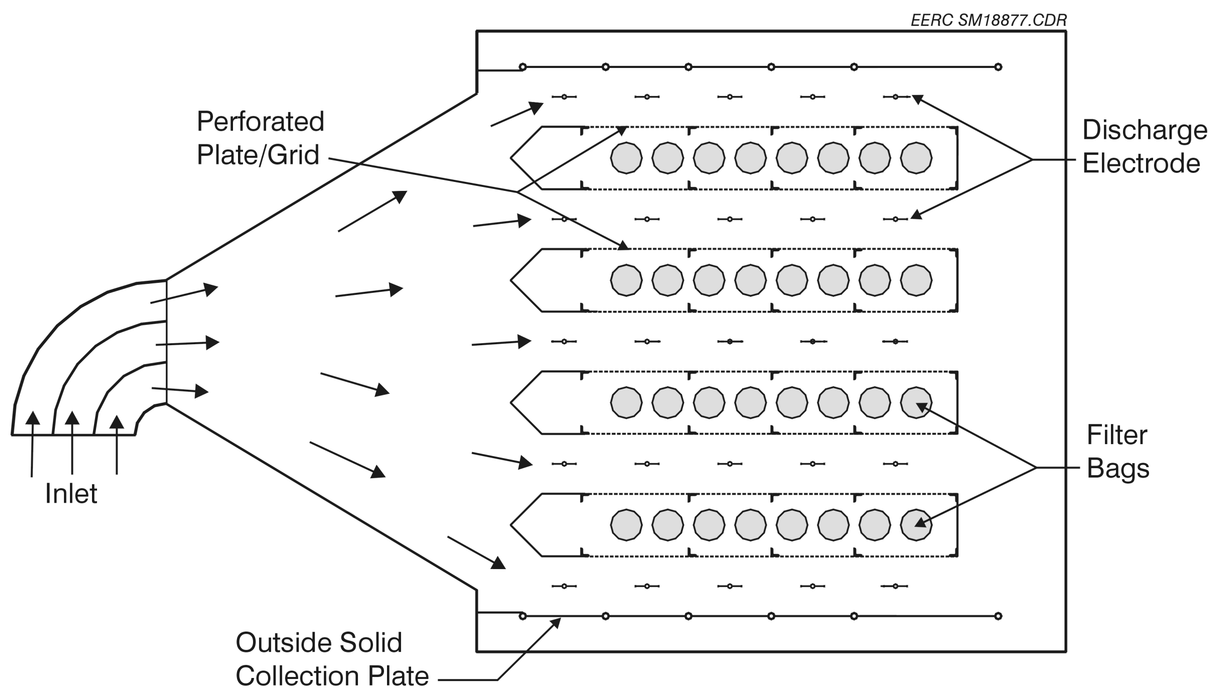


Figure 2. Top view of the perforated plate configuration for the 9000-acfm *Advanced Hybrid*™ filter.

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:

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

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

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

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:

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

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

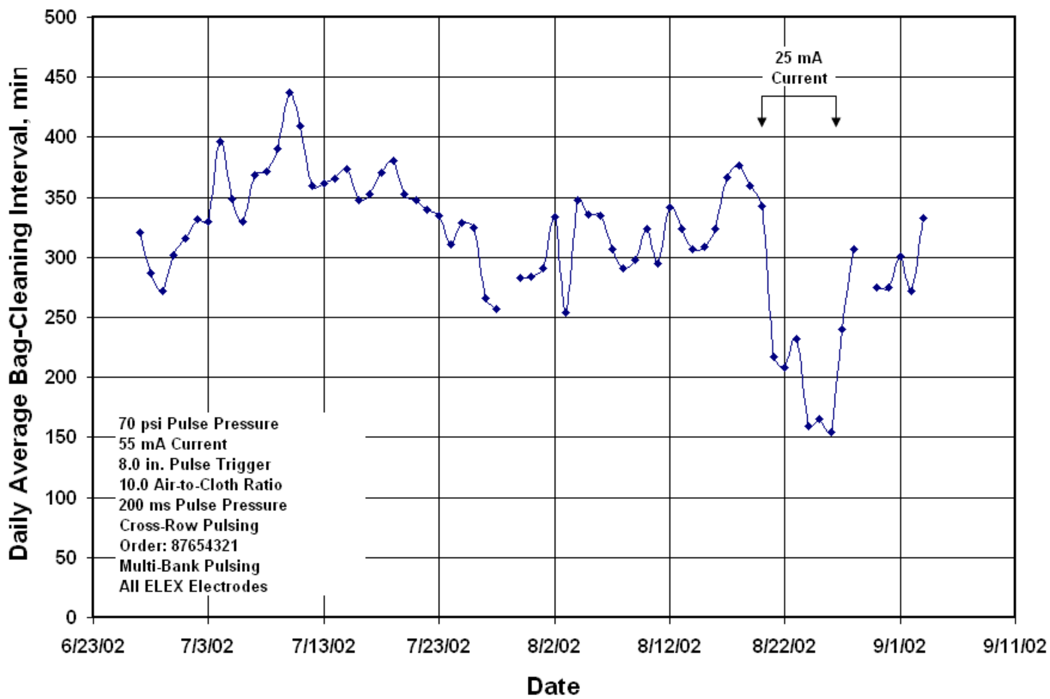


Figure 3. Daily average bag-cleaning interval for summer 2002 tests with the 9000-acfm *Advanced Hybrid*™ filter.

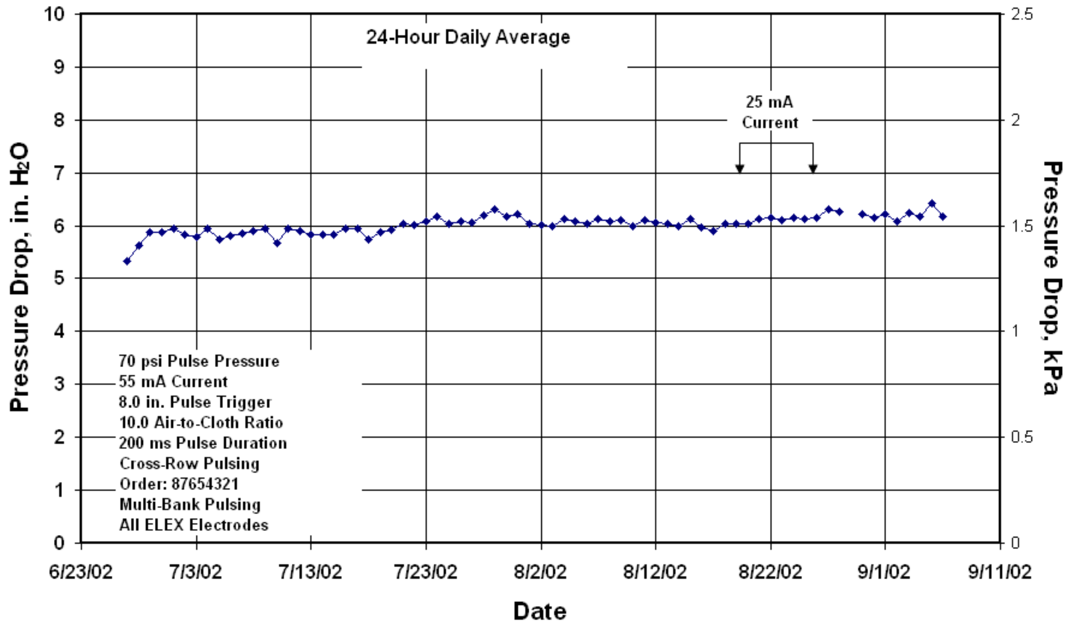


Figure 4. Daily average pressure drop for summer 2002 tests with the 9000-acfm *Advanced Hybrid*™ filter.

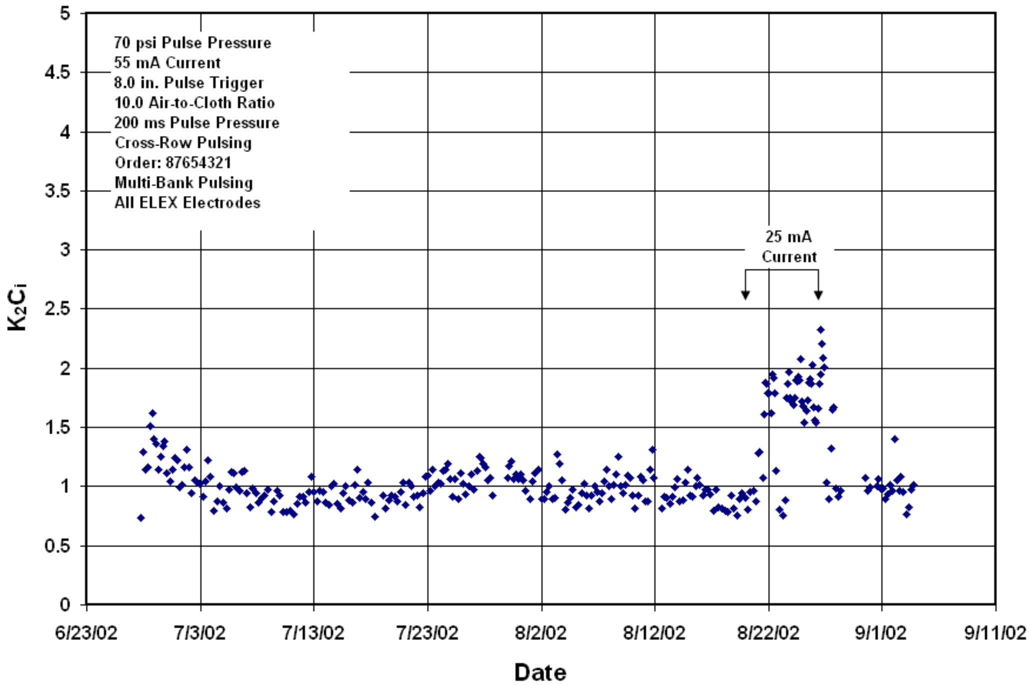


Figure 5. K_2C_i for summer 2002 tests with the 9000-acfm *Advanced Hybrid*™ filter.

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.

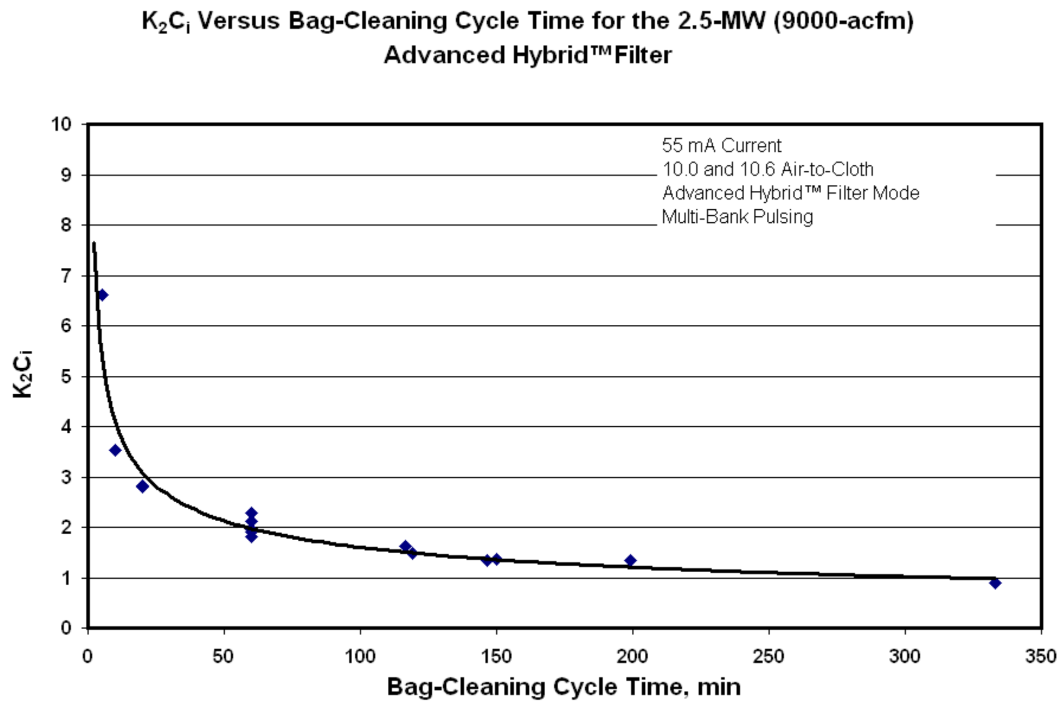


Figure 6. Effect of pulse interval on K_2C_i for 9000-acfm pilot *Advanced Hybrid*™ filter.

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).

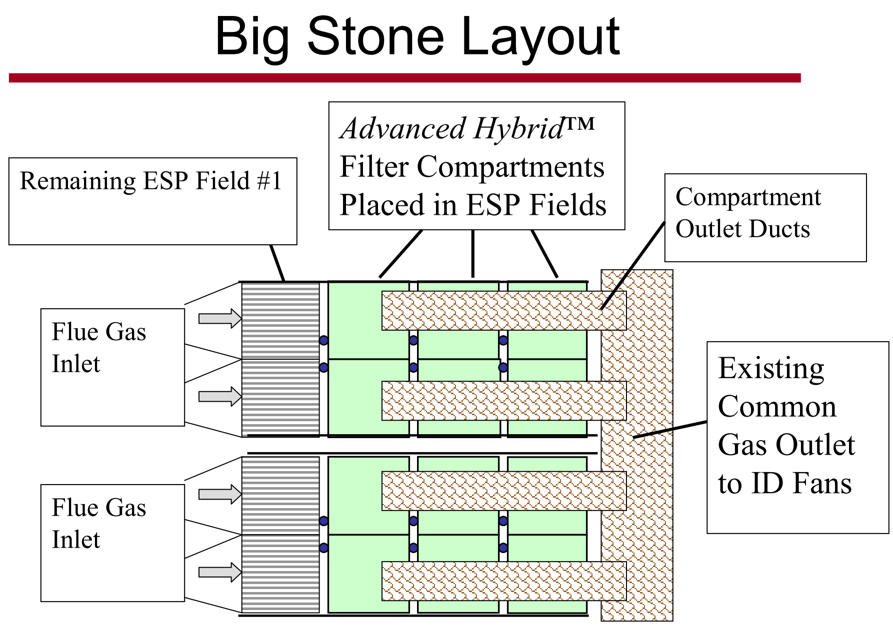


Figure 7. Top view of the *Advanced Hybrid*™ filter full-scale retrofit configuration at Big Stone.

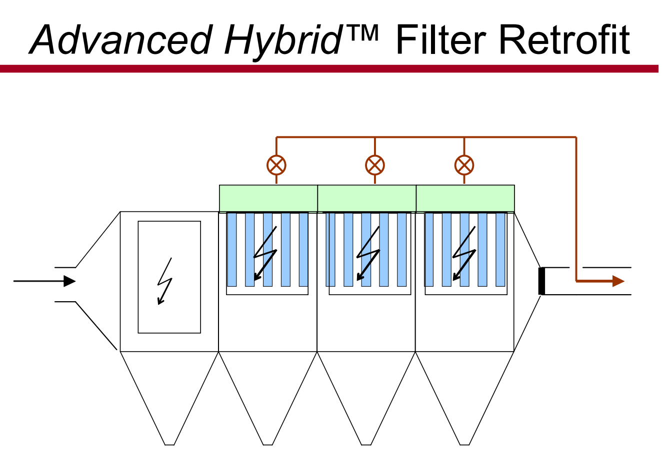


Figure 8. Side view of the *Advanced Hybrid*™ filter full-scale retrofit configuration at Big Stone.

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	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	Washed GORE-TEX™ Felt/GORE-TEX™ Membrane (originally installed 10/2002)
Chamber 1B Field 4	393	NOMEX felt/PTFE 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	Washed GORE-TEX™ Felt/GORE-TEX™ Membrane (originally installed 10/2002)
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	P-84 felt/PTFE Membrane

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:

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

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.

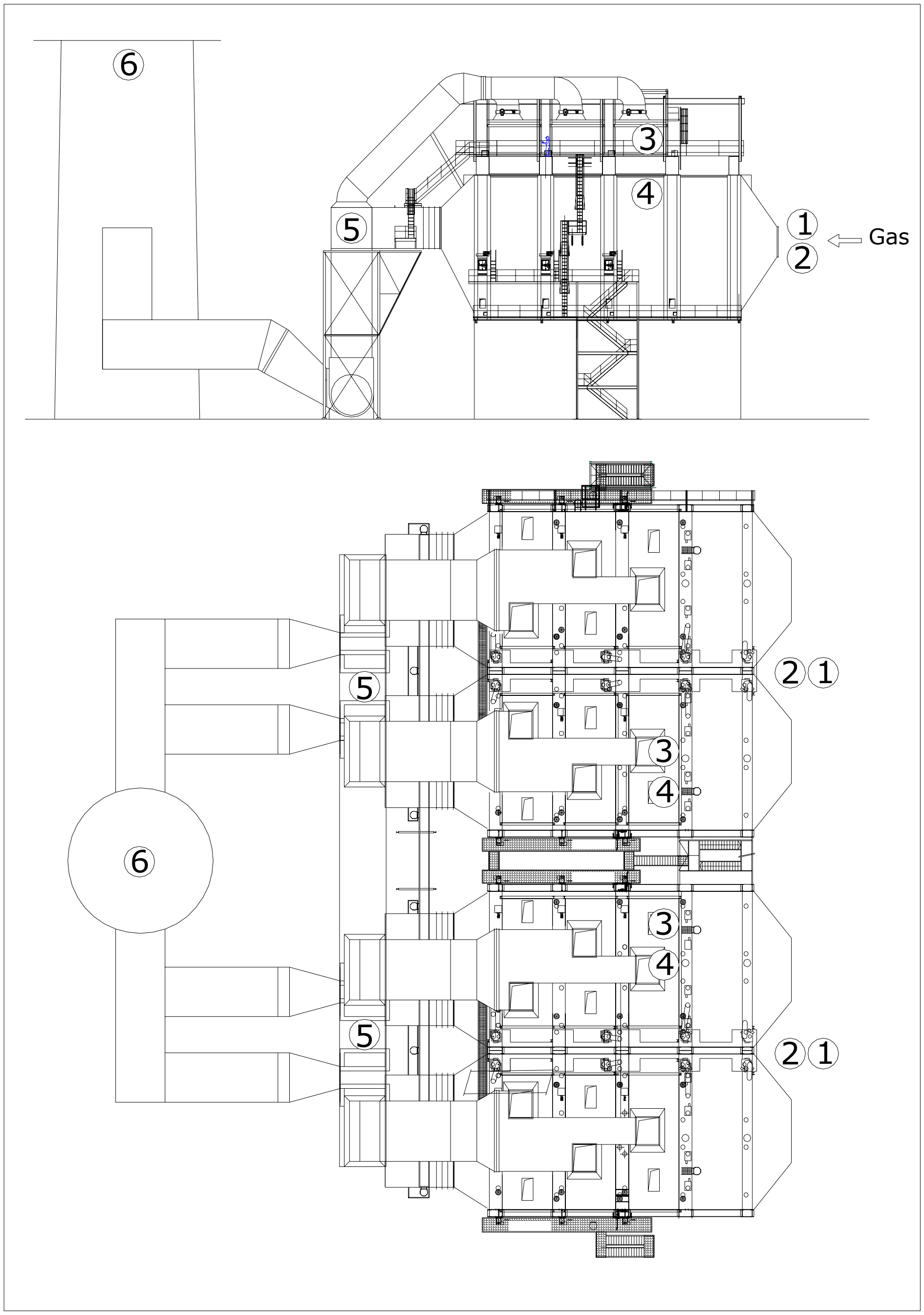
Compressed Air Flow: Continuously monitored using a Diamond II Annubar flow sensor equipped with a Honeywell 3000 Smart DP Transmitter. This ANNUBAR instrument is in the compressed air supply line after the compressors but before the desiccant dryer.

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

Quarter 1 (October 2002 – December 2002)	
System Startup	October 2002
Rapper Problems Realized	November 2002
Pulse Valve Problems Realized	November 2002
EERC Testing (99.99% particulate capture goal met)	November 2002
Inlet Field Energized	December 2002
Quarter 2 (January 2003 – March 2003)	
Soybeans burned at Big Stone as Alternative Fuels	January 2003
Derates due to high dP across the AH system begin	January 2003
Comparative Testing of Pilot unit to full-scale unit	February 2003
Plant shut down to wash boiler	February 2003
Quarter 3 (April 2003 – June 2003)	
Meeting to discuss improvement options	April 2003
Bags washed in two chambers	April/May 2003
Pitot data used for evaluation and decision	May 2003
Decision to replace filter bags	May 2003
Complete bag changeout	June 2003
Inlet field evaluated	June 2003
Plant restored to full load	June 2003
Quarter 4 (July 2003 – September 2003)	
Big Stone limited to 440 – 445 MW not due to AH	July/Sept 2003
Performance Tests	July/Sept 2003
Fluent Analysis Plan	Sept 2003
Preliminary baffle design submitted	Sept 2003
Quarter 5 (October 2003 – December 2003)	
Opacity rise attributed to initiation of bag failures	October 2003
Competitive bidding of replacement bags	November 2003
Fluent modeling results for flow baffles	November 2003
Test flow baffles installed	December 2003
Four compartments of bags replaced	December 2003
Quarter 6 (January 2004 – March 2004)	
Stable system operation	Jan/March 2004
Fluent modeling work continues	February 2004
Technology goals reviewed	February 2004
Next phase of project reviewed & proposed by OTP	March 2004

3.1.2 Discussion of Results of Significant Accomplishments

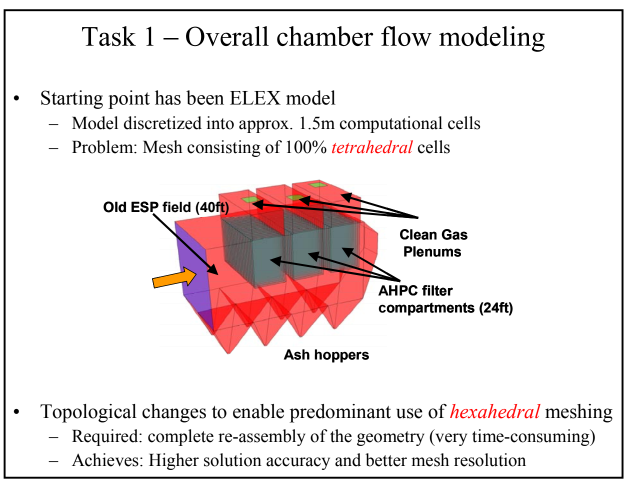
General Discussion

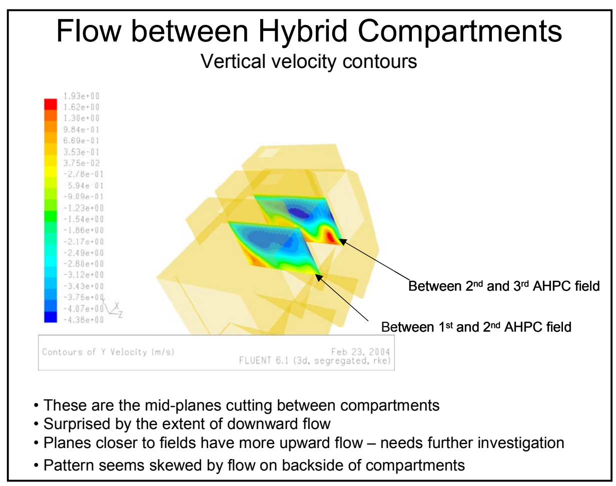
Operation of the Advanced Hybrid system has been stable since startup after the December boiler wash outage. The bags are still being aggressively cleaned. There have been no significant plant limitations due to the Advanced Hybrid system since prior to the June 2003 boiler wash outage. There have been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

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

Performance Improvement Investigation

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





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

Evaluation of Changes Made

Several changes have been made to the system. These are

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

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

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

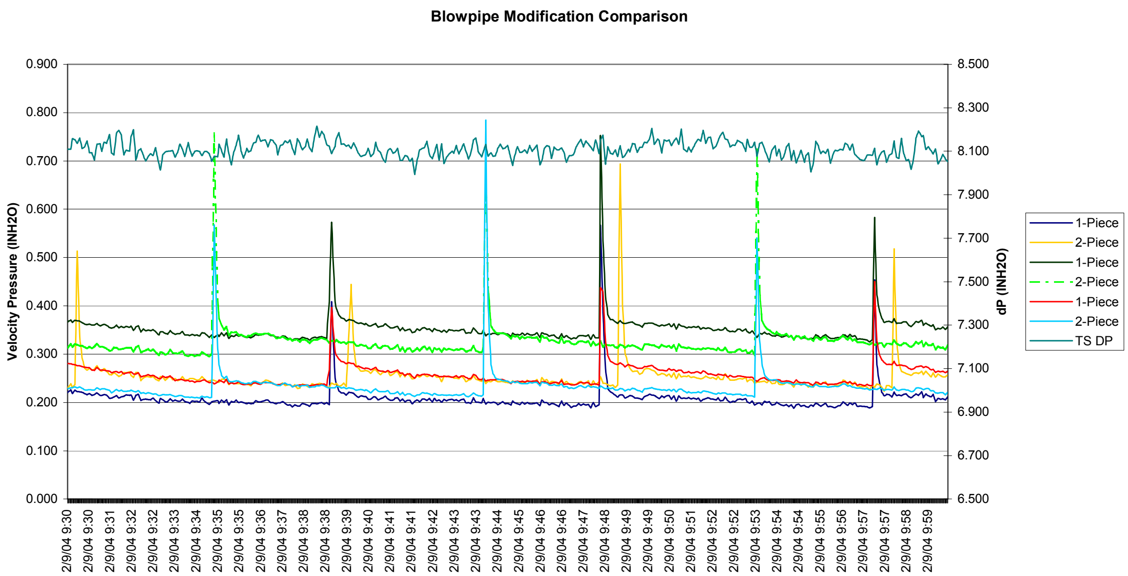
Advantages

- Better/more aggressive cleaning of bags

Drawbacks

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

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



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

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

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

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

<u>Review of Technology Results and Goals</u>

A group effort was undertaken in February to try to review the current status, goals and path forward for the technology. The real impetus behind this effort is a scheduled major outage of the Big Stone Plant in April and May of 2005. If major changes to the system need to occur this would be the only reasonable chance until a projected outage some time in 2010. OTP facilitated a review in an attempt to reach a consensus. The current active stakeholders in the project and the technology include;

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

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

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

A summary of responses is listed below.

<u>What defines successful operation of the Advanced Hybrid system?</u>

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

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

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

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

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

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

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

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

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

Proposal and Review of Second Phase of Project

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

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

Improvement ideas being currently discussed are;

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

4.0 CONCLUSIONS

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

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

Opacity remains low, however there is a general increase in opacity during the quarter. Some of the increases can be explained by the difficulty in calibrating the existing instrument. One step change occurred due to human calibration alignment of the device. Undoubtedly, some of the remaining PPS bags are beginning to fail and a general increase in opacity will be expected until the failed bags are replaced during the scheduled boiler wash outage in June.

The A/C ratio of the system has remained quite high this quarter due to the heavy loading of the plant. The levels have been approximately 11.5 fpm.

The tubesheet dP has remained controllable, however a conscious effort to raise the pulsing trigger point from 8.0 to 8.5 was made in mid-March. This will reduce the overall number of pulses seen by the bags as well as the compressed air flow.

The compressed air flow was quite high during the majority of the quarter. There was some reduction towards the end of the quarter as the threshold differential pressure for pulsing was raised from 8.0 to 8.5 INH2O. In keeping with the earlier discussion on pulse interval, a good rule of thumb can be developed. True continuous pulsing will result in a steady air flow reading of about 2000 acfm. It takes about ten minutes for all of the pulse valves to fire in one cycle of cleaning. If the valves enter a cleaning cycle for ten minutes, and then it takes ten minutes for the dP to increase to the trigger point, this means the pulse interval is twenty minutes and indicates a long term trend of about 1000 acfm on our graph in Appendix B22. As was discussed in an earlier section, the goal of the system is approximately 60 minute pulse intervals. This means that the flow would be 2000 acfm for ten minutes every 60 minutes, and indicated in our long-term graph as a usage of 333 acfm.

General Conclusions

The Advanced Hybrid system has demonstrated fairly stable operation during this quarter. There is a slight rise in opacity that is likely the result of continuing failure of the remaining PPS bags in the system.

The technology and project team has reviewed the project goals and determined that it would be extremely difficult to reach comfortable operation at the current A/C ratios. An effort is currently underway to review a proposal to install improved components and increase the size of the system, therefore decreasing the A/C ratio. This would both improve the existing system and demonstrate the operability of the technology. However, the cost of the base system would likely increase, putting more pressure on the commercialization efforts looking ahead.

The activities next quarter will likely include;

- Replacement of the remaining PPS bags
- Installation of one chamber of flow baffles
- Review of the proposal to add compartments of technology to reduce the A/C ratio

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

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

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

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

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

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

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

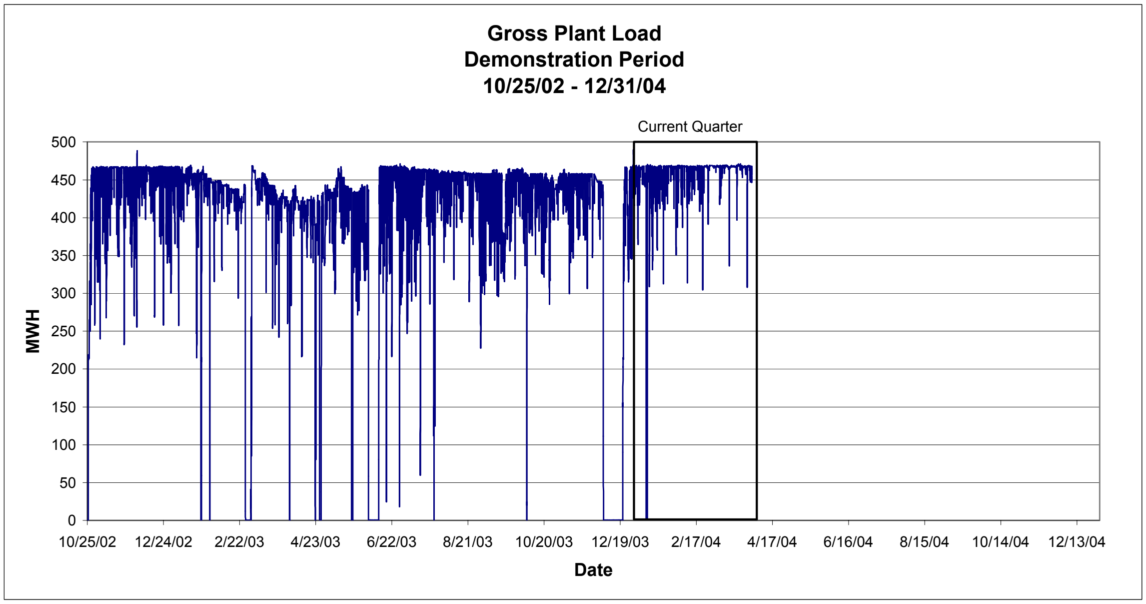
Appendix B8. During the plant outage, (the period represented approximately 12/4/2003 – 12/9/2003 on the graph), the opacity is out of scale because it was removed from the plant stack and a “clear stack” calibration was performed in a clean environment. So the data from that period is not valid.

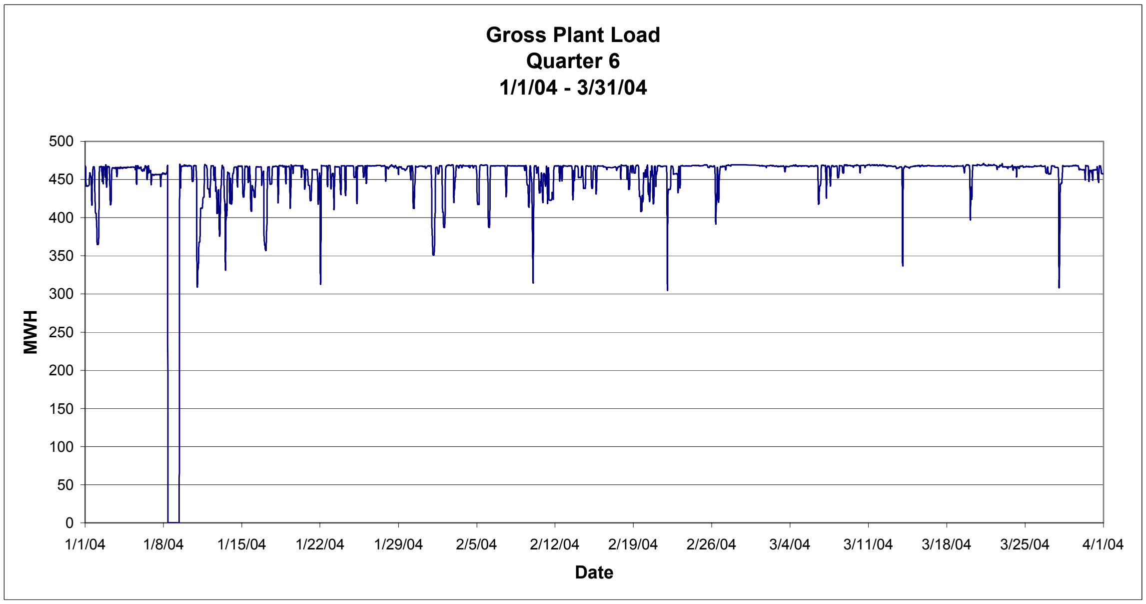
Appendix B6. There is no clear reason for the high differential pressure reading around 3/3/2003.

Appendix B8. The Opacity spike around 3/25/2005 was due to a calibration, and not a real opacity event. The step change in opacity can be attributed to a calibration issue and not a real opacity event.

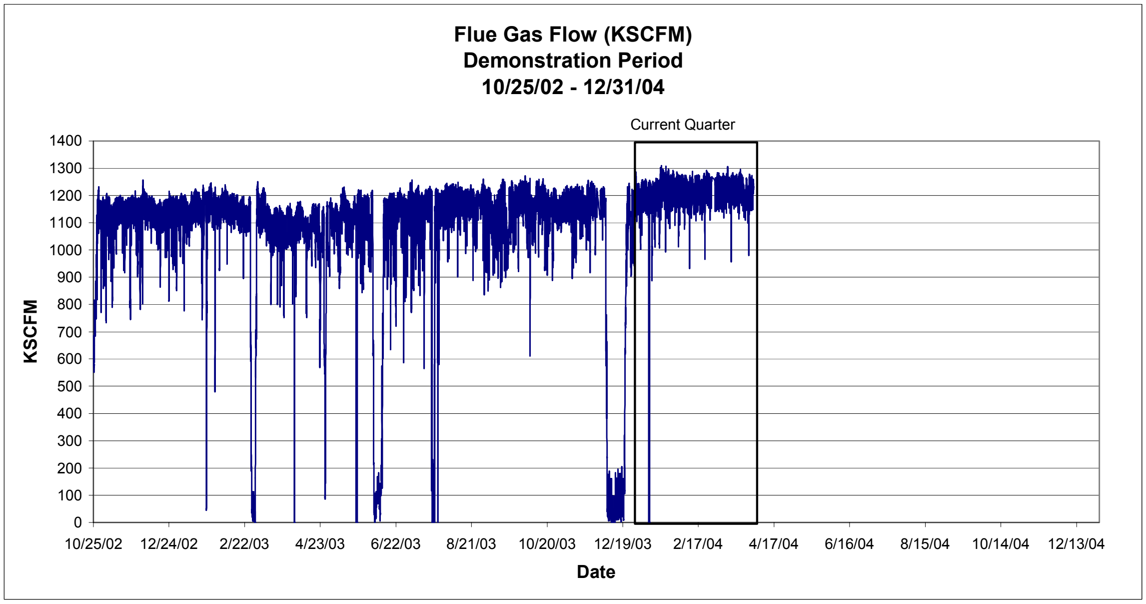
APPENDIX B – GRAPHICAL & TABULAR PERFORMANCE DATA

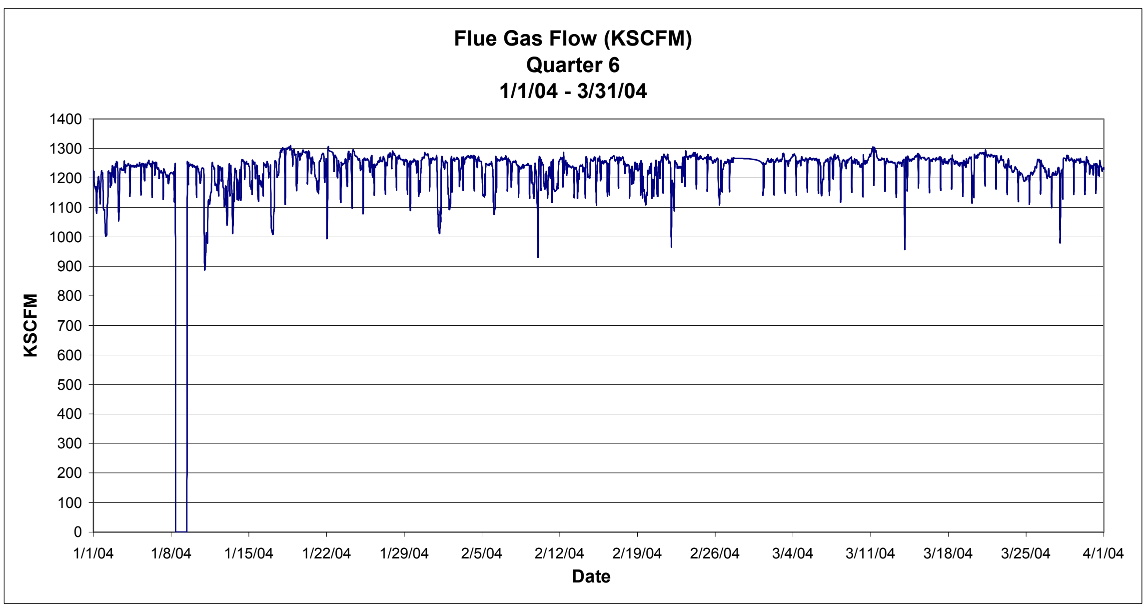
B1 Gross Plant Load



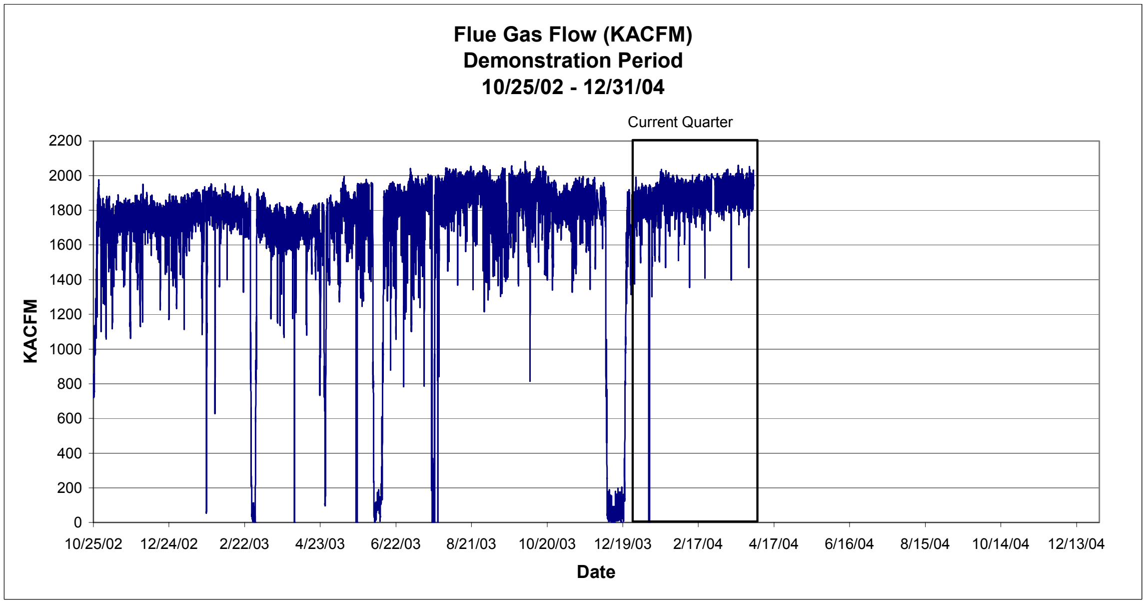


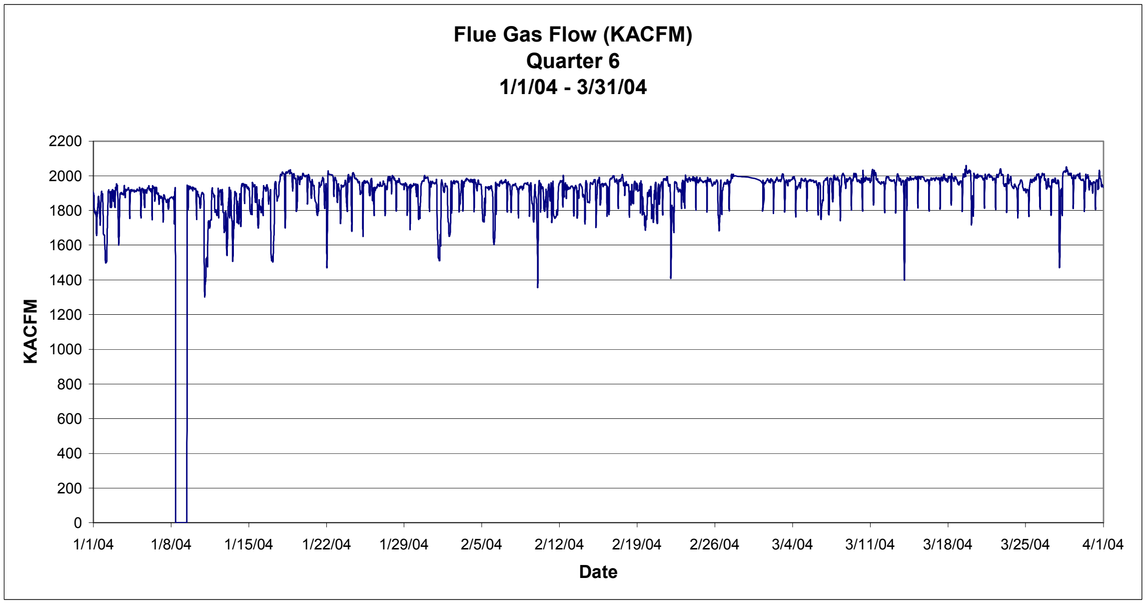
B2 Flue Gas Flow (KSCFM)



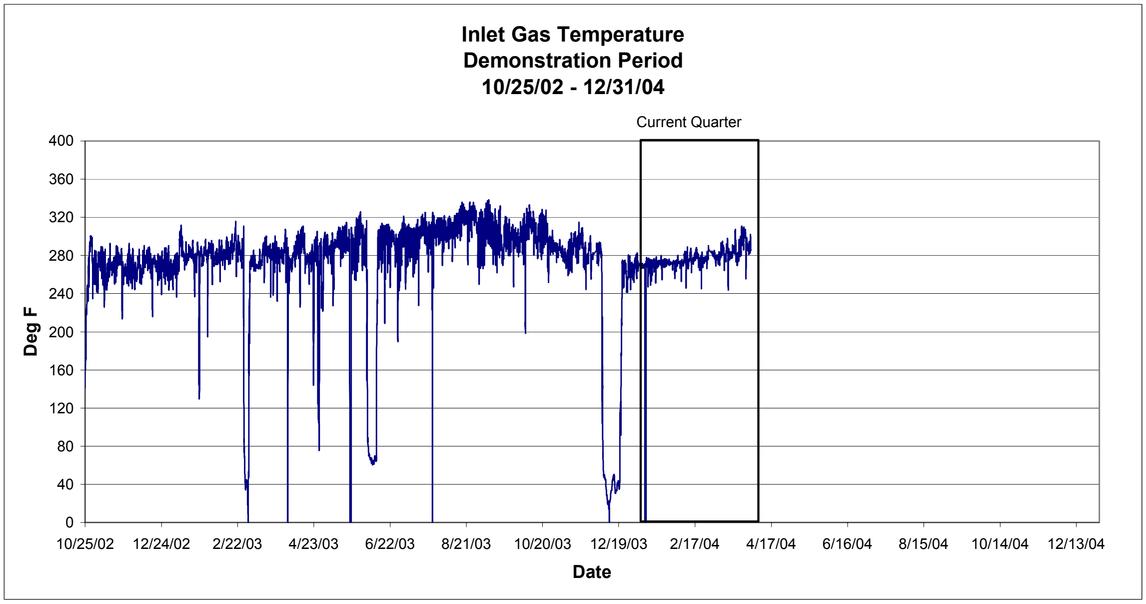


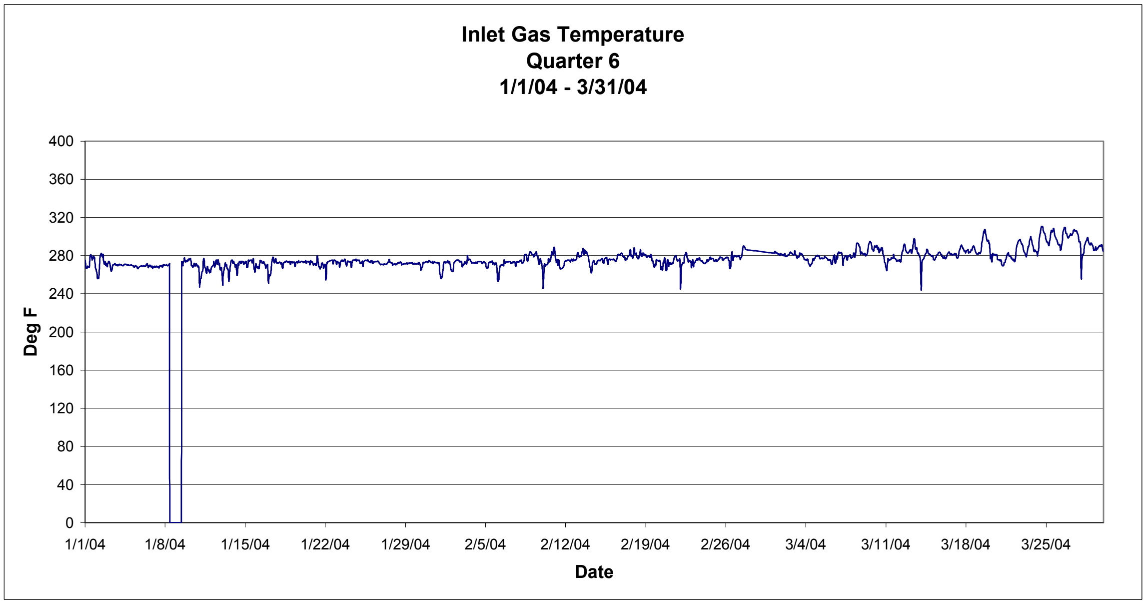
B3 Flue Gas Flow (KACFM)



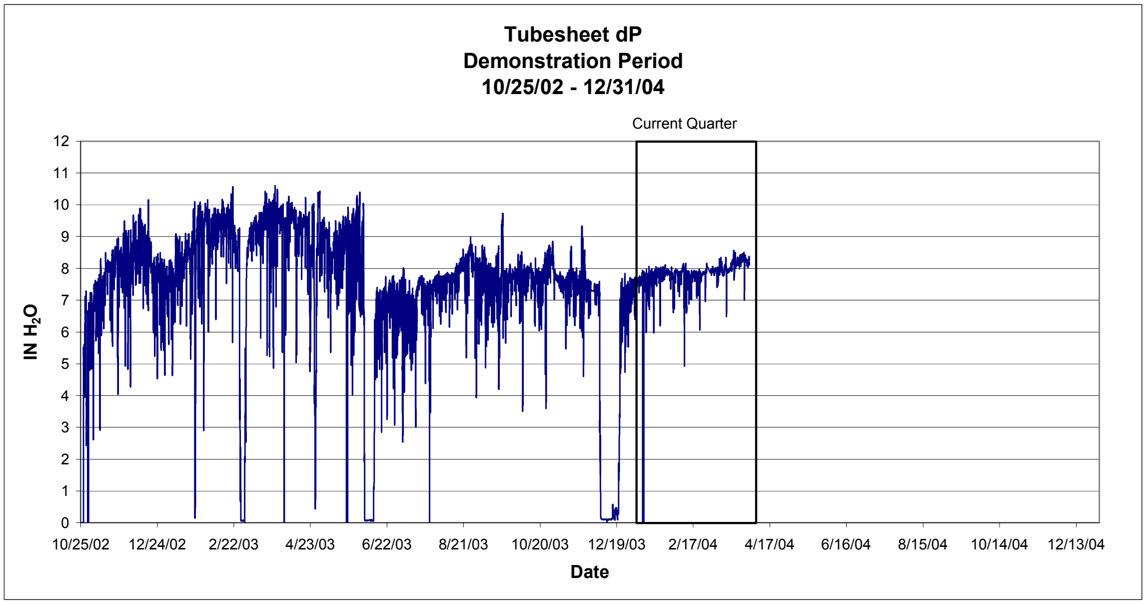


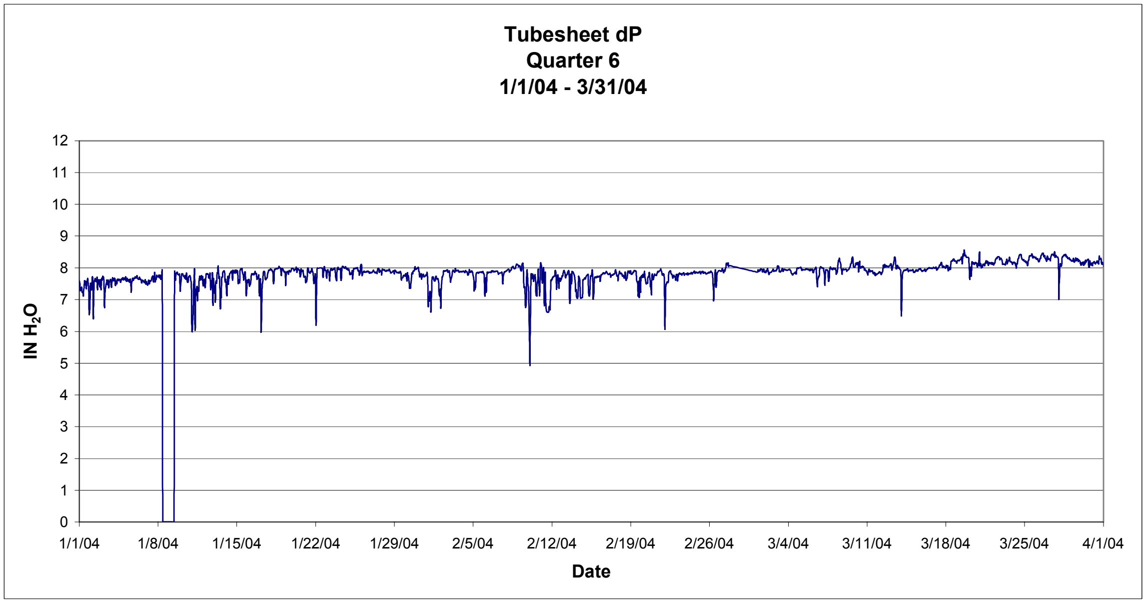
B4 Inlet Gas Temperature



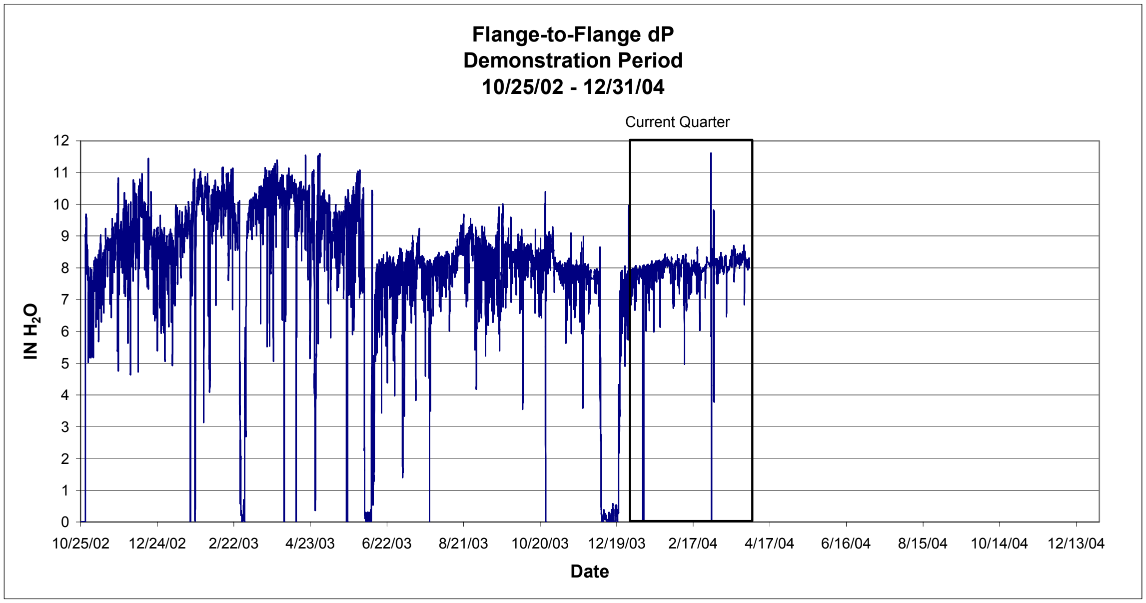


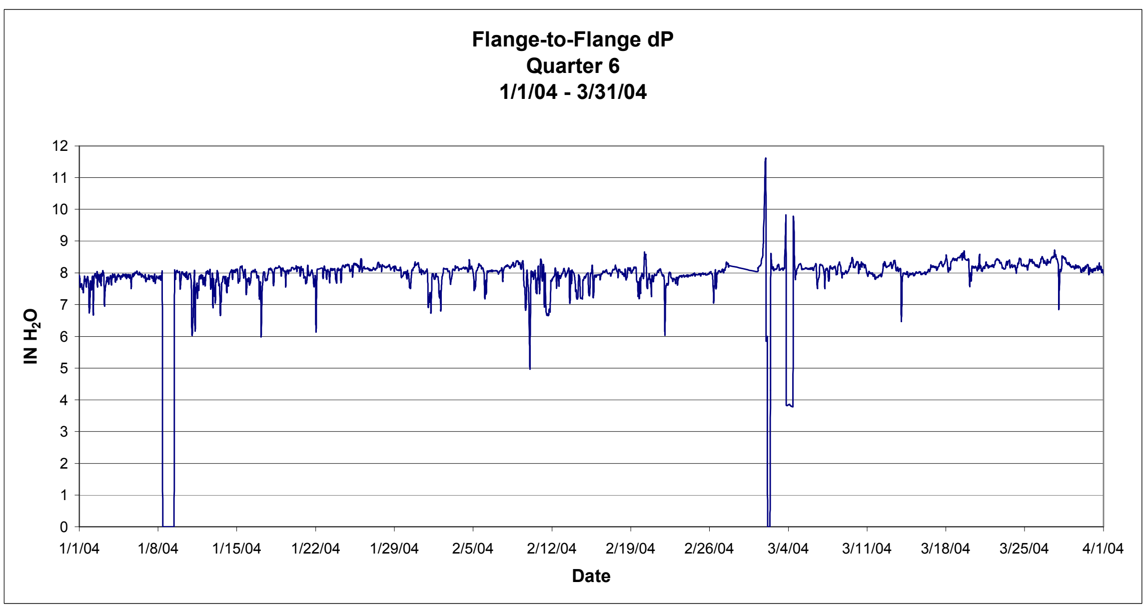
B5 Tubesheet dP



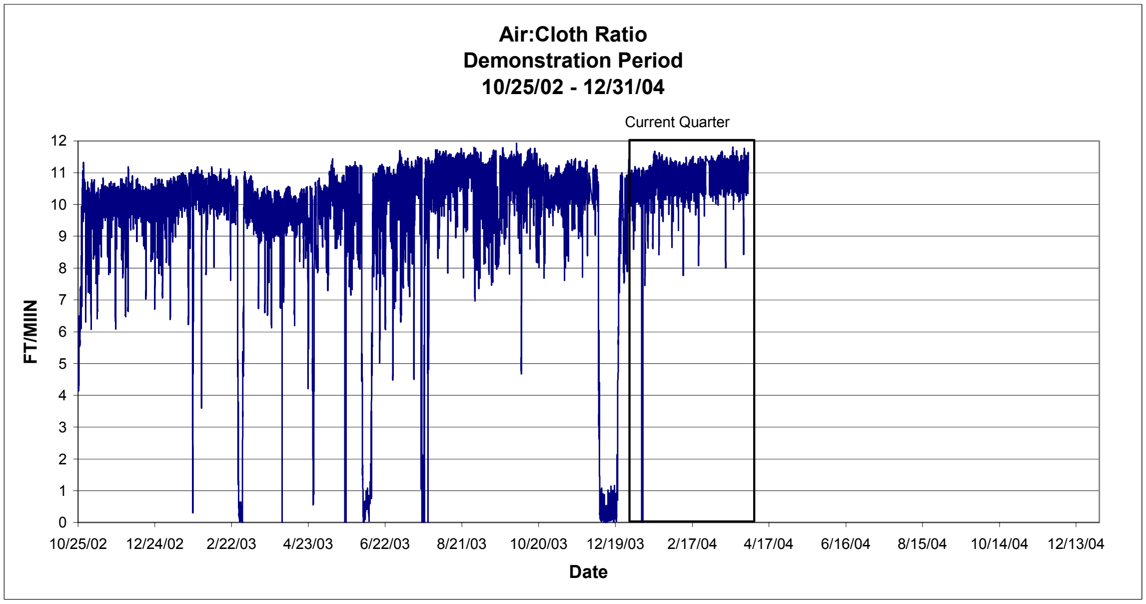


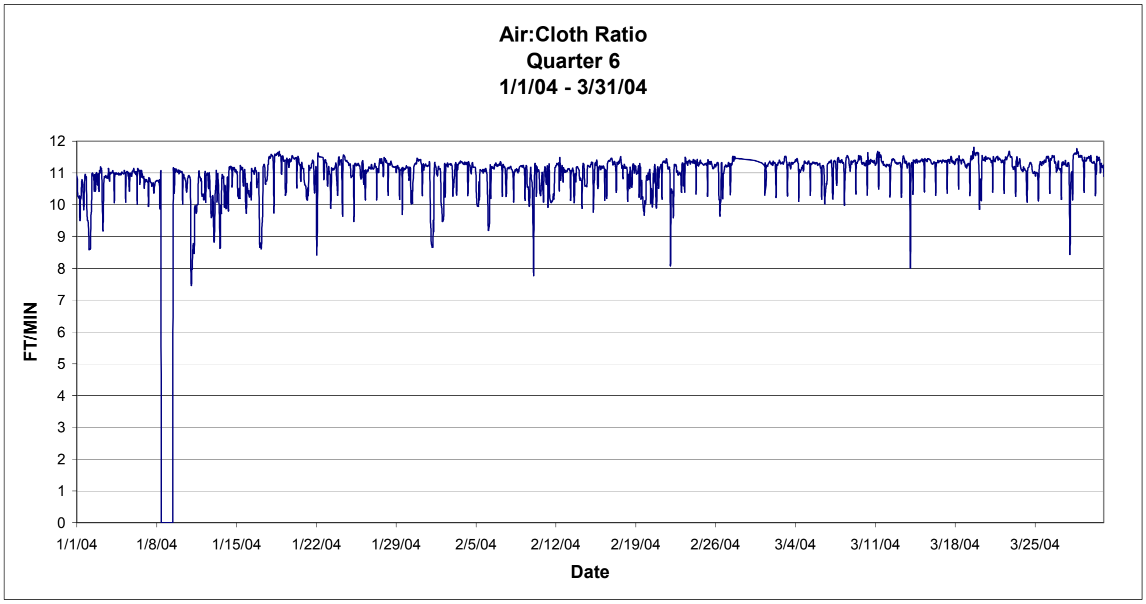
B6 Flange-to-Flange dP



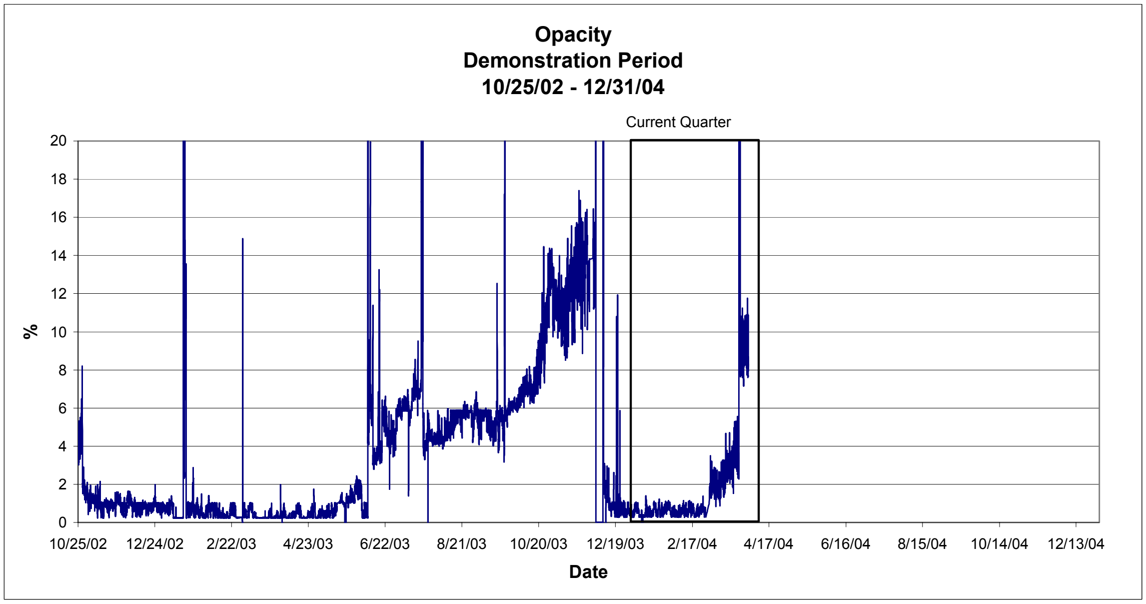


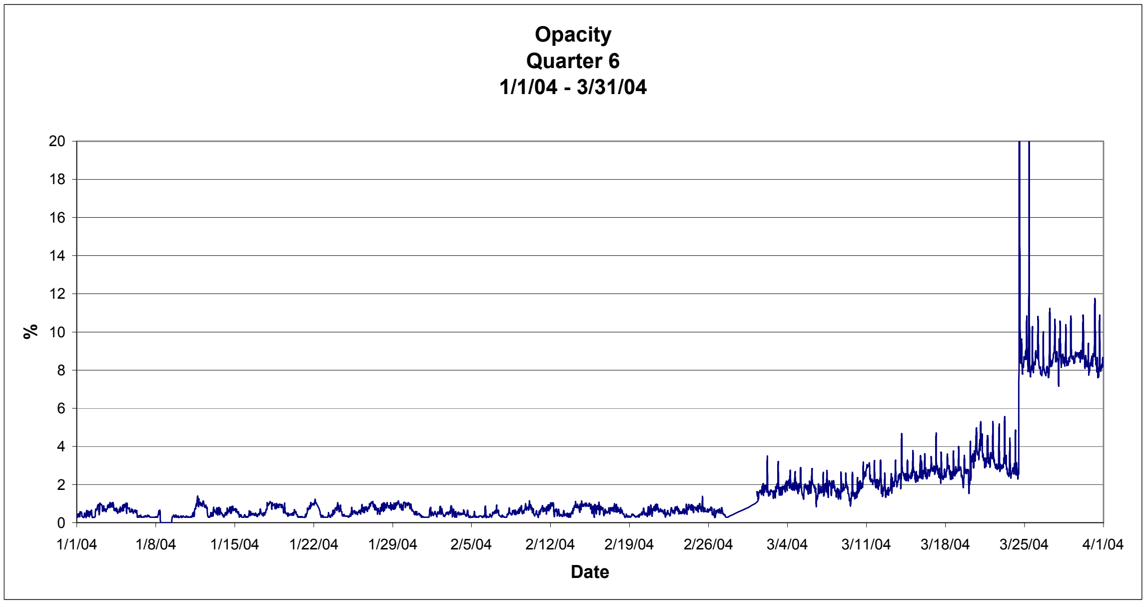
B7 Air-to-Cloth Ratio



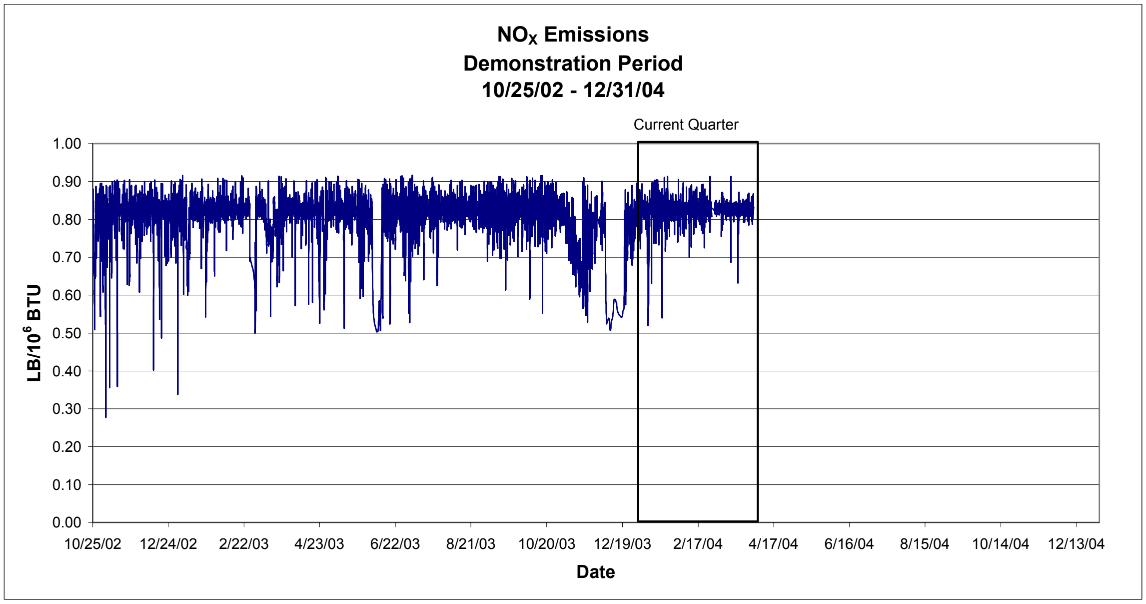


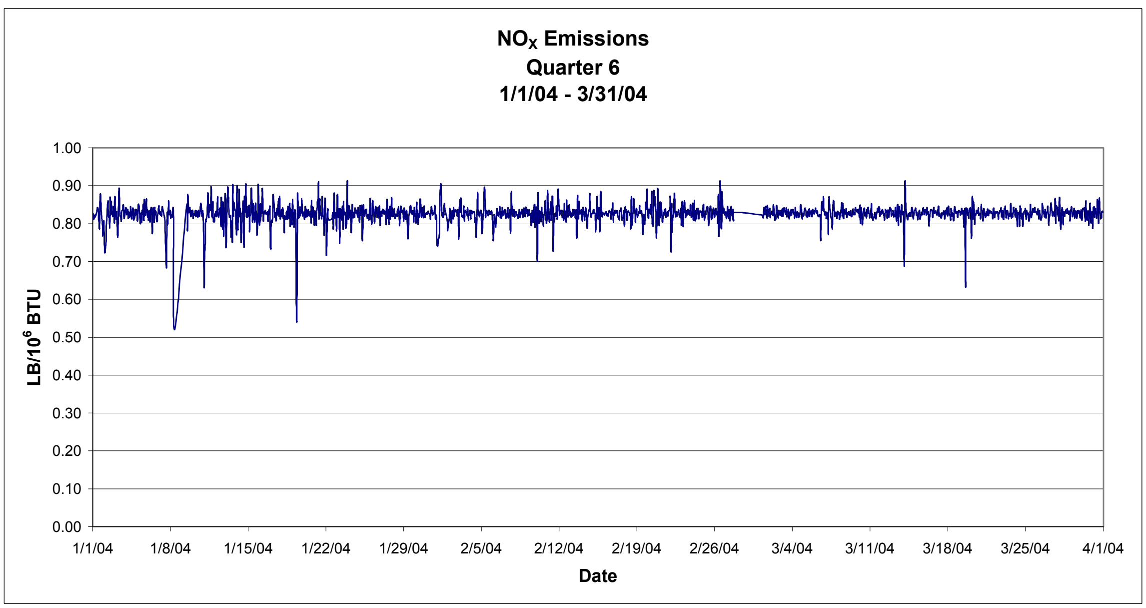
B8 Opacity


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

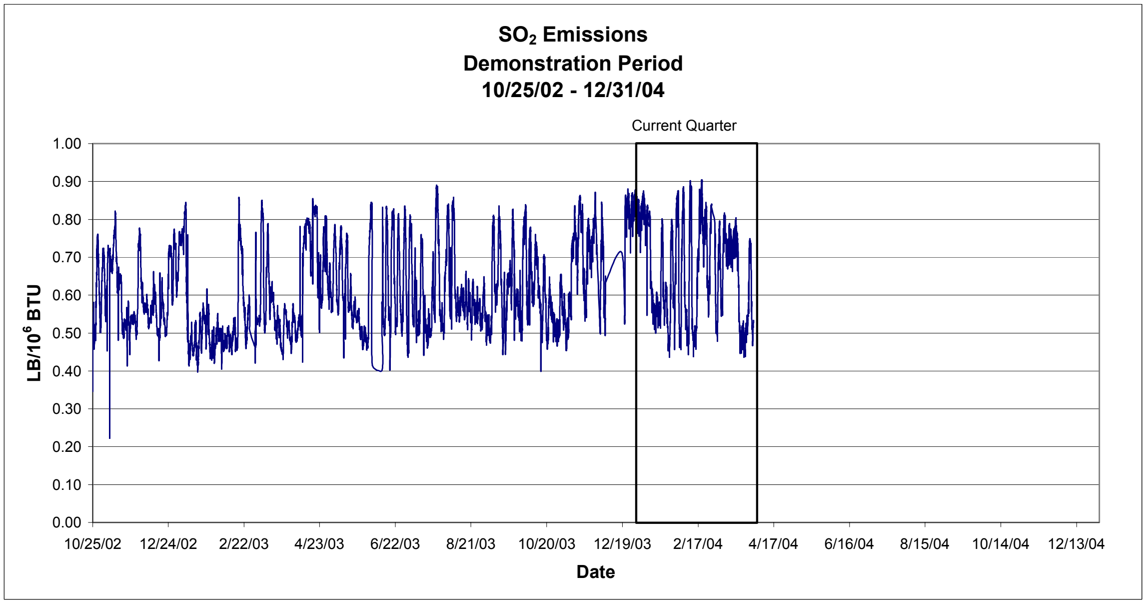

Opacity
Quarter 6
1/1/04 - 3/31/04
20
18
16
14
12
10
8
6
4
2
0
%
1/1/04
1/8/04
1/15/04
1/22/04
1/29/04
2/5/04
2/12/04
2/19/04
2/26/04
3/4/04
3/11/04
3/18/04
3/25/04
4/1/04
Date

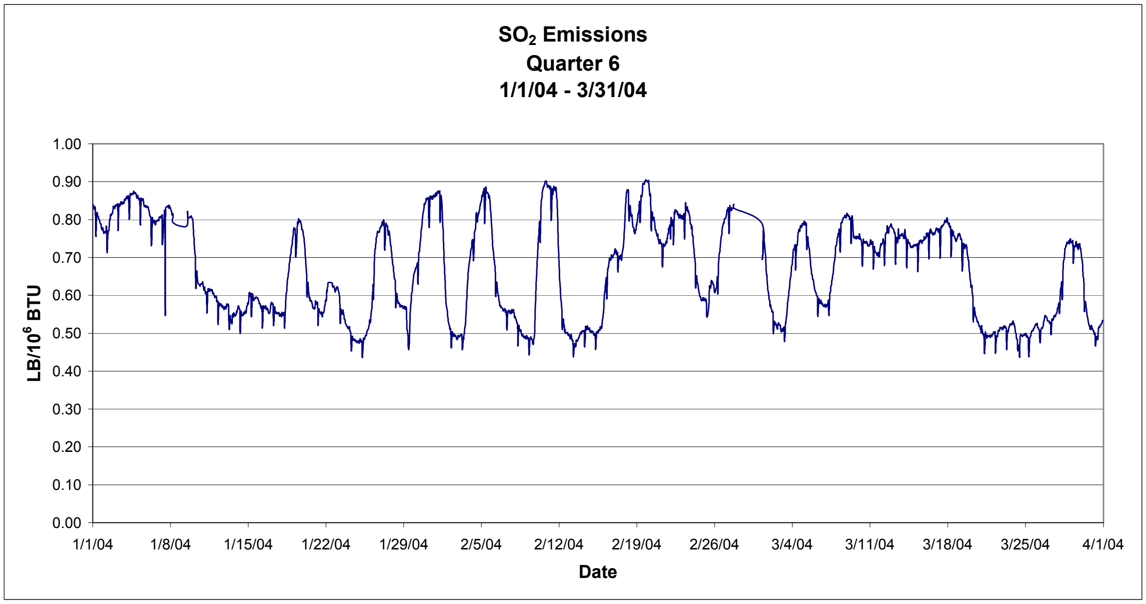
B9 NO_X Emissions



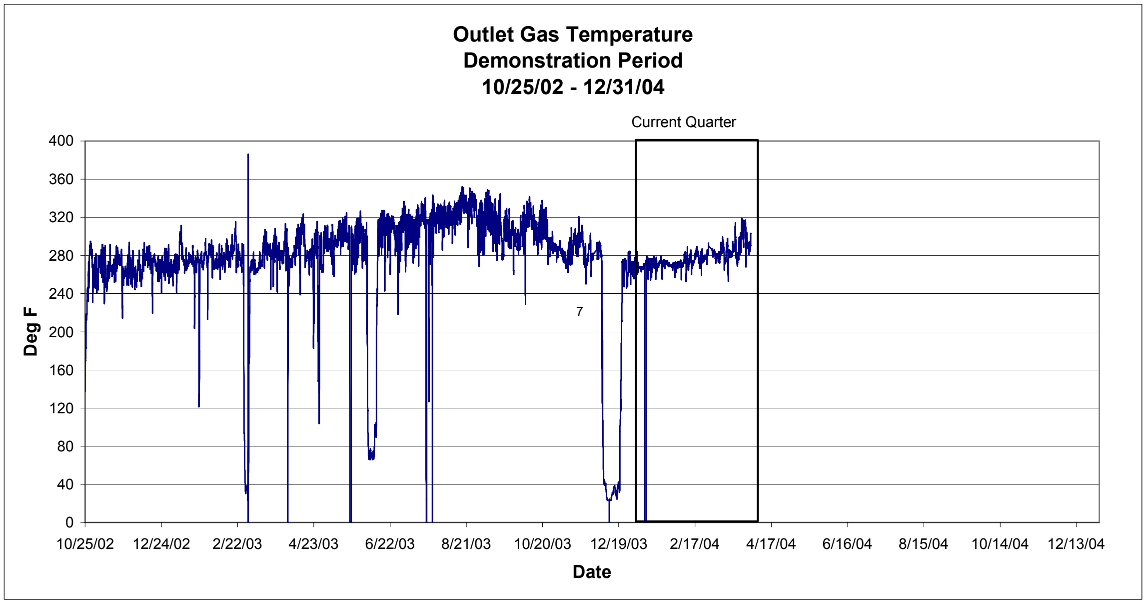


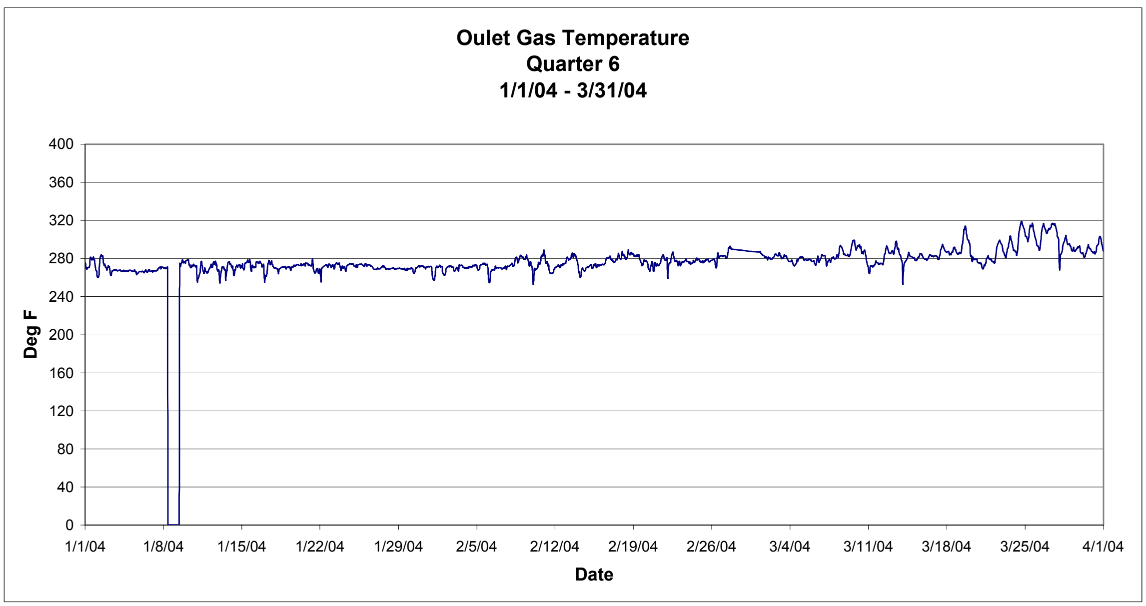
B10 SO_2 Emissions



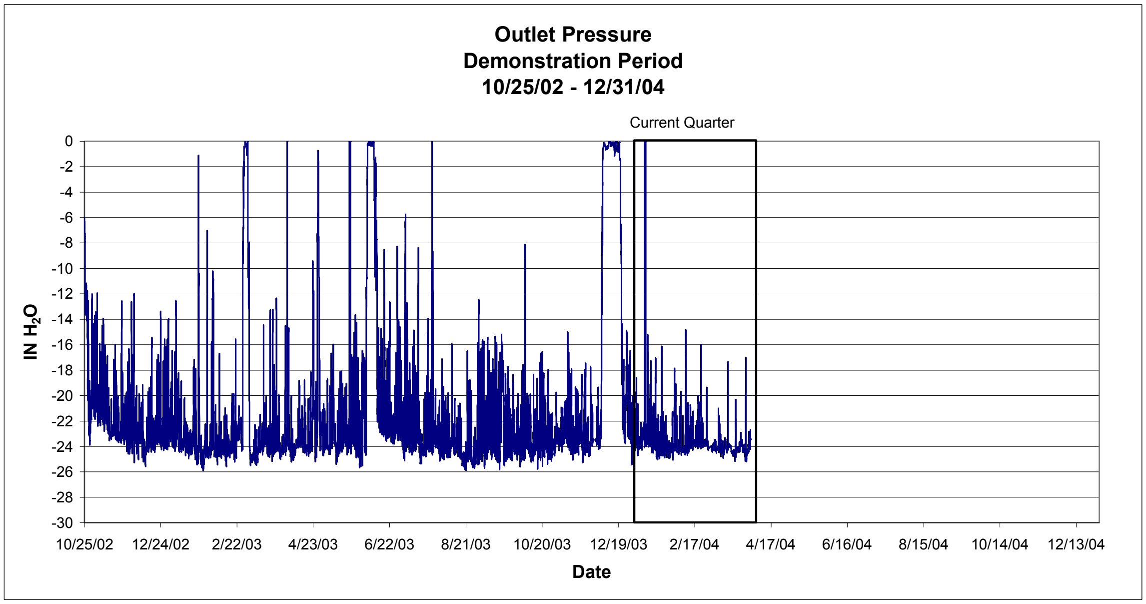


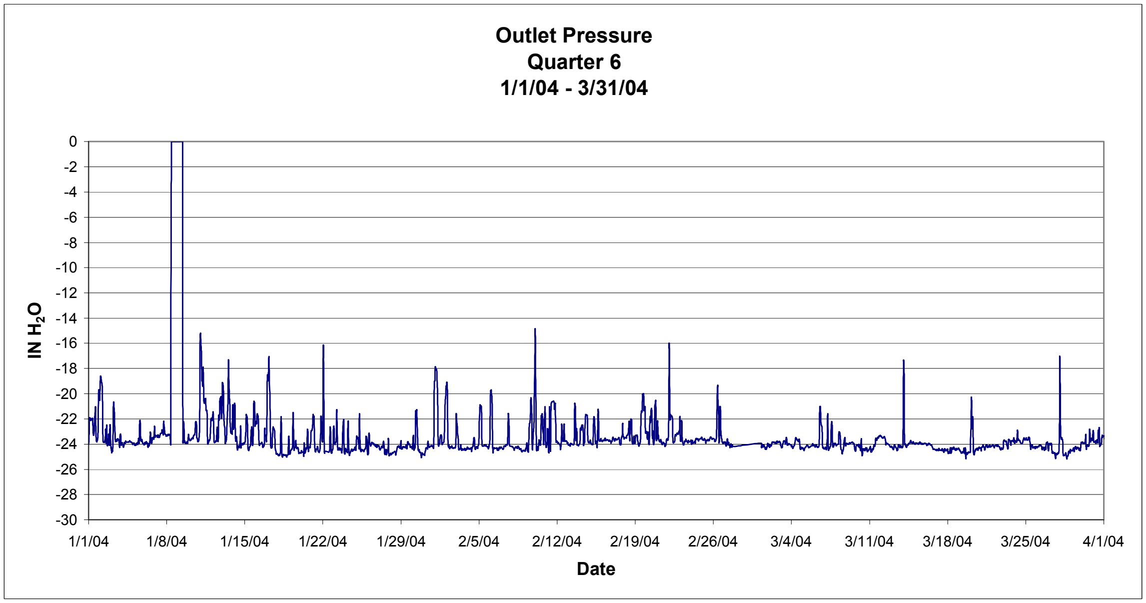
B11 Outlet Gas Temperature



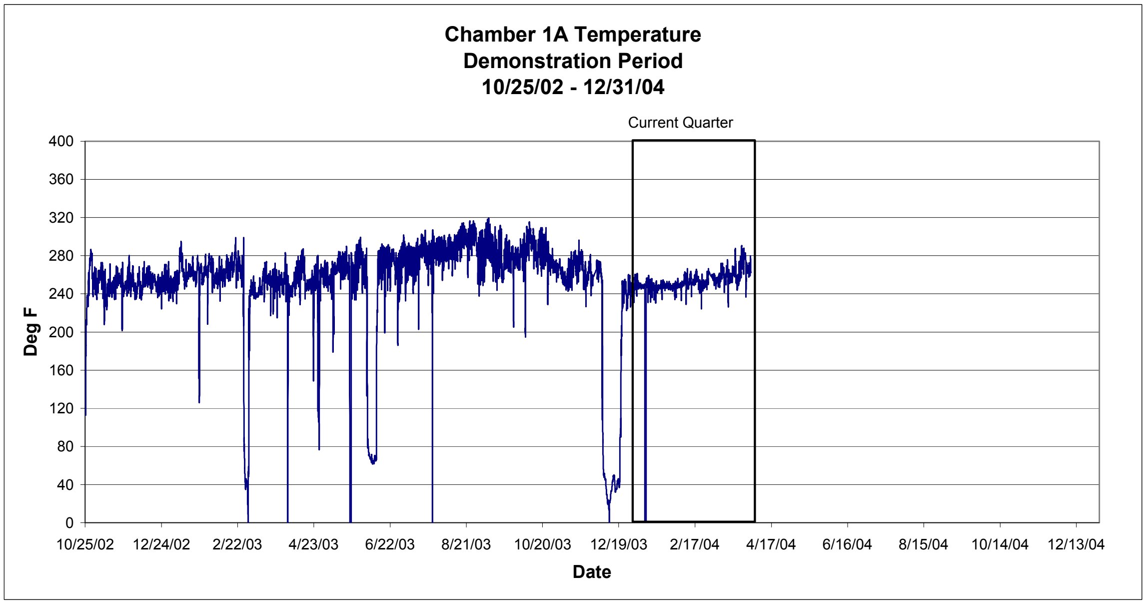


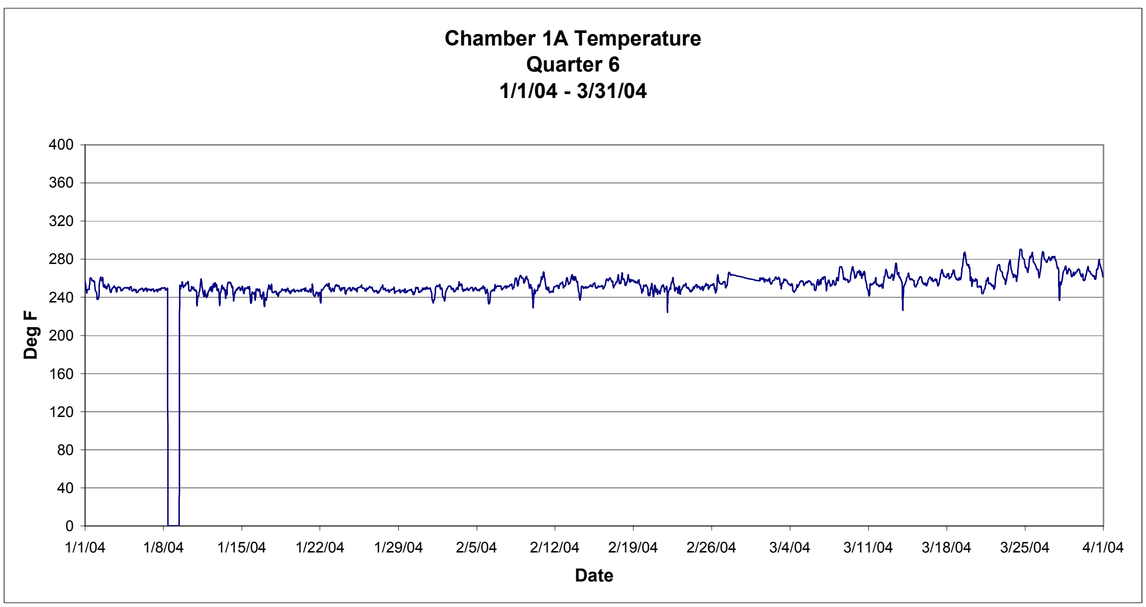
B12 Outlet Pressure

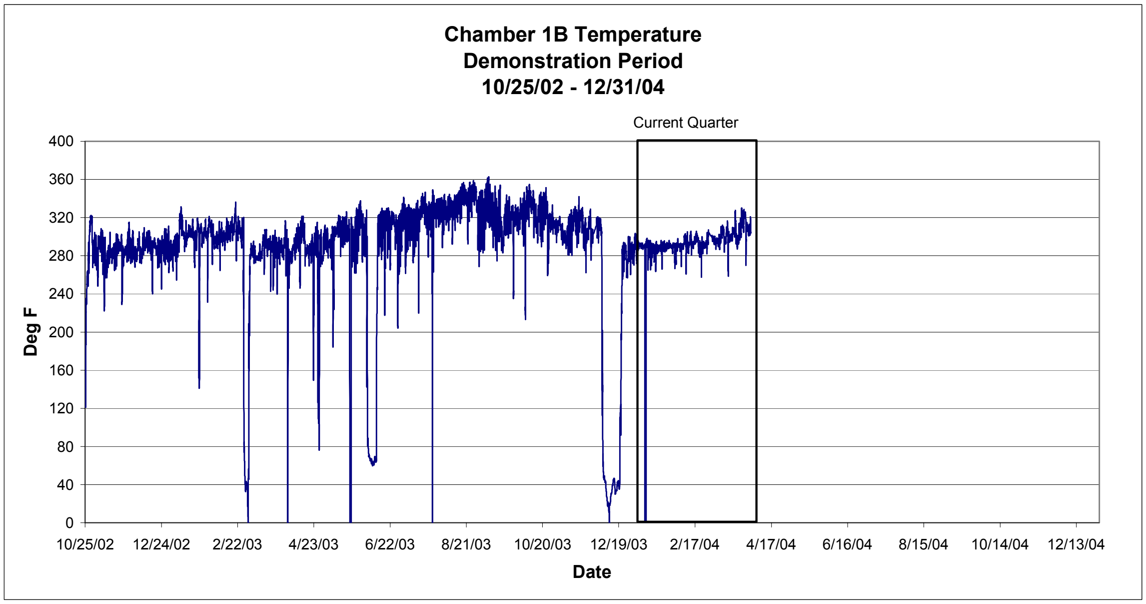


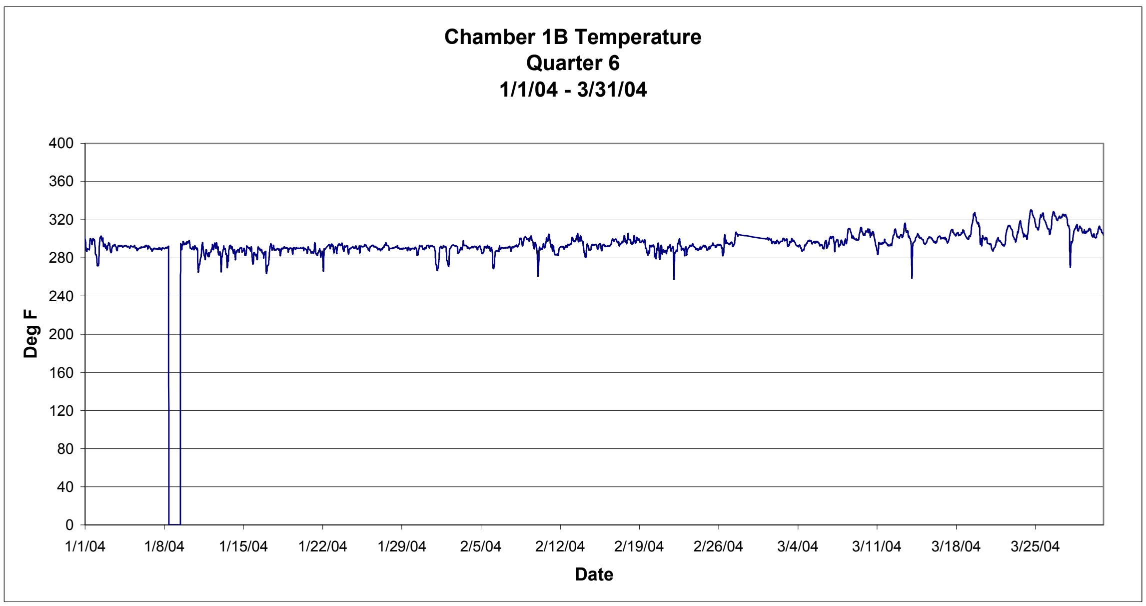


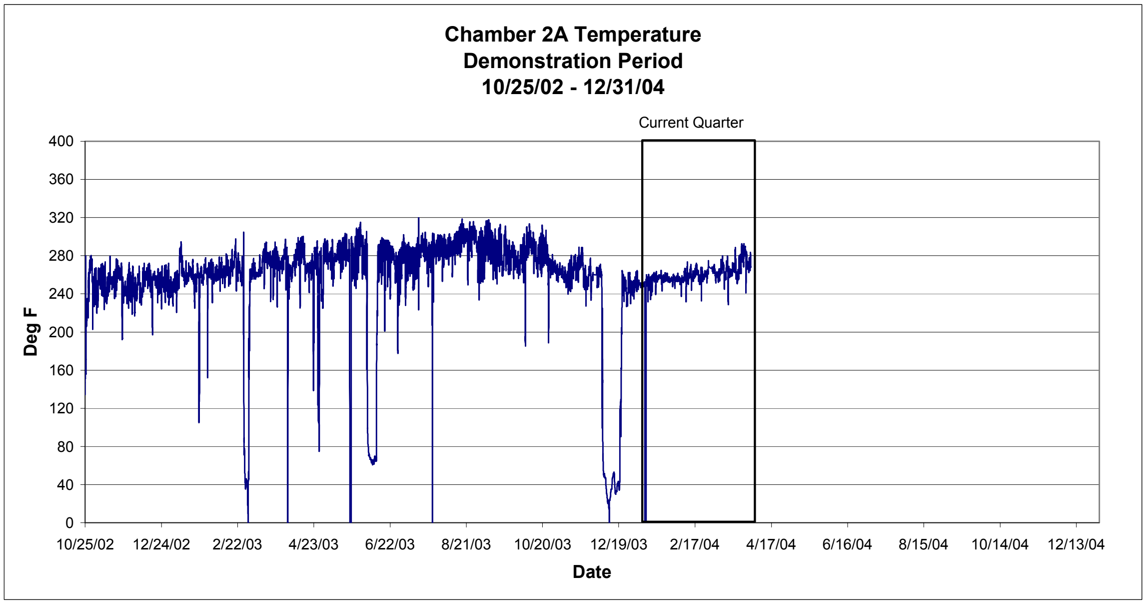
B13 Temperature per Chamber

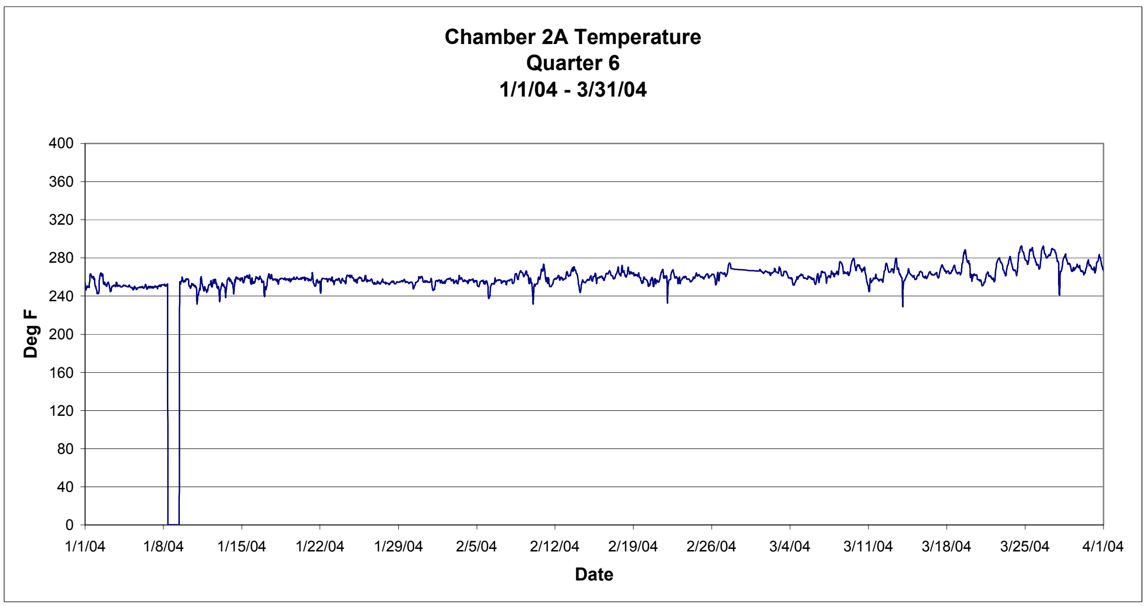


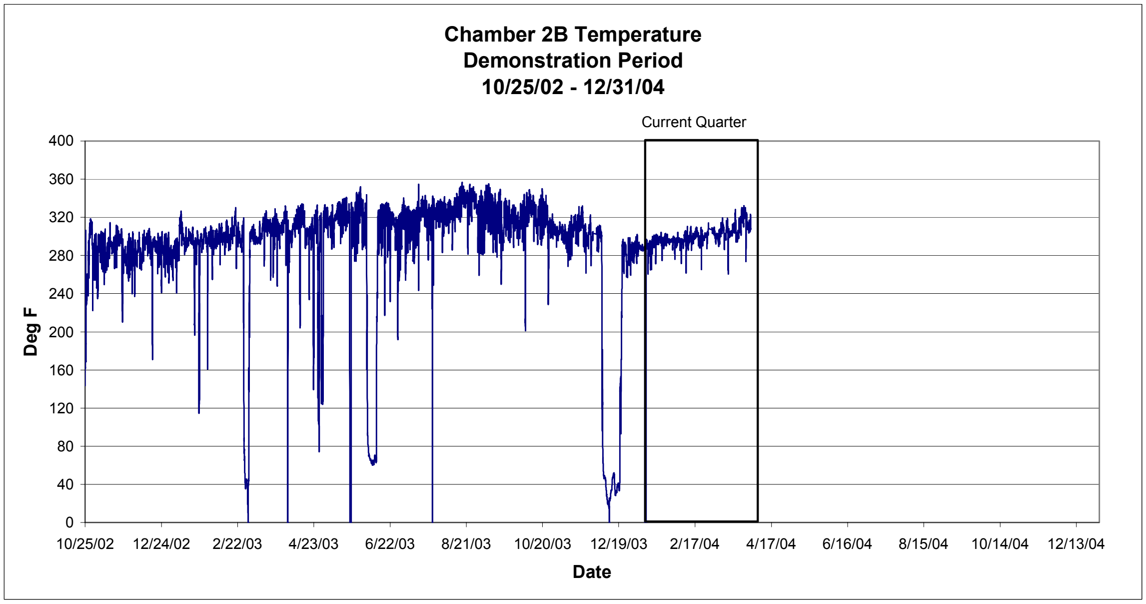


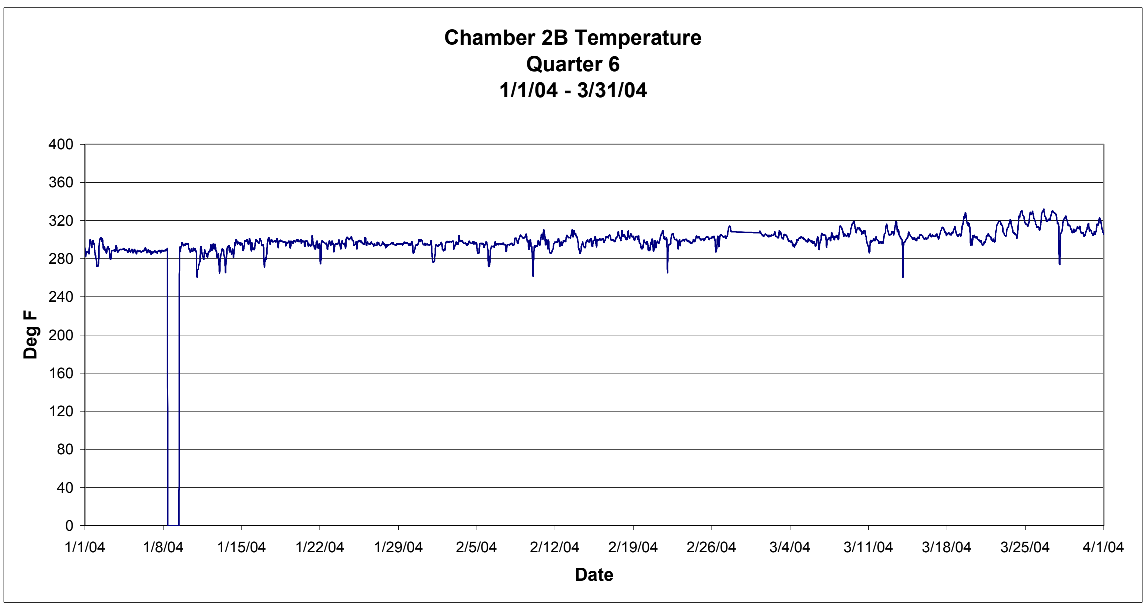

Chamber 1B Temperature
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
Deg F
400
360
320
280
240
200
160
120
80
40
0
10/25/02
12/24/02
2/22/03
4/23/03
6/22/03
8/21/03
10/20/03
12/19/03
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 1B Temperature
Quarter 6
1/1/04 - 3/31/04
Deg F
400
360
320
280
240
200
160
120
80
40
0
1/1/04
1/8/04
1/15/04
1/22/04
1/29/04
2/5/04
2/12/04
2/19/04
2/26/04
3/4/04
3/11/04
3/18/04
3/25/04
Date


Chamber 2A Temperature
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
Deg F
0
40
80
120
160
200
240
280
320
360
400
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 6
1/1/04 - 3/31/04
Deg F
0
40
80
120
160
200
240
280
320
360
400
1/1/04
1/8/04
1/15/04
1/22/04
1/29/04
2/5/04
2/12/04
2/19/04
2/26/04
3/4/04
3/11/04
3/18/04
3/25/04
4/1/04
Date


Chamber 2B 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 2B Temperature
Quarter 6
1/1/04 - 3/31/04
400
360
320
280
240
200
160
120
80
40
0
Deg F
1/1/04
1/8/04
1/15/04
1/22/04
1/29/04
2/5/04
2/12/04
2/19/04
2/26/04
3/4/04
3/11/04
3/18/04
3/25/04
4/1/04
Date

B14 Fuel Burn Record

BIG STONE PLANT
FUEL BURN RECORD
Jan-04

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

BIG STONE PLANT
FUEL BURN RECORD
Feb-04

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

BIG STONE PLANT
FUEL BURN RECORD
Mar-04

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

B15 Fuel Analysis Record

BIG STONE PLANT COAL ANALYSIS PER TRAIN
Jan-04

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

Monthly Mercury Analysis

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

BIG STONE PLANT COAL ANALYSIS PER TRAIN

Feb-04

TR		MOIS	% ASH	HHV	S, %	% ASH	HHV	S, %	NaO	MAF	COAL	TONS
DATE	#	%	AR	AR	AR	DRY	DRY	DRY	%	HHV	TONS	OK
PREV. MON.												
PREV. MON.												
1-Feb-04	bam09	29.4	4.26	8654	0.29	6.03	12260	0.41	1.51	13047	13227.65	13227.65
2-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
3-Feb-04	ebm06	29.9	4.92	8522	0.41	7.01	12148	0.59	1.77	13064	13432.30	13432.30
4-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
5-Feb-04	bam10	29.4	4.472	8617	0.3	6.26	12211	0.42	1.54	13026	13075.25	13075.25
6-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
7-Feb-04	bam11	30	4.33	8526	0.25	6.19	12176	0.36	1.61	12979	13381.70	13381.70
8-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
9-Feb-04	ebm07	30.1	5.05	8458	0.43	7.22	12093	0.62	1.66	13034	13135.92	13135.92
10-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
11-Feb-04	bam12	29.9	4.34	8575	0.26	6.19	12236	0.37	1.64	13043	13274.80	13274.80
12-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
13-Feb-04	bam13	30.7	4.37	8422	0.24	6.31	12149	0.35	1.64	12967	13331.43	13331.43
14-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
15-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
16-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
17-Feb-04	ebm08	30.3	4.88	8447	0.4	7	12117	0.57	1.73	13029	13021.83	13021.83
18-Feb-04	ebm09	29.9	5.02	8485	0.42	7.17	12110	0.6	1.6	13045	13279.58	13279.58
19-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
20-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
21-Feb-04	ebm10	29.8	4.52	8540	0.42	6.43	12159	0.6	1.99	12995	12493.23	12493.23
22-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
23-Feb-04	bam14	29.6	4.63	8560	0.28	6.58	12152	0.4	1.37	13008	13688.70	13688.70
24-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
25-Feb-04	ebm11	29.8	5.13	8474	0.39	7.3	12068	0.56	1.84	13018	13864.97	13864.97
26-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
27-Feb-04	ebm12	29.4	4.56	8599	0.4	6.46	12173	0.56	1.69	13014	13809.33	10702.49
28-Feb-04	0	0	0	0	0	0	0	0	0	0	0.00	0.00
29-Feb-04	bam15	28.9	4.41	8669	0.25	6.2	12199	0.35	1.58	13005	13969.70	0.00
ADJ.												169909.85
											Tons. OK	193730.75
Weighted Average		29.90	4.76	8508	0.34	6.79	12137	0.49	1.64		Burn	193730.75

Monthly Mercury Analysis

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

BIG STONE PLANT	COAL ANALYSIS PER TRAIN
	Mar-04

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

Monthly Mercury Analysis

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

B16 Ash Analysis Record

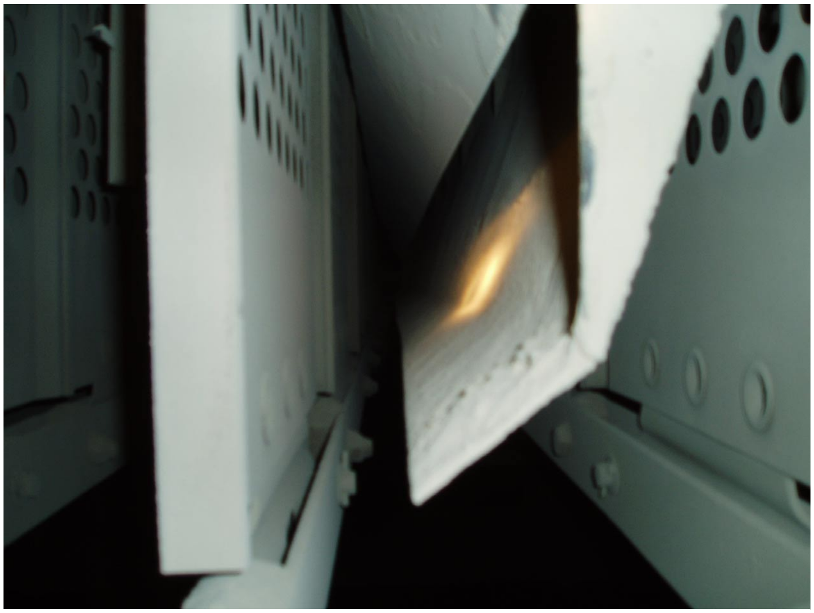
None taken this quarter.

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
04-Jan-04	29.76	5.09	48.59	0.70	0.44	3.44	11.98	8471	1.60	
11-Jan-04	29.33	4.62	49.57	0.69	0.33	3.38	12.08	8624	1.10	0.093
18-Jan-04	28.30	4.40	51.62	0.75	0.33	3.57	11.03	8602	1.70	
25-Jan-04	30.05	4.26	51.23	0.73	0.28	3.38	10.07	8548	1.70	
01-Feb-04	29.85	5.27	48.97	0.69	0.46	3.44	11.32	8503	1.80	
08-Feb-04	29.27	4.31	49.78	0.70	0.27	3.48	12.19	8604	1.40	0.035
15-Feb-04	30.58	4.38	49.39	0.68	0.26	3.34	11.37	8390	1.00	
22-Feb-04	29.67	4.99	49.05	0.70	0.44	3.59	11.56	8460	1.40	
29-Feb-04	28.68	4.83	50.30	0.73	0.43	3.36	11.67	8658	1.90	
07-Mar-04	29.65	4.70	50.04	0.69	0.34	3.43	11.15	8545	1.20	
14-Mar-04	28.54	4.87	50.47	0.72	0.40	3.49	11.51	8631	1.80	0.105
21-Mar-04	29.43	4.50	49.42	0.68	0.28	3.58	12.11	8543	1.70	
28-Mar-04	31.09	4.44	50.01	0.67	0.30	3.46	10.03	8428	1.50	
04-Apr-04										
11-Apr-04										
18-Apr-04										
25-Apr-04										
02-May-04										
09-May-04										
16-May-04										
23-May-04										
30-May-04										
06-Jun-04										
13-Jun-04										
20-Jun-04										
27-Jun-04										
04-Jul-04										
11-Jul-04										
18-Jul-04										
25-Jul-04										
01-Aug-04										
08-Aug-04										
15-Aug-04										
22-Aug-04										
29-Aug-04										
05-Sep-04										
12-Sep-04										
19-Sep-04										
26-Sep-04										
03-Oct-04										
10-Oct-04										
17-Oct-04										
24-Oct-04										
31-Oct-04										
07-Nov-04										
14-Nov-04										
21-Nov-04										
28-Nov-04										
05-Dec-04										
12-Dec-04										
19-Dec-04										
26-Dec-04										

B18 Photographs

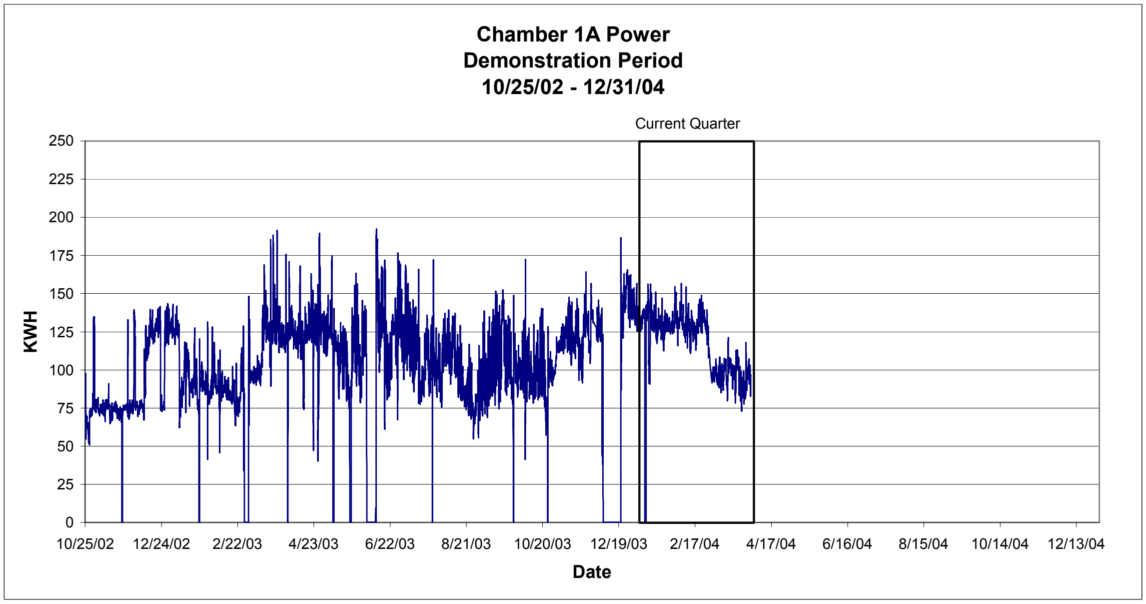


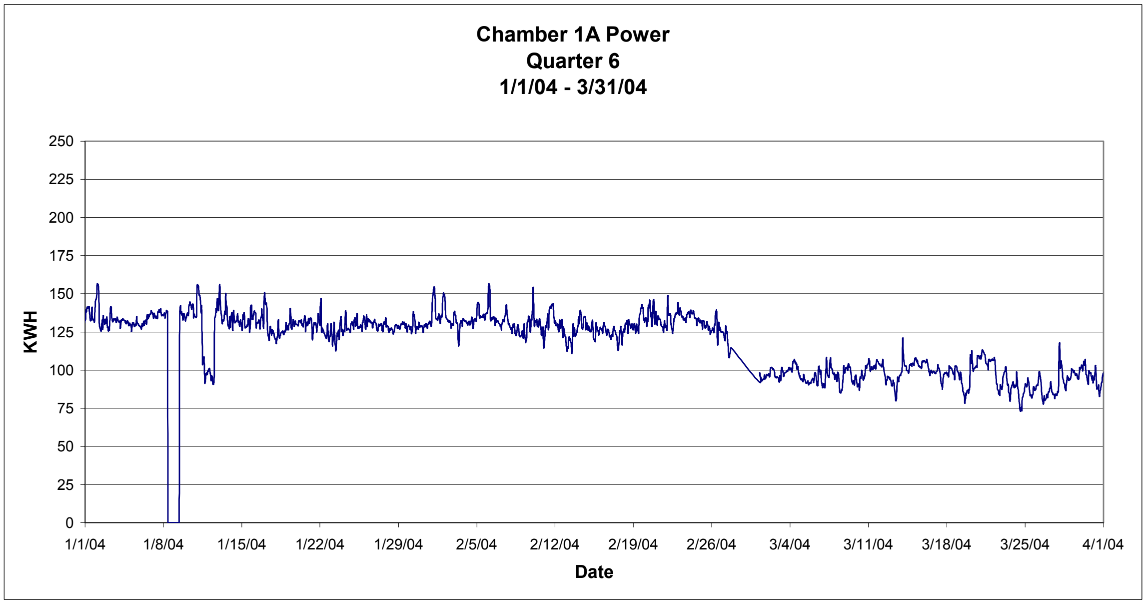
View of exterior of flow baffles

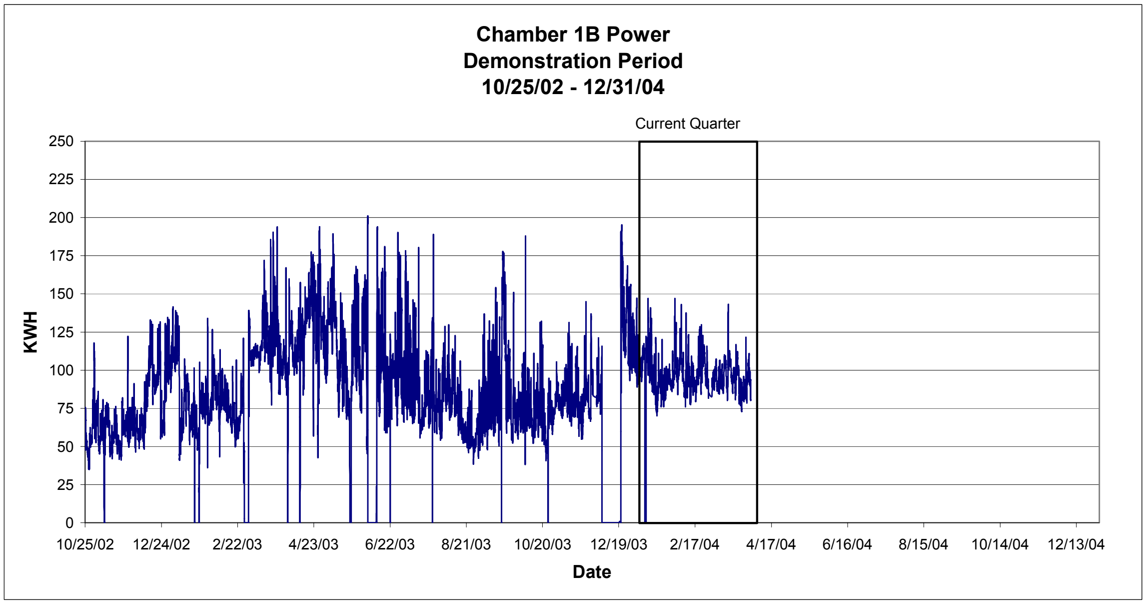
View of interior of flow baffles

Typical hole in filter bag

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
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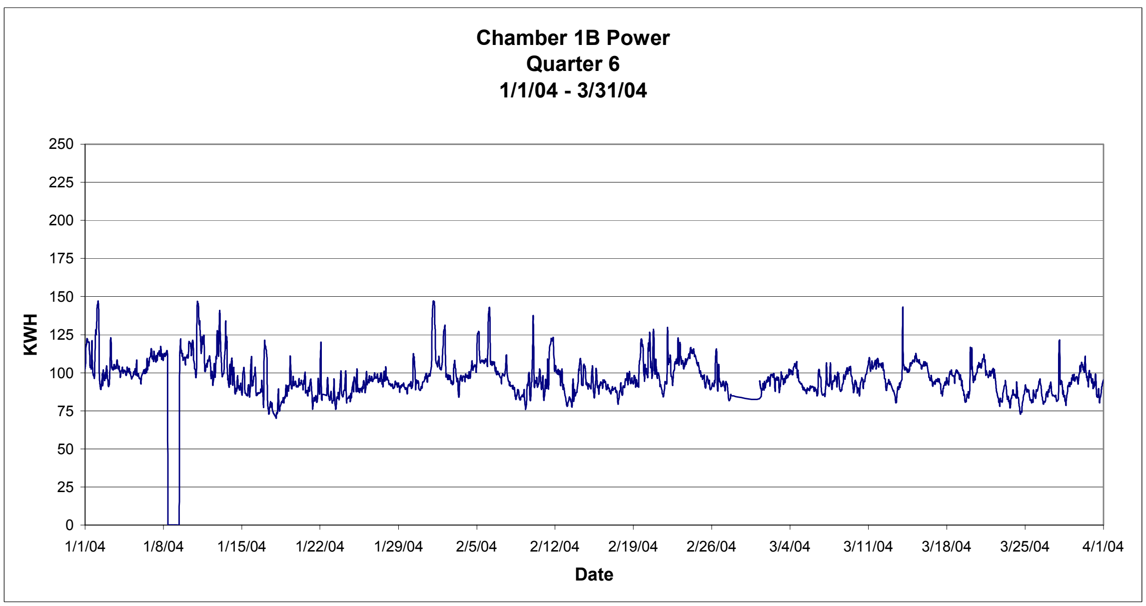
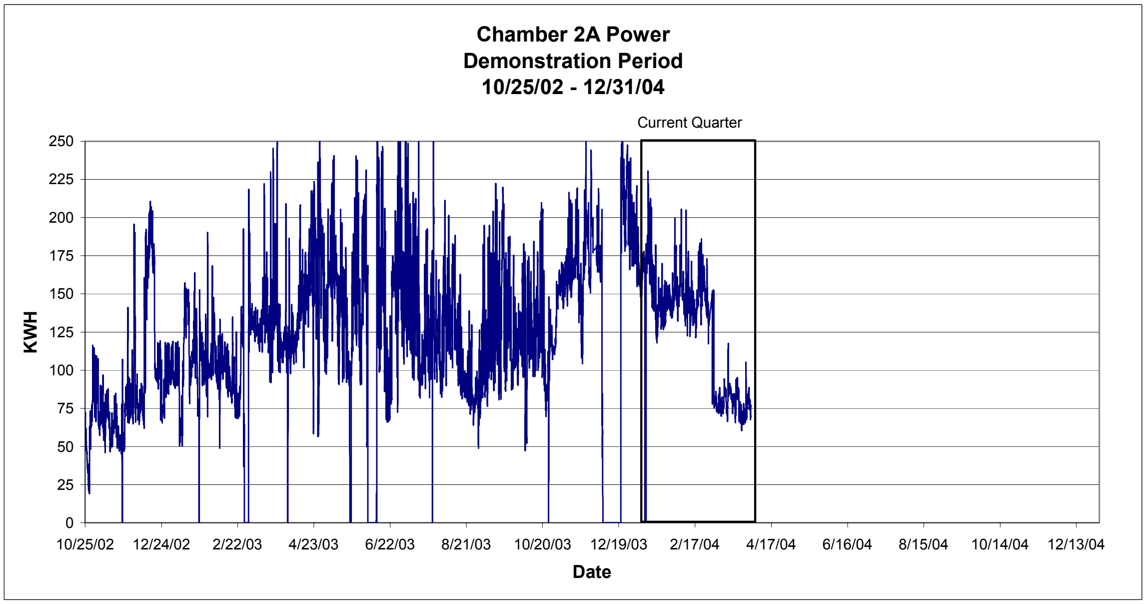
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 1B Power
Quarter 6
1/1/04 - 3/31/04
KWH
250
225
200
175
150
125
100
75
50
25
0
1/1/04
1/8/04
1/15/04
1/22/04
1/29/04
2/5/04
2/12/04
2/19/04
2/26/04
3/4/04
3/11/04
3/18/04
3/25/04
4/1/04
Date


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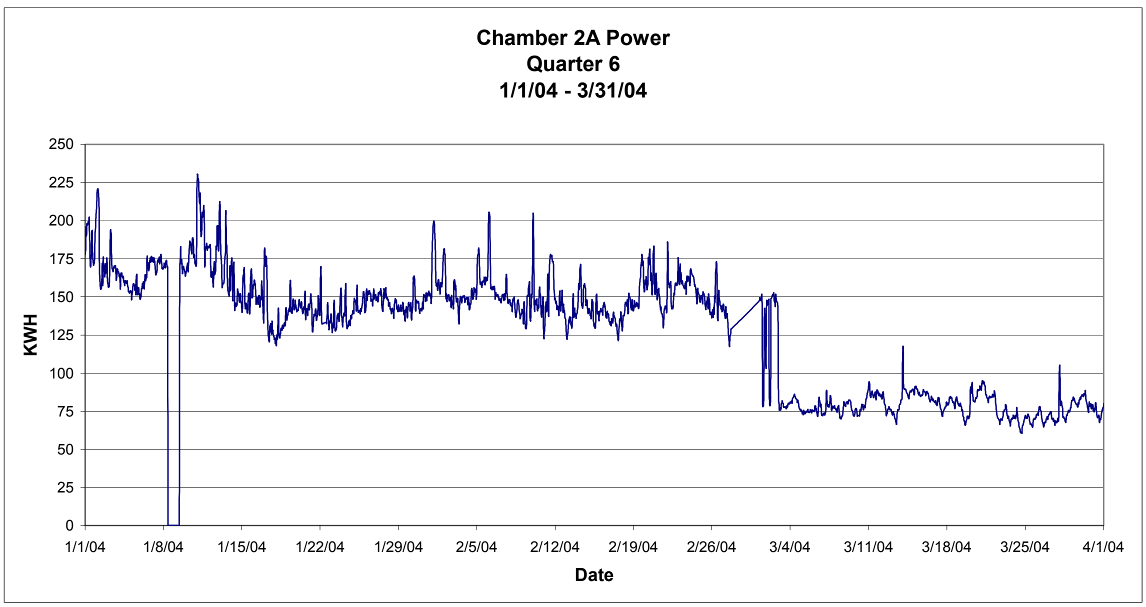
2/17/04
4/17/04
6/16/04
8/15/04
10/14/04
12/13/04
Date


Chamber 2A Power
Quarter 6
1/1/04 - 3/31/04
KWH
0
25
50
75
100
125
150
175
200
225
250
1/1/04
1/8/04
1/15/04
1/22/04
1/29/04
2/5/04
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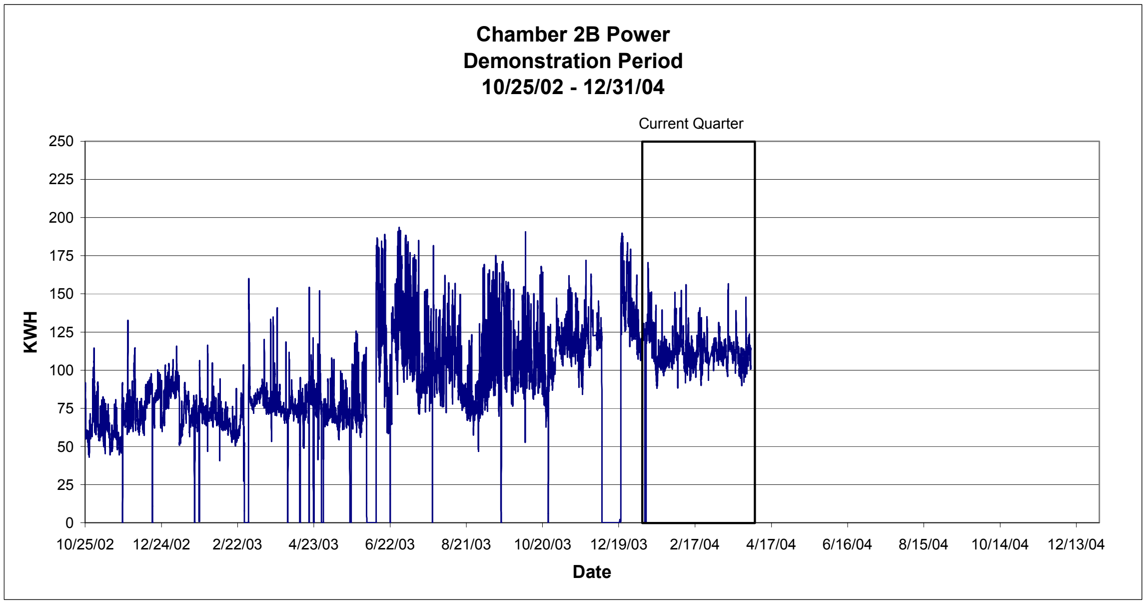
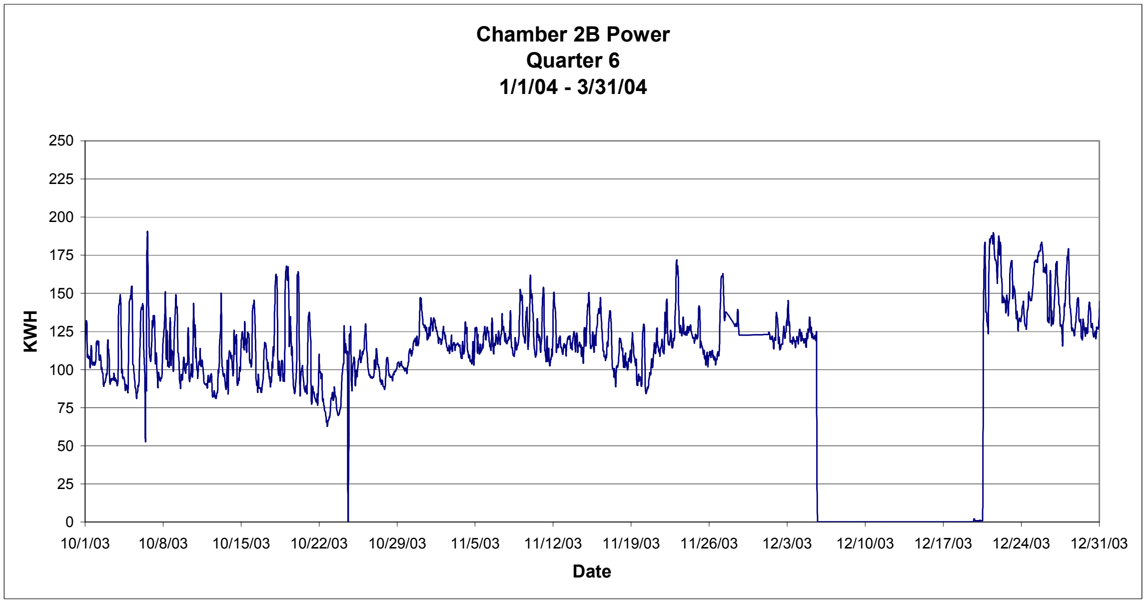
3/4/04
3/11/04
3/18/04
3/25/04
4/1/04
Date


Chamber 2B Power
Demonstration Period
10/25/02 - 12/31/04
Current Quarter
250
225
200
175
150
125
100
75
50
25
0
KWH
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 6
1/1/04 - 3/31/04
250
225
200
175
150
125
100
75
50
25
0
KWH
10/1/03
10/8/03
10/15/03
10/22/03
10/29/03
11/5/03
11/12/03
11/19/03
11/26/03
12/3/03
12/10/03
12/17/03
12/24/03
12/31/03
Date

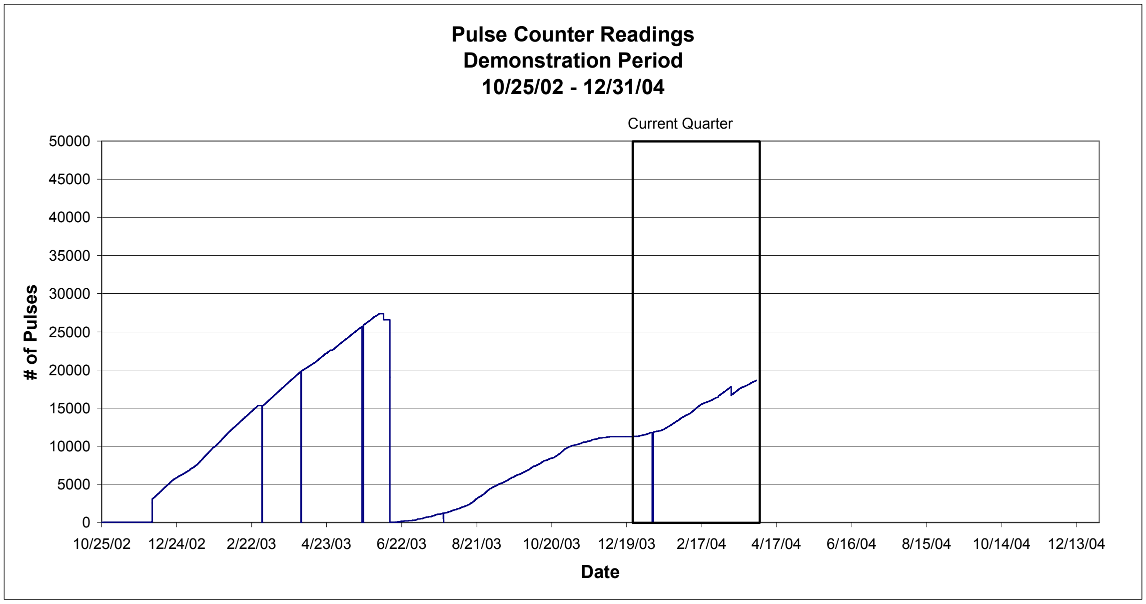
B20 ESP Tabular Data

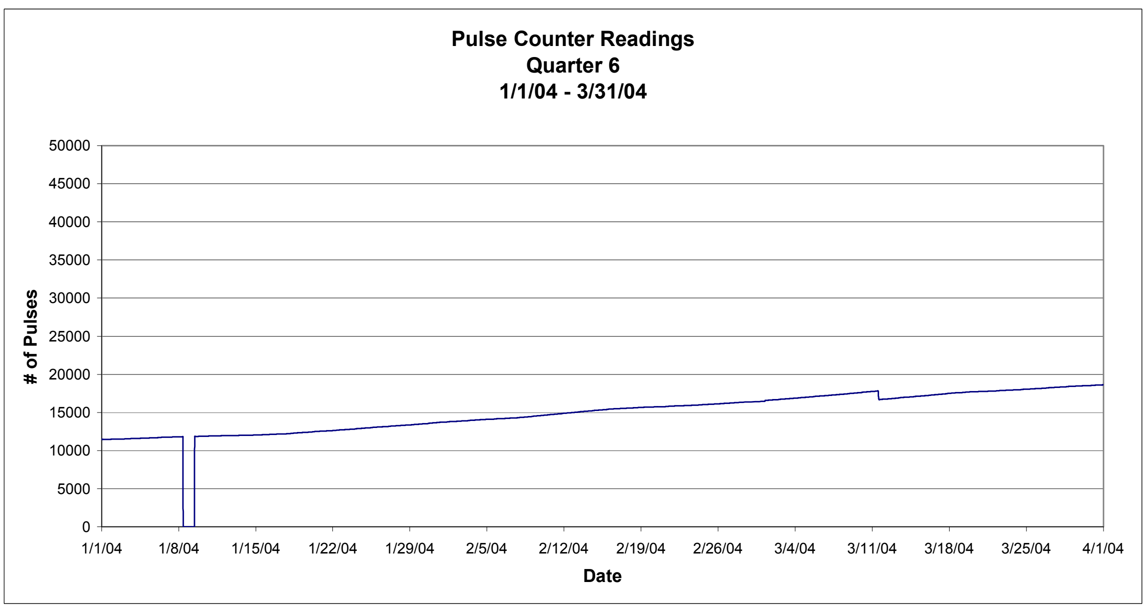
Transformer/Rectifier Performance Readings

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

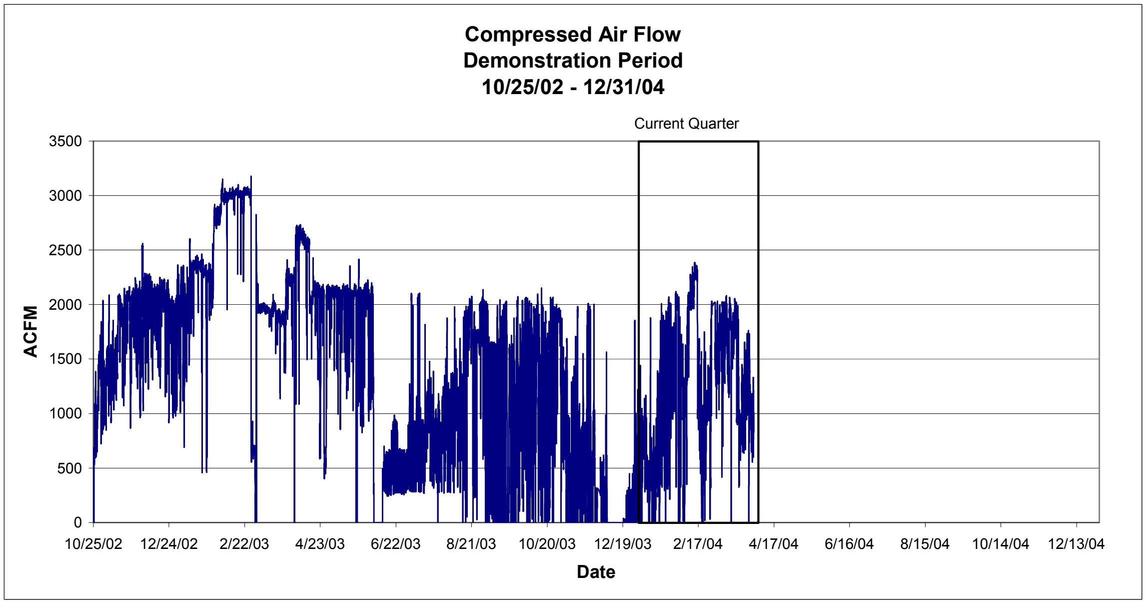
15-Mar-03	* Limiting factors highlighted											
Chamber	Field 1			Field 2			Field 3			Field 4		
	mA	kV	spm	mA	kV	spm	mA	kV	spm	mA	kV	spm
1A	Off	Off	Off	408	49.3	$\boxed{19}$	886	52.5	$\boxed{19}$	$\boxed{990}$	59.6	5
1B	229	61.6	$\boxed{97}$	549	52	$\boxed{19}$	807	52	$\boxed{19}$	$\boxed{892}$	54.4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

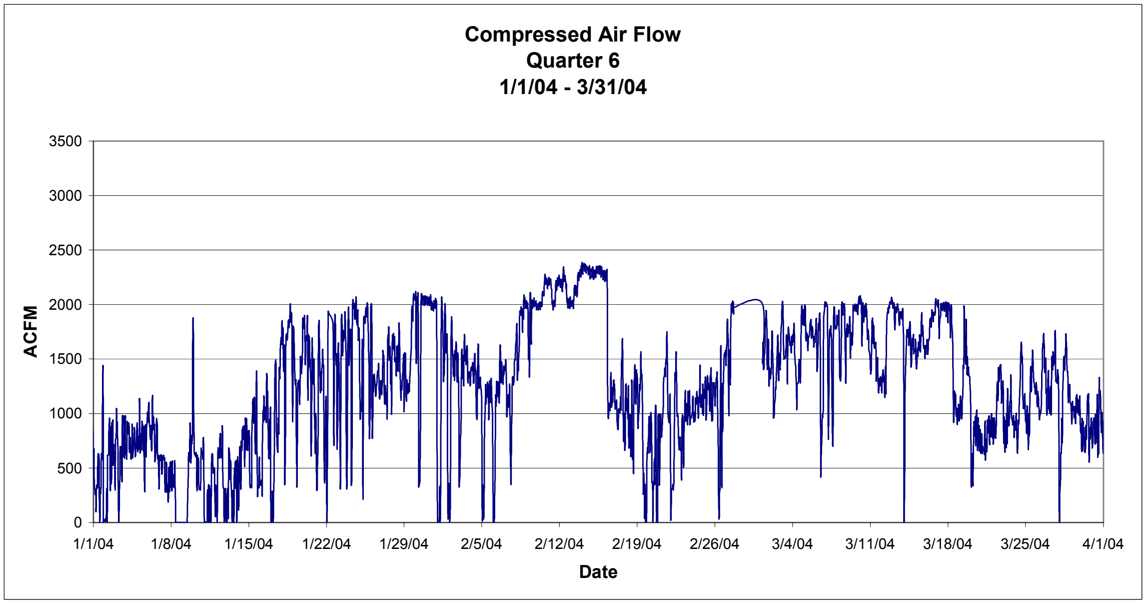
B21 Pulse Counter Readings



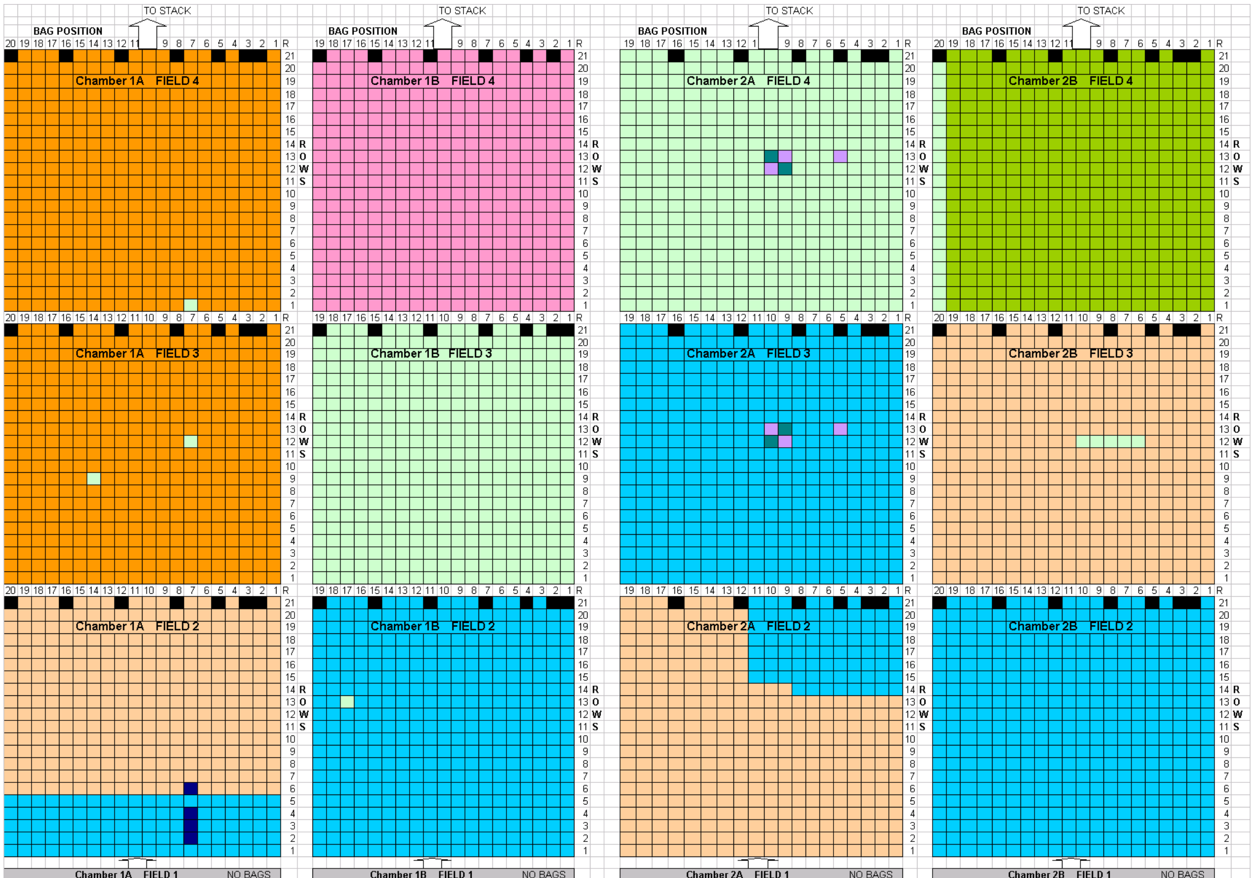


B22 Compressed Air Flow





B23 Bag Layout Diagram



- No Filter Bag
- Conductive Gore-Tex Membrane/Conductive Gore-Tex Felt (Installed 6/03)
- Conductive Gore-Tex Membrane/Conductive PPS Felt (Installed 6/03)
- Gore-Tex Membrane/PPS Felt (Installed 6/03)
- Conductive Gore-Tex Membrane/Conductive Gore-Tex Felt (Installed 10/02, removed 6/03, washed, reinstalled 12/03)
- BHA-Tex Membrane/Nomex Felt (Installed 12/03)
- BHA-Tex Membrane/P84 Felt (Installed 12/03)
- BHA Stainless Steel Cage (Installed 12/03) with Conductive Gore-Tex Membrane/Conductive Gore-Tex Felt (Removed 6/03, washed, reinstalled 12/03)
- Conductive Gore-Tex Membrane/Conductive Gore-Tex Felt (Installed 12/03)
- Gore - Superflex (Installed 12/03)
- Gore-Tex Membrane/Fiberglass (Installed 12/03)