Wyodak Station – Unit 1
SO_2 Reduction Study

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LEGAL NOTICE

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Table of Contents

EXECUTIVE SUMMARY ---------- ES-1

1. INTRODUCTION ---------- 1

2. EVALUATION OF ESP CASING ---------- 3

3. DESCRIPTION OF SO_2 REDUCTION OPTIONS ---------- 4

3.1 Option 1 - Rebuild ESP Using Carbon Steel Plates and Wires ---------- 4

3.2 Option 2 - Rebuild ESP Using Stainless Steel Plates and Wires ---------- 4

3.3 Option 3 – ESP to FF Conversion ---------- 5

3.4 Option 4 – Install New Stand-Alone Baghouse ---------- 7

4. CAPITAL COST ESTIMATES ---------- 8

5. FIXED AND VARIABLE O&M COST ESTIMATES ---------- 10

6. NET PRESENT VALUE ANALYSIS ---------- 11

7. CONCLUSIONS AND RECOMMENDATIONS FOR REDUCING SO_2 EMISSIONS ---------- 12

Appendix A – B&W Report: "Engineering Study Results for Improved SO_2 Removal"
Appendix B – ESP Casing and Hopper Thickness Readings
Appendix C – SEI Budgetary Proposal for ESP Rebuild
Appendix D – SEI Estimate for Upgrading ESP Internals to Stainless Steel
Appendix E – HRC Proposal for ESP to FF Conversion
Appendix F – ESP to FF Conversion Diagrams
Appendix G – HRC Proposal for New Fabric Filter
Appendix H – General Arrangement Drawing – Stand-Alone Baghouse Option
Appendix I – Capital Cost Estimates

EXECUTIVE SUMMARY

PacifiCorp expects the Wyoming Department of Environmental Quality (WDEQ) to propose SO_2 emission limits that are more stringent than limits originally proposed in PacifiCorp's BART submittal for Wyodak Station Unit 1. The expected SO_2 emission limits for normal operation are 0.15 lb/mmBtu for 24-hour and 30-day averaging periods. The original BART Analysis prepared by CH2M Hill proposed a limit of 0.32 lb/mmBtu. Since the uncontrolled SO_2 emission rate is 1.6 lb/mmBtu, the expected emission limits require at least 91% SO_2 removal. This change of limits impacts the AQCS equipment recommendations of the original BART Analysis. PacifiCorp directed S&L to evaluate the SO_2 and PM reduction options for Wyodak Unit 1 to comply with the expected WDEQ emission limits.

Wyodak Unit 1 has a dry FGD system that currently treats about 90% of the flue gas flow, while 10% is bypassed around the FGD system. The PM is collected in an ESP downstream of the FGD system. The ESP treats 100% of the flue gas. Based on the currently fired fuel and the WDEQ proposed emission limits, the FGD equipment will be required to remove greater than 90% of the SO_2 in the flue gas. The removal needs to be even a little greater because of variations in the coal and to provide the plant operators some operating margin.

PacifiCorp hired B&W to perform an engineering study of the dry FGD and ESP combination. B&W concluded that the three spray dryer absorbers were capable of treating 100% of the flue gas flow and that the combination of a dry FGD and an ESP with stainless steel internals could achieve over 90% SO_2 removal. B&W also concluded that 95% SO_2 removal is possible if the ESP is converted to a baghouse.

In S&L's judgment, the dry FGD and ESP combination is not a preferred technology combination for providing continuous compliance when more than 90% SO_2 removal is required. The ESP limits the SO_2 reduction that can be achieved by this combination of technologies. PacifiCorp would risk potential non-compliance with future SO_2 emission limits at Wyodak Station Unit 1 with the combination of an FGD and ESP for control of SO_2 emissions.

The combination of a dry FGD and a fabric filter system (FF) will achieve 95% SO_2 removal or an SO_2 emission rate of 0.08 lb/mmBtu. Therefore, this is the preferred control technology combination for consistently meeting the future SO_2 emission limits.

The following table provides a list of retrofit control technologies considered, their ability to meet future SO_2 limits, and a summary of estimated costs associated with each technology.

Table ES-1. Comparison of Retrofit Options and Associated NPV Costs

Retrofit Option	Can Meet WDEQ SO_2 Limits?	Net Present Value, $1,000	% Cost Increase Base
Rebuild ESP with Carbon Steel Internals	No	104,075	-17.4%
Rebuild ESP with Stainless Steel Internals	Unlikely	121,657	-3.4%
ESP to FF Conversion – Reuse Existing ESP Casing	Yes	125,952	Base
ESP to FF Conversion – Replace ESP Casing Walls	Yes	131,341	4.3%
Install Stand Alone Baghouse	Yes	130,238	3.4%

The ESP rebuild options are not expected to consistently demonstrate compliance with WDEQ SO_2 emission limits. Therefore, S&L recommends installing a baghouse for compliance with WDEQ SO_2 emission limits.

The estimated NPV costs for the ESP to FF conversion options range from $126 million to $131 million while the estimated cost for the stand-alone baghouse is $130 million. Since the cost difference among the three options is minimal, the following table has been provided to identify features for each option.

Table ES-2. Baghouse Option Features

Control Option	
ESP to FF Conversion – Reuse Casing	- Slightly lower cost option - Bag-life extended by ~1 yr due to low air to cloth ratio and a settling chamber in the first row of the casing - Outage requirement = 8 weeks - Casing reinforcement required if SCR is installed in the future
ESP to FF Conversion – New Casing	- Bag-life extended by ~1 yr due to low air to cloth ratio and a settling chamber in the first row of the casing - Outage requirement = 10 weeks
Install New Stand-Alone Baghouse	- Outage requirement = 8 weeks

The low cost option is the ESP to FF conversion reusing the existing casing. This option, however, requires an 8 week outage. By reusing the casing, there is some risk that the casing will need some unexpected repairs that could extend the outage length. In addition, if an SCR is installed in the future, the casing will need to be reinforced to accommodate the additional pressure requirement. Compared with the stand-alone baghouse, the bag-life would be extended by approximately one year because of the reduced air to cloth ratio and a settling chamber in the first row of the casing.

The ESP to FF conversion option that includes replacing the casing walls has a slightly high cost than the option that reuses the casing. In addition, this option requires a 10 week outage instead of an 8 week outage. Compared with the stand-alone baghouse, the bag-life would be extended by approximately one year because of the reduced air to cloth ratio and a settling chamber in the first row of the casing. This option removes the issues related to unexpected repairs to the casing walls and also the casing will be designed for the additional pressure requirement of a future SCR installation should it become necessary.

The cost of the stand-alone baghouse option is approximately 3% greater than the ESP to FF conversion option that reuses the casing, and slightly less than the option that replaces the casing walls. The SDA outlet duct will need to be demolished and a new one installed during the outage, but this can be done within an 8 week outage. This option poses the least risk with regard to outage length because most components can be installed while the unit is operating.

1. INTRODUCTION

Wyodak Unit 1 is a wall-fired boiler firing PRB coal and has a design gross power generation capability of 362 MW. The unit has three SDAs and an electrostatic precipitator (ESP) for SO_2 and PM reduction. The uncontrolled SO_2 emission rate is currently 1.6 lb/mmBtu. The SDAs are currently reducing SO_2 emissions by 80%, but because approximately 10% of the flue gas is bypassed around the SDAs, total SO_2 reduction is approximately 69%. The current SO_2 emission rate is 0.5 lb/mmBtu. The current PM emission rate is 0.03 lb/mmBtu.

On February 2, 2007, CH2M Hill issued to PacifiCorp a final Best Available Retrofit Technology (BART) Analysis for Wyodak Unit 1. The BART Analysis makes the following recommendations:

- Install low NO_x burners (LNB) with over fire air (OFA) to reduce NO_x emissions from 0.31 lb/mmBtu to 0.23 lb/mmBtu.

- Close flue gas bypasses around the existing spray dryer absorbers (SDA). With treatment of 100% of the flue gas and 80% control of SO_2, the total controlled SO_2 emission rate will be reduced to 0.32 lb/mmBtu.

- The current PM emission rate is 0.03 lb/mmBtu. The BART Analysis recommends no change to further reduce PM emissions.

Based on PacifiCorp's discussions with the Wyoming Department of Environmental Quality (WDEQ), WDEQ will likely issue the SO_2 and PM emission limits listed in Table 1-1 for coal fired electric generating units in Wyoming.

Table 1-1. Expected SO_2 and PM Emission Limits

Pollutant	Averaging Period	Emission Limit
SO_2	3-Hour	1.2 lb/mmBtu
	24-Hour	0.15 lb/mmBtu
	Annual	0.15 lb/mmBtu
PM		0.04 lb/mmBtu

In response to the expected BART emission limits, B&W was contracted by PacifiCorp to perform an engineering study for the spray dry absorber (SDA) system (see Appendix A). The B&W study, dated June 5, 2007, states that the SDA system was designed to treat 100% of the flue gas using three SDA chambers. The SDA design outlet temperature is 147 ºF. However, at this temperature, solids deposition and corrosion will occur within the ESP. To reduce the risk of corrosion inside the ESP, the SDA outlet flue gas temperature is currently set at 160ºF and approximately 10% of the flue gas is currently bypassed the SDAs to reheat the flue gas entering the ESP to 180ºF, or 50ºF above saturation. The B&W report includes an SDA modeling study that concludes that, by reducing the SDA temperatures, the SDA and ESP combination is capable of achieving an SO_2 reduction efficiency of 95%.

PacifiCorp has authorized Sargent and Lundy, LLC (S&L) to conduct an evaluation of SO_2 reduction options. All options assume that 100% of the flue gas will be treated by the SDAs. Since the SDA system was designed to control 100% of flue gas, minimal modifications to the SDA system are anticipated. However, an issue of concern is the atomizer flush sequence for the SDA system. During the atomizer flush sequence, the outlet temperature drops below the flue gas saturation point temperature several times per day. The SDA outlet temperature should be at least 35°F above approach to saturation to keep from having wet solids deposit in the duct and particulate control device. The B&W report provides an evaluation of the atomizer flush sequence, along with a recommendation to resolve the problem. S&L believes that Wyodak should follow B&W's recommendation of reducing the atomizer flush pressure by installing either a pressure regulator or a flow restricting orifice into the flush water piping.

The SO_2 and PM control options considered in this evaluation include the following:

1. Rebuild the ESP using carbon steel wires and plates, and operate the SDAs at an outlet temperature of 180ºF and a lime stoichiometric ratio of 1.8 (based on SO_2 entering the SDAs) to achieve a controlled SO_2 emission rate of 0.32 lb/mmBtu.

2. Rebuild the ESP using stainless steel wires and plates, and operate the SDA at an outlet temperature of 164ºF to 173ºF and a lime stoichiometry of 1.7 to achieve a controlled SO_2 emission rate of 0.08 lb/mmBtu.

3. Convert the ESP to a pulse-jet fabric filter (FF) baghouse, and operate the SDAs at a lime stoichiometry of 1.3 to achieve a controlled SO_2 emission rate of 0.08 lb/mmBtu. Two alternatives were considered:

   A. Reuse the existing ESP casing.

   B. Replace the existing ESP casing above the hopper beam.

4. Install a new, stand-alone baghouse, with SDAs operating at a lime stoichiometry of 1.3 to achieve a controlled SO_2 emission rate of 0.08 lb/mmBtu.

2. EVALUATION OF ESP CASING

Three of the SO_2 reduction options require the reuse of the existing ESP casing. S&L has reviewed the thickness readings measured by the Whitehead during the summer 2007 outage. The results indicate that the majority of the ESP casing and hoppers are still in the 3/16" to 1/4" range, which is the original design thickness. There are some isolated spots where the casing has thinned by about 1/16”. There has been very minor patching work performed in the 6th field prior to 2006. ESP casing and hopper thickness readings are provided in Appendix B.

Based on the findings, the consensus is that the ESP and hoppers would continue to operate safely. However, more frequent inspection is recommended to monitor the thickness loss in the future if the ESP is going to continue operating. Discrete patching work as necessary is the most cost efficient option.

In the event that the ESP is converted to a baghouse, an evaluation of the existing steel framing, foundations, and ductwork must be performed. Additional discussion of these issues can be found in Section 3.3.

3. DESCRIPTION OF SO_2 REDUCTION OPTIONS

The section provides descriptions of the SO_2 reduction options considered in this study. Each option is based on closing the bypass and treating 100% of the flue gas in the SDAs.

3.1 Option 1 - Rebuild ESP Using Carbon Steel Plates and Wires

This option includes replacing the existing ESP internals with new carbon steel plates and wires. To reduce the risk of corrosion inside the ESP, this option assumes an SDA outlet temperature of 180ºF and operation at a lime stoichiometry of 1.8. At this temperature and stoichiometry, the B&W model estimates an SO_2 reduction of 80%, resulting in an emission rate of 0.32 lb/mmBtu.

The preliminary design of the rebuilt ESP consists of replacing the existing internals with carbon steel plates and wires. Each of the chambers will have thirty-eight (38) gas passages spaced 16". There will be twelve (12) mechanical fields, each 9' long by 42.5' tall and twelve (12) electrical fields, each 9' long in the direction of the flow. Electromagnetic rappers will be used for both collecting and discharge electrodes. PM emissions would be less than 0.04 lb/mmBtu. Additional information is provided in Appendix C.

Capital cost estimates associated with this option are based on the following:

- Replace ESP internals with carbon steel plates and wires
- Replace the current 2" insulation in the ESP casing and hoppers with 6" insulation
- Electrical modifications

This option includes replacement of the current 2 inches of insulation on the ESP casing and hoppers with 6 inches of insulation. This would reduce the risk of corrosion inside the ESP casing.

3.2 Option 2 - Rebuild ESP Using Stainless Steel Plates and Wires

This option will allow the plant to operate at a lower precipitator inlet temperature, 160ºF to 170ºF, without concern for corrosion of the stainless steel internals. B&W's study indicates that operating at this low temperature would allow greater SO_2 removal, as high as 95%. For the purpose of this study, the SDAs were assumed to operate at B&W's modeled stoichiometric ratio of 1.7. Although S&L is not aware of any SDA and ESP combinations that can achieve 95% removal, the evaluation of this option is based on this removal efficiency and a controlled SO_2 emission rate of 0.08 lb/mmBtu.

The preliminary design of the rebuilt ESP consists of replacing the existing internals with carbon steel plates and wires. Each of the chambers will have thirty-eight (38) gas passages spaced 16". There will be twelve (12) mechanical fields, each 9' long by 42.5' tall and twelve (12) electrical fields, each 9' long in the direction of the flow. Electromagnetic rappers will be used for both collecting and discharge electrodes. PM emission would be less than 0.04 lb/mmBtu. Additional information is provided in Appendices C and D.

Capital cost estimates associated with this option are based on the following:

- Replace ESP internals with stainless steel plates and wires
- Replace the current 2" insulation in the ESP casing and hoppers with 6" insulation
- Electrical modifications

This option includes replacement of the current 2 inches of insulation on the ESP casing and hoppers with 6 inches of insulation. This would reduce the risk of corrosion inside the ESP casing.

3.3 Option 3 – ESP to FF Conversion

This option involves converting the existing ESP to a baghouse. This option provides 95% SO_2 removal and an emission rate of 0.08 lb/mmBtu. The PM emissions would be less than 0.015 lb/mmBtu. The FGD and baghouse system would provide the 95% removal without increasing the current lime requirement. The baghouse option also allows for lower cost compliance with future mercury reduction rules. The amount of powdered activated carbon (PAC) injection with a baghouse would be less than 40% of the amount if the ESP was used.

The preliminary design of the ESP to FF conversion consists of constructing four low pressure/high volume pulse-jet fabric filter, isolatable compartments in the existing ESP casings. One compartment will be installed in each ESP casing and each compartment will contain six bag bundles. The first four rows of ash hoppers will continue to be used. The first row of hoppers will collect ash from an empty settling chamber and rows two through four will collect ash collected in the baghouse.

Two alternatives were considered for this option: (A) reuse the existing ESP casing, and (B) replace the existing ESP casing above the hopper beam. Additional information on the ESP to FF conversion can be found in Appendix E. Diagrams showing the ESP to FF conversion are provided in Appendix F.

The existing ash handling system is designed to collect 65 tons of ash per hour in each of the first two rows, and 30 tons per hour in rows three and four combined. The capacity of rows one and two should be adequate for the ESP to FF conversion. However, the capacity of rows three and four will need to be increased. The potential ash handling system upgrades include: transport air compressors, feeder assemblies, and piping to the ash silo and recycle bin. In addition, depending on the design of the new feeders, additional headroom may be required under the ash hoppers.

The ESP to FF conversion is expected to result in a maximum pressure drop of 8" H_20. The B&W report states that the pressure at the ESP inlet is currently -18", and -20" to -21" at the ID fans. Based on this information, the FF conversion will result in a total pressure of -26" at the ID fans. The B&W report also states that the ID fans are currently operating at maximum capacity.

Therefore, two new 7,500 HP ID fans have been included in the cost estimate. The ID fans have been sized to provide adequate margin to account for future SCR installation.

In considering the ESP to FF conversion, the preferred approach to supporting the new arrangement (including ductwork modifications), is to utilize the existing steel framing and foundations if structural modifications are limited in scope and able to be performed while the unit is on-line to minimize total outage time. The new baghouse modifications should not add much total load to the existing support structures, but it is possible that loads will be redistributed between the various existing structural elements since the baghouse internals are configured differently. Thus, there are potential pitfalls in attempting to utilize the existing steel for the primary support of the baghouse modifications. This approach may require upgrading the existing structure to meet the most recent building code requirements that may be more demanding than the building code enforced during original construction. If upgrades result in extensive reinforcement of the existing structure(s), these modifications could require significant relocation of piping and electrical services that impact cost and outage time adversely. Another possible issue would be the potential for the upgrades to necessitate existing foundation modifications resulting from increased loads or changes in load direction. However, based on the retrofit experience at Huntington Unit 2, no major structural modifications are anticipated.

Existing foundations will need to be evaluated for adequacy to support new loads due to the addition of baghouses, pumps and ductwork. Where new foundations are needed, they typically are similar to those used in the existing power block and back-end structures, which are generally reinforced concrete footings supported on piles or directly supported on rock or hardpan. New or reinforced foundations may necessitate the relocation of underground utilities such as sewers, manholes, catch basins, electrical duct banks, and piping. The scope of potential relocation of items such as these is very difficult to quantify at this stage. Exploratory digs prior to finalizing layouts may be necessary to identify potential background obstructions and avoid surprises and delays during construction.

Capital cost estimates associated with this option are based on the following:

- Four (4) low pressure/high volume pulse jet fabric filter, walk-in plenum type design, isolatable compartments in the existing ESP casing
- Ash handling system upgrades
- Replace the ductwork between the baghouse outlet and the chimney
- 2-7,500 HP ID fans
- Replace the current 2” insulation in the ESP casing and hoppers with 6” insulation
- Electrical modifications

This option includes replacement of the current 2 inches of insulation on the ESP casing and hoppers with 6 inches of insulation. This would reduce the risk of corrosion inside the ESP casing.

The outage requirement for this option depends upon whether the existing ESP casing is reused or replaced. If the existing ESP casing is reused, an eight week outage is expected. However, if the existing ESP casing above the hopper beam is replace, a ten week outage is expected. The outage estimates are based on the demolition of the ESP and associated ductwork, construction of the baghouse, upgrading the ash handling system and tie-in. Outage time is not required for the installation of most of the baghouse outlet ductwork and ID fans.

3.4 Option 4 – Install New Stand-Alone Baghouse

This option involves abandoning the ESP and constructing a new stand-alone baghouse. This option provides 95% SO_2 removal and an emission rate of 0.08 lb/mmBtu. The PM emissions would be less than 0.015 lb/mmBtu. The FGD and baghouse system would provide the 95% removal without increasing the current lime requirement. The baghouse option also allows for lower cost compliance with future mercury reduction rules. The amount of powdered activated carbon (PAC) injection with a baghouse would be less than 40% of the amount if the ESP was used.

The preliminary design of the new stand-alone baghouse consists of one independent fabric filter casing containing fourteen compartments. Each compartment will contain two bag bundles. Additional information on the new stand-alone baghouse can be found in Appendix G. A general arrangement drawing showing the location of the new baghouse and associated ductwork is provided in Appendix H.

The stand-alone baghouse and associated ductwork is expected to result in a maximum pressure drop of 12" H_20. The B&W report states that the pressure at the ESP inlet is currently -18", and -20" to -21" at the ID fans. Based on this information, the new baghouse and ductwork will result in a total pressure of -30" at the ID fans. The B&W report also states that the ID fans are currently operating at maximum capacity. Therefore, two new 7,500 HP ID fans have been included in the cost estimate. The ID fans have been sized to provide adequate margin to account for future SCR installation.

Capital cost estimates associated with this option are based on the following:

- One (1) independent fabric filter casing containing fourteen (14) compartments
- Ash handling system upgrades
- Ductwork between the SDA outlet and FF inlet
- 2-7,500 ID fans
- Ductwork between the new baghouse outlet and the chimney
- Electrical modifications

The outage time required for the installation and tie-in of a stand-alone baghouse is expected to be less than eight weeks. The most time-intensive activity will be the demolition of the existing SDA outlet ductwork and the construction of new ductwork between the SDAs and the baghouse. Outage time is not required for the construction of the new baghouse, ID fans, and most of the outlet ductwork leading to the existing chimney.

4. CAPITAL COST ESTIMATES

Capital cost estimates were prepared for each of the options reviewed in this study. S&L used a variety of sources to develop the required capital costs, including recent ESP and FF supplier proposals and estimates, in-house cost estimating data, plant input, and available industry databases. Equipment, material, and labor costs were estimated for each option. Potential costs associated with any necessary ESP casing modifications (e.g. reinforcement) have not been included. Also, escalation, outage costs, Owner's engineering and AFUDC are not included.

Tables 4-1 through 4-3 provide summaries of direct, indirect, and total capital cost estimates for each SO_2 reduction option. Each option includes 20% contingency. The detailed cost estimates are provided in Appendix I.

Table 4-1. Estimated Direct Capital Costs (Includes Material & Labor) ($1,000)

Cost Category	**Option 1:** Rebuild ESP with Carbon Steel Internals	**Option 2:** Rebuild ESP with Stainless Steel Internals	**Option 3A:** ESP to FF Conversion – Reuse Casing	**Option 3B:** ESP to FF Conversion – New Casing	**Option 4:** Install New Stand-Alone Baghouse
Electrostatic Precipitator	48,572	62,151	NA	NA	NA
Baghouse	NA	NA	20,849	24,219	26,901
Ductwork	NA	NA	11,520	11,520	17,993
Electrical	1,398	1,398	10,204	10,204	9,063
Ash Handling	NA	NA	2,100	2,100	2,355
Fans	NA	NA	3,533	3,533	3,533
Demolition & Other Misc.	1,235	1,235	8,918	8,821	1,715
Contractor's Cost	18,016	19,374	22,636	23,339	19,260
Total Direct Costs	**69,221**	**84,158**	**79,760**	**83,736**	**80,820**

Table 4-2. Estimated Indirect Capital Costs (Includes Material & Labor) ($1,000)

Cost Category	**Option 1:** Rebuild ESP with Carbon Steel Internals	**Option 2:** Rebuild ESP with Stainless Steel Internals	**Option 3A:** ESP to FF Conversion – Reuse Casing	**Option 3B:** ESP to FF Conversion – New Casing	**Option 4:** Install New Stand-Alone Baghouse
Engineering & Procurement	2,769	3,366	6,381	6,699	5,809
Construction Management	1,038	1,262	3,190	3,349	2,905
Startup Costs	692	842	798	837	726
Total Indirect Costs	**4,499**	**5,470**	**10,369**	**10,885**	**9,440**

Table 4-3. Estimated Total Capital Costs ($1,000)

Cost Category	**Option 1:** Rebuild ESP with Carbon Steel Internals	**Option 2:** Rebuild ESP with Stainless Steel Internals	**Option 3A:** ESP to FF Conversion – Reuse Casing	**Option 3B:** ESP to FF Conversion – New Casing	**Option 4:** Install New Stand-Alone Baghouse
Direct Capital Costs	69,221	84,158	79,760	83,736	80,820
Indirect Capital Costs	4,499	5,470	10,369	10,885	9,440
Contingency	14,744	17,926	18,026	18,924	18,052
Total Capital Costs	**88,464**	**107,554**	**108,155**	**113,545**	**108,312**

5. FIXED AND VARIABLE O&M COST ESTIMATES

The fixed O&M costs include the operating labor, maintenance material, maintenance labor, and administration labor. For the proposed options, no additional operating labor, maintenance labor, or administrative labor will be required.

The variable O&M costs include the incremental cost of reagent, power consumption, and filter bag replacement. The incremental cost was calculated based on an 85% capacity factor. Table 5-1 provides the unit costs that were used to calculate variable O&M costs. The incremental variable O&M costs over the current level are provided in Table 5-2.

Table 5-1. Unit Costs for Calculating Variable O&M Costs

Lime	$115 / ton
Power: Energy Charge	$44 / MWh
Power: Capacity Charge	$60 / kW

Table 5-2. Incremental Variable O&M Costs ($1,000/yr)

Cost Category	**Option 1:** Rebuild ESP with Carbon Steel Internals	**Option 2:** Rebuild ESP with Stainless Steel Internals	**Option 3A:** ESP to FF Conversion – Reuse Casing	**Option 3B:** ESP to FF Conversion – New Casing	**Option 4:** Install New Stand-Alone Baghouse
Reagent Cost	1,349	1,219	No Change	No Change	No Change
Power: Energy Charge	No Change	No Change	721	721	1,081
Power: Capacity Charge	No Change	No Change	112	112	168
Filter Bag Replacement Cost (1)	NA	NA	705	705	646
Total Incremental Variable O&M Cost	**1,349**	**1,219**	**1,538**	**1,538**	**1,895**

(1) Does not include labor costs

6. NET PRESENT VALUE ANALYSIS

Based on the capital and O&M cost data provided in Section 4 and 5, a net present value analysis was performed for various options considered. This evaluation does not include lost generation/replacement power costs for extended outage time. Table 6-1 lists the parameters used to perform the net present value analysis:

Table 6-1. Net Present Value Analysis Parameters

Parameter	Value
Discount rate	7.5%
O&M cost escalation	3.0%
Evaluation period	20 years
Present value year	2008
Commercial operation year	2010

The capital costs for each option and the incremental fixed and variable O&M costs were used to determine the increase in net present value compared to the existing plant operation. The incremental net present value analysis is shown in Table 6-2.

Table 6-2. Incremental NPV Costs

Cost Category	**Option 1:** Rebuild ESP with CS Internals	**Option 2:** Rebuild ESP with SS Internals	**Option 3A:** ESP to FF Conversion – Reuse Casing	**Option 3B:** ESP to FF Conversion – New Casing	**Option 4:** Install New Stand-Alone Baghouse
Capital Costs, $1,000	88,464	107,554	108,155	113,545	108,312
O&M Costs (Incremental), $1,000/yr	1,349	1,219	1,538	1,538	1,895
NPV (Incremental), $1,000	104,075	121,657	125,952	131,341	130,238
% Cost Increase From Base	-17.4%	-3.4%	Base	4.3%	3.4%

7. CONCLUSIONS AND RECOMMENDATIONS FOR REDUCING SO_2 EMISSIONS

S&L has conducted an evaluation of SO_2 reduction options that will enable PacifiCorp to comply with BART emission limits. PacifiCorp expects WDEQ to impose an SO_2 emission limit of 0.15 lb/mmBtu and a PM emission limit of 0.04 lb/mmBtu.

The results of the evaluation indicate that rebuilding the existing ESP using carbon steel internals (Option 1) will not be able to achieve the required SO_2 emission rate of 0.15 lb/mmBtu. The B&W study indicates that rebuilding the existing ESP using stainless steel internals (Option 2) can achieve an SO_2 emission reduction of 95%. S&L considers an emission reduction of 95% with an SDA and ESP combination to be optimistic. This option poses a risk when it comes to demonstrating compliance with forthcoming SO_2 emission limits.

The two options involving the installation of a baghouse, the ESP to FF conversion (Option 3) and the stand-alone baghouse (Option 4), in conjunction with the SDAs will achieve an SO_2 emission rate of 0.08 lb/mmBtu. The PM emission rate for each of these options will be less than 0.015 lb/mmBtu. These emission rates are less than the expected BART emission limits. Therefore, S&L recommends installing a baghouse for compliance with the WDEQ SO_2 emission limit.

The estimated NPV costs for the ESP to FF conversion options range from $126 million to $131 million while the estimated cost for the stand-alone baghouse is $130 million. Since the cost difference among the three options is minimal, the following table has been provided to identify features for each option.

Table 7-1. Baghouse Option Features

Control Option	
ESP to FF Conversion – Reuse Casing	- Slightly lower cost option - Bag-life extended by ~1 yr due to low air to cloth ratio and a settling chamber in the first row of the casing - Outage requirement = 8 weeks - Casing reinforcement required if SCR is installed in the future
ESP to FF Conversion – New Casing	- Bag-life extended by ~1 yr due to low air to cloth ratio and a settling chamber in the first row of the casing - Outage requirement = 10 weeks
Install New Stand-Alone Baghouse	- Outage requirement = 8 weeks

The low cost option is the ESP to FF conversion reusing the existing casing. This option, however, requires an 8 week outage. By reusing the casing, there is some risk that the casing will need some unexpected repairs that could extend the outage length. In addition, if an SCR is installed in the future, the casing will need to be reinforced to accommodate the additional pressure requirement. Compared with the stand-alone baghouse, the bag-life would be extended by approximately one year because of the reduced air to cloth ratio and a settling chamber in the first row of the casing.

The ESP to FF conversion option that includes replacing the casing walls has a slightly high cost than the option that reuses the casing. In addition, this option requires a 10 week outage instead of an 8 week outage. Compared with the stand-alone baghouse, the bag-life would be extended by approximately one year because of the reduced air to cloth ratio and a settling chamber in the first row of the casing. This option removes the issues related to unexpected repairs to the casing walls and also the casing will be designed for the additional pressure requirement of a future SCR installation should it become necessary.

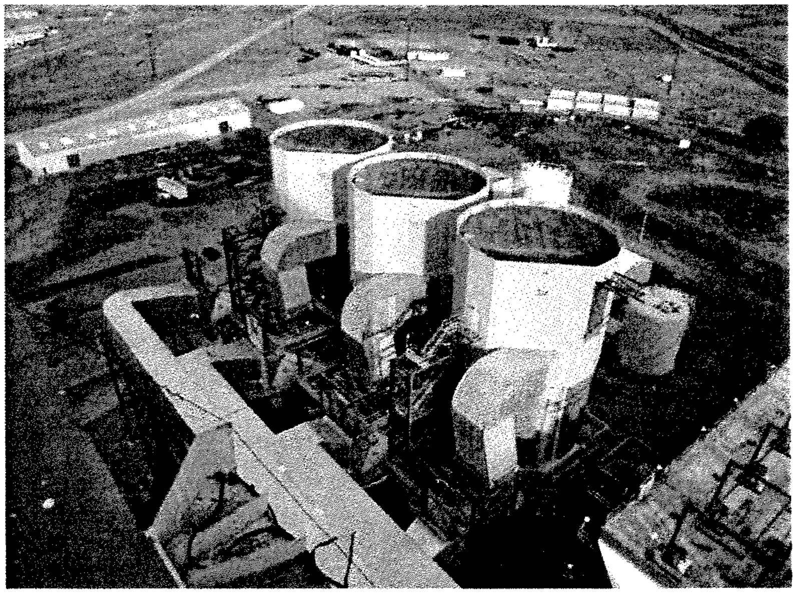
The cost of the stand-alone baghouse option is approximately 3% greater than the ESP to FF conversion option that reuses the casing, and slightly less than the option that replaces the casing walls. The SDA outlet duct will need to be demolished and a new one installed during the outage, but this can be done within an 8 week outage. This option poses the least risk with regard to outage length because most components can be installed while the unit is operating.

Appendix A

B&W Report: "Engineering Study Results for Improved SO_2 Removal"

Pacificorp Wyodak Station

Engineering Study Results
For
Improved SO_2 Removal



SUBMITTED : 6/5/07 Final including Pacificorp Comments.

BY : Bryan J. Jankura (The Babcock and Wilcox Company)
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CONTRACT NO. : Pacificorp Work Release 3000035856/B&W Contract 430-0049

TABLE OF CONTENTS

PAGE

LIST OF FIGURES I

LIST OF TABLES II

LIST OF APPENDICES II

SUMMARY 1

BACKGROUND 2
- Wyodak Plant and SDA/ESP System Description 2

SCOPE OF STUDY 6

RESULTS AND DISCUSSION 7
- Original SDA/ESP System Design 7
- Data Collection 10
- DFGD System Questionnaire 11
- Flue Work Infrared Inspection 12
- Atomizer Flush Sequence 16
- SDA Internal Temperature Profiling 18
- SO_2 Efficiency Predictions 19
- Flue Work from SDA to ESP Internal Inspection 23
- Options to Increase SO_2 Efficiency 25

CONCLUSIONS AND RECOMMENDATIONS 29

WARRANTY DISCLAIMER 30

LIST OF FIGURES

PAGE

1 Wyodak First Quarter 2006 EPA Reportable SO_2 Emissions 3

2 Wyodak SDA/ESP System Flue Gas Path Plan View 4

3 Wyodak SDA Chamber Side View 4

4 Wyodak Electrostatic Precipitator Side View 5

5 SDA Hopper Isolation Valve 9

6 SDA Hopper Ash Chute 9

LIST OF FIGURES (Continued)

Page

7 SDA Chamber IR View 13
8 SDA Outlet IR View 13
9 West ESP Inlet IR View 14
10 ESP Side IR View 14
11 ESP Outlet IR View 15
12 ID Fan Inlet IR View 15
13 Effect of Atomizer Flush on SDA Chamber Internal Temperatures 17
14 Recommended Location of Flush Water Flow Restriction Orifice 18
15 "B" SDA Internal Temperature Profile 19
16 Niro Performance Program Calibration to Wyodak 21
17 SDA/ESP System SO_2 Removal, 0.67% S, 300F 22
18 SDA/ESP System SO_2 Removal, 1.1% S, 300F 22
19 SDA/ESP System SO_2 Removal, 1.1% S, 330F 23
20 Flue Gas Reheat 25% Mix Point 24
21 SDA Outlet Flue Work 24
22 Emergency Flue Gas Bypass Mix Point 25

LIST OF TABLES

PAGE

1 SDA Outlet Temperature Required to Achieve 85% SO_2 Efficiency 20
2 Wyodak "All Options" to Achieve 85% SO_2 Efficiency 26

LIST OF APPENDICES

A B&W Wyodak DFGD Questionnaire

SUMMARY

In February, 2006, the Babcock and Wilcox Company (B&W) was contracted by Pacificorp to perform an Engineering Study for the Wyodak Spray Dry Absorber (SDA) system. The goal of this Study is to identify several options to increase SO_2 efficiency from the current level of 70% removal to 85% removal and make recommendations for the most practical solutions. Pacificorp has determined that this level of improved SO_2 efficiency is required to meet the Environmental Protection Agency (EPA) Regional Haze Rule, which requires implementation of Best Available Retrofit Technology, or BART.

B&W has teamed with Niro A/S to complete this Study as Niro was the original designer of the Wyodak SDA/ESP System. This is a long-standing partnership as B&W has held for many years an exclusive license agreement with Niro to apply the Niro SDA technology in the North American Market on coal-fired and waste-fired steam boilers. For simplicity, "B&W" indicates the team of B&W and Niro A/S.

The results of this Study indicate that the best options for improved SO_2 efficiency are to either:

- Retrofit the Electrostatic Precipitator (ESP) to a Pulse-jet Fabric Filter (PJFF), or η_{SO_2} = 95% @ 1.3
- Upgrade the ESP with stainless steel internals, eliminate flue gas bypass, and reduce the SDA outlet temperature from 180F to approximately 164F - 173F, or η_{SO_2} = 95 @ 1.8
- Eliminate flue gas bypass, complete system operating changes to minimize over-spraying, and reduce the SDA outlet temperature to approximately 164F - 173F. η_{SO_2} → 95 @ 1.8 Risk

B&W recommends that if Pacificorp selects the last option, then a long-term corrosion evaluation with coupons at the ESP outlet should be included. This option could be accomplished in relatively little time, with no outage, and with relatively minor expense.

While budgetary pricing for selected options is included in the scope of this Study, these costs are not included in this document. Instead, a separate report will be issued to Pacificorp.

BACKGROUND

Pacificorp Corporate Engineering is charged with determining the best approach to reduce SO_2 emissions from the Wyodak plant, which are known to contribute to regional haze. The emission reductions are a requirement of the 1999 EPA Regional Haze Rule. This Rule requires emission controls known as BART, for industrial facilities emitting air pollutants that reduce visibility in designated national parks and wilderness areas. The State of Wyoming must develop their implementation plans by December 2007.

After consideration of the Wyodak plant's contribution to regional haze, Pacificorp has determined that SO_2 emissions must be reduced by 50%. The goal of this Study is to identify several options that achieve these emission reductions by increasing SO_2 efficiency from the current level of 70% removal to 85% removal and to make recommendations for the most practical solutions.

Wyodak Plant and SDA/ESP System Description

Net

285

The Wyodak Plant is located in Campbell County, Wyoming, four miles east of Gillette. The boiler nameplate rating is 362 Megawatts ~~gross~~ (MWg), with full load generation typically at ~~386~~ MWg. The fuel is Sub-bituminous coal, 7900 Btu/lb, 8% ash, 0.68% sulfur (1.7 lb SO_2/MBtu). The single-unit boiler began commercial operation in 1978. The unit has a pulverized-coal, opposed-wall-fired boiler. The unit has an air cooled condenser and no waste water is discharged from the plant. Coal is received by conveyor from a dedicated coal mine. The power plant is located in an air attainment area.

The original boiler plant was supplied by B&W with only an ESP for particulate emission control. The SDA/ESP System was installed by the Joy Company using SDA technology licensed from Niro A/S (Denmark). This FGD retrofit was required as a concession to the state of Wyoming to allow construction of Unit 4 at the Jim Bridger Station in Western Wyoming. The SDA/ESP System started operation in December, 1986 with a stack emissions requirement of 0.5 lb SO_2/MBtu. The SDA/ESP System uses on-site slaked lime reagent and recycles a portion of the ESP product ash back to the SDA in slurry form to minimize lime usage. Figure 1 shows the ability of the SDA/ESP System to maintain compliance with the three-hour averaging period SO_2 emission permit. A Permit exceedence predominantly occurs during boiler startup.

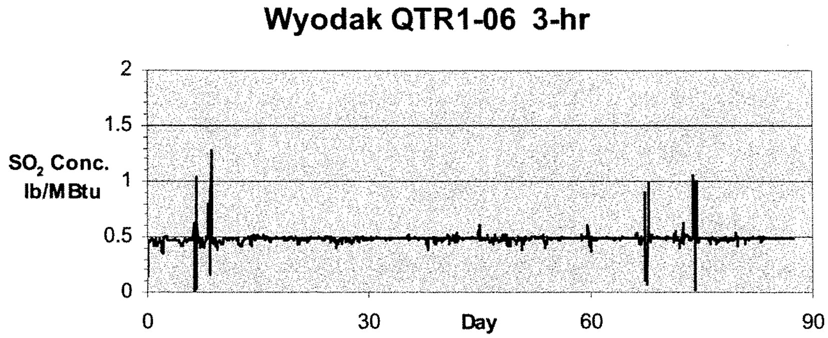

Figure 1 - Wyodak First Quarter 2006 EPA Reportable SO_2 Emissions.

The flue gas from the boiler's two air heaters is combined to a single flue and diverted to three, parallel-path SDA chambers. The chambers had to be located to the side of the ESP system due to lack of space between the boiler and ESP. Figure 2 provides a plan view of the flue work from the air heaters to the stack. The treated flue gas from each SDA is recombined into a common flue. A portion of the air heater outlet flue gas is typically diverted to bypass around the SDA chambers and recombined with the treated flue gas before entering the ESP's. Sufficient flue gas is currently diverted around the SDAs to provide about 20F of reheat before entering the ESP. There are two separate flue gas crossover flues for reheat – one for 4% of the total air heater outlet flue gas flow and another for 26% of the flow. A third emergency bypass flue rated at 35% capacity is rarely used.

The reheated flue gas is split into four separate flue gas paths each containing an ESP. Two Induced Draft (ID) fans transfer the flue gas from the ESP's to the single stack. Needless to say, this SDA/ESP System has a tremendous amount of flue work surface area with accompanying heat loss.

Flue gas enters each SDA chamber through a top-mounted Roof Gas Disperser (RGD) and a side-entering Central Gas Disperser (CGD) – See Figure 3. The flue gas flow split between the top RGD and the side entering CGD is approximately 60/40. A single, rectangular flue penetration is used to discharge flue gas from each SDA chamber. The SDA chamber dimensions are 49 ft diameter and 43 ft high from the roof to the top of the hopper.

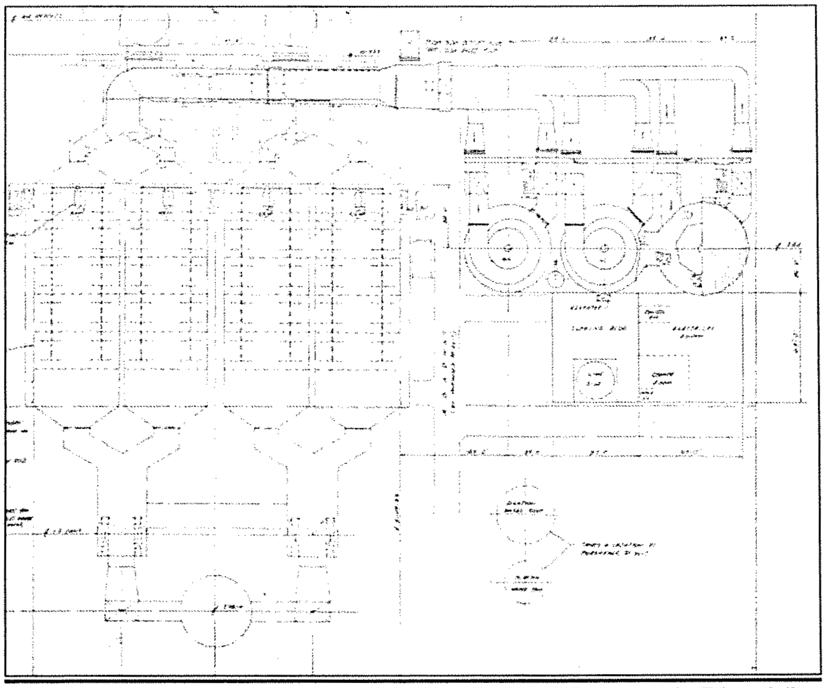

Figure 2 - Wyodak SDA/ESP System Flue Gas Path Plan View.

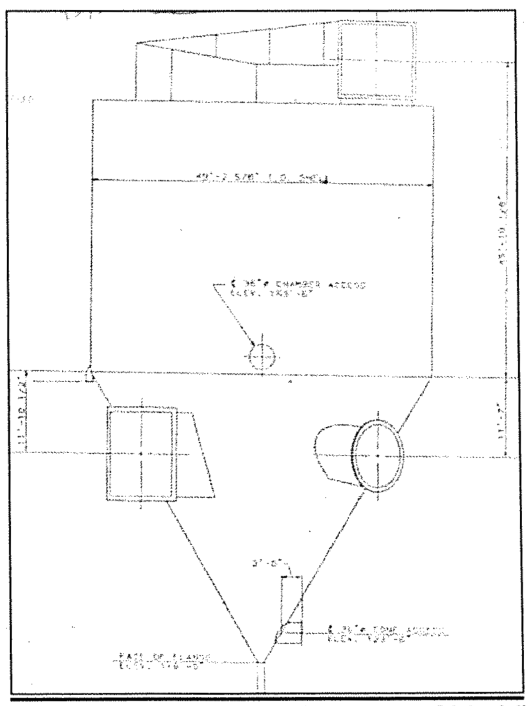

Figure 3 - Wyodak SDA Chamber Side View.

The ESP system has four separate flue gas paths. Each path has a manual louver isolation damper at the outlet. There are six fields, but only the first five fields have discharge wires and collector plates. All ESP internals are carbon steel. A side view of the ESP is shown in Figure 4.

The original, total ESP Specific Collection Area (SCA) is approximately 772 ft^2 / kacfm. The design condition for sizing was with three of the four chambers in service, which had a lower SCA of 579. With operation of all four ESP paths, and the SDA at lower flue gas temperature, the ESP typically operates at about 920 SCA! There is approximately 1,383,200 ft^2 of collector plate surface area. All five fields in each ESP path must be used to maintain acceptable stack opacity.

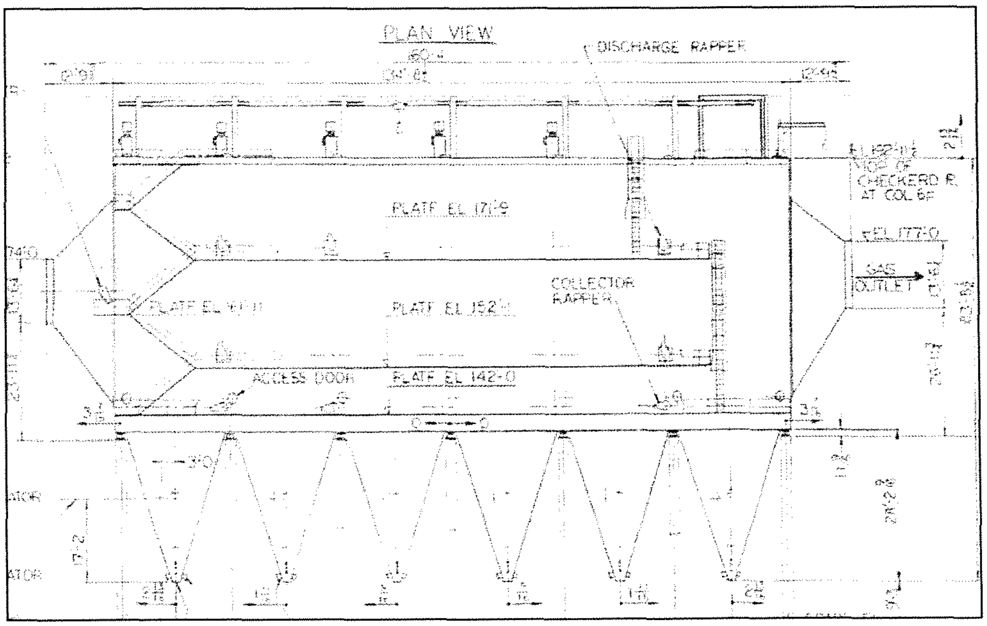

Figure 4 - Wyodak Electrostatic Precipitator Side View.

SCOPE OF STUDY

As detailed in the contract documents, B&W has performed an Engineering Study to determine the best means to increase the Wyodak plant's SO_2 efficiency from the current level of 70% to 85%. This Study included:

- Original design review
- Data collection
- Plant operational review
- Operational and/or upgrade recommendations
- Budget pricing to implement recommendations

The approach used in this Study was to conduct a fact finding survey of the SDA/ESP System to understand as much as possible how the system was originally designed and how the system is currently being operated. The next step was to conduct a site visit to collect detailed process operating data that would allow Niro to calibrate their heat and material balance, and performance prediction program, commonly referred to as "ABSORB" to the Wyodak SDA/ESP System. With this calibrated model, it is possible to evaluate more aggressive operating conditions at higher SO_2 efficiency and understand whether various equipment in the existing system would require upgrades. Physical sampling of selected process streams at the Plant, if necessary, was included.

During the site visit, various equipment inspections were completed to better understand the effects of plant operations. Finally, alternatives to improve performance were identified based on the combined experience of B&W and Niro from previous efforts to troubleshoot and improve operation of other SDA/ESP Systems. These alternatives include various combinations of mechanical and operational changes.

RESULTS AND DISCUSSION

The following sections discuss the results of the completed activities to collect information on the SDA/ESP System and develop a list of options to increase SO_2 efficiency. The major activities included:

- Review Original SDA/ESP System process drawings and design basis.
- Obtain DCS operating data.
- Completion of the B&W DFGD System Questionnaire.
- Conduct site visit to collect SDA/ESP System operating data, obtain infrared thermal images of the flue work, conduct internal flue work inspections, and discuss operations with site personnel.

The site visit was conducted by B&W and Niro during the week of September 18, 2006, No physical sampling for off-site analysis was required for this Study. Several lime and recycle slurry samples were obtained by B&W and analyzed for weight percent solids content using the Plant's automated drying scale.

It is important for the reader to understand that the SDA/ESP System is in its 21st year of operation. Overall, the equipment and operating philosophy has changed very little.

Original SDA/ESP System Design

The design basis for the original SDA/ESP System was to treat 100% of the flue gas using three SDA chambers. While it is possible to treat 100% of the boiler flue gas with only two SDA chambers, this mode of operation significantly overloads the SDAs and may cause chamber deposits. Through discussions with the Plant personnel, it was determined that the SDA/ESP System generally runs with all three SDA chambers in service when at full load. Operation with only two SDAs is possible with acceptable stack emissions. Typically, this operating mode occurs at most once a month for a few hours.

Since startup, there have been occasions, when the flue work before the ID fan has significant air infiltration, at typical SDA operating conditions, where the ID fans could no longer maintain 100% load operation. This usually occurs at the end of the Plant's six-year major outage cycle. During the recent major outage completed in 2006, the volumetric gas flow to the ID fans was reduced by 20% - 30% after air heater and flue panel repairs were completed.

The design SDA inlet temperature used to design the slurry supply system was 360F. The SDA outlet temperature was for 147F and flue gas bypass was used to reheat by 9F for an ESP inlet temperature of 156F. Over the years, operation of the control temperatures were raised for a normal SDA outlet temperature of 160F and use of flue gas bypass to reheat by 20F for an ESP inlet temperature of 180F due to ESP solids buildup and corrosion. It should be noted that no additional ESP casing insulation was added during the SDA retrofit, to the original 2 inch thickness. For new DFGD systems, B&W installs 4" of insulation from the air heater to the ID fan. This insulation not only greatly reduces cold spots, but, reduces overall heat loss to maximize the amount of water that can be added through the atomizer. By maximizing the amount of water added to the atomizer, the amount of alkaline solids in the feed slurry is also increased. Any air leakage is a significant potential contributor to corrosion.

The SDA/ESP System lime and recycle slurry preparation systems operate for the most part, as originally designed. Some notable changes to the SDA/ESP System are:

- Removal of all slurry strainers and screens except for the feed slurry return.
- Removal of the feed slurry flush water pressure regulator.
- ESP doors were changed to a double-door arrangement.
- Addition of dust venting from the lime belt feeder and recycle slurry tank to the B-SDA hopper.
- Modification of the SDA hopper discharge to a larger opening and to include a gear-operated knife gate valve.

The SDA hopper modifications were quite extensive as access platforms and a hopper ash product chutes were added. Figures 5 and 6 show a general area of the B-SDA hopper bottom and isolation valve.

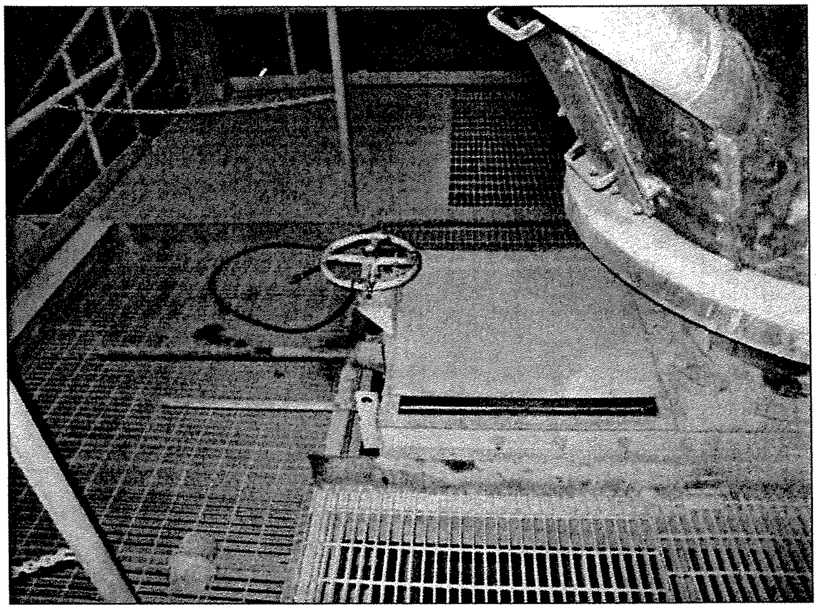

Figure 5 - SDA Hopper Isolation Valve.

Figure 6 - SDA Hopper Ash Chute.

The SDA hopper outlet opening was increased from 2 ft to 3 ft diameter. The isolation blade has a 1ft diameter air bleed hole. The isolation blade's gear drive is actuated using a portable drill drive. On occasion, the hopper gate is inadvertently left open during startup. The additional air infiltration is so great that insufficient feed slurry can be added to meet the required SO_2 emissions. There are no limit switches on this valve.

Data Collection

Performance data for the SDA/ESP System was obtained from the Plant's Distributed Control System (DCS) and from various Pacificorp test reports. The data were evaluated to determine the operating conditions for the Niro SO_2 performance model. The following Operating data were provided by Pacificorp:

- Apr05 Low Load PiData
- Apr05 Mid-load PiData
- Apr05 Full Load PiData
- Apr05 RATA Data
- 9/17/06 1700 – 9/20/06 0600 PiData
- Feed Solids 080106-111706

During the boiler's major overhaul in May, 2006, significant repairs were made to the secondary air heater, ESP casing, and flue work in the SDA/ESP System. The DCS data from before and after the outage indicate that the volumetric flue gas flow through the SDA/ESP System has been reduced by 20-30%. At the reduced flow rate, the SDA/ESP System appears to be able to treat 100% of the boiler flue gas for 70% SO_2 efficiency using only two SDA chambers. As discussed later in this report, obtaining 85% efficiency may require reducing the SDA outlet temperature. Here, operation with only two SDAs may not sufficiently evaporate the feed slurry and cause deposits inside the SDA.

The plant data also shows that the SDA/ESP System operates at times with flue gas bypass for 20F reheat, and at other times with no flue gas bypass. Based on B&W's surveying of the Plant Operators, there is no written procedure or guidance regarding when to use flue gas bypass. But, flue gas bypass is utilized the majority of the time.

Since the flue gas that bypasses the SDA contains sulfur trioxide (SO_3), B&W strongly recommends that the use of flue gas bypass be minimized. B&W estimates that the flow rate of SO_3 to the ESP is 15,000 – 20,000 lb/year. Any condensed water present inside the ESP will absorb this acid gas to form sulfuric acid (H_2SO_4), and there will be a significant increase in metal corrosion.

ID Induced Draft Fan

DFGD System Questionnaire

B&W's principle route to collecting information on an SDA/ESP System is to submit a questionnaire and thoroughly clarify the information that is provided. The questionnaire was submitted to Pacificorp in April, 2006. After several reviews, a consensus document was finalized in December, 2006. The major findings from the questionnaire are:

1. There is no extra ID fan pressure capacity available to support a baghouse.

2. The best estimate for the required future stack SO_2 emissions is 0.27 lb/MBtu 3-hr block AVG (85% for 1.67 lb/MBtu coal or 0.67% S as rec'd)

3. The SO_2 block average requirement starts when the boiler load is above 180 MWgross.

APH Air preheater

4. The APH outlet temperature typically ranges from 300F -335F, which is much lower than the original design of 360F. Operations maintains this temperature above 300F in the winter months. In the summer months, the temperature naturally stays above 300F.

5. The two most used set points are either no flue gas bypass and 180F, or 165F – 175F and sufficient flue gas bypass to maintain 180F ESP inlet temperature.

6. The minimum allowable operating flue gas temperature to the ESP is 180F with typical operation at 180F – 185F. The 180 F limit is based upon operating experience at Wyodak with regards to corrosion of ESP internals. The problem appears to be mainly with wires and for casing in low flow areas. There has also been notable flue panel corrosion at the ID fan inlets and outlets. Going to lower temperatures (such as 160 F) is not considered prudent without installing, at least, stainless electrodes and probably stainless plates in the ESP.

7. The lime slaking system has two ball mills. Only one ball mill operates, on an intermittent basis, at approximately 70% capacity, or 4.9 Tons per Hour (TPH) to meet demand. Each mill has original design capacity of 7 TPH.

8. B&W confirmed during the September, 2006 site visit that flue gas wet bulb temperature is very stable, at 130F. An ESP outlet temperature of 160F corresponds to a 30F Approach to Saturation (AS).

9. B&W and Pacificorp inspected the flue gas bypass mixing internals on October 30, 2006. The internals are located at least 150ft before the closest ESP inlet and

appeared to be in good working order. Pacificorp evaluated potential modifications between 1992 -1994 to add B&W designed air foil flue gas mixers that were based on physical flow modeling. No modifications were ever implemented (even though the mixing foils were fabricated), possibly due to lack of confidence that the flue work would support such weight.

Based on the questionnaire information, B&W could not justify the need for any physical sampling and analyses for coal, lime slurry, water, etc. Since the Wyodak coal mine also supplies the Black Hills Wygen 1 Plant, coal analyses available from B&W testing at Wygen1 in February, March and May of 2006 were used.

Pacificorp independently contacted other operators of SDA/ESP systems such as Tennessee Eastman, Laramie River, etc. The feedback was that for various reasons, the ESPs are operated at or above 175F.

Flue Work Infrared Inspection

Infrared (IR) thermal imaging is a diagnostic tool that measures surface temperatures from a distance. The digital image assigns various colors that visually represent temperature within the instrument's field of view. For this Study, IR images were obtained at various locations in the SDA/ESP System to survey for either unexpected or significant surface temperature profiles.

The images shown in Figures 7 – 12 are representative of the 91 images obtained. Overall, the images do not show any significant problems that would normally warrant repair of either the insulation or lagging. However, considering the relatively large amount of flue work in this SDA/ESP System and the historical corrosion problems being experienced in the ESP, yearly inspections would alert the Plant to areas that have degraded or require repair. Any efforts to minimize heat loss will benefit the SDA/ESP System's performance by allowing for more feed slurry flow to the atomizer.

The reader is cautioned that when interpreting IR images, some temperature variations are "apparent" and result from changes is surface emissivity (dirt or metal type) or reflections. Other variations are actual, but caused by conditions such as convective heat losses due to wind, and solar radiation. For example, in Figure 8, the temperature of the roof of the horizontal-flow flue work from the SDAs appears to be extremely cold. This is most likely NOT an indication of low heat loss. Rather, this section of flue work is covered with a mixture of dirt, water and ice. The images for this Study were obtained well before or after day light and with no significant wind to minimize the effect of solar radiation and wind.

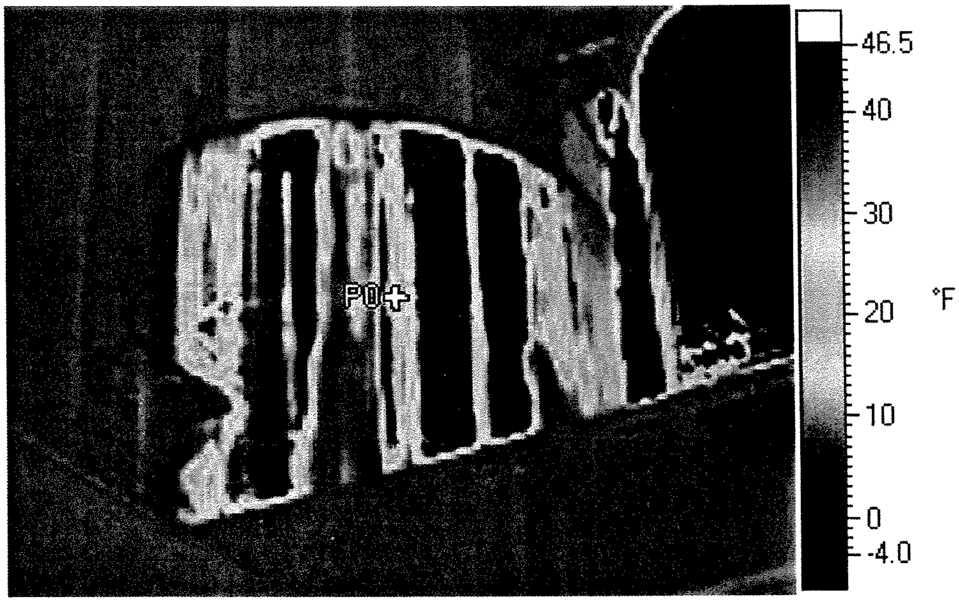

Figure 7 - SDA Chamber IR View.

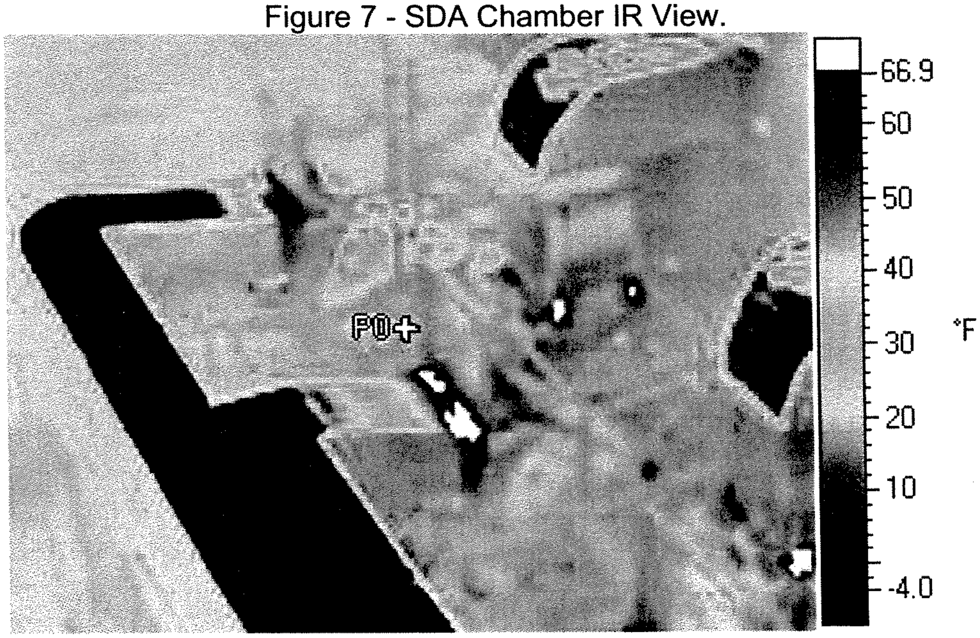

Figure 8 – SDA Outlet IR View.

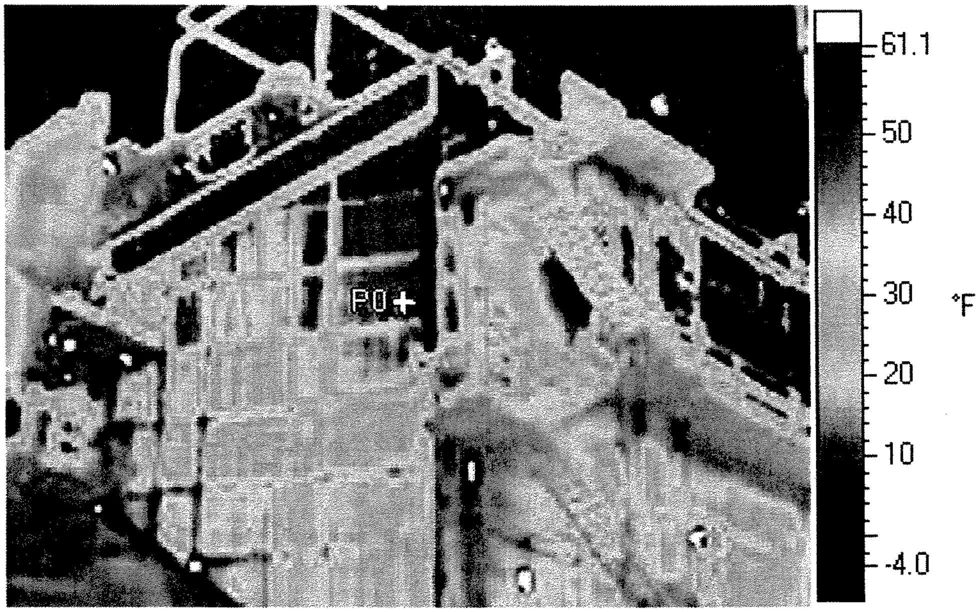

Figure 9 - West ESP Inlet IR View.

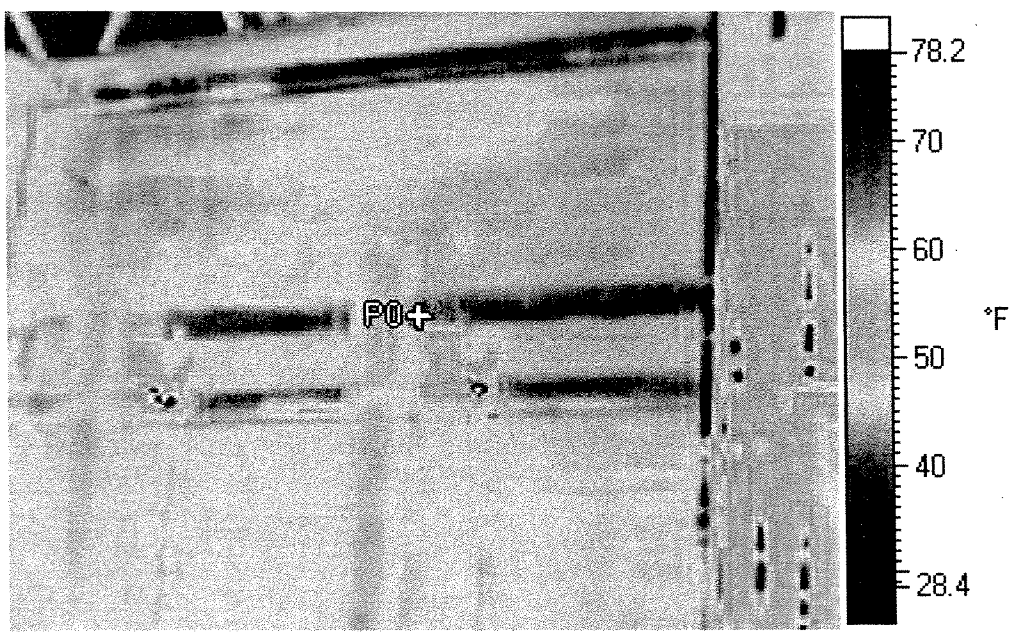

Figure 10 – ESP Side IR View.

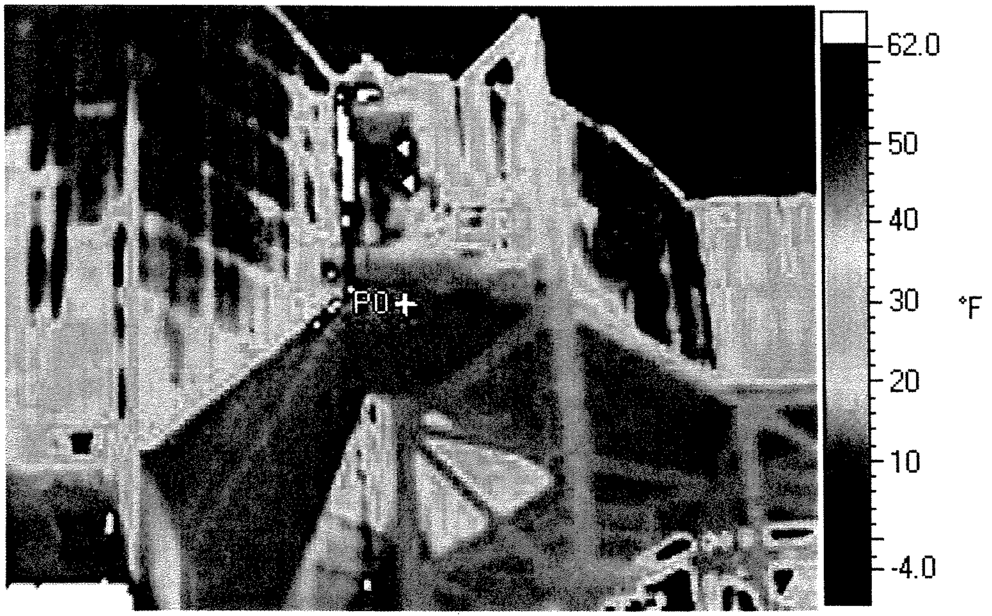

Figure 11 - ESP Outlet IR View

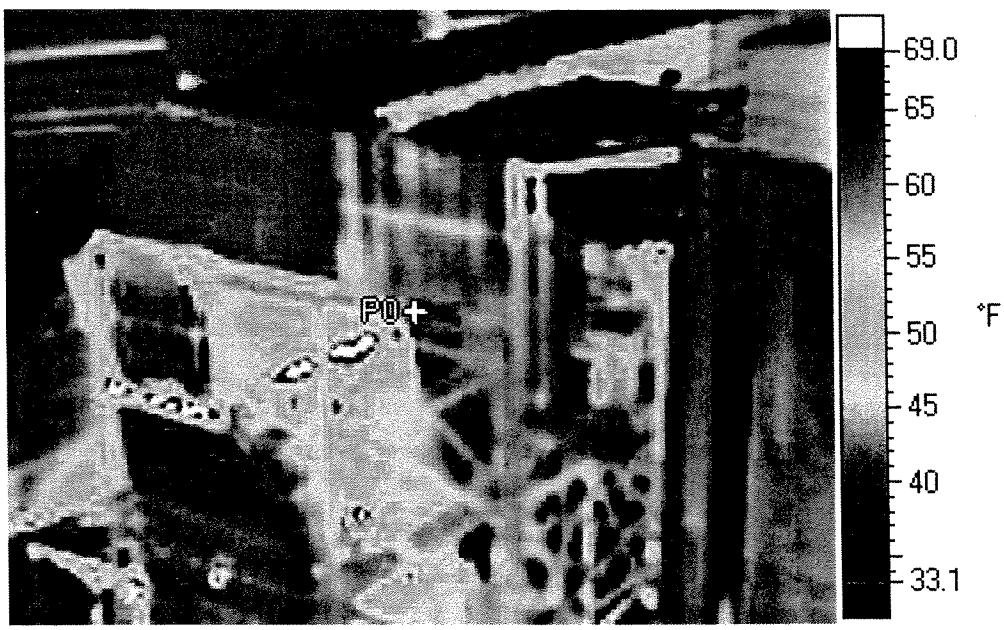

Figure 12 - ID Fan Inlet IR View.

Atomizer Flush Sequence

The original system design utilized a pressure regulator to limit the atomizer flush water pressure to less than 30 psig. The pressure regulator was removed many years ago so that now full service water pressure is used for flushing the feed slurry piping and atomizer. With much higher pressure, the water flow to the atomizer during a flush will be too great and the flue gas will become saturated inside the SDA chamber. Saturated flue gas significantly increases the rate of solids deposition and acid water condensation/metal corrosion. Significant corrosion is only expected in and after the first field of the ESP as the alkaline SDA product ash provides protection. While the solids deposition and acid water condensation will stop soon after the end of the flush sequence, corrosion in the downstream equipment will continue until the excess water can evaporate. Unfortunately, the water evaporation rate is quite slow as the flue gas inside the ESP is typically only 50F above the saturation temperature of 130F.

B&W conducted a test to investigate the effect of atomizer flushing on the temperature profile inside the SDA chamber. Specifically, we wanted to measure both the approach to saturation and the recovery time during a flush sequence. The test consisted of placing fast response thermocouples inside the SDA chamber from the roof to the start of the hopper. The thermocouple measurements were located at eight inches from the wall and at 16 equally spaced locations vertically down from the roof. Since the flexible TC assembly has only eight TC's, testing was conducted first in the upper portion and then in the lower portion of the SDA chamber.

Figure 13 shows the SDA internal thermal profiles before during and after the water flush. Before the flush, the TC's show a typical trend for the upper area with a 1-3 minute cycle and 10F range for any individual TC. At 7.5 minutes, the eight-second flush was initiated. All six upper-area TC's immediately measured a significant reduction with TC #5 indicating saturation. At about 20 seconds after the flush was completed, the upper TC's returned to normal readings.

At 10.5 minutes the flexible TC assembly was moved to the lower portion of the SDA chamber. At this location, TC#5 measures the lowest temperature of all 16 locations as it is inside the spray cloud where the slurry is still evaporating. Since TC#5 is greater than 145F, the evaporation is acceptable.

At 13.0 minutes, another, eight-second flush was initiated. All six lower-area TC's immediately measured a significant reduction with TC #11 and #12 indicating saturation. At about 20 seconds after the flush, the lower TC's returned to normal readings.

Through discussions with the Plant Operators, the atomizer flush is completed on all operating SDA chambers on a daily basis. Considering the frequency and magnitude of the temperature reductions inside the SDA chamber, it is plausible that this daily flush is contributing to metal corrosion in the ESP. A reasonable solution to reduce the flush water flow rate would be to install a 30 gpm flow restricting orifice in the flanged connection just below the flush water automated open/close valve – see Figure 14.

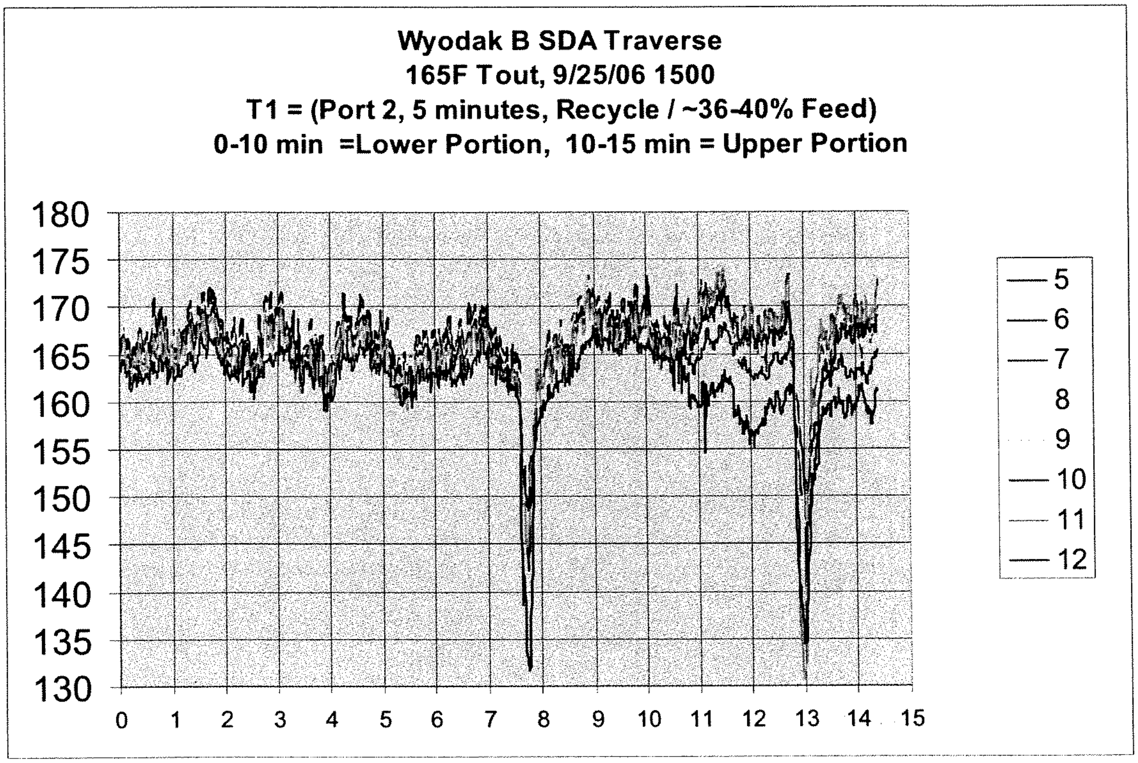

Figure 13 - Effect of Atomizer Flush on SDA Chamber Internal Temperatures.

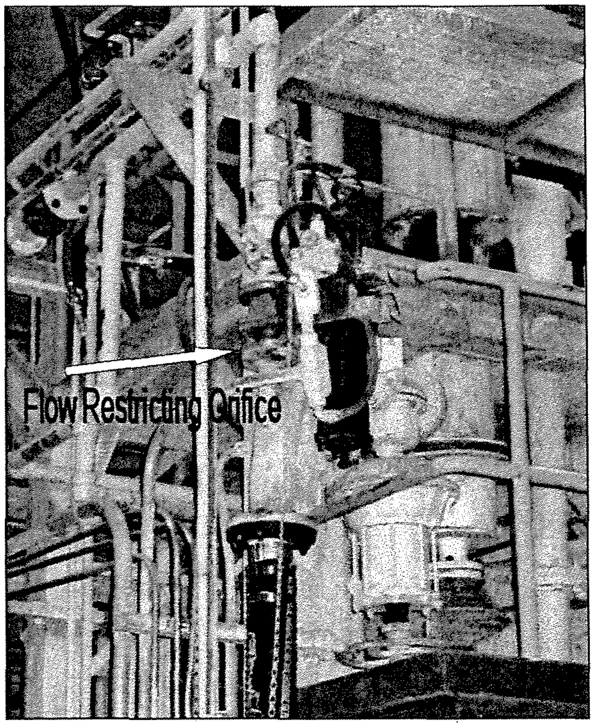

Figure 14 – Recommended Location of flush Water Flow Restriction Orifice.

SDA Internal Temperature Profiling

B&W obtained temperature measurements inside the "B" SDA chamber to determine whether there was acceptable evaporation of the atomized feed slurry. The measurements used the same multi-point TC flexible assembly used for the atomizer flush testing. The SDA internal temperatures shown in Figure 15 start at Port 1, which is immediately clockwise on the SDA roof from the RGD inlet flue. Ports 1-8 covers slightly over half (~54%) of the SDA outer wall circumference.

The benchmark for acceptable evaporation of the feed slurry is to have no temperature measurements below the elevation of the atomizer that are less than 10F – 15F above the flue gas saturation temperature. Therefore, for Wyodak, the acceptable minimum temperature is 140F – 145F. The lowest temperature of 150F was recorded on Port 4. This temperature profile is consistent with B&W and Niro expectations considering that the all three SDAs were in service for an estimated load factor of at 0.9, or 90% of the SDA chamber volumetric flow rate design capacity.

B&W cautions that if there were only two SDAs in service, the load factor would increase to 1.3 and it is very possible that the evaporation would be unacceptable. Under two chamber operation the Operators would have to raise the SDA outlet temperature possibly to as high as 175F.

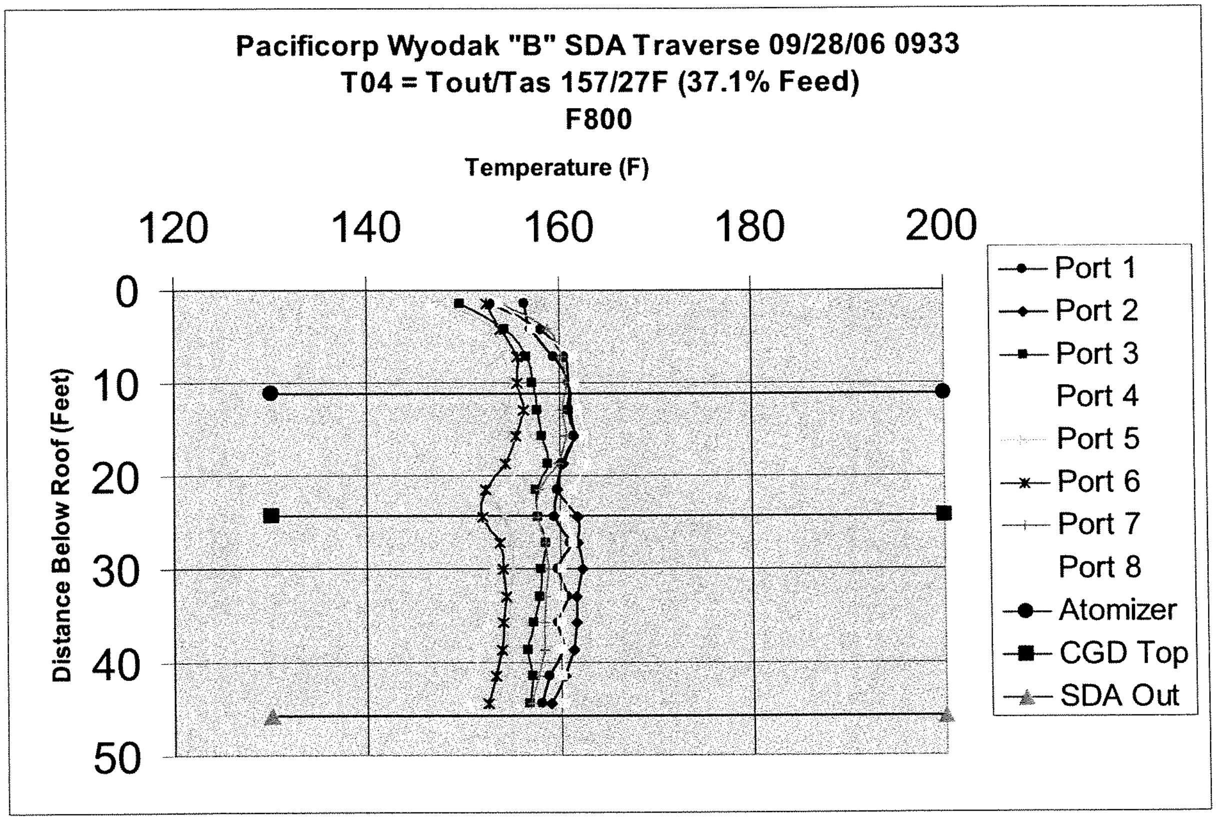

Figure 15 - "B" SDA Internal Temperature Profile.

SO_2 Efficiency Predictions

B&W and Niro utilized the operating data from the September, 2006 site visit and the DCS data provided by Pacificorp to calibrate Niro's proprietary ABSORB DFGD process computer model to the Wyodak SDA/ESP System with all three SDAs in service. The specific time period for the calibration was on September 19, 2006 from 3PM – 5PM. There are forty-three items that comprise those conditions that must be defined for the calibrated "Base Case".

The modeling results shown in Figure 16, represent the one-page, condensed results for the calibration. The calibration results are very close to the actual operating conditions. B&W and Niro, therefore, have good faith in our model as well as in the established Base Case. For reference, the Base Case operating point is shown in Figure 15. Note that the

SDA/ESP System was operated at 71.2% SO_2 efficiency, without flue gas bypass, and 180F SDA outlet temperature. Significant results of the base case model are:

- Lime Stoichiometry SO_2 Removed (molar) = 1.83
- Feed Slurry Solids (wt %) = 37.7
- Lime Requirement (TPH) = 3.7
- Atomizer Power (kW) = 395
- ESP Product Ash Moisture (%) = 1.0
- Total Water Consumption (GPM) = 296
- Size Load Factor (1.0 = 100% gas load) = 0.88

Stoichiometry on a removed basis is the ratio of moles of calcium in the fresh lime slurry to the moles of SO_2 removed in the SDA/ESP system.

The Base Case model was then used to generate several graphs to show the effect of coal sulfur, SDA inlet temperature, and SDA outlet temperature on SO_2 efficiency – see Figures 17, 18, and 19. For this Study, the graphs allow selection of the appropriate SDA outlet temperature to achieve 85% SO_2 efficiency. As shown in Table 1, it should be possible to obtain 85% SO_2 efficiency and still maintain the SDA outlet temperature above the minimum allowable limit of 164F (34F approach –to-saturation) The required SDA outlet temperatures in Table 1, are from the graph curve for a stoichiometry limited to 1.8 (moles of lime per mole of SO_2 removed). B&W and Niro believe that there is little benefit in performance at a stoichiometry above 1.8.

	SDA Inlet Temperature (F)	
Coal Sulfur (%)	300	330
1.1	164	168
0.67	173	NA

Table 1 – SDA Outlet Temperature Required to Achieve 85% SO_2 Efficiency.

B&W and Niro believe that a properly designed and operated SDA/ESP system should operate well down to at least 35F AS and under some conditions as low as 30F. A 35F AS would be 165F at Wyodak. Another restriction for operation at 85% SO_2 efficiency is that all three SDAs should be in service to minimize the SDA load factor and maintain acceptable feed slurry drying.

```
Program Absorb * Ver 4.5 PHH *  Project : WYODAK UNIT 1          2006-12-14 13:56
Saved in: NO DATA SET FILE                                        Initials: bjankura
---------------------------------------------------------------------------------

                    Condensed output ABSORB Program.
---------------------------------------------------------------------------------
SDA inlet gas flow SCFM  wet :   981330. / lb/h :  4500002.  /  Temp. F : 310.0
---------------------------------------------------------------------------------
                        System inlet condition    ! Stack requirements  Removal
      Mass   Volume    Actual     Dry      Corr   !   Actual    Spec       %
N2   68.374  70.440    70.500   80.571   80.571   !   80.425   80.442
O2    5.517   5.000     5.000    5.714    5.714   !    6.952    6.955
CO2  18.211  12.000    12.000   13.714   13.714   !   12.605   12.603
H2O   7.767  12.500    12.500    0.000    0.000   !    0.000    0.000
   ( Dry  5.71% O2  )   PPM       PPM      PPM    !(DRY) PPM    PPM
SO2   0.131   0.060   595.002  680.002  680.002  !  180.139  180.105      71.2
DUST    (GR/SCF  )      3.697    4.225    4.225   !    0.010    0.010      99.7
---------------------------------------------------------------------------------
SDA outlet temp     :    180.0 F                       Adsat approach  : 49.8 F
AR :  2.349                SR (total acids) :  1.302   SR (removed acids) :  1.829
Total water consumption :   148222. lb/h (296.02 GPM ) Slaking ratio    :  3.607
---------------------------------------------------------------------------------
Reagent Storage & Reagent Preparation :      Carbon sorbant cons. lb/h       0.0
Dry reagent cons.              lb/h     7490.  % CaO     :                  90.00
Slaking water cons.            lb/h    27015.  % Solids  :                   0.15
Conc. Reagent Suspension       lb/h    34504.  % Solids  :                  28.10
Dilution Water                 lb/h        1.  % Solids  :                   0.30
Diluted Reagent Suspension     lb/h    34505.  % Solids  :                  28.10
---------------------------------------------------------------------------------
Reash slurry preparation :                    Reash amount lb/h            78367.
Dilution water                 lb/h   119406.  % Solids  :                   0.30
Reash slurry                   lb/h   197773.  % Solids  :                  39.41
---------------------------------------------------------------------------------
Atomizer feed system :
Atomizer feed    lb/h        232278. Feed conc.                 % Solids    37.73
Atomizer size                     800  Atomizer Power (incl.idl.) KW          395.
---------------------------------------------------------------------------------
Absorber system :
No of modules :  3  Module size :   8000  Chamber size :  15.00 x  11.80 M
Gas Disp I  type/size : DCS  /   3150     Gas Disp II type/size : DGA  /   5000
Gas retention time SEC       :     11.73          Size load factor :        0.883
Gas disperser pressure drop inWG :    1.9  Absorber pressure drop inWG :      3.3
---------------------------------------------------------------------------------
Dust filter :
Inlet gas amount         SCFM      1036914.  Inlet gas RH       %             27.07
                         ACFM      1547043.  Inlet gas temp     F            180.0
Inlet gas moist. Volume % H2O       16.77    Dust load          GR/ACF         9.22
---------------------------------------------------------------------------------
Powder conveyor :
Powder from Chambers lb/h           0.  Powder from Dustfilter  lb/h      122437.
Powder to recycle     lb/h      78367.  Powder to Disposal      lb/h       44071.
---------------------------------------------------------------------------------
Flue Ducts :
Gas amount. Chamber inlet  ACFM     1742088.  Filter  outlet  ACFM      1653716.
---------------------------------------------------------------------------------
Disposal material composition mass :        Carbon sorbant              :   0.00 %
Flyash        :        66.59 %              Inerts from lime + water  :   2.53 %
Free water    :         1.00 %              Crystal water              :   1.94 %
CaSO3         :        15.20 %              CaSO4                      :   3.04 %
CaF2          :         0.00 %              Ca(OH)2                    :   8.04 %
CaCl2         :         0.00 % ( 0.00 %Cl)  CaCO3                      :   1.66 %
---------------------------------------------------------------------------------
```

Figure 16 - Niro Performance Program Calibration to Wyodak.

1.63 SO_2 lb/mmBtu

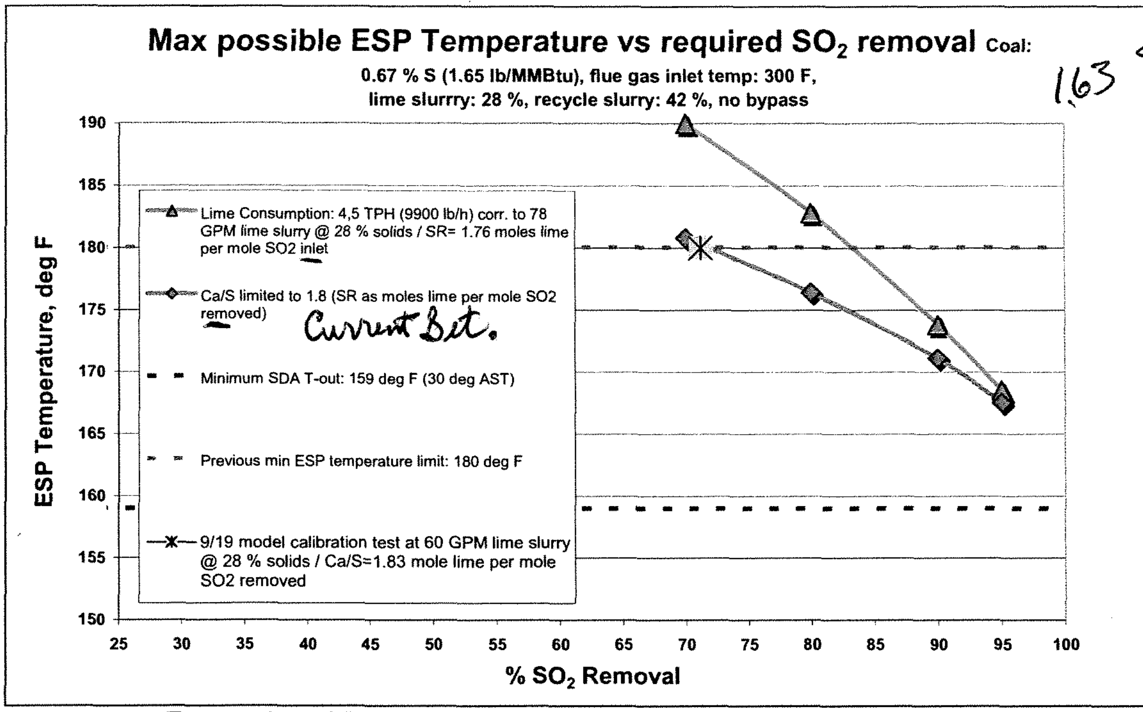

Figure 17 - SDA/ESP System SO_2 Removal, 0.67% S, 300F.

Higher Sulfur 2.7 lb SO_2/mmBtu

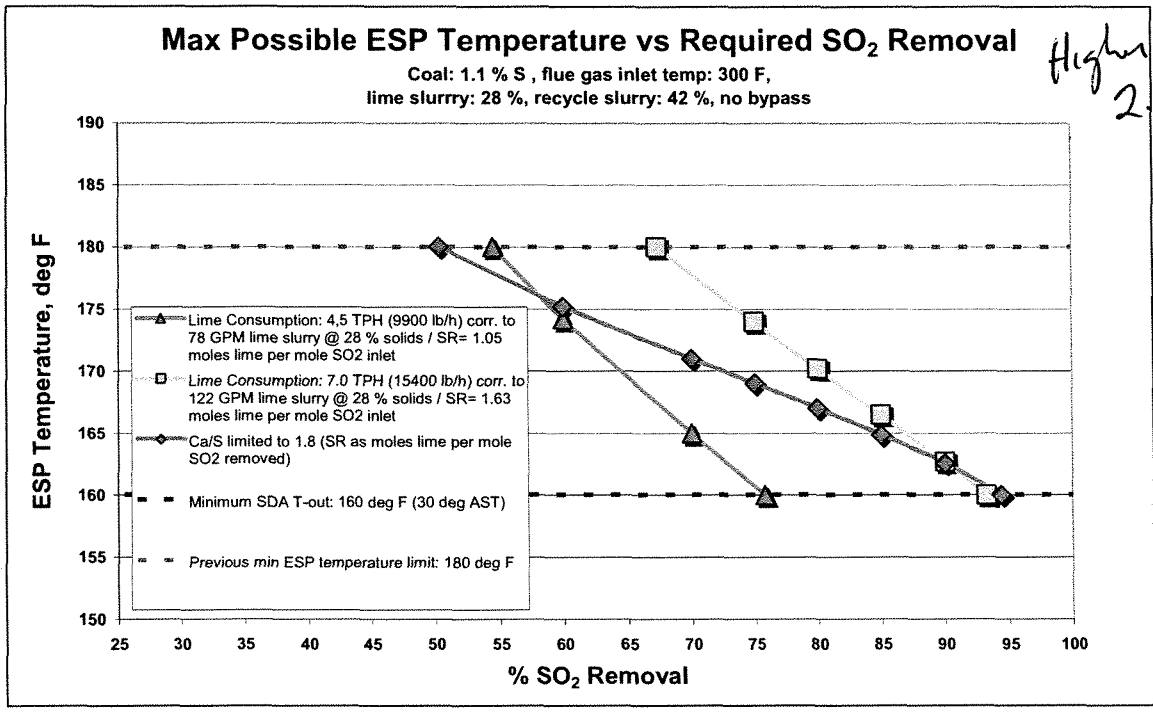

Figure 18 – SDA/ESP System SO_2 Removal, 1.1% S, 300F.

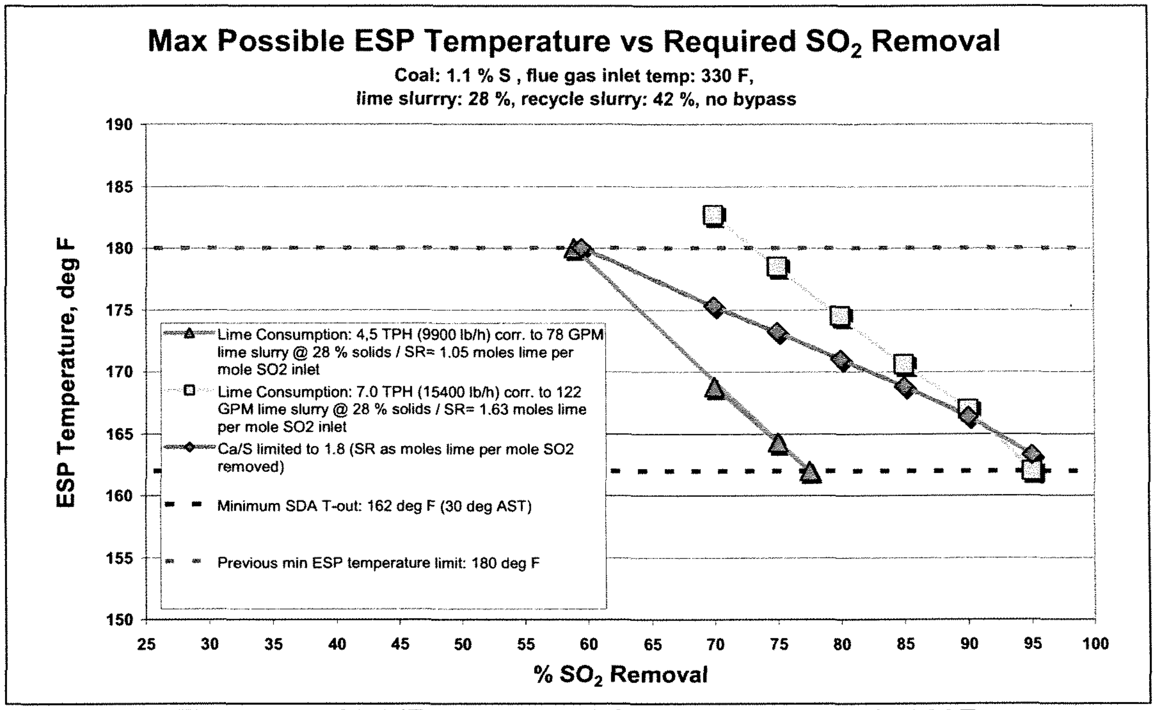

Figure 19 - SDA/ESP System SO_2 Removal, 1.1% S, 330F.

Flue Work from SDA to ESP Internal Inspection

The flue work from the SDA to the ESP was inspected on September 30, 2006. Considering that ~300 tons of ash was removed during the June outage, it was no surprise to see only a minor amount of loose ash and truss clinkers. The flue gas reheat plenums are well designed and appear to be uniformly mixing bypass gas. There were only a few small areas of erosion break-thru. The truss clinkers contained many micro layers that B&W believes are the result of the daily feed slurry piping flush with full, high pressure water. This flush lasts about 8-10 seconds but is sufficient to reduce the SDA outlet temperature to saturation for several seconds. Selected pictures from the internal inspection are shown in Figures 20 - 22.

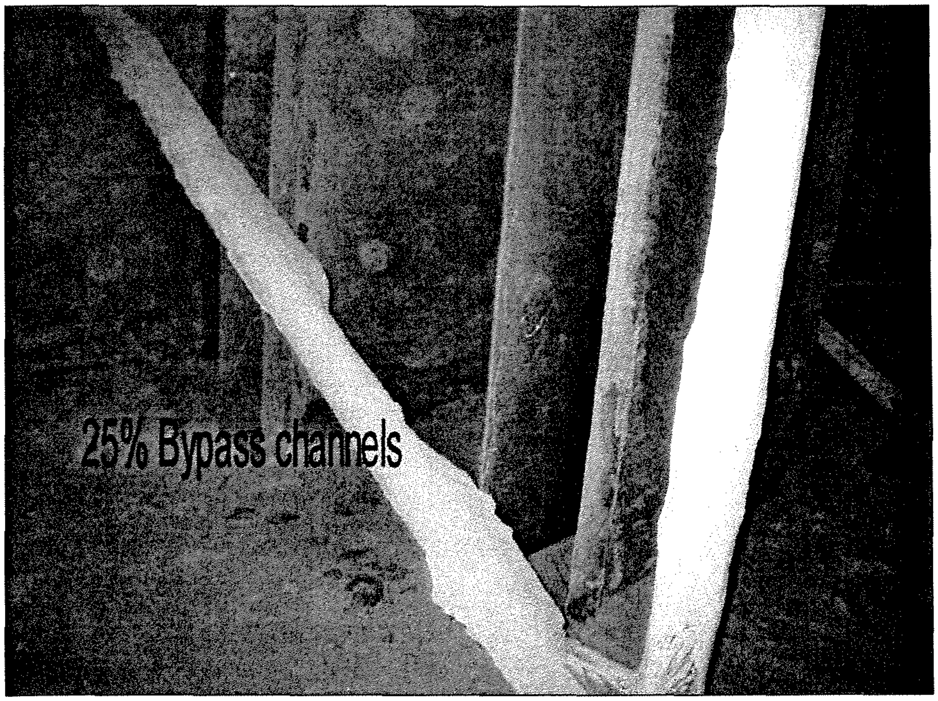

Figure 20 - Flue Gas Reheat 25% Mix Point.

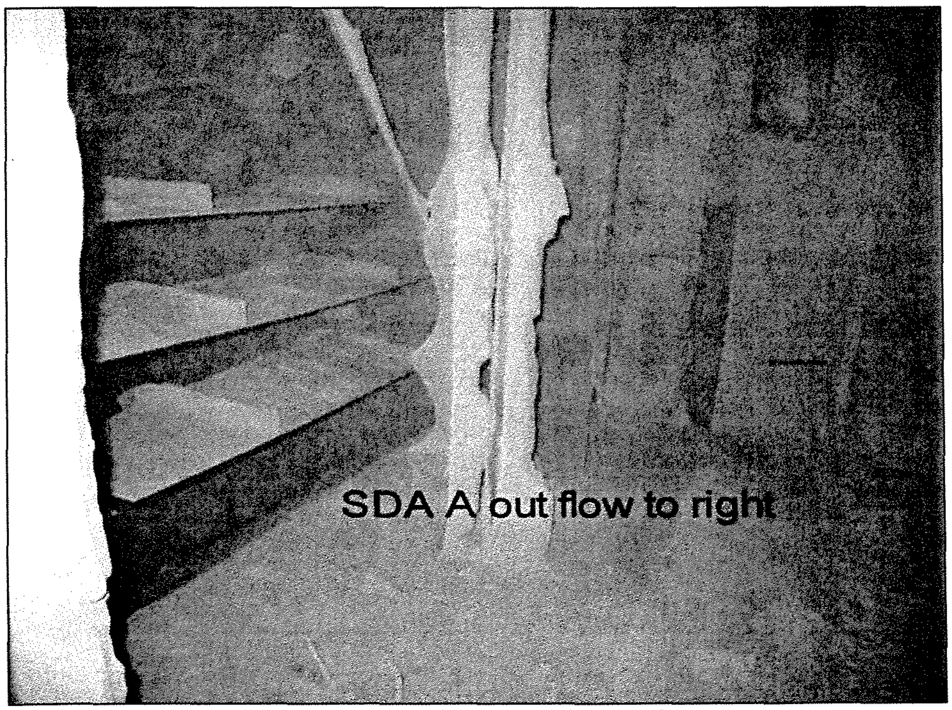

Figure 21 - SDA Outlet Flue Work.

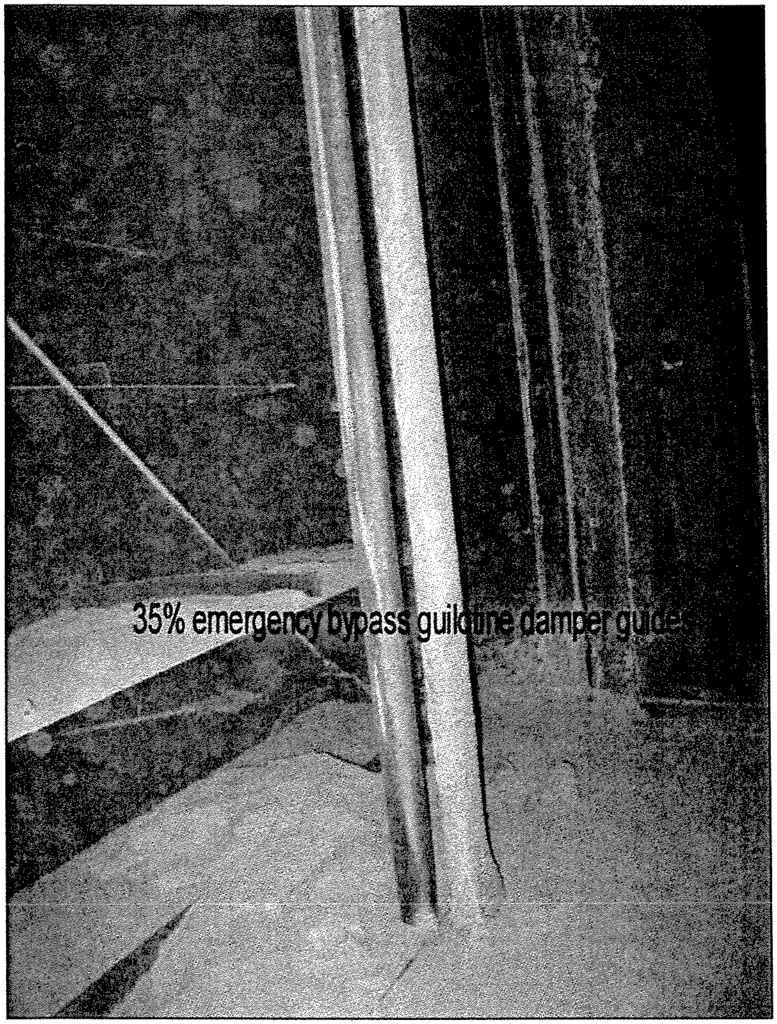

Figure 22 – Emergency Flue Gas Bypass Mix Point.

Options to Increase SO_2 Efficiency

B&W and Niro have reviewed the information collected through this Study on the Wyodak SDA/ESP System and considering previous efforts to troubleshoot and improve operation of other SDA/ESP Systems, several options to improve SO_2 efficiency were identified. These alternatives are listed in Table 2 and include various combinations of mechanical and operational changes. The alternatives are referred to as "All Options" as the list includes all technically possible methods that would increase SO_2 removal including options that provide only incremental improvement, if any.

Option	Description	Advantages	Disadvantages	Comments	Is 85% Removal Possible?
Mechanical					
PJFF Baghouse Retrofit	Replace 4 ESP trains with 2 baghouse trains	Much higher SO2 removal possible without additional lime addition. Higher removal of condensable particulate and HAPS such as mercury.	High cost, higher DP	This option will allow up to 95 % SO2 removal efficiency. ID fan capacity may be insufficient.	Yes
Add ESP Flue Gas Heating System other than flue gas bypass	Maintain SDA at 160F Tout and add new reheat source	Short tie-in schedule	High cost, maintenance .	Add Steam coils for 20F reheat from about 160 F to about 180F. Probably have to add more flue support structural steel.	Yes
Upgrade ESP Wires and Plates to SS	Upgrade the areas showing significant corrosion that upon failure cause high opacity. Reduce ESP inlet temperature significantly below 180F.		High cost and still may have casing corrosion and wire deposits.	Uncertain where to locate the SS: CS interface	Yes
Add 4th module	Add another SDA chamber with accessories		High cost. Mmore heat loss for the additional flue surface area.	No benefit except during periods with 1 SDA out of service	No
Operations					
Eliminate Flue Gas Bypass and lower SDA Tout	Send all Flue Gas to the SDA's.	Should reduce ESP corrosion. SO2 removal will increase. Eliminate SO3 to the ESP	ESP corrosion should decrease, but only verified after long-term operation. Corrosion coupons may be prudent. Potentail for higher wall deposits if less than 160F	< 180F operation not acceptable Pacificorp corrosion concerns. Recommend "Spruance Genco" corrosion probe study, or use boroscope study. The major problem with bypass is that the SO3 in this flue gas is not completely removed and forms sulfuric acid in the ESP. The SDA removes essentially all (~99%) of the SO3.	Yes
Increase Lime Stoichiometry			Higher lime costs	With current operation at relatively high stoich of about 1.8 not much benefit with more lime addition - probably only a few percentage points (to be determined by prediction model calculations)	No
Increase SDA Inlet Temperature		Increase Recyle Rate	Reduce boiler efficiency	Similar situation with increasing stoichiometry, but some measurable inprovement would occur.	Maybe
ESP Dry Product Recycle		Increase Recycle Rate	More tank cleaning	At 41% solids, and minor improvement at 45%.	No
Lime Slaking			Higher water cost (if available)	minor improvement if slaking water is high in SO4, even optimum lime slaking conditions will not make significantly higher SO2 removal possible. However, better lime slaking may reduce lime consumption	No
Add Chlorides			more corrosion	Will make higher So2 removal possible, but is not recommended due to increased corrosions rates	No
More coarse atomization				Weak Theoretical basis (more time but less surface area). Significantly higher SO2 removal is unlikely.	No
Increase Lime Purity		Increase Reccyle Rate		Very small improvement at best	No
Other feed additives			high cost	Not recommended, since no known additives will do the job	No

Table 2 - Wyodak "All Options" to Achieve 85% SO_2 Removal

The most promising option to be selected for implementation must consider such factors as cost, installation downtime, balance-of-plant effects, and Pacificorp preferences. Only options that will provide 85% SO_2 efficiency are discussed in the balance of this Section.

Pulse Jet Fabric Filter Retrofit - This option provides the greatest potential to increase SO_2 efficiency and can achieve at least 85% with no additional lime usage. A major expense would be required for materials and installation.

B&W recommends that the clean side flue work (areas after the bag filters) have an internal protective coating for long-life without corrosion. Typically, the coating will be of the resin-type. This is B&W standard practice for new installations. The retrofit could be accomplished with only two of the four ESP trains as the pulse jet design requires relatively low filter bag collection surface.

The primary advantage of this system is that while an ESP removes essentially no SO_2, a PJFF removes more than 50% of the entering SO_2. Also, any SO_3 that was either not absorbed in the SDA or bypassed the SDA would be removed.

Add ESP Flue Gas Heating System other than Flue Gas Bypass - This option would replace the flue gas bypass with a series of in-line steam reheat coils. B&W installed this type of reheat system at the Tri-State Generation Craig DFGD system, in Craig, Colorado. The system utilizes two sections horizontal steam pipes, each section containing four, smooth tubes. This steam reheat system has been successfully operated at the Craig Plant since 1983.

The primary advantage of this system is that 100% of the flue gas can be treated without reducing the flue gas temperature to the ESP. At 85% SO_2 efficiency, the SO_2 loading to the ESP is reduced by 50% and the SO_3 loading to the ESP is essentially eliminated. Sulfur trioxide is a very corrosive acid gas that absorbs into water to form sulfuric acid. This approach should significantly reduce ESP corrosion.

This option has several disadvantages that through discussions with Pacificorp eliminate it as a viable option. Specifically, there would be:

- A significant static weight load increase to the support steel for the flue work between the SDA and ESP requiring an Engineering Study of the structure.
- Over time, more SDA product solids would collect on the floor of the flue work.
- A steam soot blowing system is required to periodically clean the smooth pipe heat exchanger surface.

- Significant piping is required to supply steam to the reheat coils.

A redesign of the flue work support steel, and probability of more solids drop-out are just not acceptable to Pacificorp.

Upgrade ESP Wires and Plates to SS – This option focuses on upgrading materials to withstand the corrosive environment inside the ESP due to the presence of the acid gases SO_2 and SO_3. The preferred material would be 316L stainless steel for at least the discharge wires and collector plates. Additional material changes may be required depending on the location of the interface between the new stainless steel components and the existing carbon steel structure.

The primary advantage of this system is that 100% of the flue gas can be treated and the SDA outlet temperature can be reduced without additional corrosion after the SDA.

There is also some unknown risk for increased casing corrosion and solids deposits on the wires.

Eliminate Flue Gas Bypass and Lower the SDA Outlet Temperature - This option does not require any mechanical changes to the SDA/ESP System. Rather, the operation is adjusted to significantly reduce the amount of the acid gases SO_2 and SO_3 to the ESP. For the design basis set forth in this Study of 0.67% sulfur coal and 300F SDA inlet temperature, with no flue gas bypass, 85% SO_2 efficiency should be possible by operating the SDA outlet temperature at 173F, or 43F above the flue gas saturation temperature.

B&W believes that this is a promising option, especially since essentially all of the SO_3 can be removed. However, this option would operate the ESP at 7F below Pacificorp's operating policy to maintain the ESP inlet temperature above 180F. Corrosion coupons located at the ESP outlet would be a reasonable method to monitor the monthly corrosion rate under these operating conditions. If the corrosion rate is acceptable, then this option may be the best choice for Pacificorp to reduce the stack SO_2 emissions.

B&W recommends, however, that all three SDA chambers should be in service when the SDA outlet temperature is less than 180F. This it to minimize solids deposits on the chamber walls.

B&W feels very strongly that the use of high pressure atomizer flush water may be a significant contributor to the observed ESP corrosion. If this option is chosen for further investigation, then it is worthwhile to reduce the flush water pressure. This can be accomplished by installing either a downstream pressure regulator or a fixed orifice into the flush water piping.

CONCLUSIONS AND RECOMMENDATIONS

An Engineering Study was completed for Pacificorp's Wyodak Power Station to identify options to increase the SO_2 efficiency in the SDA/ESP System. This Study has also provided B&W, Niro and Pacificorp detailed information on how the SDA/ESP System is currently being operated and has identified areas for general improvements.

The results of this Study show that Pacificorp has several viable options to increase SO_2 efficiency. B&W feels that the best options for improved SO_2 efficiency are to either:

- Retrofit the Electrostatic Precipitator (ESP) to a Pulse-jet Fabric Filter (PJFF), or
- Upgrade the ESP with stainless steel internals, eliminate flue gas bypass, and reduce the SDA outlet temperature from 180F to approximately 164F - 173F, or
- Eliminate flue gas bypass, complete system operating changes to minimize overspraying, and reduce the SDA outlet temperature to approximately 164F - 173F.

B&W recommends that if Pacificorp selects the last option, then a long-term corrosion Study with coupons at the ESP outlet should be included. This option could be accomplished in relatively little time, with no outage, and with relatively minor expense.

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APPENDIX A

B&W WYODAK DFGD QUESTIONNAIRE

The Babcock and Wilcox Company

DFGD System Questionnaire

INSTRUCTIONS

- **Please print the questionnaire and fill in the information , or you may return the filled in WORD document, renamed, adding you plant name and date ("Plant Name" DFGD QTE "Date".doc)**
- **Include relevant documents.**
- **Please Fax or E-mail the questionnaire and other documents to your B&W Contact.**
- **After we have received the documents, we will acknowledge receipt and advise if we need anything more from you.**
- **If physical sampling is included, please carefully follow all shipping instructions.**

If you have questions, please reply to your B&W Contact.

CUSTOMER: Pacificorp

PROJECT: Wyodak 1 DFGD Upgrade

CONTRACT NO.: Pacificorp Work Release 3000035856 / B&W Contract 430-0049

REVISION RECORD			
Rev. Level	**Description**	**Author**	**Date**
0	Initial Release To Customer (Glenn Fosher)	B. Jankura	4/12/06
1	Release to D. Thorfinnson with Partial Entries	B. Jankura	8/18/06
2	Final Draft Release to Pacificorp	B. Jankura	10/26/06
3	Final Draft Release to Pacificorp	B. Jankura	12/04/06
4	Final Release	B. Jankura	12/21/06

and/or its representatives have, by receiving same, agreed to maintain its confidentiality and shall not reproduce, copy, disclose or disseminate the contents, in whole or in part, to any person or entity other than the Recipient and/or Recipient's representatives without the prior written consent of B&W.

BOILER SYSTEM OPERATION

Condition	Low Load	Full Load
Heat Input (MBtu/hr)	NA	NA
Electrical Generation (MWgross)	180	385

How much flue gas path draft loss would be available to operate a baghouse without fan modifications?

Pacificorp Response - Presently, The boiler is running at -9" at the scrubber inlet, -18" at the Precip Inlet, and -20 to -21" at the ID Fans. Things are running well, but we just came out of an outage. Prior to the outage we had no extra ID fan. The general consensus is that there is no extra ID fan available to support a Baghouse.

STACK EMISSIONS PERMIT

Emission	Current Limits	Future Limits
SO_2	0.5 lb/MBtu 3-hr block AVG (70% for 1.67 lb/MBtu coal)	Not know if basis will be % removal or lb/MBtu. Please assume 0.27 lb/MBtu 3-hr block AVG (85% for 1.67 lb/MBtu coal or 0.67% S as rec'd)
Opacity	20%, 6min block AVG, except for one 6min AVG/hr of not more than 27%.	No Change
Particulate	0.10 lb/MBtu	No Change

Pacificorp Notes

- The SO_2 block average starts when the boiler load is above 180 MWgross for the entire 3-hr period. The SO_2 removal is typically 68% - 70% with occasional peaks of 72%. Yearly particulate RATA ranges from 0.01 – 0.29 lb/MBtu.

- Pacificorp is completing a BART review that may only require 82.5% SO_2 efficiency.

SDA/ESP SYSTEM OPERATION

Item	Low Load	Full Load
Roof Gas Disperser Pres Loss (inwc)	See Pidata	See Pidata
SDA Pres Drop (inwc)	See Pidata	See Pidata
4% Bypass Damper Position (% open)	See Pidata	See Pidata
26% Bypass Damper Position (% open)	See Pidata	See Pidata
35% Bypass Damper Position (% open)	See Pidata	See Pidata
SDA inlet Static Pres (inwc)	See Pidata	See Pidata
SDA Inlet O_2 Conc. (%dry)	See Pidata	See Pidata
SDA Outlet Temperature (F)	See Pidata	See Pidata
SDA Inlet Flue Gas Flow (□lb/hr or □ACFM)	See Pidata	See Pidata

SDA Inlet Flue Gas Flow (lb/hr)

Boiler Load	Current	Future
Min	See Pidata	Same as Current
Avg	See Pidata	Same as Current
Max	See Pidata	Same as Current
Peak	See Pidata	Same as Current

SDA inlet flue gas temperature (F)

Boiler Load	Current	Future
Min	300	300
Avg	330	330
Max	330	330
Peak	330	330

<u>Pacificorp Note</u> – The APH outlet temp ranges from 300-335 degrees F. Operations maintains this temp above 300 degrees in the winter months. The summer months, the temp naturally stays above 300 degrees.

SDA Full Load, Average, Stoichiometry Data

Item	Units	Value
Stack SO_2	See PiData	See PiData
Lime Slurry Flow	See PiData	See PiData
Recycle Slurry Flow	See PiData	See PiData

SDA inlet SO_2 Concentration (ppm dry)

Coal Range	Current	Future
Min	See Coal Sulfur Data	See Coal Sulfur Data
Avg	See Coal Sulfur Data	See Coal Sulfur Data
Max	See Coal Sulfur Data	See Coal Sulfur Data
Peak	See Coal Sulfur Data	See Coal Sulfur Data

<u>Pacificorp Note</u> - The SDA inlet SO_2 process analyzer are not used for regulatory reporting. A daily calibration is usually completed and calibration gas is periodically used to check the monitor's accuracy.

SDA Outlet Temperature Control

Please describe the SDA Operator's procedure/guidelines to determine the DCS outlet temperature setpoint.

<u>AUTOMATIC CONTROL -</u> There are no formal guidelines and the SDA Operator or the Unit Operator may be responsible for control. The two most used setpoints are 1) No flue gas bypass and 180F, or 2) 165F – 175F and flue gas bypass for 180F ESP inlet temperature.

With flue gas bypass, the 4% and 26% dampers will modulate as necessary. The 35% bypass is for emergency use only and is either 100% open or closed.

<u>MANUAL CONTROL</u>

Only used when the automatic controls are not stable. Minimum 160 SDA outlet temperature with flue gas bypass at 180F.

Please describe the stability of the DCS automatic outlet temperature control.

The SDA outlet temperature will typically range from a minimum of 175F to a maximum of 186F over a cycle that lasts about 4 minutes seconds.

Additional comments – Wider ranges have occurred depending on the feed slurry flow control valve's condition.

Do you have outlet flue gas adiabatic saturation gas temperature monitors and if so what are the typical values?
Pacificorp Response – No.

Please include any available stack testing results downstream of the air heater. Specific information on SO_2, HCL, and fly ash loading is useful.

ESP SYSTEM OPERATION

Item	Low Load	Full Load
Inlet Static Pressure (inwc)	See PiData	See PiData
Outlet Static Pres. (inwc)	See PiData	See PiData
Disposal Ash Moisture (wt%)	NA	NA
Air In-leakage (%)	Not Available	Not Available
Outlet Temperature (F)	See PiData	See PiData
Stack Particulate Emissions (lb/MBtu)	Not Available	See RATA Data

Pacificorp Note – The minimum allowable operating flue gas temperature to the ESP is 180F with typical operation at 180F – 185F. The 180 F limit is based upon operating experience at Wyodak with regards to corrosion of ESP internals. The problem appears to be mainly with wires and the casing from low flow areas. There has also been notable flue panel corrosion at the ID fan inlets and outlets. Going to lower temperatures (such as 160 F) is not considered prudent without installing, at least, stainless electrodes and probably stainless plates in the ESP.

B&W confirmed in October, 2006 that flue gas wet bulb temperature is very stable, at 130F. An ESP outlet temperature of 160F corresponds to a 30F approach to saturation.

B&W and Pacificorp inspected the flue gas bypass mixing internals on October 30, 2006. The internals are located at least 150ft before the closest ESP inlet and appeared to be in good working order. Pacificorp evaluated potential modifications between 1992 -1994 to add B&W designed air foil flue gas mixers that were based on physical flow modeling. No modifications were ever implemented (even though the mixing foils were fabricated), possibly due to lack of confidence that the flue work would support such weight.

LIME SLAKING SYSTEM OPERATION

Condition	Value
Slaker Discharge Solids (wt%)	28%

Control Temperature (F)	See PiData
Slaking Water Temperature Winter (F)	62
Slaking Waster Temperature Summer (F)	78
Slaking Water Control Temperature (F)	Manual Steam injection for minimum 70F
Maximum production capacity flow (gpm)	One mill runs continuous at no more than 70% capacity to meet current demand. Both mills could operate to meet significantly higher demand.
Maximum production capacity solids (%)	Unknown

PHYSICAL SAMPLING

Please provide available information for the following list of process samples. After initial review of the questionnaire, physical sampling may be required.

Coal (as Received)

Analyte	Low Sulfur	High Sulfur
Ultimate C (%wt)	47.3	46
Ultimate H (%wt)	3.0	3.5
Ultimate N (%wt)	1.3	1.3
Ultimate O (%wt)	11	11.1
Ultimate S (%wt)	0.4	1.1
Ultimate H2O (%wt)	30	30
Cl (ppm)	30	30
F (ppm)	40	40
Br (ppm)	3.0	3.0
Ultimate Ash (%wt)	7	7
Higher Heating Value (Btu/lb)	8,100	8,100
Ash SiO2 (%wt)	34	34
Ash TiO3 (%wt)	.90	.90
Ash Fe2O3 (%wt)	5.9	5.9
Ash Al2O3 (%wt)	15	15
Ash CaO (%wt)	18	18
Ash Na2O (%wt)	.50	.50
Ash P2O5 (%wt)	.70	.70
Ash MgO (%wt)	4.0	4.0
Ash SO_3 (%wt)	16	16
Ash Mn (%wt)	.04	.04
Hg (ppm)	0.30	0.30
As (ppm)	3	3
Cd (ppm)	<0.01	<0.01
Cr (ppm)	8	8
Pb (ppm)	3	3
Mn (ppm)	23	23
Ni (ppm)	9	9

<u>Pacificorp Note</u> - Coal is blended by contract for less than 0.7%S monthly weighted average. Typical historical monthly actual sulfur is 0.65%. The future coal sulfur is expected to stay within the range of 0.5 - 0.8%.

B&W Note – The detailed analyses are based on May 2006 sampling by B&W from Wygen1. The coal S ranges are by Pacificorp.

Slurry Streams

Type	% Solids	Location
Lime Slurry	28%	Ball Mill
Recycle Slurry	42%	Supply Loop
Feed Slurry	38%	Supply Loop

Slaking / Recycle Prep Water

Analyte	Slaking Water	Recycle Water
pH	NA	NA
TDS (%)	0.23	NA
SO4 (ppm)	1,300	NA
Cl (ppm)	NA	NA

Pebble lime

Test Method	Value
ASTM C25 CaO (%)	88.6
ASTM Temperature Rise (C)	NA

Do you have any capabilities to obtain samples of SDA inlet fly ash?

Pacificorp Response - Yes. There are sampling ports with access, across the bottom of the flue work prior to the scrubber.

Do you have any capabilities to obtain samples of ESP ash?

Pacificorp Response – Only to the extent that there are sampling ports with access across the top of the flue work before and after the ESP's.

DESCRIPTION OF CUSTOMER ATTACHMENTS

Title	Description
Apr05 Low Load PiData	042005 file acquired on 080406 delivered
Apr05 Mid-load PiData	042005 file acquired on 080406 delivered
Apr05 Full Load PiData	042005 file acquired on 080406 delivered
Apr05 RATA Data	Received
9/17/06 1700 – 9/20/06 0600 PiData	Received 11/8/06 and 11/14/06
Feed Solids 080106-111706	080106@0700-111706@0300 Tabulated PDF format rec'd 11/27/06.

Appendix B

ESP Casing and Hopper Thickness Readings

PacifiCorp Wyodak Power Plant

Section D-1

	Inlet Perf Plate Side		Leading Edge 1st Field
8 Feet	.148	.137	.167
6 Feet	.146	.159	.171
8 Feet	.161	.174	.181
6 Feet	.303	.185	.195

PacifiCorp Wyodak Power Plant

Section D-2

	Trailing Edge 1st Field		Leading Edge 2nd Field
8 Feet	.185	.189	.171
6 Feet	.149	.180	.161
8 Feet	.164	.178	.167
6 Feet	.156	.173	.152

PacifiCorp Wyodak Power Plant

Section D-3

	Trailing Edge 2nd Field		Leading Edge 3rd Field
8 Feet	.169	.181	.176
6 Feet	.165	.176	.176
8 Feet	.168	.171	.172
6 Feet	.177	.179	.165

PacifiCorp Wyodak Power Plant

Section D-4

	Trailing Edge 3rd Field		Leading Edge 4th Field
8 Feet	.179	.182	.178
6 Feet	.169	.183	.172
8 Feet	.175	.179	.181
6 Feet	.161	.176	.171

PacifiCorp Wyodak Power Plant

Section D-5

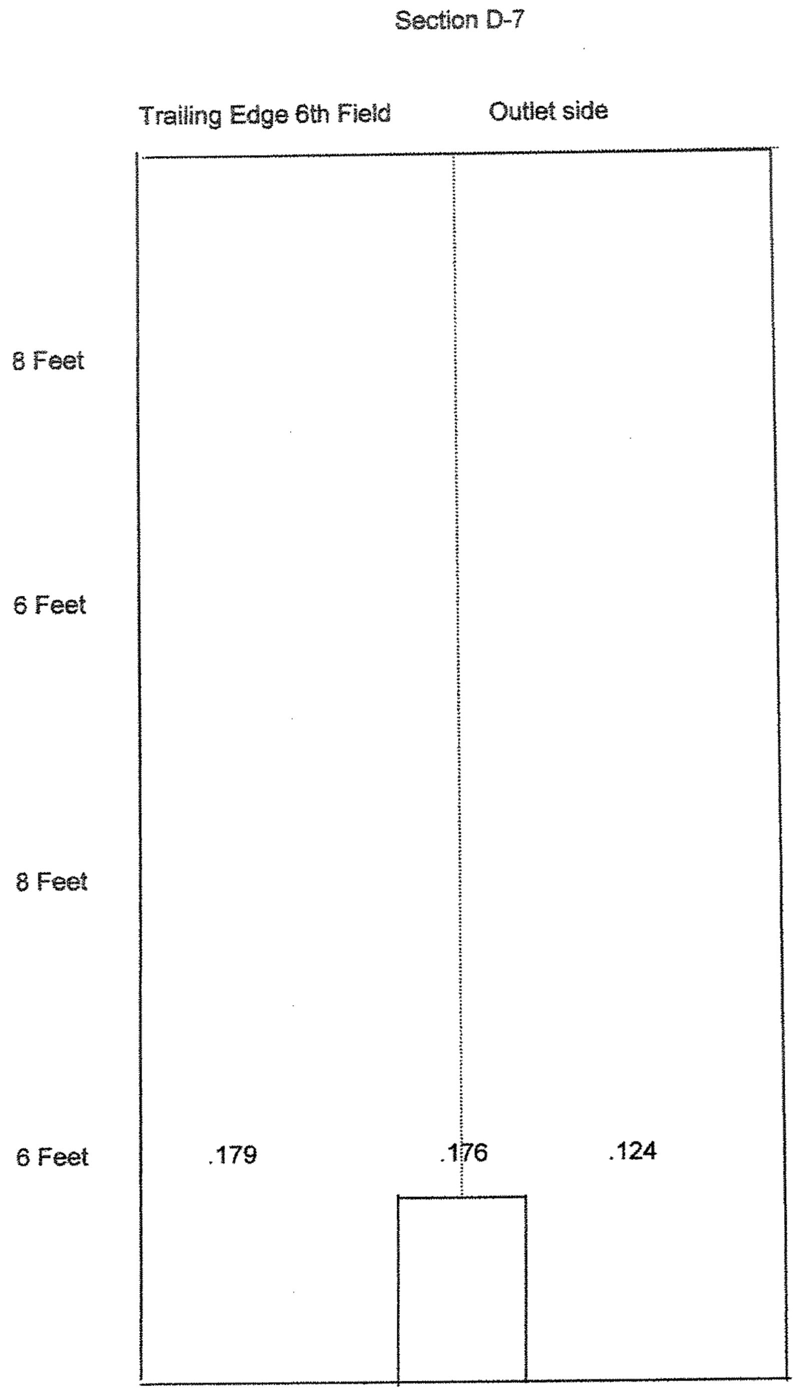
	Trailing Edge 4th Field		Leading Edge 5th Field
8 Feet	.167	.101	.187
6 Feet	.185	.183	.174
8 Feet	.175	.089	.104
6 Feet	.167	.177	.177

PacifiCorp Wyodak Power Plant

Section D-6

	Trailing Edge 5th Field		Leading Edge 6th Field
8 Feet	.176	.207	.212
6 Feet	.162	.182	.167
8 Feet	.177	.179	.178
6 Feet	.102	.081	.140

PacifiCorp Wyodak Power Plant



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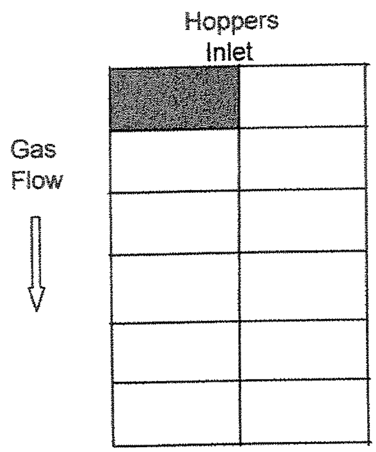
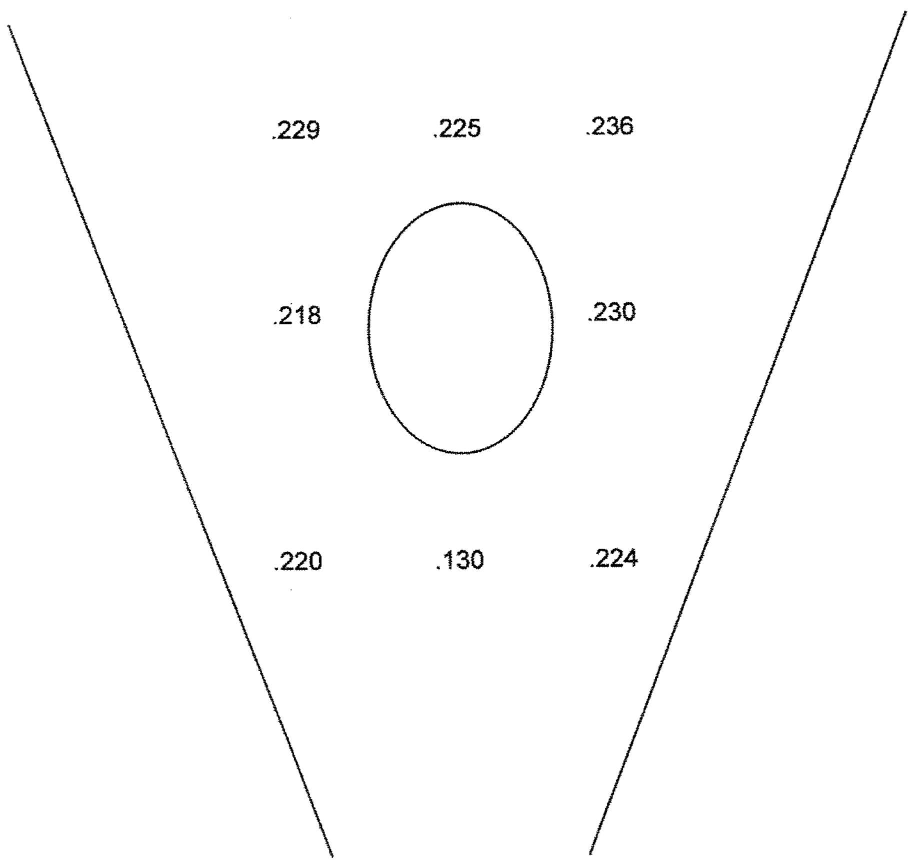


Hopper 1D1



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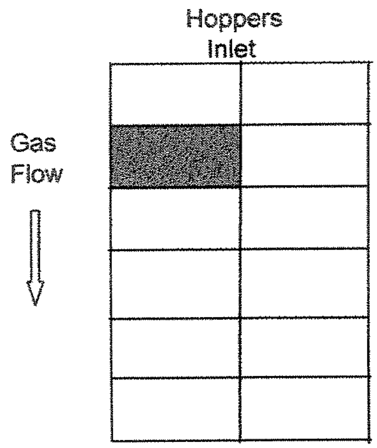
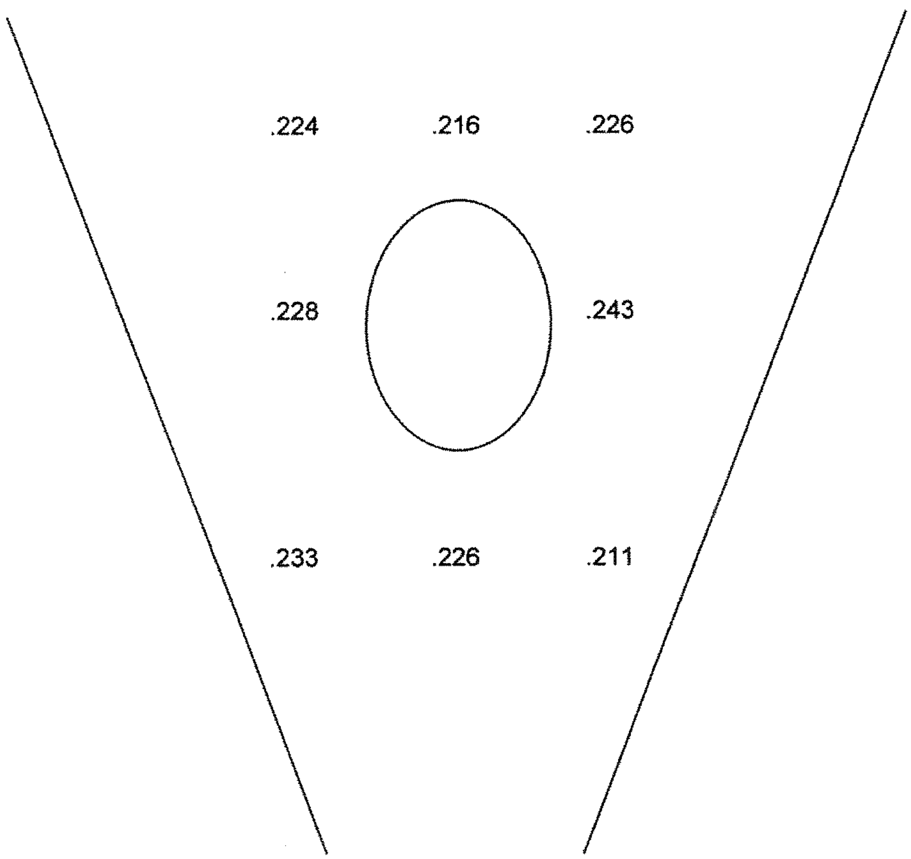


Hopper 2D1



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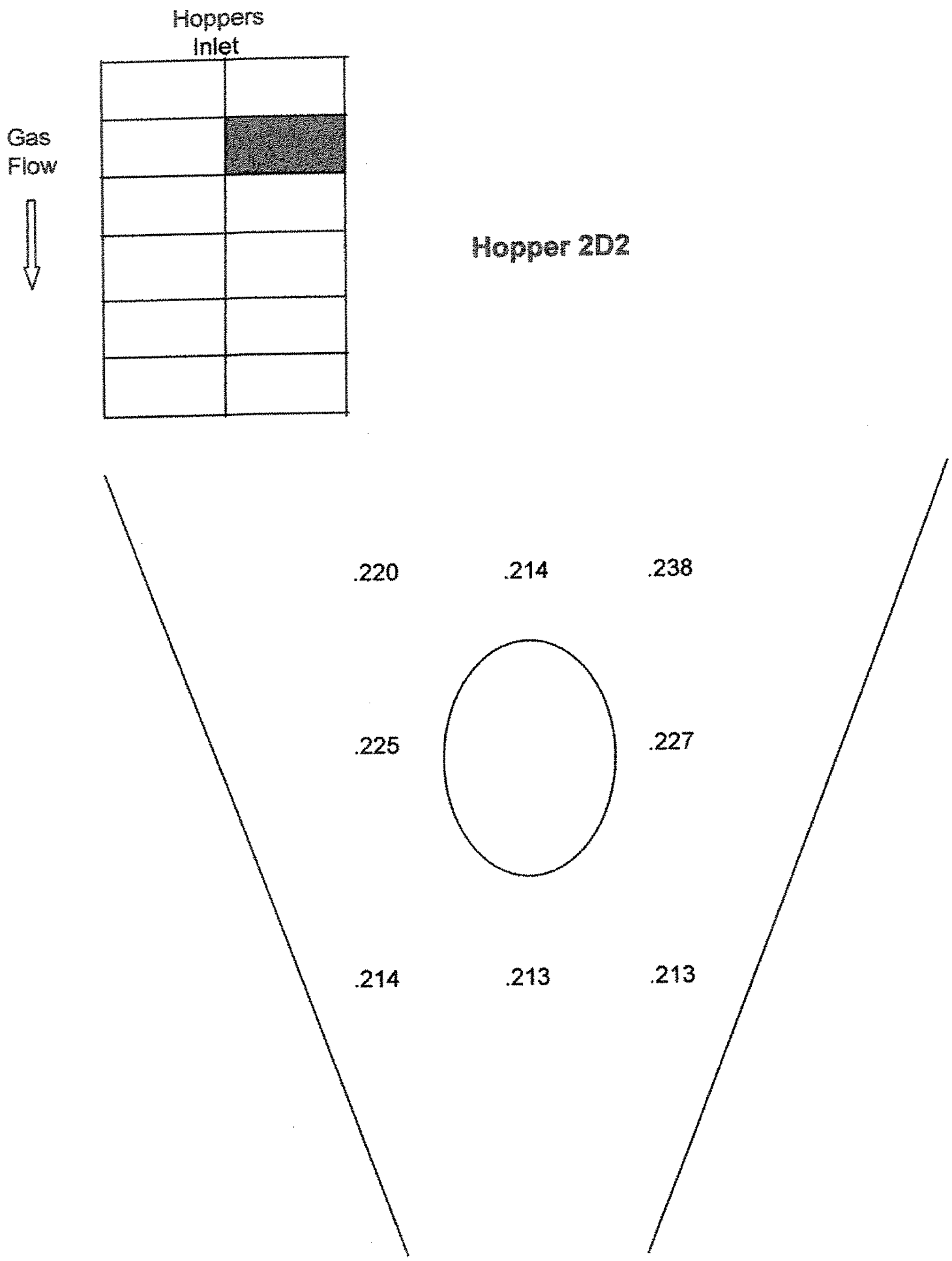

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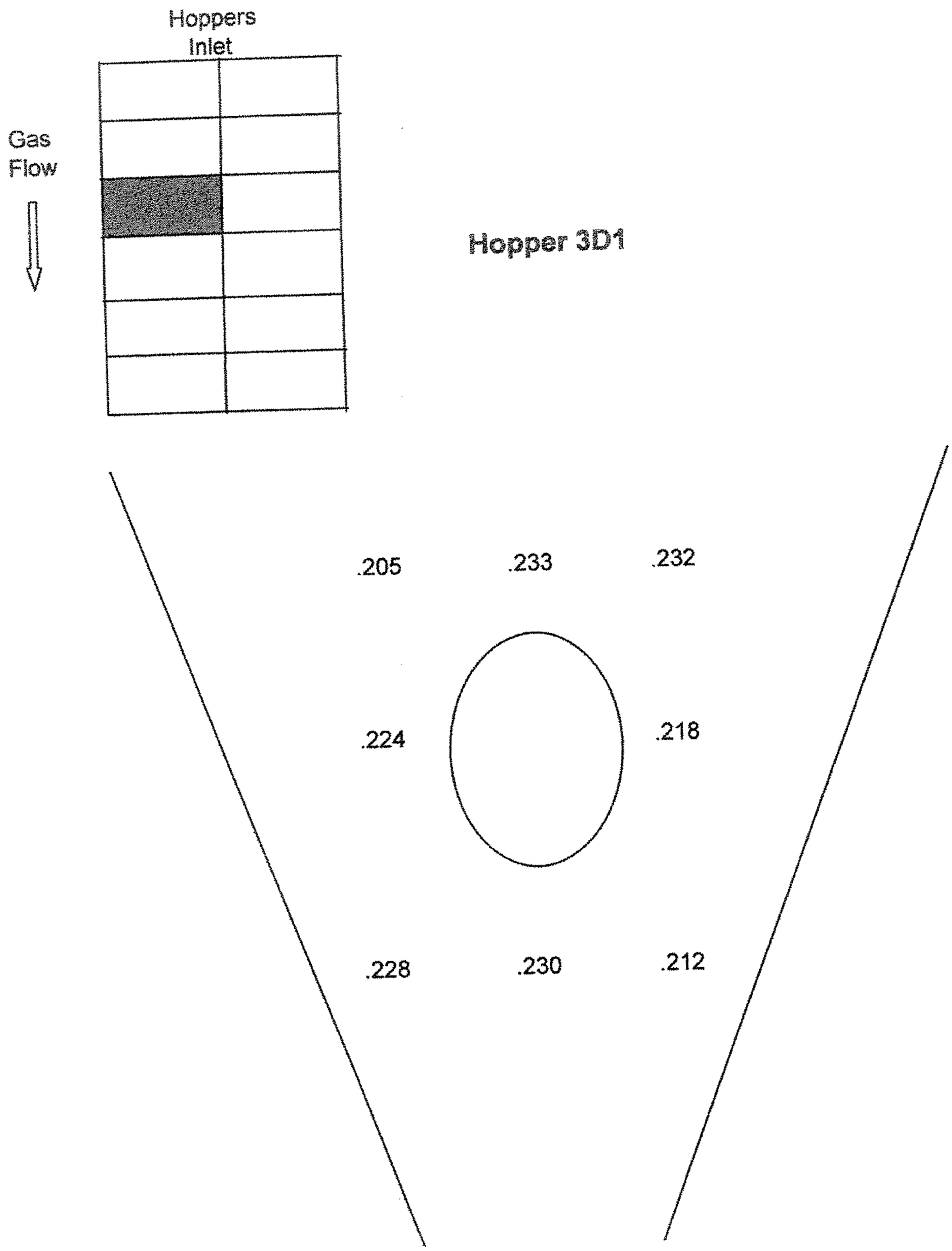

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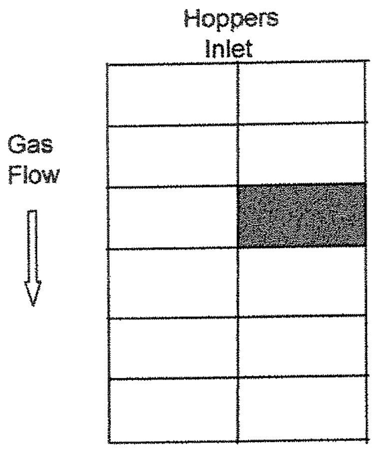
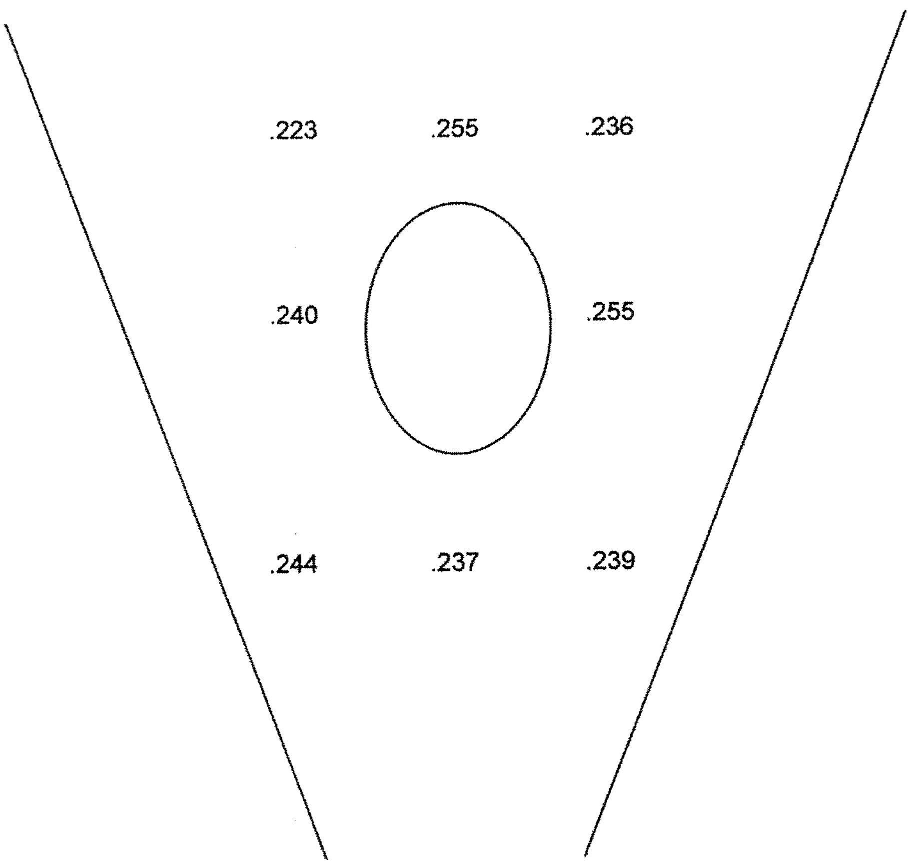


Hopper 3D2



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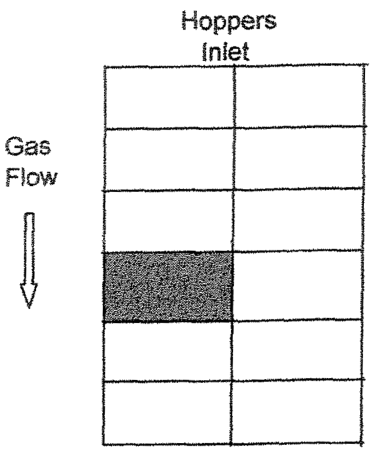
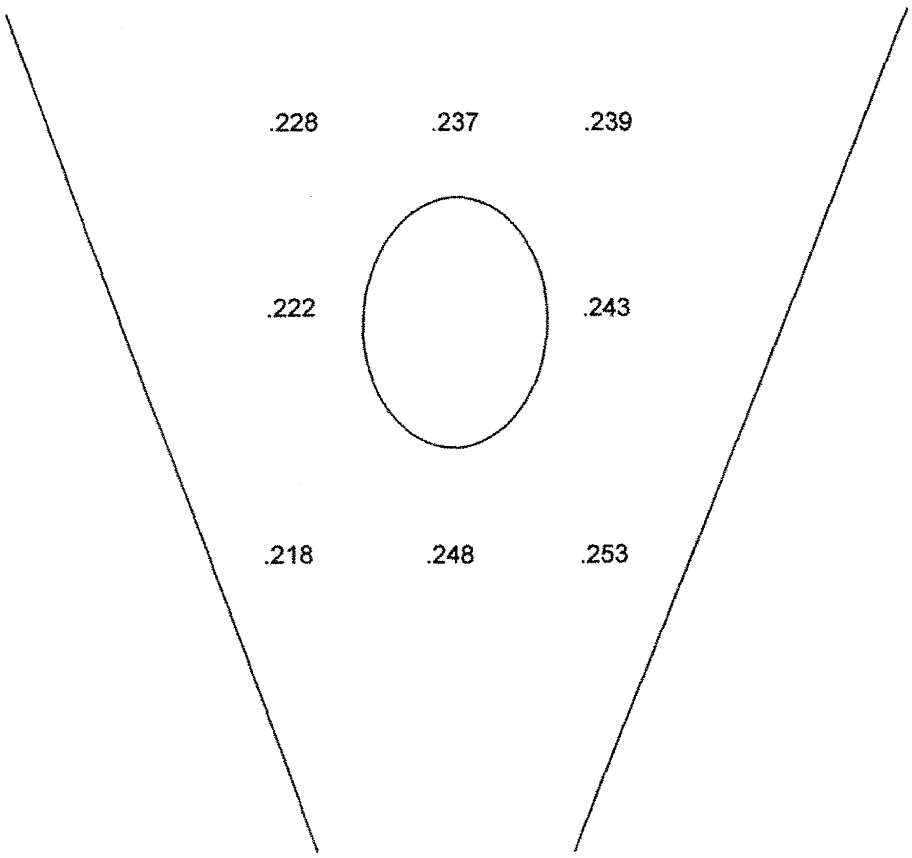
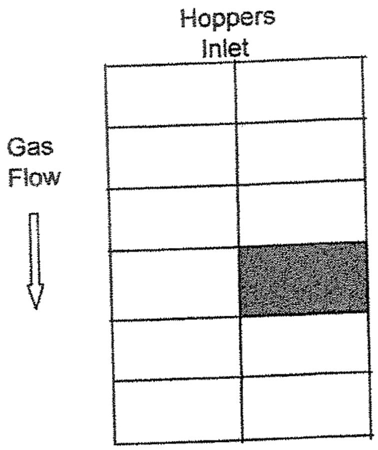


Hopper 4D1



PacifiCorp Wyodak Power Plant



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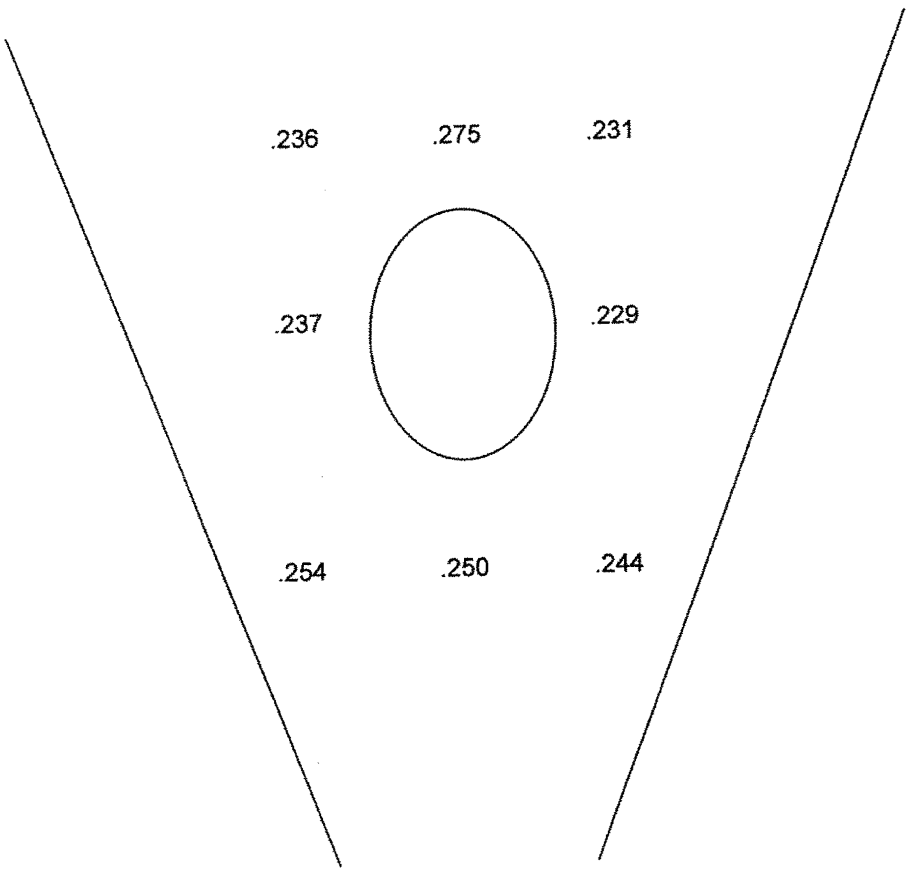

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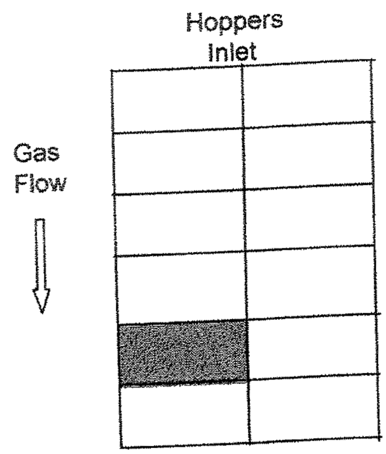
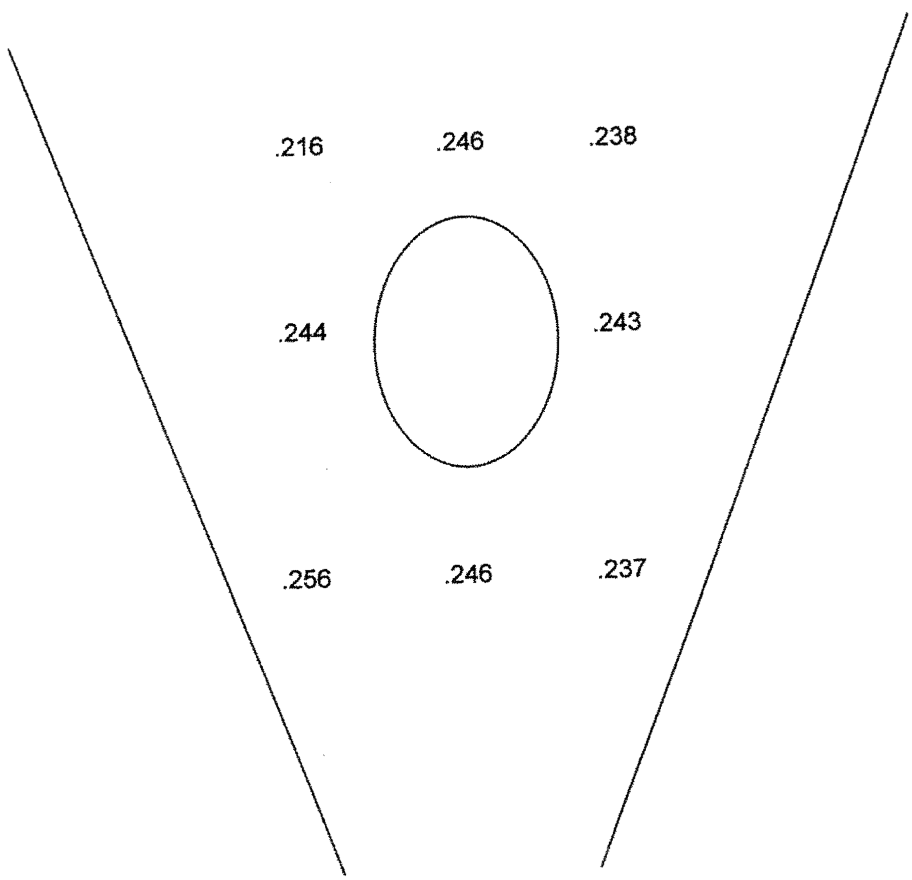
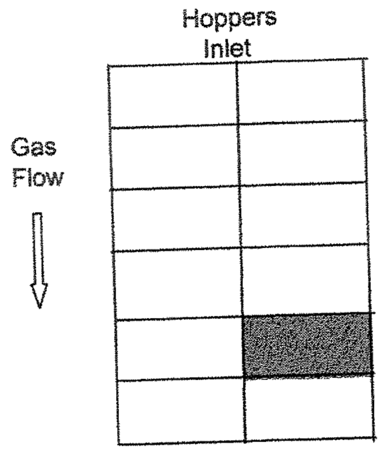


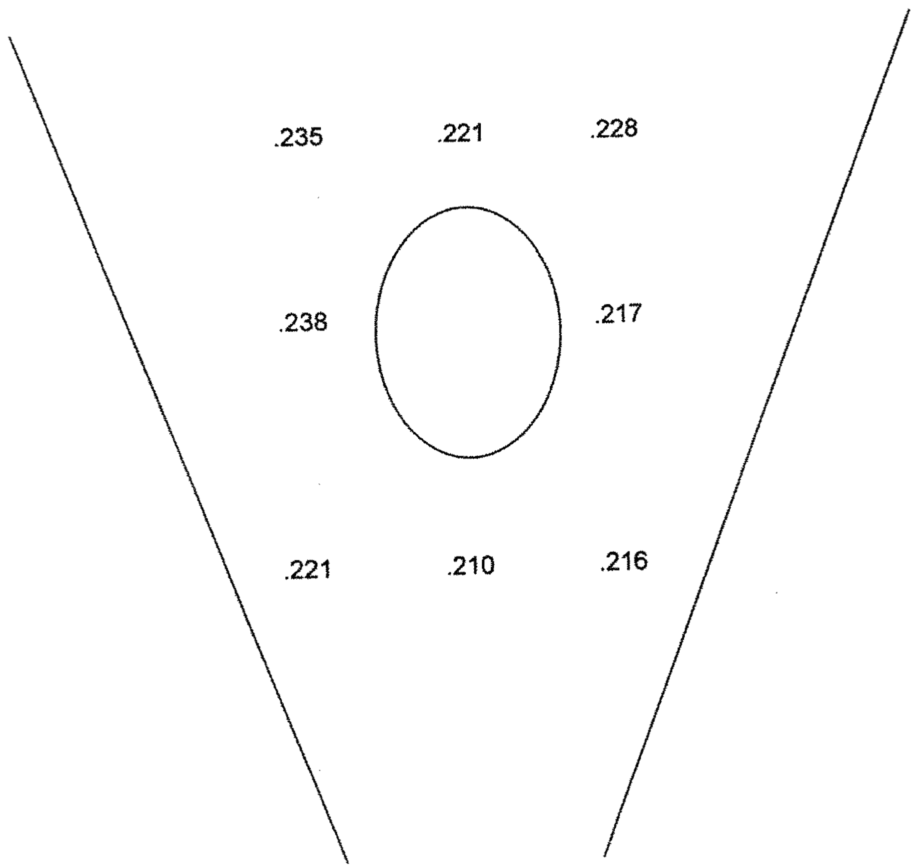
Hopper 5D1



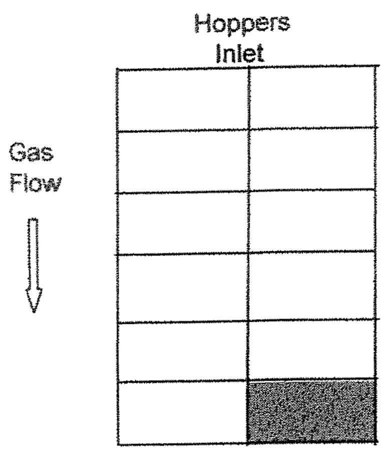
PacifiCorp Wyodak Power Plant



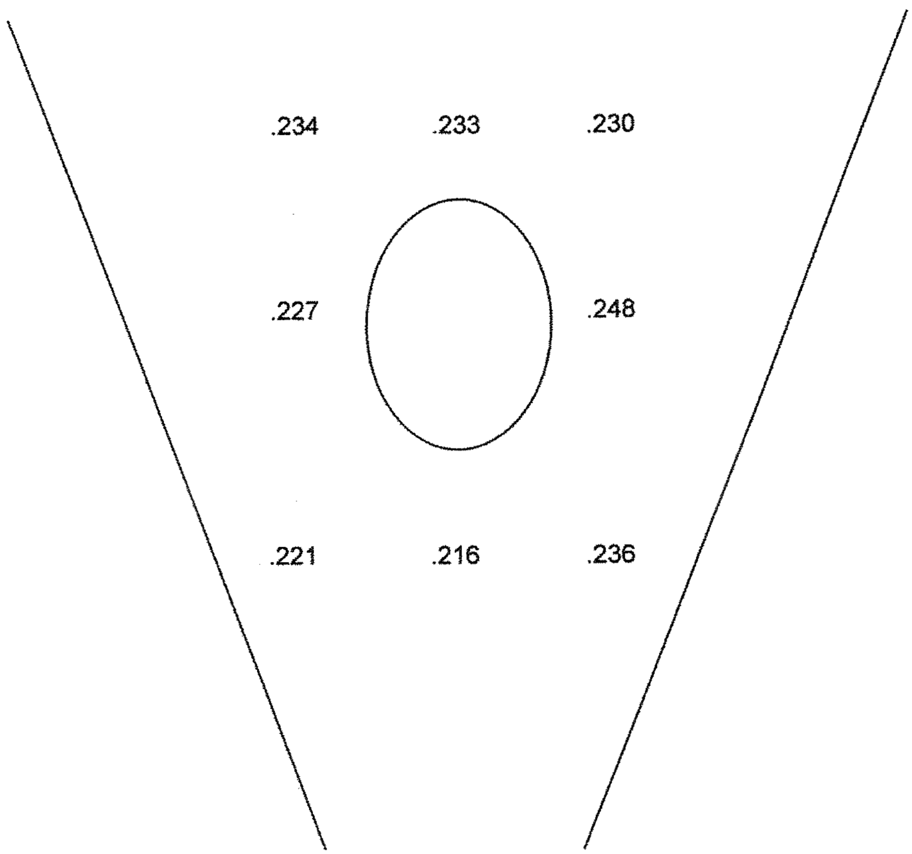
Hopper 5D2



PacifiCorp Wyodak Power Plant



Hopper 6D2



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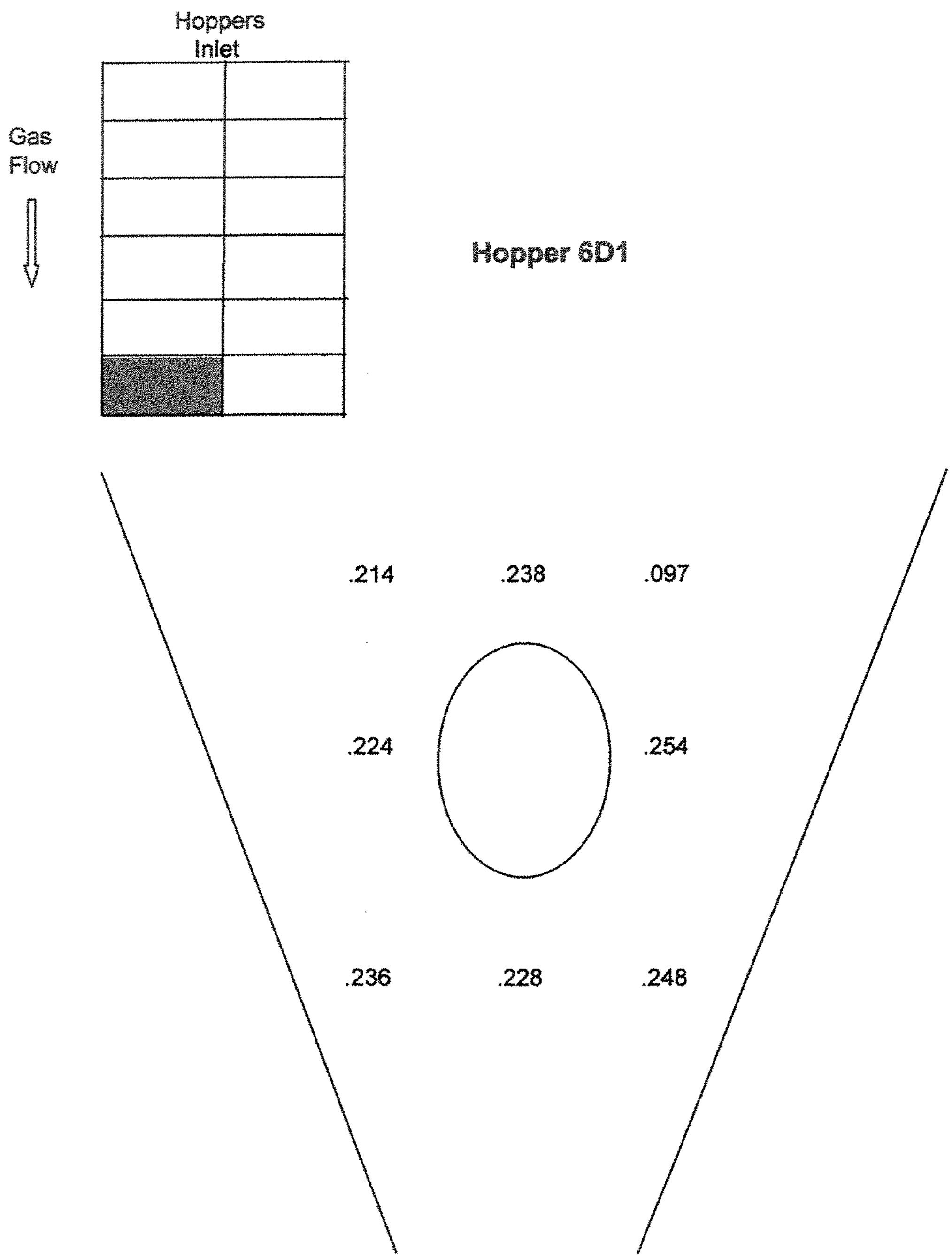

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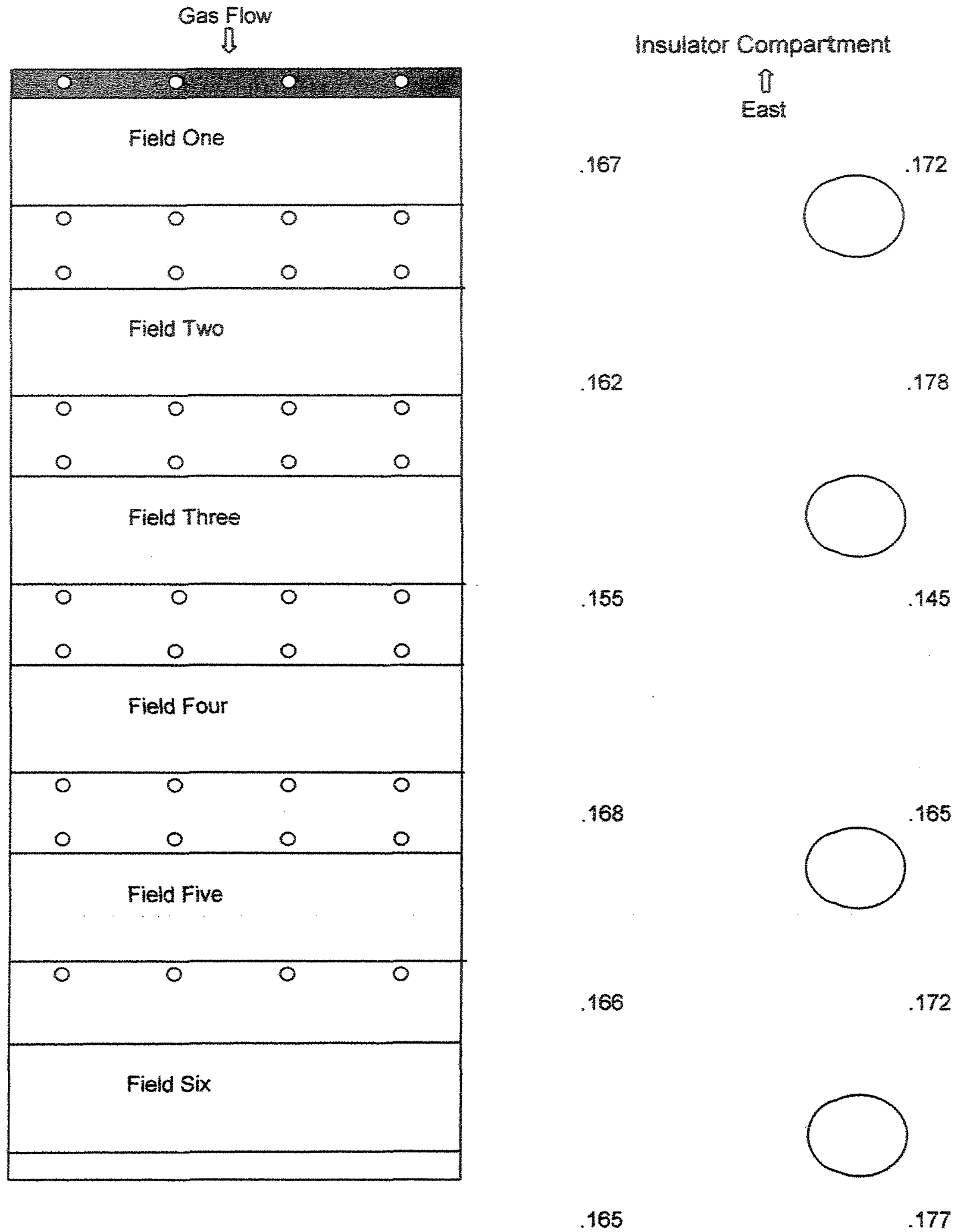

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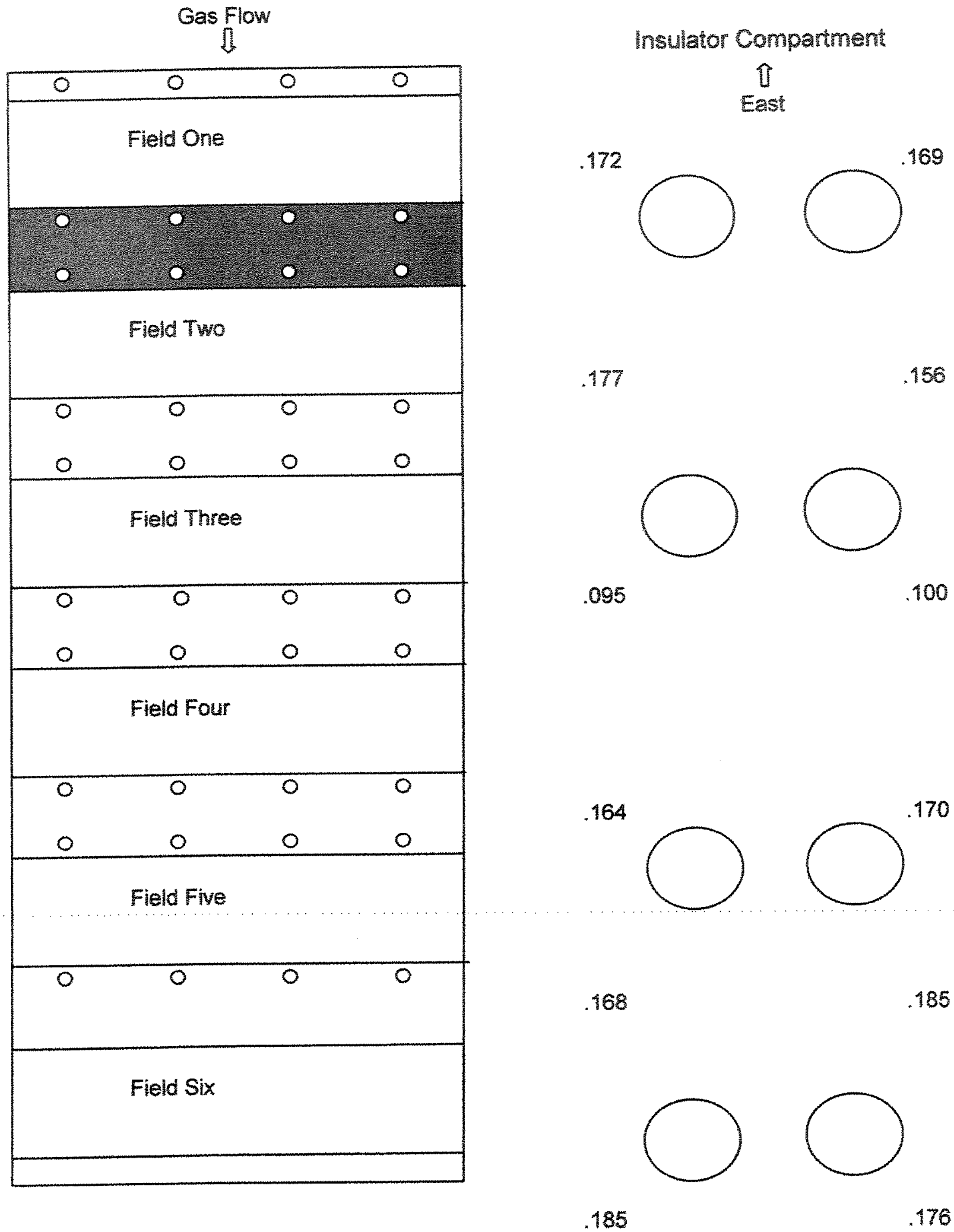

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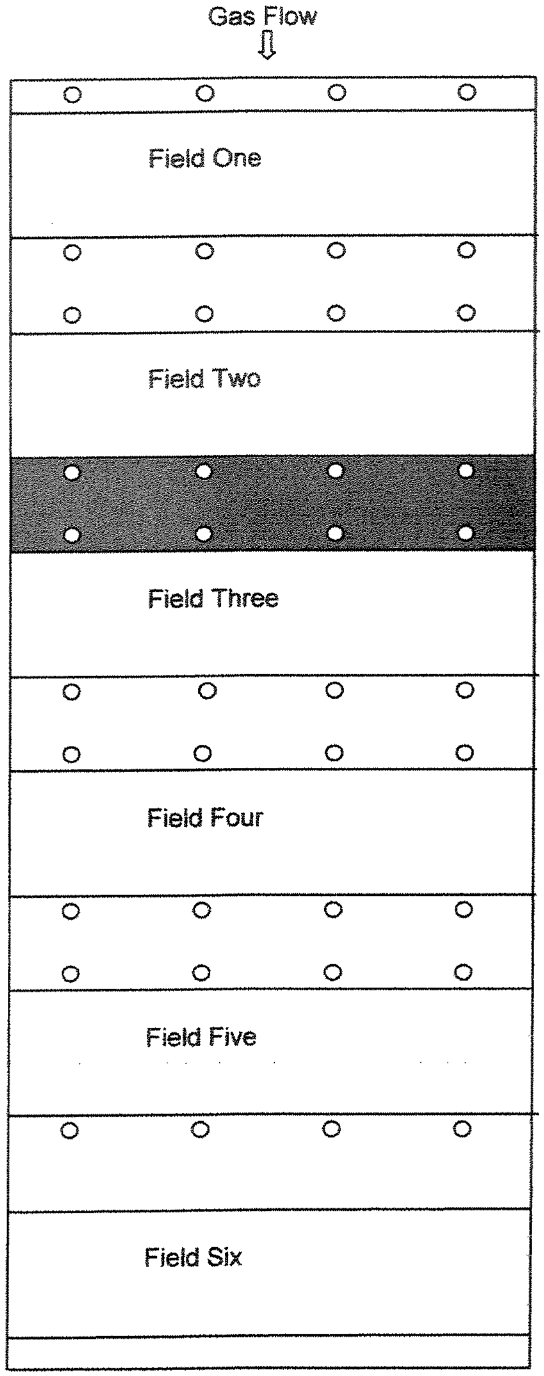

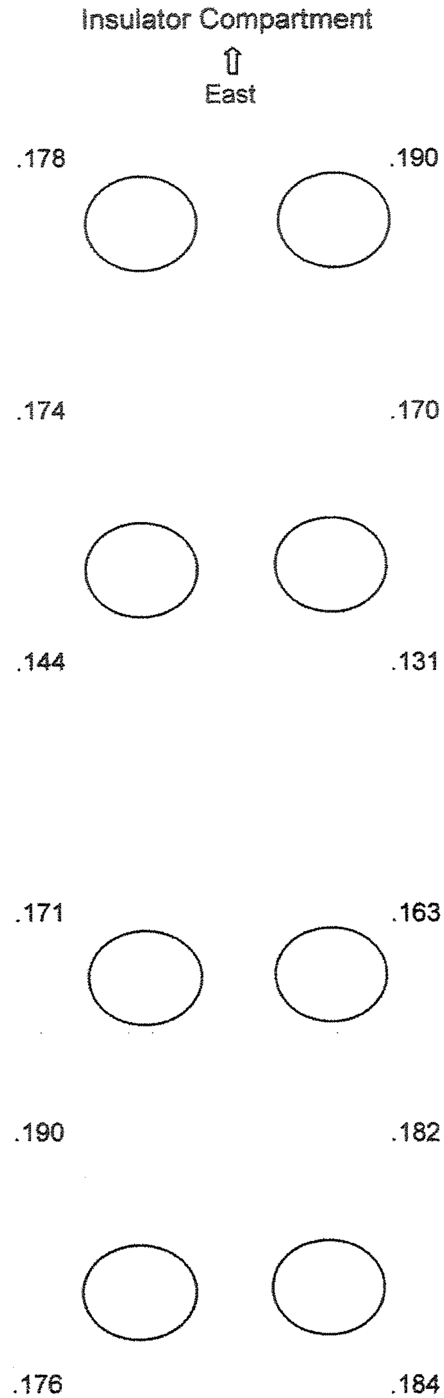

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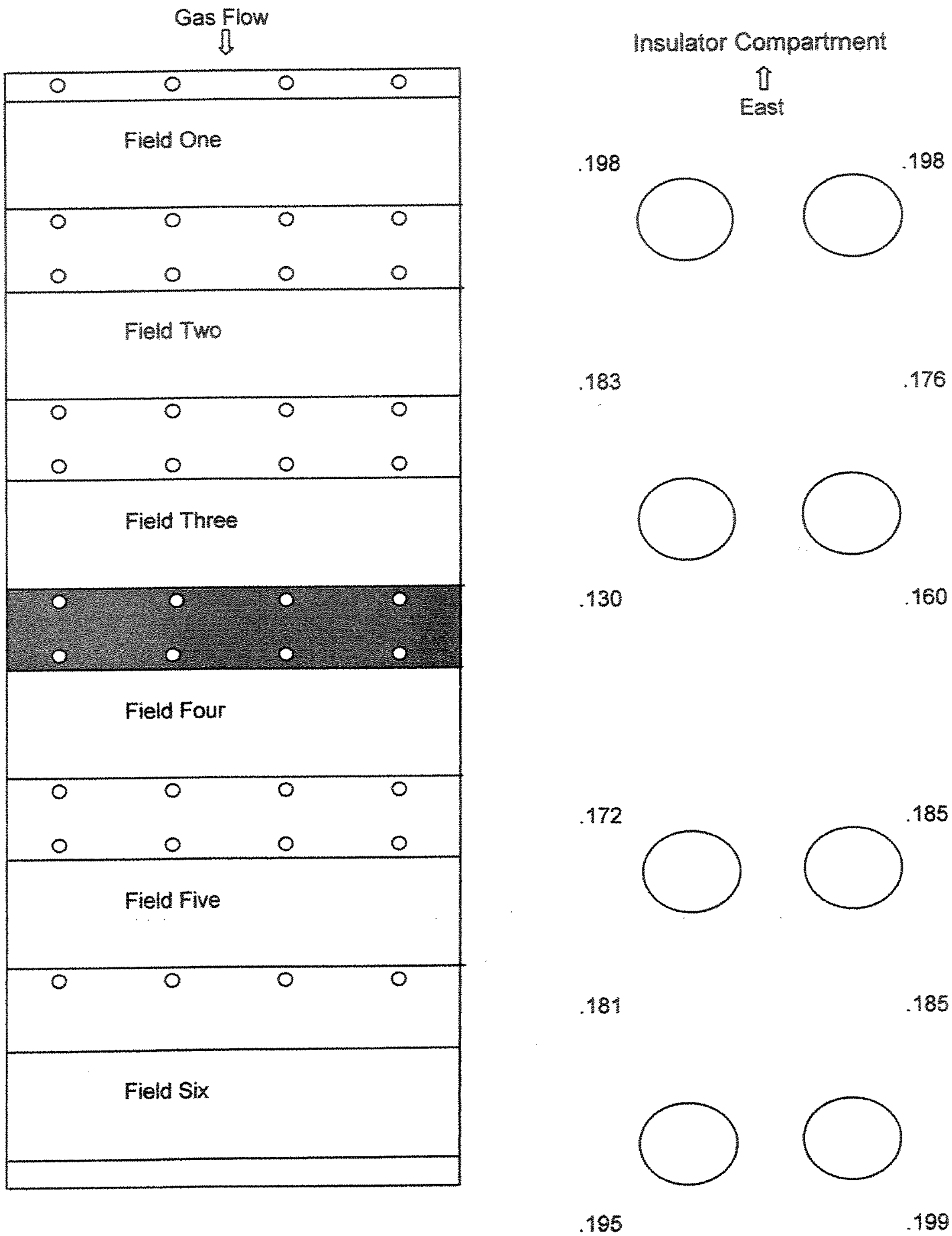

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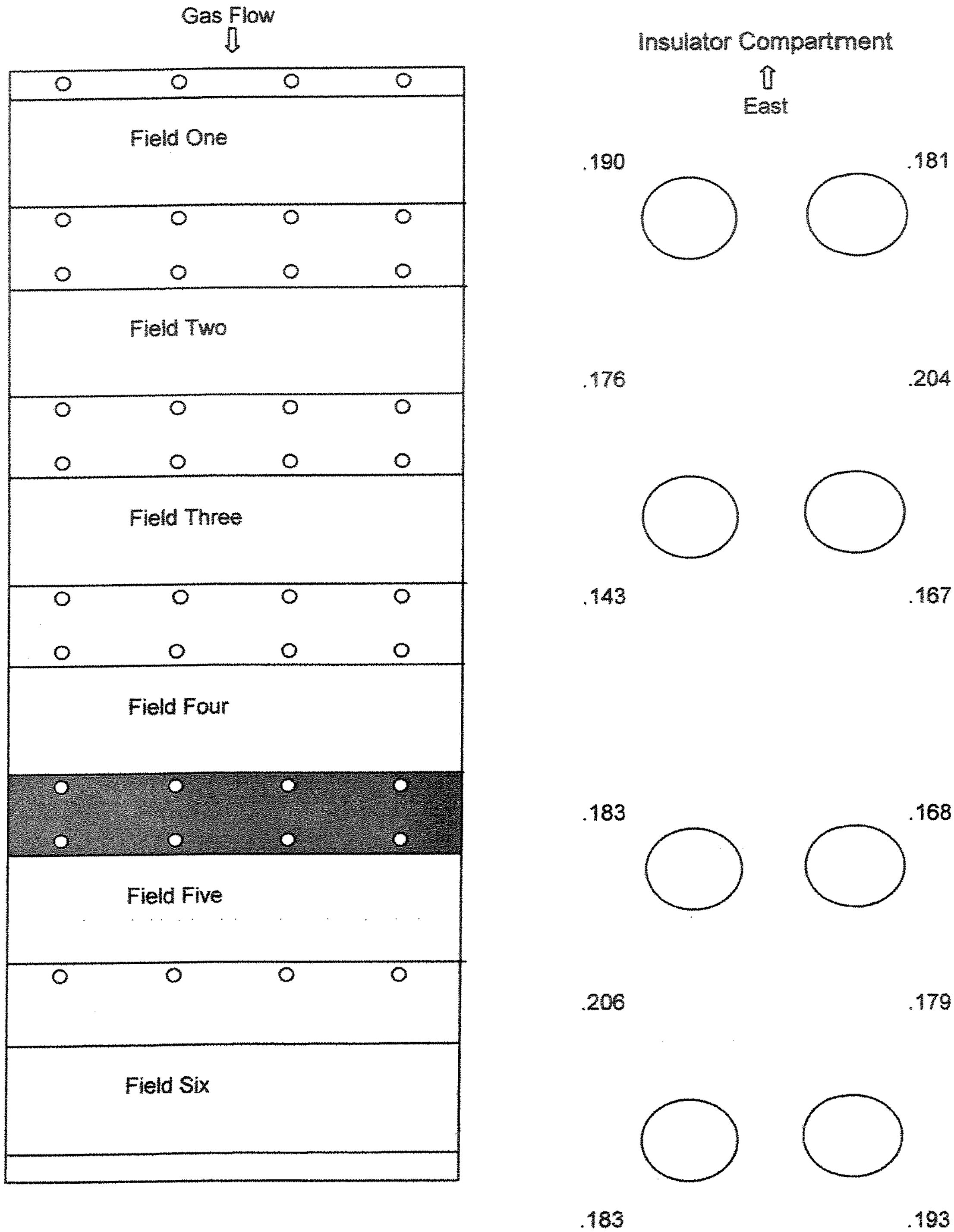

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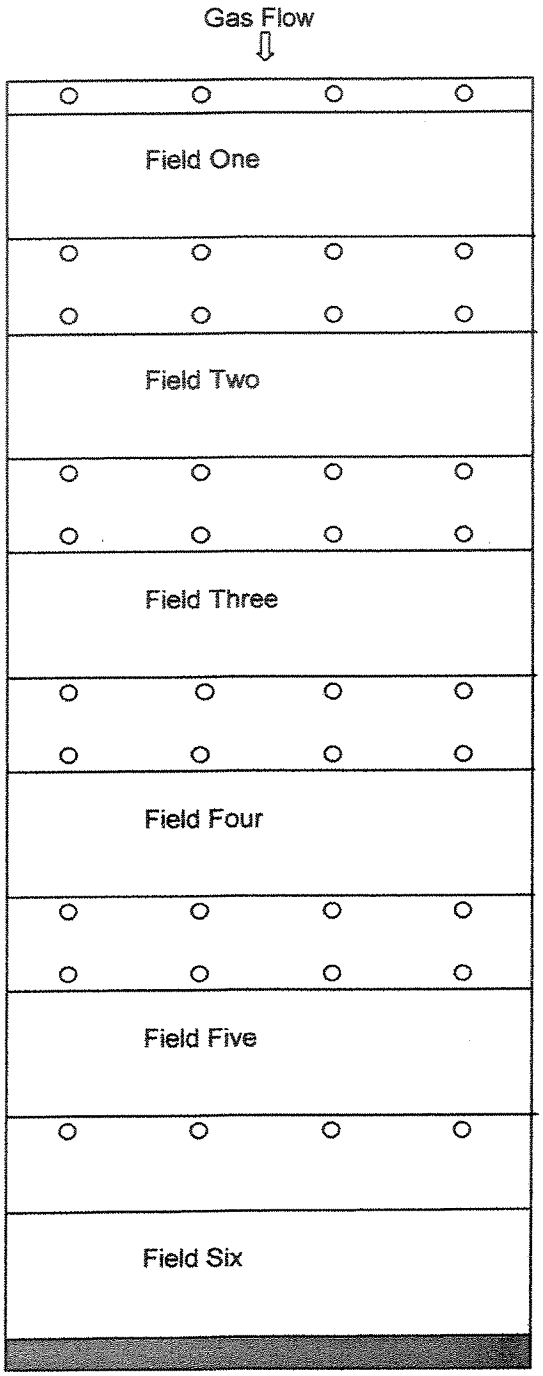

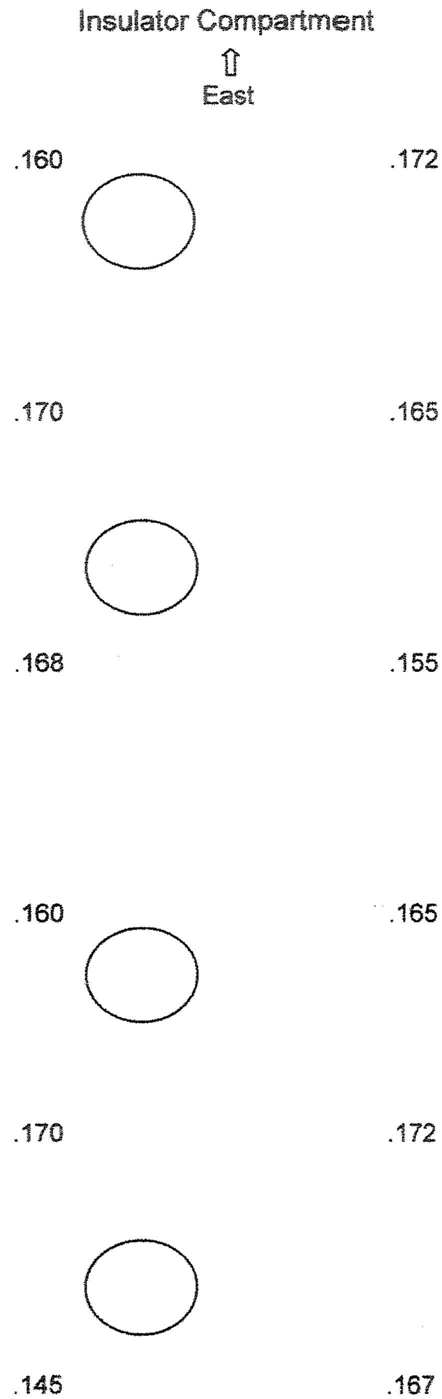

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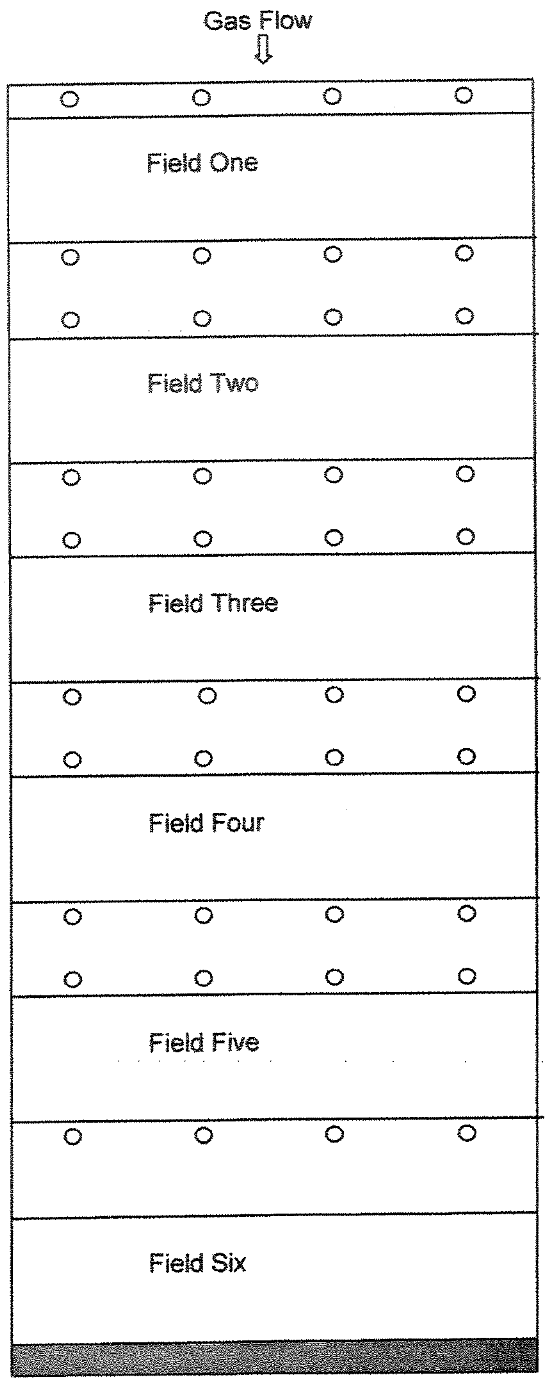

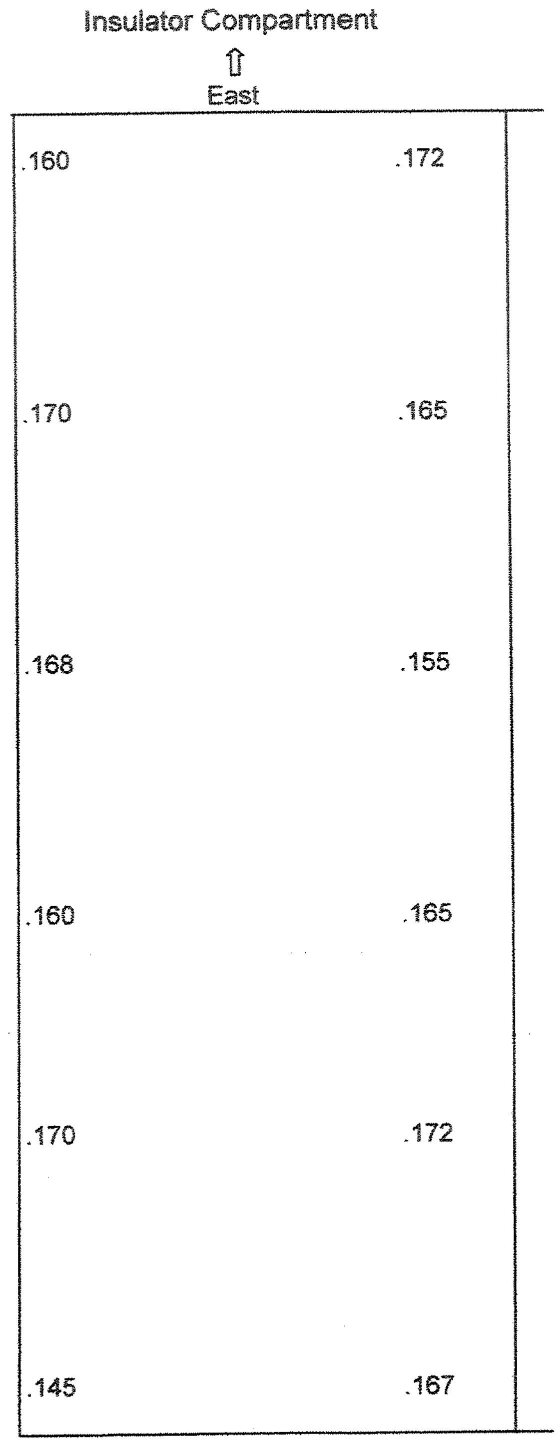

Appendix C

SEI Budgetary Proposal for ESP Rebuild

07 December 2007

VIA ELECTRONIC MAIL
ajay.jayaprakash@sargentlundy.com

Sargent and Lundy, LLC
55 E. Monroe
Chicago, IL 60603-5780

Attention: Mr. Ajay Jayaprakash

Reference: Budget Inquiry for Wyodak ESP rebuild

Subject: SEI Budget Proposal No. 07-173

Dear Mr. Jayaprakash:

Following is Southern Environmental's budgetary proposal for the supply, design, fabrication, delivery to the jobsite, installation, erection supervision, and start-up services required to rebuild the coal fired Electrostatic Precipitator (ESP) located in Wyodak Station.

Existing Installation and Proposed Design

The existing ESP unit consists of two (2) casings. Each casing consists of two (2) chambers with one hundred (100) gas passages spaced at twelve inch (12") centers. A total of twenty (20) TR sets currently power both the casings. The ESP has six (6) mechanical fields in the direction of gas flow.

Our approach to rebuilding these units is to completely remove the existing wire frame internals and convert the ESP's into an "American" design, including adding a penthouse, replacing the collecting plates, substituting rigid discharge electrodes for the existing wire frames, and providing new power supplies. In so doing, our design will be optimized in such a manner as to maximize the performance of the unit, while minimizing equipment and installation costs. Our experience indicates this design, utilizing wide plate spacing and switchmode power supplies, may well be the ideal combination of design features. This new design will greatly extend the life cycle of the ESP by significantly reducing maintenance downtime, as there will no longer be tumbling hammer rappers requiring maintenance that can only be performed with the unit off line, and no wire breakages.

The rebuilt ESP's at Wyodak will each have a configuration of two (2) chambers and twelve (12) mechanical fields, each nominally nine feet (9') long in direction of gas flow, and a collecting plate height of forty two feet and six inches (42.5'). There will be thirty-eight (38) gas passages per chamber, spaced at sixteen inches (16") totaling one hundred fifty-two (152) gas passages for both the casings.

To further maximize the corona power transfer into the precipitators we are offering, as an option, state-of-the-art switch-mode power supplies in lieu of conventional transformer-rectifier sets, current limiting reactors, and automatic voltage controllers. A switch-mode power supply combines the functions of a transformer-rectifier set, a current limiting reactor, and an automatic voltage controller into one compact package, but is in every way superior to these devices. A switch-mode power supply has very little DC ripple (3%-5% kVp-p) versus a conventional transformer-rectifier set (35%-45% kVp-p), and can react to sparks and arcs in microseconds versus milliseconds. The result of this is that a switch-mode power supply can deliver as much as 30% more corona power into a precipitator than a conventional transformer-rectifier set with a similar kVA rating. A switch-mode power supply unit has added benefits in that it presents a balanced 3-phase load to the electrical power system, with a power factor near unity (0.94), eliminating the electrical imbalances and other problems caused by the large single-phase loads and the low power factor of conventional transformer-rectifiers sets. Additionally, switch-mode power supplies provide a cost savings advantage in installation as there are fewer terminations and only a single three-phase power cable to install.

For Wyodak, sixteen inch (16") collecting plate spacing is being proposed. This is done mainly for two reasons. First, sixteen inch (16") plate spacing ensures that more power can be put in the box. In addition to that, sixteen inch (16") plate spacing entails fewer parts and pieces to be assembled, which in turn leads to lower material and installation costs.

ESP Design

The ESP consists of two casings each with two (2) chambers. The rebuilt ESP will have thirty-eight (38) gas passages in each chamber spaced at sixteen inch (16") centers, and is twelve (12) mechanical fields deep, each nominally nine feet (9') long by forty two feet and six inches (42.5') tall. The ESP also has twelve (12) electrical fields each nominally nine feet (9') long in the direction of gas flow. New electromagnetic rappers will be provided for both collecting plates and rigid discharge electrodes.

1.0 SCOPE OF SUPPLY

1.1 Scope of Work by SEI

1.1.1. One Unit (comprised of two (2) ESPs having two (2) chambers each) will be rebuilt in place, with a complete replacement of the internals, as follows (quantities are for one (1) unit):

1.1.1.1 Each rebuilt ESP will have twelve (12) mechanical fields each nominally nine feet (9') long in direction of gas flow. The collecting electrode height will be nominally forty two feet and six inches (42.5'), and each ESP will have seventy-six (76) gas passages spaced at sixteen inches (16"). There are two (2) such ESP's with similar configuration comprising one unit.

The ESP's will be equipped with Southern Environmental's **SEI/ELEX RS** discharge electrode made of SS 316. Customized high current-generating electrodes will be installed in the first two fields for effective charging of finely divided flyash particles. Standard ELEX discharge electrodes will be installed in the downstream fields for maximum corona current and voltage distribution at high current flow.

1.1.1.2 The rebuilt ESP will be equipped with Opzel, or equal, collecting electrodes. This solid, one-piece plate design is a rigid, baffled collecting electrode specifically designed to match the electrical characteristics of the SEI/ELEX discharge electrode. A total of one thousand eight hundred seventy-two (1872) collecting plates will be supplied.

1.1.1.3 The ESP's will be equipped with Southern Environmental's **SEI/ELEX RS** discharge electrode made of stainless steel. Customized high current-generating electrodes will be installed in one field for effective charging of finely divided flyash particles. Standard ELEX discharge electrodes will be installed in the downstream fields for maximum corona current and voltage distribution at high current flow. A total of nine thousand one hundred twenty (9120) electrodes are supplied for both the ESPs.

1.1.1.4 The unit will be equipped with a gas tight, pressurized and heated penthouse, with approximately six-foot (6') tall sidewalls fabricated from 10 ga. A36 plate, and a 1/4" thick cold roof covering the entire precipitator roof. The penthouse provides the housing of high voltage insulators and bus bars, and is complete with purge air heaters, and pressurization blower system.

1.1.1.5 The ESP's will be powered by SMPS (Switchmode power supplies) complete with microprocessor controls, and external ground switches/splitter switches to provide positive grounding of the high voltage side of each SMPS. This system will be housed in a ventilated roof weather enclosure.

1.1.1.6 The precipitators will be equipped with electromagnetic rapper systems for cleaning the discharge electrodes and the collecting electrodes, respectively. These systems will be supplied complete with microprocessor rapper controls.

1.1.1.7 Gas flow to the precipitators will be through horizontal inlet nozzles and will exit the precipitators through horizontal outlet nozzles.

1.1.1.8 Ventilated roof type weather enclosure.

1.1.1.9 Complete replacement of hot roof, cold roof, and casing walls

1.1.2 Complete key interlock system for personnel access doors and high voltage power supplies.

1.1.3 Complete insulation of cold roof and casing components. (With installation price)

1.1.4 Complete erection and installation of the materials listed herein as supplied by the contractor.

1.1.5 Field Service personnel for the mechanical and electrical inspections, and precipitator start-up. A total of twenty (20) days have been included.

1.1.6 Site staffing by an SEI Erection Technical Advisor for the duration of the project from receipt of material through completion of check out and start up. A total of 70 days have been included.

1.1.7 Freight, FOB job site predicated upon standard width unescorted loads.

1.1.8 Engineering and design services for the particulate emission system.

1.2 Scope of Work by Others

1.2.1 EXISTING EQUIPMENT

1.2.1.1 Existing common wall and hoppers, including accessories, in good condition.

1.2.1.2 Foundations and anchor bolts capable of supporting rebuilt ESP.

1.2.1.3 Thermal insulation for hoppers, plenums, and ductwork assumed to be in good condition.

1.2.1.4 Structural steel assumed sufficient to support Contractor's rebuilt ESP.

1.2.1.5 Hopper, hopper flanges, flyash removal below hopper flanges assumed to be in good condition.

1.2.1.6 Station grounding system in place below grade for attachment to precipitator support steel.

1.2.1.7 Existing structural wall between chambers in good condition.

1.2.2 ADDITIONAL ITEMS FURNISHED BY BUYER

1.2.2.1 Project and site permitting.

1.2.2.2 All LV power, control and instrumentation cable, and conduit between SEI furnished devices and their controllers/power supplies.

1.2.2.3 Tie-in of Contractor supplied controls to local control stations.

1.2.2.4 All final lubricants.

1.2.2.5 Area lighting and duplex receptacles.

1.2.2.6 Service air, 480 VAC electric power, and portable water during construction.

1.2.2.7 Opacity monitor and CEMS equipment, as required.

1.2.2.8 Unloading and storage of equipment prior to Contractor's arrival on site.

1.2.2.9 Performance testing.

1.2.2.10 Operating personnel for starting and preliminary operation.

1.2.2.11 Laydown areas.

1.2.2.12 Access platforms, ladders, and stairs from grade to sidewall platform level.

1.2.2.13 Ductwork upstream and downstream of tie-in points including dampers and expansion joints, as required.

1.2.2.14 Any additional equipment or component that becomes necessary to complete the installation as a result of information not revealed or available at the time of the bid submittal.

1.2.2.15 Timely and accurate completion of activities designated within Company's scope to enable Contractor to complete its portion of the work in accordance with execution dates stipulated in the specification.

2.0 PRICING

The budgetary break out price to provide the materials and services to rebuild the ESP unit (2 casings) is as follows:

Lump sum price for materials:

Twenty-one million ninety-one thousand six hundred dollars

($21,091,600.00)

Lump sum price for erection and installation:

Twenty-two million four hundred forty-six thousand one hundred dollars

($22,446,100.00)

The price quoted herein is in U.S. currency and is valid for forty (40) days. This budgetary price is present day, subject to escalation, and is exclusive of any applicable sales and/or use tax. The price is subject to mutually acceptable terms and conditions of sale. Payment terms will be determined at a later date. Also please note that the installation cost is based on merit shop labor performed by our own in-house construction company, Southern Erectors, Inc.

3.0 OTHER COMMERCIAL CONSIDERATIONS

3.1 All costs for the equipment and services as outlined in this proposal are included in the numbers above with the exception of any local, state, federal, or other such taxes, duties, etc.

3.2 Terms and conditions will be negotiated at a later date and will be subject to mutual acceptance by both Southern Environmental, Inc. and the client prior to award of contract.

3.3 Security at the job site will be the responsibility of the plant. This includes both men and equipment for access to, from, and while on the job site.

This proposal is being sent electronically via email. If you have any questions, or if additional information is required, please feel free to contact me at (850) 941-3034.

We at SEI feel that we provide a unique benefit to our customers due to our ability to provide a significant majority of the work within our own organization. Design and Engineering for the ESP modifications is accomplished within the SEI organization. Our sister company, Southern Erectors, Inc., fabricates all of the flat plate-work, structural components, and discharge electrodes at the same Pensacola, Florida location. Together, we represent the highest degree of vertical integration in today's market place and have a highly successful track record of quality installations as well.

We trust that this meets your current needs. If you have any questions, please do not hesitate to contact me. We stand ready to help you with any other issues you may have with the ESP. We at Southern Environmental, Inc. are pleased to be of service and look forward to working with you in the future.

Regards,
SOUTHERN ENVIRONMENTAL, INC.

Jit Chatterjee
Jit Chatterjee
Applications Engineer

Jit/slm

Cc: David.G.Sloat@sargentlundy.com
Amanda.L.Flynn@sargentlundy.com
Mick Chambers - SEI
John Caine - SEI
Charles Hayes – SEI
Dennis Oberg – Steam Sales

Appendix D

SEI Estimate for Upgrading ESP Internals to Stainless Steel

Smubear@aol.com
12/19/2007 12:54 PM

To david.s.helm@sargentlundy.com
cc
bcc
Subject Fwd: Wyodak SEI 07-173

David, I located your Email address from earlier correspondence.

----- Message from Smubear@aol.com on Wed, 19 Dec 2007 12:01:59 EST -----

To: ajay.jayaprakash@sargentlundy.com
cc: David.G.Sloat@sargent@lundy.com, Amanda.L.Flynn@sargentlundy.com, achatterjee@sei-group.com, smcwilliams@sei-group.com
Subject: Wyodak SEI 07-173

In response to the request for an adder to supply Stainless Steel collecting plates as an option to Carbon Steel, please be advised that the net adder is $13, 579, 300.00 (Thirteen million five hundred seventy nine thousand three hundred US dollars).

Yours truly,

Charles Hayes SEI 850-982-1769

Southern Environmental, Inc Chayes@sei-group.com ,Smubear@aol.com

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See AOL's top rated recipes and easy ways to stay in shape for winter.

Appendix E

HRC Proposal for ESP to FF Conversion

BUDGETARY Technical Proposal
ESP to PJ Conversion
Utilizing A Low Pressure Pulse Jet
Type Fabric Filter System

For

PacifiCorp

WYODAK POWER STATION

PROPOSAL NUMBER P-B720 Rev.1

HAMON RESEARCH-COTTRELL, INC.
Somerville, New Jersey

Mar. 19, 2008

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	3
2.0	SYSTEM DESCRIPTION	3
3.0	BASIS OF DESIGN	8
4.0	EQUIPMENT DESCRIPTION	9
5.0	MATERIALS OF CONSTRUCTION	10
6.0	DIMENSIONS	11
7.0	SCOPE OF SUPPLY	12
8.0	PERFORMANCE GUARANTEES	13
9.0	SCHEDULE	15
10.0	PRICING	16
11.0	EXCEPTIONS	17
12.0	APPENDIX	22

1.0 INTRODUCTION

This proposal is provided in response to **Sargent & Lundy's** request for a proposal to convert the existing PacifiCorp WYODAK Station, Electrostatic Precipitators to a Pulse Jet Fabric Filter system as previously supplied for Huntington Station, Unit #2.

Presented in this proposal is conceptual design data and pricing for the engineering design, and supply, of equipment required to construct four **(4)** Low Pressure/High Volume Pulse Jet Fabric Filter, Walk-in Plenums type design, isolatable compartments in the existing ESP casings. A total of one **(1)** compartment will be constructed in each ESP casing, for a total of four **(4)** compartments per boiler. A flow communications duct will be provided at the inlet and outlet of the ESP casings to allow flow to transfer to each ESP/PJ casing to provide both flow balancing and compartment isolation and to treat the each ESP/PJ casings as a single fabric filter system. An integral, 100% flow bypass system has also been provided to allow the newly constructed fabric filter compartments to be isolated in case of system upsets and prevent damage to the filter bags.

The ability to convert the existing ESP casings into four **(4)** isolatable compartments will provide PacifiCorp with the highest degree of operational flexibility and system availability.

HRC is utilizing its vast amount of experience with the conversion of ESP's into pulse jet fabric filters. Our Low Pressure-High Volume **(LPHV)** pulse jet fabric filter technology has been effectively installed in many ESP casings in the past both domestically as well as internationally with many installations in Australia, South Africa and other countries, including China and Europe. Our installations at Alabama Power's E.C. Gaston power station provided unique challenges due to both space constraints as well as outage restrictions. We welcome PacifiCorp and your associates to visit this installation and see our successful installations on both Units #2 & #3. All guarantee levels have been achieved at this facility, with emission levels well under **0.012** lb/MMBtu and associated opacity levels typically under **5%**. All current ESP/PJ conversions are based upon the use of on-line pulse cleaning and many of the installations have as few as only two **(2)** isolatable compartment/boiler. HRC is truly one of the Leaders in the Industry on this type of pulse jet installations.

2.0 SYSTEM DESCRIPTION

Hamon Research-Cottrell is proposing to convert the existing ESP casings into a pulse jet fabric filter system on PacifiCorp's WYODAK Power Station, coal-fired boiler, utilizing our **Low Pressure High Volume** (LPHV) fabric filtration technology to collect particulate from the flue gas. Four (**4**) independent fabric filter compartments will be constructed within the existing **Rothemuhle ESP** casings, utilizing a walk-in plenum design for bag/cage access. Large compartment modules will be sub-assembled and pre-insulated to the greatest degree possible at grade and lifted into place by crane for installation in the existing ESP casings. Each walk-in plenum compartment section will contain six **(6)** filter bag bundles, each having a total of **904** bags per bundle for a total of

5,424 bags per compartment. The proposed LPHV pulse cleaning system has successfully been utilized on many similar ESP/FF retrofit and conventional boiler baghouse installations.

2.1 Description of Operation

Our Low Pressure-High Volume pulse jet fabric filter utilizes a unique cleaning mechanism which provides on-line cleaning with the cleaning manifold continuously rotating at approximately 1 R.P.M. above the tube sheet.

The bags are oblong in shape and are arranged in concentric circles with regular spacing specific to each circle. The compactness of this arrangement is only possible with non-alignment of the bags in the radial direction. In the circumferential direction, the bag spacing is regular but specific to each row. This high packing density is uniquely suitable to its use on ESP conversions.

To more fully understand the low pressure pulse jet fabric filter system you must realize that almost all of the full complement of the powerful cleaning flow is derived from the compartment's air reservoir. Figure 1 depicts an integral tank mounted design.

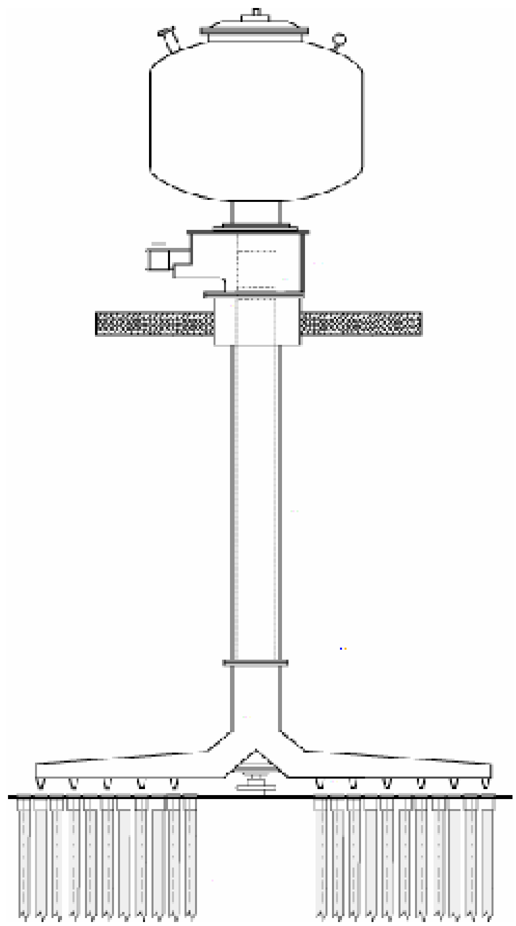


Figure 1

2.0 SYSTEM DESCRIPTION (CONTINUED)

2.1 Description of Operation (Continued)

For this proposal, we will be offering an integral tank design with either a chain drive or direct drive arrangement. The LPPJ system's nozzle can be located anywhere on the lengthwise centerline of the bag top, with some degree of "blockage" of the cage top, without detriment to the cleaning effectiveness.

Unlike conventional pulse jet fabric filters, relative position of the LPHV nozzle to bag is not as critical. The cleaning air will be released from the reservoir either by a preset timer, or by pressure drop, and will be directed to the manifold via a quick opening pilot assisted diaphragm valve.

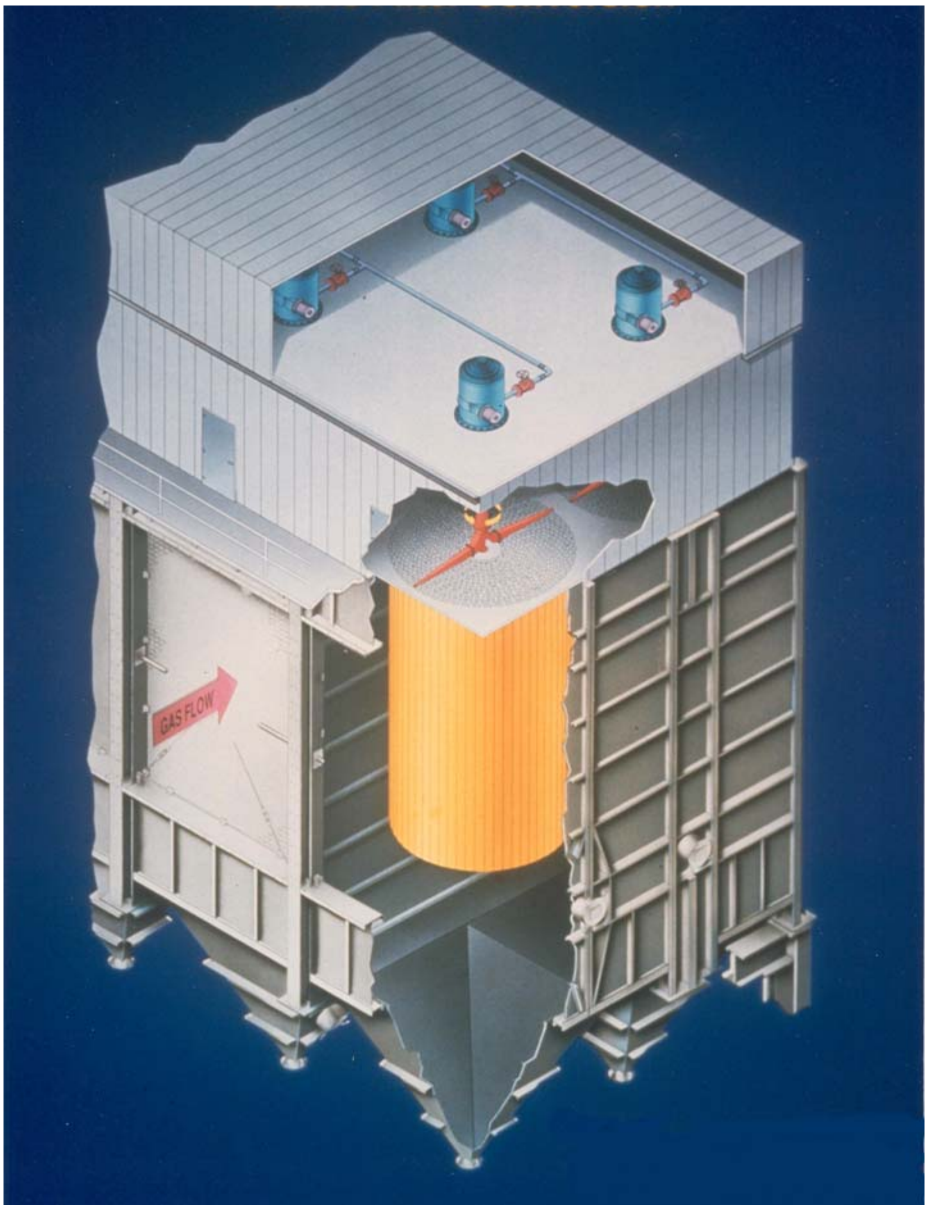
The rotating manifold is supported on the tube sheet by a heavy duty, sealed thrust type bearing, designed for long life and low maintenance. The cleaning air distribution pipe and rotating manifold/nozzle assembly is designed such that pressure losses are kept to a minimum and stored energy in the reservoir is utilized to the fullest.

In addition to the primary cleaning action, which is produced by an initial rapid fabric deceleration and dust cake dislodgment, the LPHV Pulse jet incorporates an additional feature, which enhances fabric cleaning. The high volume of stored cleaning air flowing to the bags in the reverse direction provides a "Back-Flush", or reverse air cleaning effect, which augments the dynamic cleaning of the "pulse" itself. The cleaning air volume includes an extra margin for those cases where the nozzle may be located between bags.

The flue gas enters each compartment through electric actuated inlet louver dampers designed for low mechanical pressure drops, and compartment isolation for maintenance. To ensure the best possible flow distribution within the converted ESP casing, compartment entrance velocities are kept low, approximately **350 fpm** or less in the gross operating condition at the compartment inlet face, to minimize mechanical pressure drop and to also allow larger particulate to fall out into the hopper. The compartment internal flow design, utilizes internal perforated plate distribution devices and vaning as required, providing full height filtration and low resulting can velocities, thus promoting reduced cleaning frequency, extending bag life and improving filtration efficiency.

Cleaning air will be delivered to the overall baghouse system via sixteen **(14)** 33% capacity, low pressure positive displacement blowers. A total of four **(3)** blowers will be provided per compartment, three **(3)** operating, plus one **(1)** common spare for two compartments.

The blowers for the overall fabric filter are connected by a common piping manifold system, which feeds the clean air manifold reservoir tanks located at the baghouse roof level. The air reservoir tanks are sized to deliver a total air volume of **48 cu. ft,** per pulse of cleaning air. The blowers are expected to be at located on the roof of the ESP/FF walk-in plenum, under the ESP weather enclosure.



2.0 SYSTEM DESCRIPTION (CONTINUED)

2.1 Description of Operation (Continued)

The use of low pressure, positive displacement blowers, is a major improvement over the use of air compressors and dryers that are required for high pressure pulse jet designs. Air dryers are not required with positive displacement blowers because of the relatively low pressure. In addition, the cleaning air piping is not subject to freezing and/or condensation that can occur in high pressure, compressed air lines in locations subject to cold ambient temperatures such as found at Huntington Station.

A particular benefit of this unique technology is the requirement for **fewer pulse cleaning air diaphragm valves**. The LPHV technology requires only one "heavy duty" valve to clean **904** filter bags per bag bundle or six (6) per compartment. For this project, only **twenty four (24),** diaphragm valves are required per baghouse/boiler. In contrast, a conventional medium/high pressure pulse jet design would require at least 272 valves per compartment assuming a maximum of 20 bags per valve, equating to **1,088 valves and associated pulse pipes** per baghouse. Not to forget the significant reduction in required I/O's

In addition, the LPHV diaphragm valve, located outside the gas stream, is designed to last longer than conventional valves. A silencer is included over each diaphragm valve to maintain sound pressure levels below **90** dba.

The volume of each cleaning air pulse is derived from theoretical gas laws as well as the number and length of bags being cleaned. The frequency of cleaning, and therefore the required flow rate of cleaning air, is determined from formulae derived from empirical data that has been gathered from an extensive amount of testing carried out at many pilot and full scale pulse jet installations.

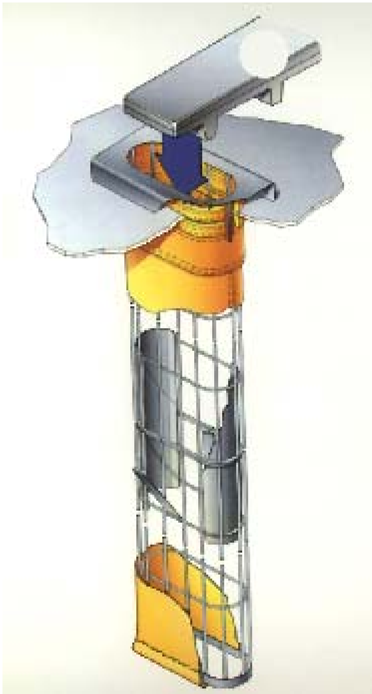
Bag Inspection and Replacement

A significant benefit of this cleaning method is the absence of blow pipes in the tube sheet area. This allows the bags and cages to be easily accessed for inspection or replacement. Only a single, trifurcated rotating manifold arm is located over each bundle of bags. This manifold arm can be moved should it happen to be stopped over the top of a failed bag. With only three **(3)** rotating cleaning manifold arms located in each compartment, inspection and maintenance costs in locating and replacing a potentially failed bag are greatly reduced. All other maintenance is done externally and can be accomplished while the system is on-line. This is a significant improvement over the current ESP maintenance, which must be accomplished while the entire ESP casing is isolated or the boiler is off-line.

2.2 Filter Bags

Each compartment will contain six **(6)** cylindrical bag bundles, each with **904** filter bags, with a **total of 21,696 bags installed** in the entire fabric filter plus an additional **(2%)** will be supplied as spares. The base filter bags for this project are **28'-3"** in length and will be fabricated from a nominal **18 oz/yd^2 weight PPS felt** which is HRC and EPRI's standard recommended fabric for this application. Industry experience has found the proposed **18 oz**. PTS felt fabric adequate to meet the required emission levels.

The bags have an elongated cross section, which is essentially oblong with rounded ends to promote better movement and release of the dust. The bag/cage fixing method has been designed for ease of installation and maintenance. The bags are secured in the tube sheet by means of a stainless steel snap band that is sewn into the cuff of the bag. No tools are necessary for installation of the bags and/or cages.



2.3 Filter Bag Support Arrangement

The filter bag support cages correspond in cross section to the "oblong" shape of the bags and tube sheet openings. The outside dimensions of the cage are slightly smaller than the inside dimensions of the bag along with a tapered lower section to facilitate cage insertion into the bag and help promote more efficient bag cleaning.

Cages are constructed of heavy **9 gauge mild steel** wires for rigidity, durability and long life. There are **14** vertical wires, secured by horizontal wires spaced at a minimum of 6" intervals. Cages are supplied in three **(3)** sections to reduce the need for inordinately high headroom in the clean air plenum, thus reducing steel and weight. Over 100,000 similar type cages have been provided on similar retrofit installations. The cage sections are firmly held together by an interlocking connection and internal guide plates at the joint to achieve a smooth, rigid, and perfectly aligned connection. This cage design has been successfully used on similar pulse jet boiler applications. In addition to those cages required for the initial installation, an additional **(2%)** will be supplied as spares.

3.0 BASIS OF DESIGN

The following table lists the Basis of Design criteria assumed for this proposal.

DESIGN CONDITIONS		
	Maximum	
Flue Gas Flow Rate	**1,876920 ACFM**	
Inlet Concentration	259,000 Lb./HR 16.1 /GR/ACF	
Guaranteed FF Outlet Emission (Filterable)	**0.012** Lb/MMBtu	
Guaranteed Opacity (%) FF Outlet	**10**	
Operating Temperature	170 degrees F	
Excursion Temperature – (excluding bags)	Not provided degrees F	
Operating Pressure	20 +/-, "W.C.	
Design Pressure	**35** +/-, "W.C.	
Seismic Zone		
LOADS		
Snow	30 PSF	
Wind Load	100 MPH Exp “C”	
Air Temperature		
Min	-25 ˚ F	
Max	105˚ F	
Bulk Density; Structural	90 PCF	
El. Above Sea Level	6,000 Ft	

4.0 EQUIPMENT DESCRIPTION

The following table lists the salient features of the proposed design for this proposal.

FABRIC FILTER CONFIGURATION			
	COMPARTMENT	**TOTAL CASING**	
No. of Baghouses		1	
No. of Compartments / Baghouse		4	
No. of Bundles	1	24	
No. of Bags	5,424	21,696	
Bag Length		28'-3"	
Bag Diameter (Nominal) Oblong Shape		4.9"	
Effective Cloth Area/Bag	31.59		
Total Effective Cloth Area	171,338	685,351	
Air-to-Cloth Ratio			
Gross	On-Line Cleaning	2.74	
Net	Maintenance	3.65	
Net-Net	NA	NA	
Number of Pulse Valves	6	24	
Cleaning Air Blower System			
No. of Blowers		10	
Blower Capacity		1,450 CFM	
Blower Design Pressure		9-14.9 psi	
Estimated Total Operating Load		1,080 KW	

5.0 MATERIALS OF CONSTRUCTION

The following table lists the Materials of Construction for major fabricated items included in this proposal.

MATERIALS OF CONSTRUCTION			
	PLATE THICKNESS MATERIAL	STIFFENER MATERIAL	
ESP/PJ Walk-in Plenum	5 mm JIS 3101 SS400	Same	
Hoppers	NA		
Tubesheet	6mm JIS 3101 SS400	Same	
Bag Material	PPS, 18oz: Felt		
Bag Cage	Mild Steel (MS)		
ESP Ductwork Modifications	Not included		
Insulation & Lagging	By Others		
Handrail and Posts	1 1/4" std. pipe - HR		
Toe Plates	1/4" x 4" C.Q.M.S.		
Grating and Stair Treads	1- ¼" x 3/16"bearing bars		

6.0 DIMENSIONS

For overall dimensions of this unique ESP/PJ Conversion, please reference the attached General Arrangement drawings. The FF system will be installed within the existing ESP footprint with no additional space required nor foundations needed.

7.0 SCOPE OF SUPPLY

The scope of supply includes the engineering design and material supply, is as follows:

7.1 Four **(4)** Fabric Filter Compartments with Walk-in Plenums
7.2 Compartment tube sheets will be sized for 22 ring bundles which will allow for future installation of up to 160 bags per bundle or 3,840 bags in total.
7.3 **21,696** 18 oz PPS filter bags, oblong shape, **28'-3"** long.
7.4 Mild steel cages, **14** vertical wires, **9 gauge**, **three-piece** construction.
7.5 **2%** spare filter bags and **2%** spare cages.
7.6 Ten **(10)** positive displacement cleaning air blowers, eight operating at **50%** capacity each and two common spares
7.7 Twenty four **(24)** Cleaning Air Mechanisms
7.8 Inlet and Outlet Duct Modifications and support steel as required.
7.9 Full Weather Enclosure over the roof of the fabric filter including heaters and ventilators
7.10 Pneumatic actuated Inlet Dampers
7.11 Pneumatic actuated Outlet Dampers.
7.12 Inlet and Outlet Expansion Joints as well as those at the fan inlets
7.13 Clean air piping from blower package to cleaning assembly air reservoirs.
7.14 Access to the Walk-in plenum at the tube sheet level, existing stairs will be reused.
7.15 Visolite or equal leak detection powder will be provided for bag leak detection
7.16 HRC will conduct a structural analysis of the existing Outlet Ductwork, ESP casing and support structure to determine the extent of casing reinforcement and bracing modifications required, as related to converting the ESP to a baghouse. All necessary materials to make the modifications will be provided as a project change order.
7.17 Design for baghouse heat insulation on hot roof
7.18 Checkered plate walking surface over customer supplied insulation on hot roof
7.19 ESP access door blank-offs plates
7.20 CFD Model of ESP/FF System
7.21 Twelve **(12)** IMTEC 2'x 5'compartment access doors.
7.22 Twelve **(12** HRC standard 3'x3' doors on the roof
7.23 Inspection & Startup service
7.24 Training, three **(3)** class sessions, 6 to 8 hrs per class
7.25 Erection Advisor, **1,000** Hrs

7.0 SCOPE OF SUPPLY

Scope to be performed by others:

7.26 Induced draft fans
7.27 MCC's & Power Distribution System and Control House including HVAC
7.28 DCS
7.29 Foundations (As required)
7.30 Performance Testing
7.31 Wire and Conduit
7.32 Pipe Insulation and Heat tracing, as required, by others
7.33 Heat Insulation and Lagging, as required
7.34 Area lighting
7.35 Installation of HRC supplied equipment, including relocation and re-use of existing weather enclosure over top of new HRC provided plenums
7.36 Any other items not specifically outlined in HR-C scope of supply.
7.37 Hopper Level Detectors
7.38 Hopper Heaters if required

8.0 PERFORMANCE GUARANTEES

Seller's sole guarantees are those contained in this proposal. These guarantees are contingent upon the correctness and accuracy of the information provided by the Buyer.

8.1 Particulate

Hamon Research-Cottrell guarantees that when the fabric filter is operating under the design conditions, the maximum particulate concentration at the baghouse outlet using EPA Method 5, (excluding condensibles), will not exceed **0.012 LB/MMBtu**.

8.2 Opacity

Hamon Research-Cottrell guarantees the particulate opacity at the fabric filter outlet will not exceed **10%** downstream of the fabric filter based on a 6-minute average, exclusive of water vapor. Final opacity guarantee is contingent upon final Client location of opacity monitors.

8.3 Pressure Drop

Hamon Research-Cottrell guarantees when the fabric filter is operating at the design conditions, the time average pressure drop from the AH outlet to the ID fan inlet will not exceed **5.5"** w.c. with all compartments in operation, and **6.5"** w.c. with one (**1**) compartment isolated for maintenance.

8.4 Bag Life

Hamon Research-Cottrell guarantees, when the fabric filter is operating under the design conditions, the life of the filter bags for a period of **42** months, from the date of initial flue gas entry into the compartments, or **48** months from delivery, which ever occurs first. Hamon Research-Cottrell will provide a replacement bag for any bag that fails under normal use during this guarantee period on a one-for-one basis.

8.5 Auxiliary Power

Hamon Research-Cottrell guarantees that when the equipment supplied in this proposal is adjusted and operated at the design conditions given in Section 2.0, the average annual 24-hour power consumption, as measured on the line side of the MCC, will not exceed **1,080 kw, excluding all seasonal loads, hopper heaters and auxiliary equipment.**

8.6 Delays or Improper Operations

If, because of delays or improper operation between completion of erection and the performance tests, the equipment is not in the same condition when the tests are to be made as during initial operation, the Owner shall restore the equipment to such condition before any tests are conducted.

9.0 SCHEDULE

HRC estimates that it will take approximately 42,700 direct manhours to install the modifications required to convert the existing ESP to a fabric filter. Assuming we can work two shifts of 7/12's during the outage, with an average crew size of 36 journeyman and two cranes we anticipate the following installation duration:

1. Pre-outage work……………….. 7 weeks (1 shift - 5/10's)
2. Outage, including DEMO…….. 8 weeks (2 shifts – 7/12's)
3. Post Outage……………………… 4 weeks (1 shift - 5/10's)

Replacing the casing above the hoppers would add approximately 2 weeks to the outage duration.

10.0 BUDGETARY PRICING

Hamon Research-Cottrell's price to furnish engineering design and material, as outlined in this proposal, is as follows:

Material Only……………………………………………..**$13,200,000**

Option to replace casing above the existing hoppers and add new access;

Add………………………………………………………..$2,400,000

- **Note: -** Buyer shall pay to Seller, in addition to the prices provided for herein, any foreign or domestic duty, sales or use tax, Value Added Tax (VAT), fee, or other tax or charge (hereinafter "tax"), now or hereafter imposed, that Seller may be required by any municipal (including special taxing authority), state, federal or foreign government law, rule, regulation or order to collect or pay with respect to the sale, transportation, storage, delivery, installation or use of the Work furnished hereunder, or will provide Seller with appropriate exemption or direct payment certificate. Buyer shall defend, indemnify and hold harmless Seller from and against all liabilities for such taxes or charges and attorneys' fees or costs incurred by Seller in connection therewith.

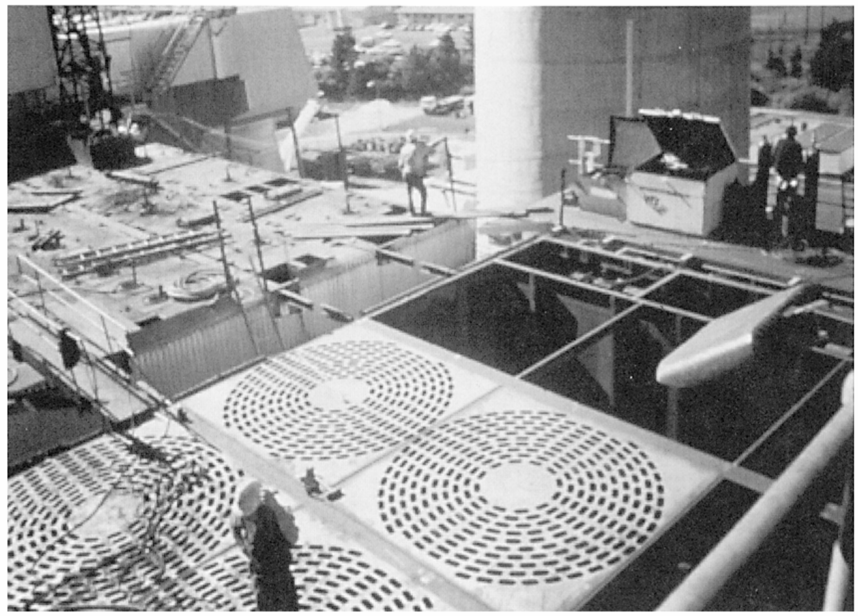
11.0 EXCEPTIONS/CLARIFICATIONS (TO BE COMPLETED)

None at this time.

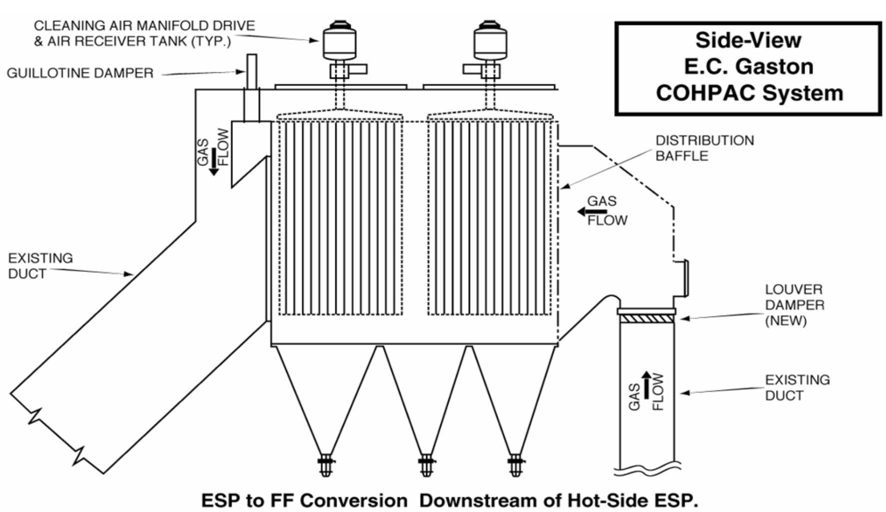
APPENDIX:

Typical ESP Conversion Photos:

ESKOM SA - Hendrina Station

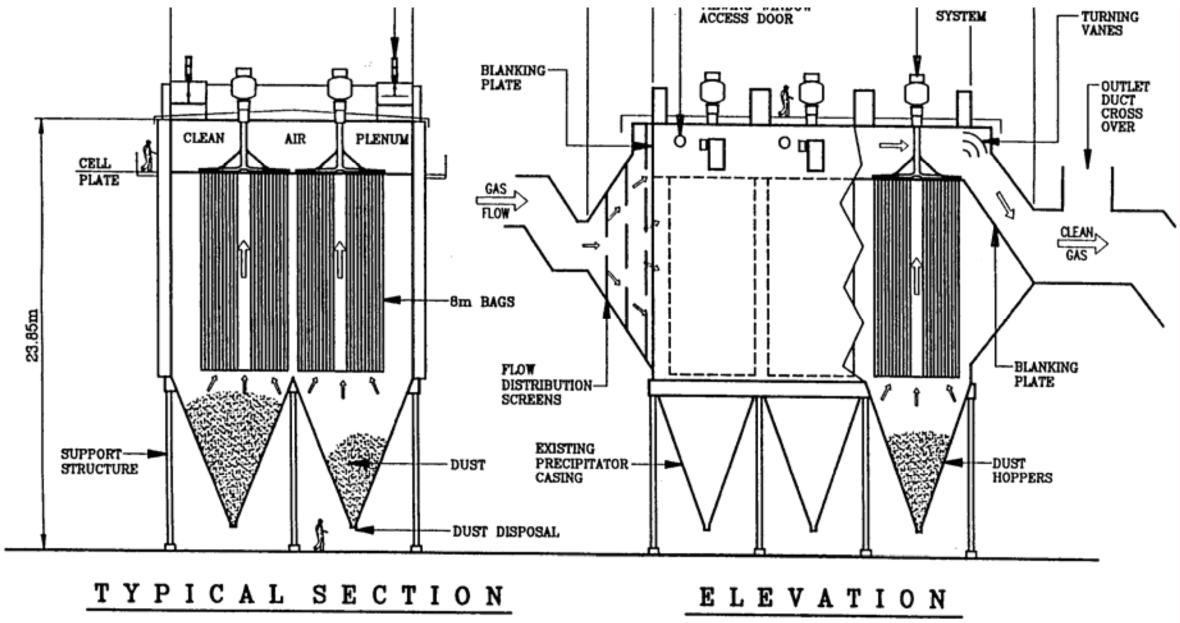


Pacific Power Australia – Munmorah Station



Alabama Power, E.C. Gaston Station, Units #2 & 3

Additional ESP Conversion Installations:

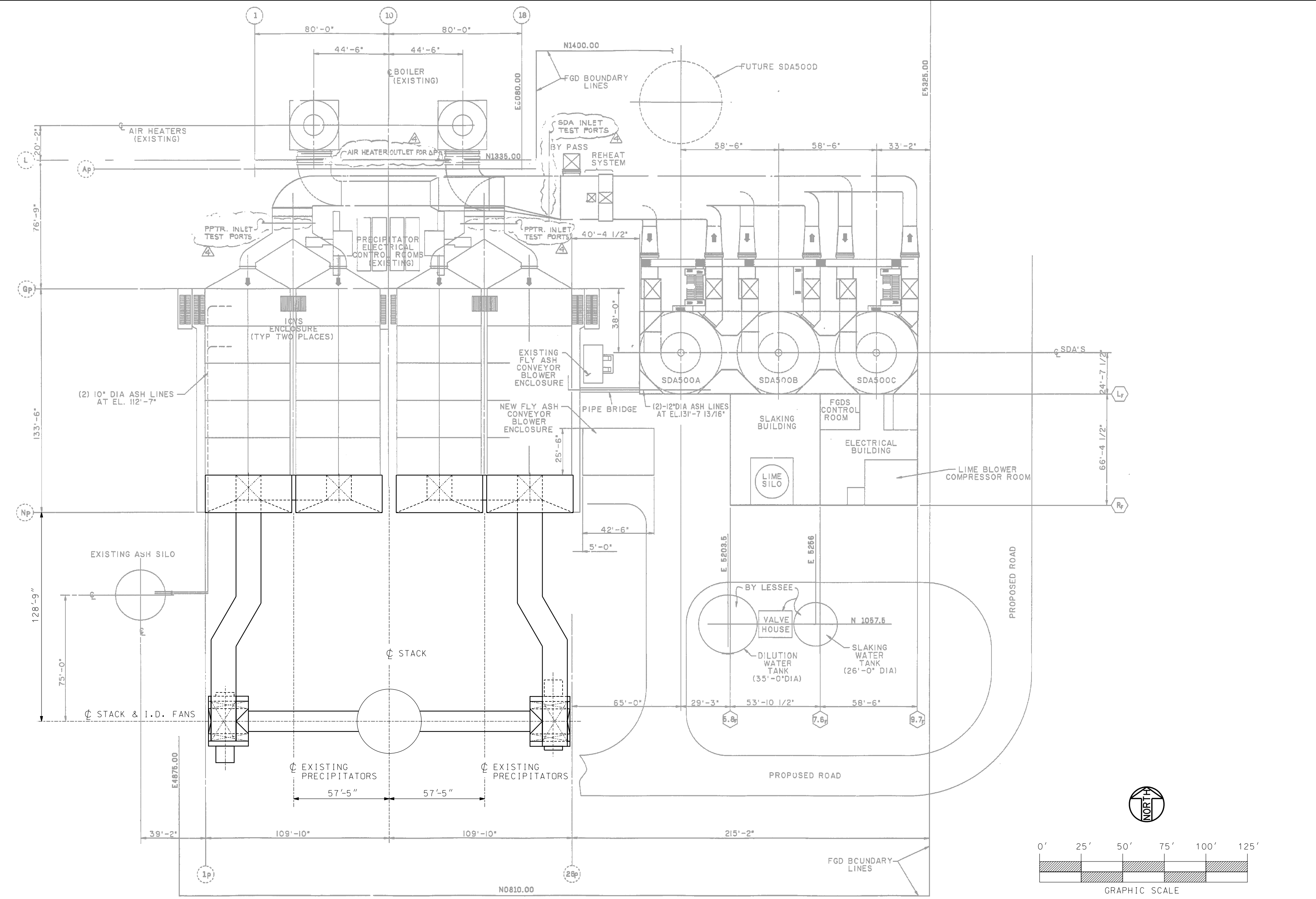


NRG Gladstone Station, Australia Units #1 – 6 (300 MW /Unit)

ESKOM Arnot Station, ESP/PJ Conversions – Units #1-3 (350 MW/Boiler)

Appendix F

ESP to FF Conversion Diagrams



PLOT PLAN

PRELIMINARY

CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.

FILENAME:WYODAK1.DGN

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

DRAWING RELEASE RECORD					
REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

SCALE

PROJECT NUMBER

GENERAL ARRANGEMENT
WYODAK BAGHOUSE
STUDY

BLACK HILLS POWER
& LIGHT CO.
PACIFIC POWER & LIGHT CO.

Sargent & Lundy LLC

DRAWING NO. MSK-WYO-001

REV.

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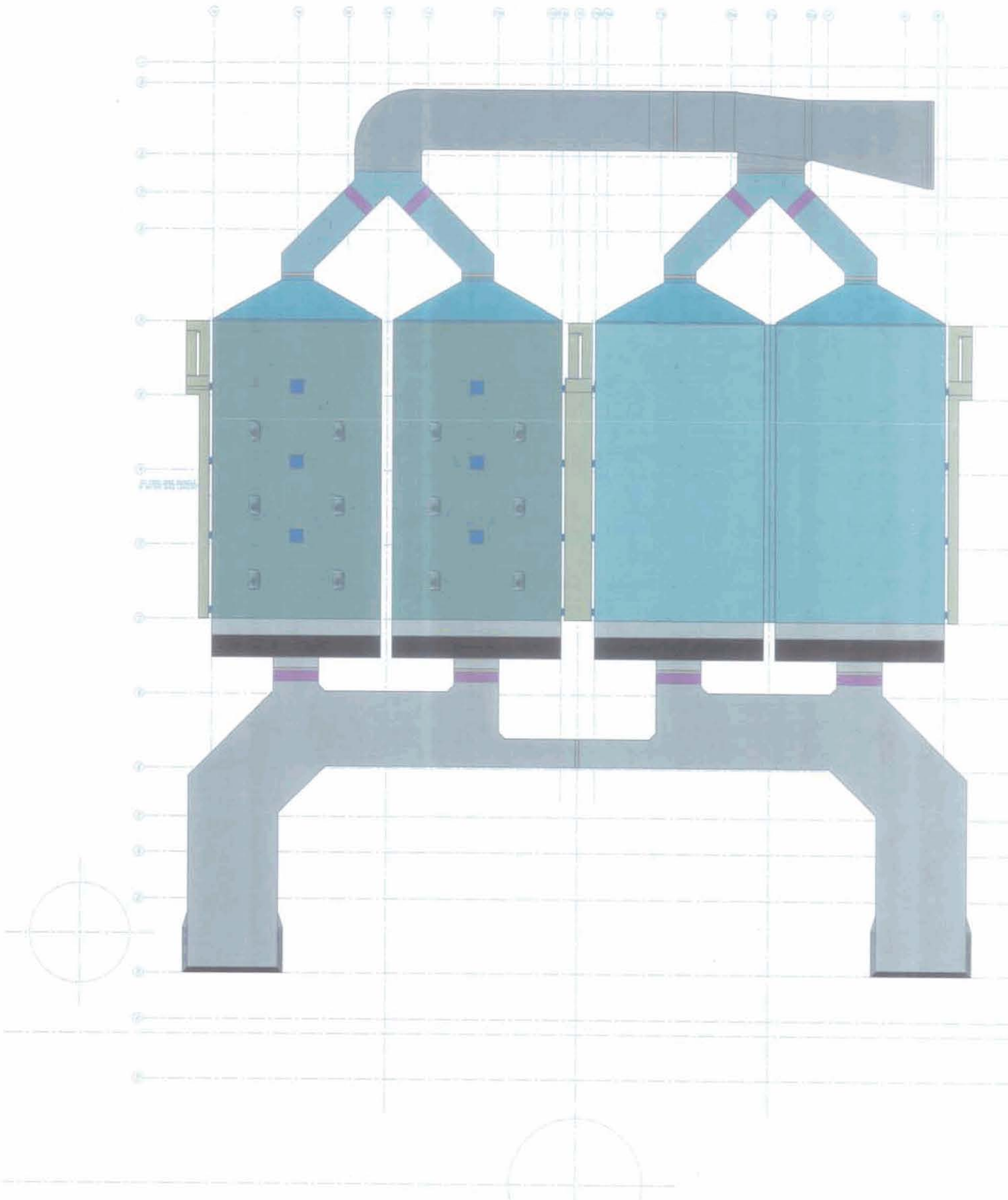
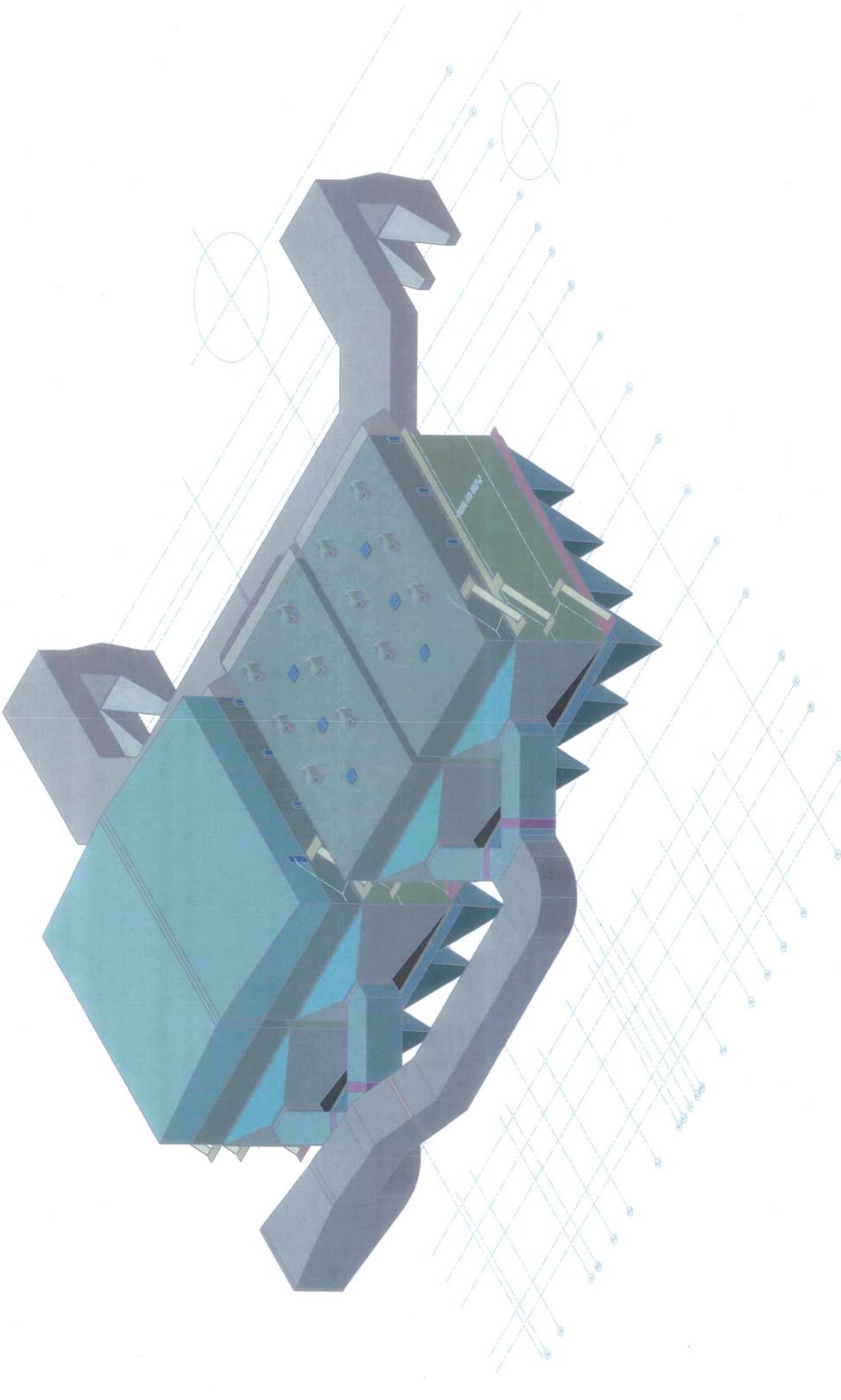
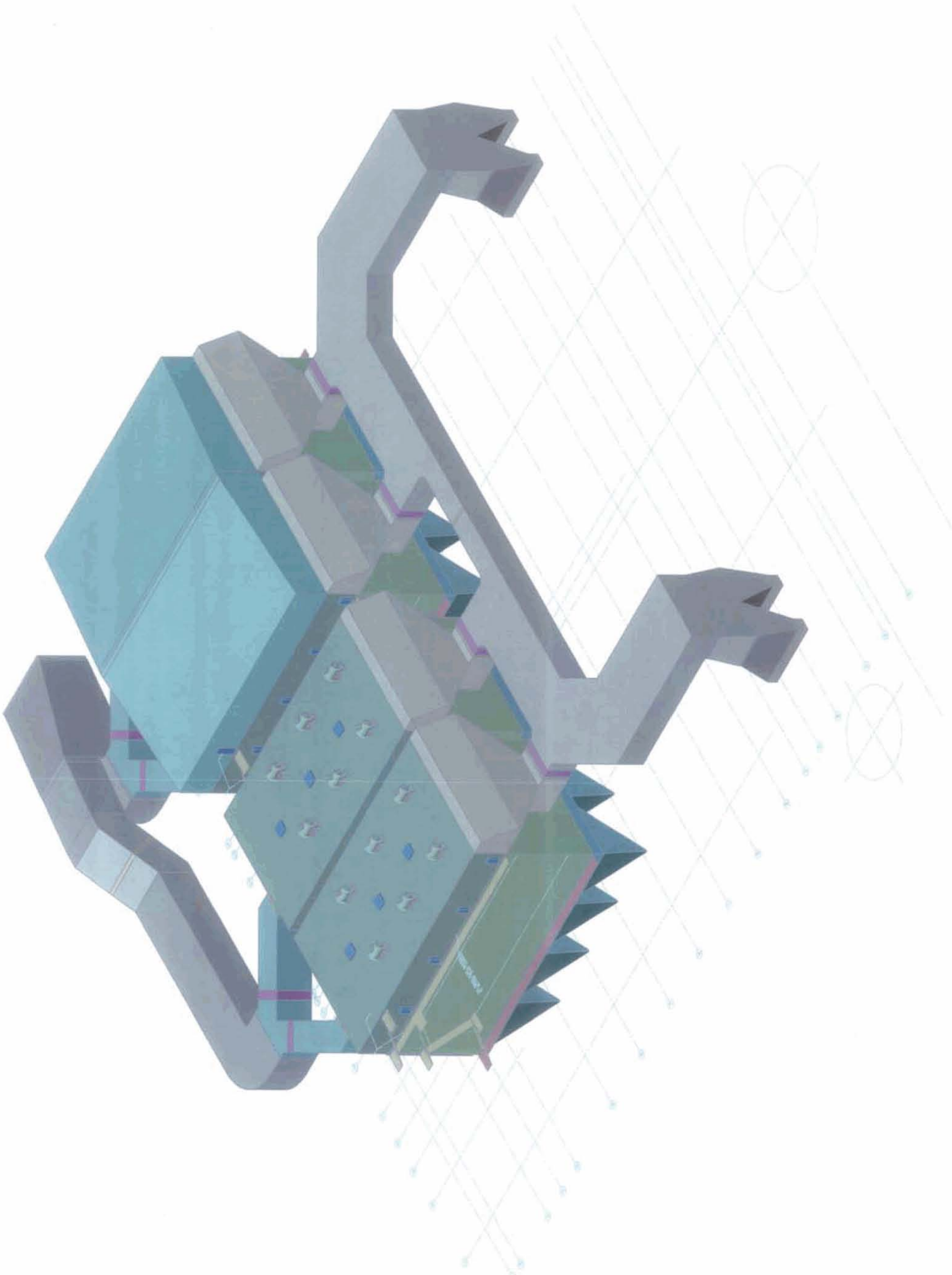






Appendix G

HRC Proposal for New Fabric Filter

SARGENT & LUNDY For
WYODAK POWER STATION

NEW LPHV FABRIC FILTER

HRC PROPOSAL

P-B720

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

2.0 DESIGN CONDITIONS

3.0 CONFIGURATION

4.0 MATERIALS OF CONSTRUCTION

5.0 SYSTEM DESCRIPTION
- 5.1 Description of Operation
- 5.2 Filter Bags
- 5.3 Filter Bag Support Arrangement
- 5.4 Bag Pre-coat
- 5.5 Not Used
- 5.6 Casing
- 5.7 Hoppers
- 5.8 Tube Sheet
- 5.9 Dampers
- 5.10 Support Steel
- 5.11 Slide Plates
- 5.12 Compartment Ventilation
- 5.13 Access
- 5.14 Access Doors
- 5.15 Instrumentation and Control
- 5.16 Hopper Enclosure
- 5.17 Roof Enclosure
- 5.18 Model Study
- 5.19 Shop Paint
- 5.20 Erection Consultant
- 5.21 Commissioning
- 5.22 Training

TABLE OF CONTENTS - CONTINUED

6.0 EQUIPMENT AND SERVICES BY OTHERS

7.0 PERFORMANCE GUARANTEES
- 7.1 Particulate
- 7.2 Power Consumption
- 7.3 Pressure Drop
- 7.4 Bag Life

8.0 SCHEDULE

9.0 TECHNICAL EXCEPTIONS/CLARIFICATIONS

10.0 COMMERCIAL EXCEPTIONS/CLARIFICATIONS

11.0 PRICING

1.0 EXECUTIVE SUMMARY

Hamon Research-Cottrell is proposing our patented, Low Pressure/High Volume (LPHV) Pulse jet fabric filter technology that has been successfully used on a large number of boilers around the world, on a wide range of applications handling gas volumes over **3.0** million acfm, with bag lengths in excess of 26 feet. Emission levels have been consistently under the required removal levels. The vast majority of these installations, including the system being proposed, have utilized on-line cleaning.

Some highlighted features of our proposed fabric filter offering include:

- Proven fabric filter design for large utility boilers, including conventional, and both COHPAC™ and TOXECON™ type installations
- Ability to meet required guarantee levels
- No visible emissions from stack
- Greater fuel flexibility
- More compact fabric filter design
- Fewer cleaning components than conventional medium and high pressure pulse jet designs
- Lower overall operating and maintenance costs

Hamon Research-Cottrell's professionals are air pollution control specialists. Our regional technical service representatives, our engineering and technical support staff, as well as international license affiliates and research and development engineers all work together to provide our clients with optimal solutions that work.

Other important features of the Hamon Research-Cottrell offering include:

Hamon Research-Cottrell Design and Engineering **-** Hamon Research-Cottrell has a significant number of APC system installations around the world, on both industrial as well as utility combustion applications. Hamon Research-Cottrell is one of the most recognized industry leaders in air pollution control, accommodating stringent particulate control needs by providing both complete new systems and retrofit of existing systems with both ESP and Fabric Filtration Systems.

1.0 EXECUTIVE SUMMARY (CONTINUED)

Project Management - The project team will be led by a Project Manager who will be the primary contact between the Buyer and Hamon Research-Cottrell. He will be assisted by a Project Engineer and the various department heads of Engineering, Purchasing, Construction, Health and Safety, and Finance.

World Wide Sourcing – The project team that will be assigned this project has vast experience in world sourcing of goods and materials, to provide you, the customer with a high quality product, completed on time, and at the lowest possible cost. The HRC team will secure steel and other components world wide and will comply with the contractual codes required by the contract.

Construction Supervision and Field Services - The success of any project lies not only with the proper design and engineering of the fabric filter and associated equipment, but the completion of construction in a timely matter. To ensure that the dust collection system is erected in an efficient and workmanlike manner, and to minimize the disruption of other ongoing construction activities, Hamon Research-Cottrell will provide an on-site Erection Field Consultant. Our erection advisor will also coordinate activities with our home office Senior Project Manager. Start-up and training is provided with this offering. Our training sessions are specialized for each individual project and audience.

Quality Assurance/Quality Control – Hamon Research-Cottrell also recognize the importance of quality assurance and quality control in each of our projects and is committed to the implementation of an effective quality assurance program to control the production and inspection of all of the products and services we provide.

The purpose of the QA program is to provide, by means of planned and systematic actions, adequate confidence that materials and workmanship, during all stages of design, procurement and construction, are in compliance with contract specifications. Hamon Research-Cottrell is an ISO 9000 Certified Company.

1.0 EXECUTIVE SUMMARY (CONTINUED)

Conclusion

With our **large scale** fabric filter and electrostatic precipitator experience, the Hamon Research-Cottrell team stands ready to work with **S&L** in the implementation of **S&Ls** air pollution control strategy for this facility. We can assure you of a team effort with focus on technical proficiency, fiscal accountability and professional integrity. With our extensive fabric filter operating experience, our aim is not simply to satisfy your expectations in all aspects of job performance, but to exceed them and, by doing so, to demonstrate to you and your clients our corporate commitment to excellence and the ultimate success of this important project.

We as a company stand alone, amongst our competitors and are uniquely qualified in our understanding of what is required to make this emissions reduction project successful. HRC was the pioneer license holder of both these unique technologies and we understand what it takes to make this highly visible project successful. We will work closely with **S&L** to ensure the success of this important APC project. HRC has operating experience with similar type systems with filtration rates significantly higher than those being proposed. This unique experience will be incorporated in this design to ensure success.

We welcome the opportunity to meet with you to provide an overview of our overall experience and capabilities.

2.0 DESIGN CONDITIONS

Specific conditions which will be incorporated into the design are:

Flue gas volume, S-type pitot tube	1,876,920 acfm per FF
Mass Flow without dust	5,567,882 LB/H per FF
Operating temperature	170°F
Structural Design temperature	550°F (excludes bags)
Excursion temperature	Not Given (excludes bags)
Inlet pressure	-20” w.c.
Design pressure	+35 / -35” w.c.
Upset pressure for 30 minutes, once per year	Not Given
Wind	Per IBC
Snow	Per IBC
Seismic	Per IBC
Particulate loading	16.1 gr/acf
Particulate density	45 pcf – volumetric 90 pcf - structural
Ash handling system load	5,000 pounds per hopper
Live load	Baghouse roof – 50 psf Platforms – 100 psf
Insulation load	5 psf
Elevation	6,000ft amsl
Ambient conditions	-25 to 105ºF

3.0 CONFIGURATION

Salient features of the fabric filter configuration are as indicated below:

Number of fabric filters per Boiler	1
Number of compartments/fabric filter	14
No. bag bundles/compartment – Base	1
No. of cleaning arms/bundle	3
No. bags/compartment	1,064
No. bags/fabric filter	14,896
Bag length	29'-6"
Equivalent bag diameter (nominal)	4.9" Oblong (approximately 2 1/2" x 6")
Effective cloth area (sq. ft.): (with seams and cuffs deducted) Per bag Per compartment Per fabric filter	 35.59 37,866 530,130
Air-to-Cloth Ratio: Gross (on-line cleaning) Net (1 compartment off for maintenance)	 3.54 3.81
No. of pulse valves/compartment	1
No. of bags/pulse valve	1,064

4.0 MATERIALS OF CONSTRUCTION

The materials of construction for the major components are shown below:

Casing & partition walls	5 mm mild steel plate with mild steel stiffeners
Roof	5 mm mild steel with mild steel stiffeners, Checkered plate in the enclosure area
Hoppers	5 mm mild steel plate with mild steel stiffeners
Tube sheet	5 mm mild steel plate with mild steel stiffeners
Manifolds	5 mm mild steel with mild steel stiffeners
Inlet elbows	5 mm mild steel with mild steel stiffeners
Bag material	18 oz. PPS
Bag cages	9 gauge mild steel, three piece construction with 14vertical wires
Handrail and posts	1 1/4" Sch. 40 pipe
Toe plates	6mm x 4" C.Q.M.S.
Grating & stair treads	1 ¼" x 3/16"

5.0 SYSTEM DESCRIPTION

Hamon Research-Cottrell is proposing our **Low Pressure High Volume** (LPHV) fabric filtration technology to collect particulate from each of the existing air heater. One **(1)** independent fabric filter casing, containing **fourteen (14) compartments** is proposed for the **base case**. As requested, we are including an option for one fabric filter with twelve compartments capable of handling the flue gas from both of the air heaters. Each compartment in this case will contain two bag bundles. The filter bag cleaning system is designed for on-line cleaning which allows any one of the compartments to be isolated for maintenance. The proposed LPHV pulse cleaning system has successfully been utilized on many conventional fabric filter installations.

5.1 Description of Operation

Our Low Pressure-High Volume pulse jet fabric filter utilizes a unique cleaning mechanism which provides on-line cleaning with the cleaning manifold continuously rotating at approximately 1 R.P.M. above the tube sheet.

The bags are oblong in shape and are arranged in concentric circles with regular spacing specific to each circle. The compactness of this arrangement is only possible with non-alignment of the bags in the radial direction. In the circumferential direction, the bag spacing is regular but specific to each row.

To more fully understand the low pressure pulse jet system, you must realize that almost the full complement of the powerful cleaning flow is derived from the compartment's air reservoir. Figure 1 depicts an integral tank mounted design. For this proposal, we will be offering a side mounted tank design. The low pressure system's nozzle can be located anywhere on the lengthwise centerline of the bag top, with some degree

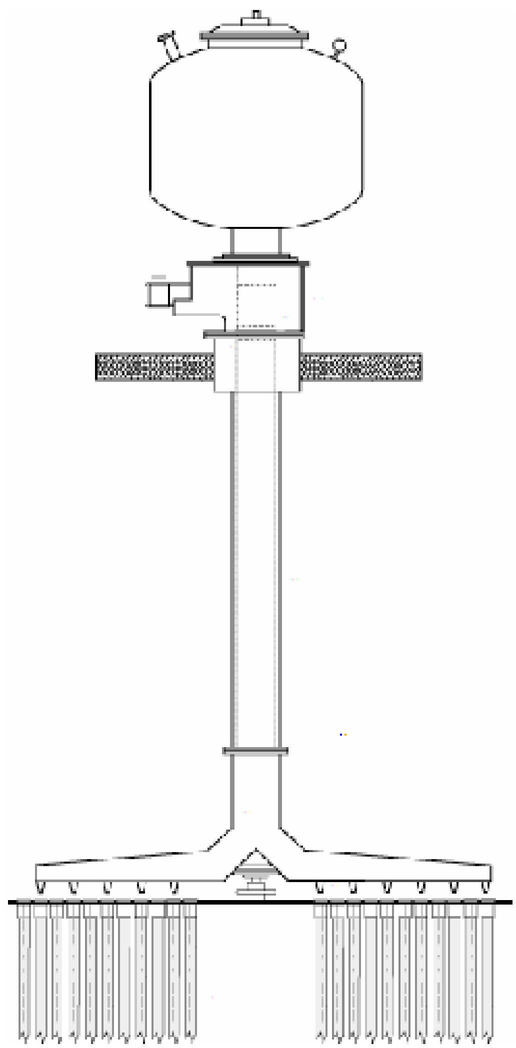


Figure 1

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.1 Description of Operation (Continued)

of "blockage" with the cage top, without detriment to the cleaning effectiveness. Unlike conventional pulse jets, relative position of the LPHV nozzle to bag is not critical. The cleaning air can be released from the reservoir either by a preset timer or pressure drop initiated (preferred) and directed to the manifold via a quick opening pilot assisted diaphragm valve.

The rotating manifold is supported on the tube sheet by a heavy duty, sealed thrust type bearing, designed for long life and low maintenance. The cleaning air distribution pipe and rotating manifold/nozzle assembly is designed such that pressure losses are kept to a minimum and stored energy in the reservoir is utilized to the fullest.

In addition to the primary cleaning action which is produced by an initial rapid fabric deceleration and dust cake dislodgment, the LPHV Pulse jet incorporates an additional feature which enhances fabric cleaning. The high volume of stored cleaning air flowing to the bags in the reverse direction provides a "Back-Flush", or reverse air cleaning effect, which augments the dynamic cleaning of the "pulse" itself. The cleaning air volume includes an extra margin for those cases where the nozzle may be located between bags.

The flue gas enters each compartment through the casing side wall. Entrance velocities are kept low, approximately **1,500 fpm under normal operating conditions**, to minimize mechanical pressure drop and to also allow larger particulate to fall out into the hopper. This compartment entrance design, along with appropriate can velocities, promotes reduced cleaning frequency, extending bag life and improving filtration efficiency as previously demonstrated on similar type applications. With our use of round bag bundles in a square compartment, the empty corners in the compartments help in promoting both horizontal and vertical flow, thus reducing the actual velocities within the compartments, thus promoting effective cleaning of the bags and ash dropout into the hoppers. Can or interstitial velocities, therefore are not applicable to our LPHV PJ design.

Cleaning air will be delivered via **ten (10)** ~11% capacity, low pressure positive displacement blowers **per fabric filter**, nine operating and **one (1)** in place spare will be provided.

The blowers for the fabric filter are connected by a common piping manifold system that feeds the clean air manifold reservoir tanks located at the fabric filter roof level. The air reservoir tanks are sized to deliver a total air volume of approximately 48 cu.ft. per pulse, of cleaning air. The blowers will be located at grade.

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

The use of low pressure positive displacement blowers is a major improvement over the use of air compressors and dryers which are required for high or intermediate pressure pulse jet designs. Air dryers are not required with positive displacement blowers because of the relatively low pressure. In addition, the cleaning air piping is not subject to freezing and/or condensation which can occur in high pressure compressed air lines in locations which are subject to cold ambient temperatures.

Blowers are more efficient and require less maintenance than compressor and air dryer systems.

A particular benefit of this unique technology is the requirement for fewer pulse cleaning air diaphragm valves. The LPHV technology requires only one "heavy duty" valve to clean all the filter bags in each compartment. As an example, only **fourteen (14)** diaphragm valves are required, that is one per compartment. In contrast, a conventional pulse jet design could require at least **54** valves per compartment assuming a maximum of 20 bags per valve, equating to **756** valves. This would result in a total of **756** high pressure pulse valves to inspect and maintain as opposed to only **14** valves with our low pressure design. In addition, the LPHV diaphragm valve, located outside the gas stream, is designed to last longer than conventional valves.

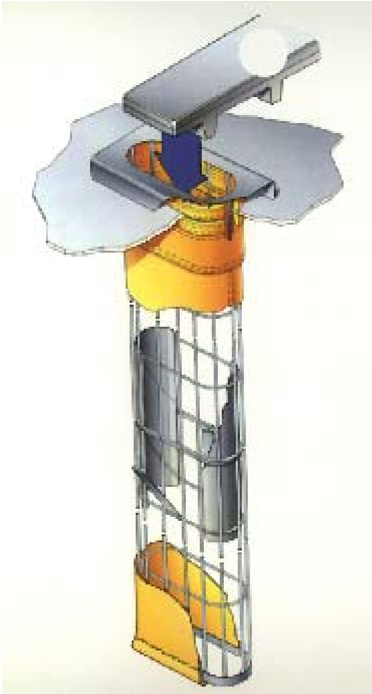
The volume of each cleaning air pulse is derived from theoretical gas laws as well as the number and length of bags being cleaned. The frequency of cleaning, and therefore the required flow rate of cleaning air, is determined from formulae derived from empirical data that has been gathered from an extensive amount of testing carried out at many pilot and full scale pulse jet installations.

Bag Inspection and Replacement

A significant benefit of this cleaning method is the absence of blow pipes in the tube sheet area. This allows the bags and cages to be easily accessed for inspection or replacement. Only a single, trifurcated rotating manifold arm is located over each bundle of bags. With only three rotating cleaning manifold arms in each compartment, inspection and maintenance costs in locating and replacing a potentially failed bag are greatly reduced.

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.2 Filter Bags



Each compartment will contain two cylindrical bag bundles with **1,064** filter bags per bundle. This equates to a total of 14,896 bags installed, and an additional 2**%**, are included as spares. The filter bags for this project will be fabricated from heavy weight 18 oz/yd^2 nominal weight PPS, scrim supported and a fused seam.

The bags have an elongated cross section which is essentially oblong with rounded ends to promote better movement and release of the dust. The bag/cage fixing method has been designed for ease of installation and maintenance. The bags are secured in the tube sheet by means of a stainless steel snap band that is sewn into the cuff of the bag. No tools are necessary for installation of the bags and/or cages.

5.3 Filter Bag Support Arrangement

The filter bag support cages correspond in cross section to the "oblong" shape of the bags and tube sheet openings. The outside dimensions of the cage are slightly smaller than the inside dimensions of the bag along with a tapered lower section to facilitate cage insertion into the bag and to help promote more efficient bag cleaning.

Cages are constructed of heavy **9 gauge** mild steel wires for **rigidity, durability** and **long life**. There are **14** vertical wires, secured by horizontal wires spaced at **7"** intervals. Cages are supplied in **three (3) sections** to reduce the need for inordinately high headroom in the roof weather enclosure or clean air plenum, thus reducing steel and weight. The cage sections are firmly held together by an interlocking clip arrangement and internal guide plates at the joint to achieve a smooth, rigid, and perfectly aligned connection. This cage design has been successfully used on similar pulse jet boiler applications. In addition to those cages required for the initial installation, an additional 2**%, are included as spares**.

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.4 Bag Pre-coat

A sufficient amount of Alumina Silicate (Neutralite) or equal will be provided in order to pre-coat the initial set of filter bags.

5.5 Not Used

5.6 Casing

The fabric filter casing will include the following design features:

- Steel supplied; **5mm JIS 3101 SS400**
- Structural design will be based on 5mm
- 5 mm checkered plate roof
- Plenum design for ease in bag inspections/replacements.
- Tube sheet of welded 6 mm mild steel, suitably reinforced
- Two (2) access door, **24”x 48”**, will be provided per compartment

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.7 Hoppers

Each fabric filter compartment will have one pyramidal hopper with a **57º VA**, equipped with the following auxiliaries:

- 5 mm mild steel construction.
- Reinforced to support 5,000 lbs. of ash handling equipment
- Flanged outlet opening, 12" ANSI 150#, tack welded to hopper.
- One **21" x 30"** mild steel access door with safety latch to prevent rapid full door opening.
- Two (2) 4" diameter angled poke holes with caps located on opposite hopper walls.
- Two (2) strike plates.
- One (1) capacitance type hopper level detector, as manufactured by Drexelbrook Engineering Co. or equal.
- Provisions for installing wall mounted vibrator (supplied by others)
- Hopper heater system will include the following:
  - ➢ Modular type heaters, as manufactured by Heat Trace, or equal, designed to maintain the bottom 1/3 of the hopper height at a temperature of 250°F with the unit in operation. The heaters are designed to raise the heated surface area **150°F above ambient in approximately 8 hours**.
  - ➢ Two (2) RTD's per hopper, one for on-off control and the other for low temperature alarm.
  - ➢ Throat heaters and poke hole heaters will be provided.
  - ➢ One NEMA 4X control panel will be provided in the hopper area for hopper heater control. These panels will contain feed circuit breakers and individual hopper contactors.

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.8 Tube Sheets

The tube sheet for each compartment, complete with all stiffeners, will be shop fabricated from **6 mm** thick plate to minimize deflection and insure that the highest standards of quality are maintained.

5.9 Dampers

The following dampers will be provided:

- Pneumatically operated, low leak inlet louver damper per compartment, complete with solenoid valve, and two proximity limit switches for indication of damper open/closed position with fail in place provision.
- Pneumatically operated, low leak single disc outlet poppet dampers per compartment complete with solenoid valve and two proximity limit switches, for indication of damper open/closed position with fail in place provision.
- Pneumatically operated double disc bypass dampers per fabric filter, complete with ambient purge for zero leakage, solenoid valve and two proximity limit switches for indication of damper open/closed position. These dampers will allow bypass of the fabric filter during temperature excursions, boiler upsets and start-up. The bypass dampers are located internally in each fabric filter thus providing preheating capabilities during startup conditions with fail in place provision.

5.10 Support Steel

Support steel will be provided by others.

5.10 Slide Plates

Provided by others

5.11 Compartment Ventilation

A 6" butterfly valve will be provided in each compartment to provide ventilation for maintenance.

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.12 Access

Hamon Research-Cottrell will furnish the following access system:

- A stairway, **30"** wide, will be provided from the compartment access platform level to the weather enclosure on one end of the fabric filter. A caged ladder from the weather enclosure to the hopper platform will be provided on the other.
- **36"** wide platforms will be provided around the outside of the fabric filter to the compartment access doors in the clean air plenum.

5.13 Access Doors

HRC designed mild steel access doors will be furnished at the following locations:

- Hoppers — One (1) 21"x 30" door per hopper
- Clean air plenum — Two (2) 24"x 48" side mounted compartment door

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.14 Instrumentation and Control

The fabric filter will be controlled via owners DCS. HRC will provide instrumentation to allow the Buyer to monitor and /or control the following:

- Gear box drives for cleaning air manifold
- Inlet louver damper open/closed status
- Outlet poppet damper open/closed status
- Bypass poppet damper open/closed status
- Cleaning air pressure control (P&ID loop)
- Fabric filter on-line pulse-cleaning sequence
- Thermocouples wells at the inlet and outlet flange of each fabric filter
- Inlet and Outlet Manifold Temperature Transmitters
- Differential Pressure Gauge for each compartment
- Differential Transmitters for pressure drop across the flange to flange fabric filter
- Manifold drive motor starter status, manifold drive speed switch, and cleaning air pressure
- Graphic display design

5.15 Hopper Enclosure

Not provided.

5.16 Roof Enclosure

Framing, girts and roof purlins will be provided for an enclosure over each fabric filter roof.

- Minimum eave height of 12'-0"
- Roof slope of 1 on 12
- Two (2) 3' x 7' personnel doors frames only.
- Thermostatically controlled wall mounted ventilation fans with manually operated wall louvers
- Electric wall mounted space heaters.
- One (1) 6'x 10' double door frame only.
- One monorail beam
- One Hand chain hoist with a manual push type trolley
- One (1) one ton capacity, electric hoists.
- Insulated roofing and siding and gutters and downspouts to be designed and furnished by others

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.17 Model Study

A CFD model study will be conducted. Scope will be from the inlet flange of the fabric filter to the fabric filter outlet flange. The model study will identify pressure drop in the fabric filter.

It will also be used to determine the optimal design of the internal flow control devices to provide good flow distribution to all the bags, minimize pressure loss and undesirable dust buildups and to ensure that the baghouse hoppers have low velocity flow behavior to prevent dust re-entrainment. The model results will be displayed in a wide range of tabular and graphical formats including percent deviation maps, contour maps and histograms.

5.18 Shop Paint

All surfaces which are exposed to flue gas or covered by insulation will not be painted.

The following surfaces will be cleaned per **SSPC-SP6** and given one (1) shop coat of inorganic zinc primer, such as Carboline, **Carbo Zinc-11**:

- Baghouse stilts

The following surfaces will be cleaned per **SSPC-SP6** and given one (1) shop coat of inorganic zinc primer, such as Carboline, **Carbo Zinc-11**:

- grating, stair treads, handrail, toe plates & ladders
- weather enclosure framing, girts and purlins
- monorail beam
- access framing

The following manufactured components will be supplied with manufactures standard paint system:

- dampers & actuators
- hoist
- jib crane
- instrumentation

5.0 EQUIPMENT DESCRIPTION (CONTINUED)

5.19 Erection Consultant

A Hamon Research-Cottrell will provide an erection consultant for a period of **1,300 manhours,** based on a 40 hour work week. His responsibilities include recommending facilitative procedures to Purchaser's installation contractor. Please see the pricing section for this adder which is subject to escalation.

If additional time is required and or additional trips, they will be invoiced in accordance with the attached "Conditions of Sale for Field Services".

5.20 Commissioning

Hamon Research-Cottrell will provide technical direction for the checkout and start-up of the Hamon Research-Cottrell supplied equipment.

An HRC Field Service Engineer is included for **320 hours** for the above services. If additional time is required and or additional trips, they will be invoiced in accordance with the attached "Conditions of Sale for Field Services".

5.21 Training

As part of our offering, plant operating personnel will receive a comprehensive training course covering the theory, operation, and maintenance of the system. This training will be supplementary to, and based upon, the Operation and Maintenance Manual which will be furnished by Hamon Research-Cottrell. There will be **two (2)** training sessions. The initial training session will be conducted approximately one (1) month prior to start-up. The follow-up training session will be conducted approximately two (2) months after start-up. These sessions will consist of classroom lectures and conducted tours to inspect and discuss the operation and maintenance of the fabric filter and all auxiliaries.

If additional time is required or if a separate trip is required for this service, it will be invoiced in accordance with the attached "Conditions of Sale for Field Services".

6.0 EQUIPMENT AND SERVICES BY OTHERS

Hamon Research-Cottrell's scope of supply for materials and services is as described in this proposal. Equipment, materials, and services which are not included but are to be provided by others include the following. This list is not intended to be all inclusive.

6.1 All waste handling system including valves at the fabric filter hopper outlet flanges, pipes, programming, supports, gaskets and bolts.

6.2 All foundations, floor slabs, anchor bolts and grouting.

6.3 Ductwork, ductwork support steel and expansion joints, including those at the inlet and outlet flanges of each fabric filter including all frames.

6.4 Motor control centers for the fabric filter.

6.6 ID fans

6.7 Subterranean grounding system brought above grade at every other column around the perimeter of the fabric filter.

6.8 CEMS

6.9 Compressed air, dry and oil free for fabric filter dampers and instruments at 90 psi minimum

6.10 All fees, taxes, duties, permits and/or license required to construct or operate

6.11 Electrical and instrument equipment enclosure

6.13 Material supply and installation of insulated siding and roofing for the roof weather enclosure including gutters and downspouts and insulated siding for the hopper enclosure, and any required roof walking surfaces. Heat insulation contractor is also responsible for design of any required subgirt system.

6.14 Receiving, unloading and storage of all HRC supplied material and equipment

6.0 EQUIPMENT AND SERVICES BY OTHERS

6.15 Supply of all interior and exterior area lighting associated with the fabric filter including convenience receptacles and welding receptacles, local switches and controls.

6.16 Supply and Installation of Instrument quality Piping to each device, as required

6.17 Portable stair to obtain access to hopper doors and other hopper auxiliaries

6.18 Supply and installation of all required cable, conduit, cable tray and supports including grounding and instrument cables.

6.19 Communications system design and supply.

6.20 Office space and office facilities, including phone, fax and internet service, for HRC's field personnel.

6.21 Test ports as required.

6.22 Start-up and Check-out craft personnel.

6.23 Performance test equipment and personnel to conduct the performance tests.

6.24 Structural steel supports for the cable trays as required.

6.25 Finish painting.

6.26 DCS and or PLC as required by owner

6.27 Support steel and slide plates, as required to interface with fabric filter stilts.

6.28 Stairway to compartment access level.

7.0 PERFORMANCE GUARANTEES

Sellers sole guarantees are those contained in this proposal. These guarantees are contingent upon the correctness and accuracy of the information provided by the Buyer and is based upon the operating conditions listed in the Nov. 29th e-mail to Rod Hendricksen.

Particulate

Hamon Research-Cottrell guarantees that when the fabric filter is adjusted and operating at conditions up to and including 100% of design flue gas flow, the maximum outlet solid particulate mass emission leaving the fabric filter will not exceed **0.012 lb/mmBtu at chimney test port, based on a 24 hour average, with one (1) compartment out of service**

- The particulate sampling method shall be that of the current issue Environmental Protection Agency **Method 5B,** front half only, excluding condensables, as outlined in the Federal Register.
- Guarantee will be based on the average of 3 tests.
- Test duration to be a minimum of four (4) hours.

7.1 Power Consumption

Hamon Research-Cottrell, guarantees, that the average annual, **24** hour power consumption, will not exceed **1,000 KW,** excluding all seasonal (hopper heaters) and intermittent loads. See attached correction curve.

7.2 Pressure Drop

Hamon Research-Cottrell guarantees when the fabric filter is operating at the design conditions, the **24** hour averaged pressure loss between the inlet and outlet flange connections of the fabric filter will not exceed **8.0”** w.c. **with no more than one compartment off line** and **7.5”** with all compartments on line.

7.0 PERFORMANCE GUARANTEES AND WARRANTY (CONTINUED)

7.3 Bag Life

Hamon Research-Cottrell guarantees, when the fabric filter is operating under the design conditions, the life of the filter bags for a period of **36 months** from the date of initial flue gas entry into the compartments or **42** months from the date of delivery, which ever occurs first. Hamon Research-Cottrell will provide a replacement bag for any bag that fails under normal use during this guarantee period on a one-for-one basis. Installation will be by others.

Owner must operate and maintain the equipment in accordance with Hamon Research-Cottrell's Operation and Maintenance Manual and shall report, in writing, within 7 days of any bag failure. Any replacement bags shall only carry the balance of the initial bag life warranty.

Conditions Applicable To Performance Guarantees and Warrantees

- If, because of delays or improper operation between completion of erection and performance tests, the equipment is not in the same condition as when erection was completed, the Owner shall restore the equipment to such condition before any tests are conducted.
- Operation of the equipment in strict accordance with the Operations and Maintenance Manual.
- The Contractor must be advised in writing within seven (7) days of any bag failure.
- Temperature of the flue gas stream at the inlet of the baghouse shall not exceed 370ºF on a continuous basis.
- Temperature of the flue gas stream at the inlet of the baghouse shall not be less than 25ºF above the expected acid dew point, except as is unavoidable during start-up and shutdown.
- Performance tests to be conducted after 60 days of operation but no later than 120 days of operation.

8.0 SCHEDULE

The "Preliminary Project Schedule" given below reflects the timing and duration of key phases and milestones for this project. Dates are based on an award of Contract on or before **Mar 14, 2008**.

Delivery Schedule

	Delivery Dates
Casing and Hoppers	3/01/2009
Support Steel and Platforms	5/31/2009
Enclosures	9/30/2009
Air System and Piping	11/30/2009
Bags	3/30/2010

Notes:

a. Our experience indicates that a turn-around cycle for approval drawings of two (2) weeks is adequate for proper review. The proposed schedule includes and is contingent upon adherence to this maximum approval cycle.

b. All schedules are contingent on the Purchaser making available all information necessary for Hamon Research-Cottrell to perform its design and fabrication of materials at the time that the authorization to proceed is given to Hamon Research-Cottrell.

9.0 TECHNICAL EXCEPTIONS/CLARIFICATIONS

None at this time.

10.0 COMMERCIAL EXCEPTIONS/CLARIFICATIONS

HRC's offering is based on HRC's Standard Conditions of Sale.

11.0 PRICING

Hamon Research-Cottrell's price to furnish engineering design, supply and delivery, DDP, to the job site, is based on World Wide Sourcing of the scope of work as outlined in this proposal; is as follows:

Base Price …….……………………………………………………………….,,..$12,800,000*

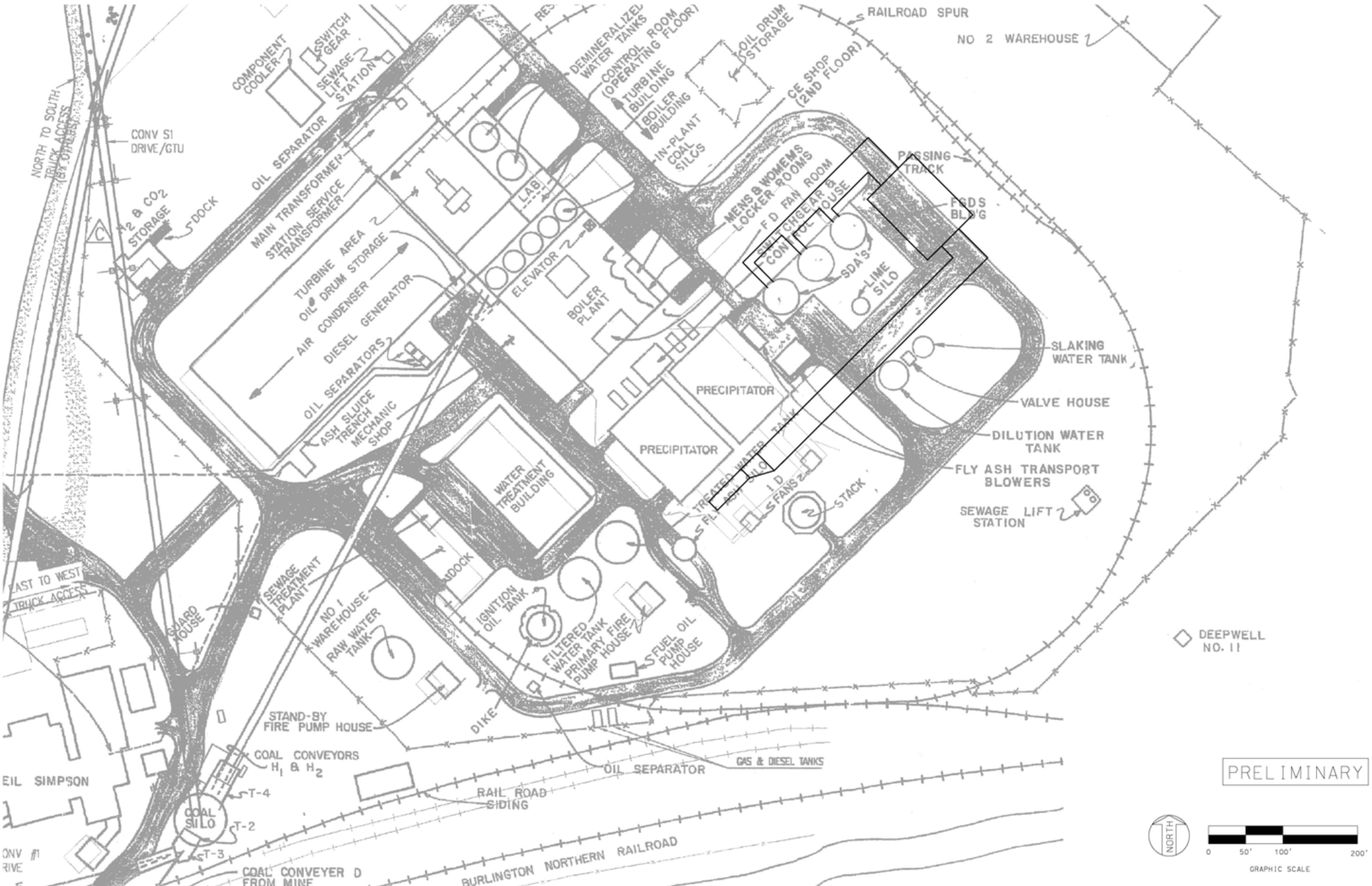
* Pricing is current, and based on delivery dates identified in this proposal.

NOTES:

TAXES - Buyer shall pay to Seller, in addition to the prices provided for herein, any foreign or domestic duty, sales or use tax, Value Added Tax (VAT), fee, or other tax or charge (hereinafter "tax"), now or hereafter imposed, that Seller may be required by any municipal (including special taxing authority), state, federal or foreign government law, rule, regulation or order to collect or pay with respect to the sale, transportation, storage, delivery, installation or use of the Work furnished hereunder, or will provide Seller with appropriate exemption or direct payment certificate. Buyer shall defend, indemnify and hold harmless Seller from and against all liabilities for such taxes or charges and attorneys' fees or costs incurred by Seller in connection therewith.

Appendix H

General Arrangement Drawing – Stand-Alone Baghouse Option



CONTRACTOR/INSTALLER SHALL TAKE ALL APPROPRIATE PRECAUTIONS TO ENSURE THE SAFETY OF ALL PEOPLE LOCATED ON THE WORK SITE, INCLUDING CONTRACTOR'S/INSTALLER'S PERSONNEL (OR THAT OF ITS SUBCONTRACTOR(S)) PERFORMING THE WORK.

FILENAME: WYE GA-01.DGN

DRAWING RELEASE RECORD

REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

DRAWING RELEASE RECORD

REV.	DATE REL'D.	PREPARED	REVIEWED	APPROVED	PURPOSE

SCALE 1" = 50'

PROJECT NUMBER

WYODAK PLANT
UNIT 1 BAGHOUSE STUDY

Sargent & Lundy LLC

DRAWING NO. WYE-GA-01
REV. 0
SHEET OF

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11/9/2007 3:11:01 PM

Appendix I

Capital Cost Estimates

Capital Cost Estimate for Option 1: Rebuld ESP with CS Internals

Estimate No. : 23300A
Project No. : 11801-002
Issue Date : 01/23/2008
Preparer : RK
Reviewer : PG

Pacificorp
WYODAK Station ESP Rebuild
With Carbon Steel Internals

Description	Scope Definition	Quantity	Unit of Measure	Equipment & Material Cost	Installation Cost	Total Cost
CIVIL	NONE					
MECHANICAL						
DEMOLISH ESP CASING INSULATION & LAGGING		138,000	SF	0	835,000	835,000
INSTALL ESP INTERNALS		1	EA	21,092,000	22,446,000	43,538,000
INSULATION AND LAGGING		166,300	SF	1,713,000	3,321,000	5,034,000
SUBTOTAL MECHANICAL				**22,805,000**	**26,602,000**	**49,407,000**
ELECTRICAL						
SUBTOTAL ELECTRICAL				**999,000**	**399,000**	**1,398,000**
GENERAL SUPPORT						
EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	1 Crane With Crew - 6 Months	1	LT	0	400,000	400,000
SUBTOTAL GENERAL SUPPORT				**0**	**400,000**	**400,000**
Subtotal Equipment, Material and Install Costs				**23,804,000**	**27,401,000**	**51,205,000**
OUTAGE WORK						
NON OUTAGE WORK						
Craft Support During Startup	% of Installation Cost	3.0	%		822,000	822,000
Mobilization / Demobilization	% of Installation Cost	1.5	%		411,000	411,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	Working 6 -12 Hour Days	25.0	%		3,577,000	3,577,000
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	Working 6 -12 Hour Days	22.0	%		1,259,000	1,259,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	Working 5 -10 Hour Days	8.0	%		1,449,000	1,449,000
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	Working 5 -10 Hour Days	10.0	%		725,000	725,000
Per Diem		65.0	$/DAY		2,555,000	3,394,041
Freight-ExWorks To Site	% of Equipment/Material Cost	4.0	%	108,000	0	108,000
Taxes - Sales	Not Included		%	0	0	0
Contractor's General and Administration Expense	% of Equipment/Material/Install Cost	5.0	%	136,000	248,000	384,000
Contractor's Profit	% of Equipment/Material/Install Cost	10.0	%	271,000	496,000	767,000
EPC Fee	% of Equipment/Material/Install Cost	10.0	%	2,380,400	2,740,100	5,120,500
SUB-TOTAL CONSTRACTOR'S COST				**2,895,400**	**14,282,100**	**18,016,541**
Total Direct Project Costs				**26,699,400**	**41,683,100**	**69,221,541**
Indirect Project Costs						
Engineering, Procurement, & Project Services	% of Direct Project Cost	4.0	%			2,769,000
Construction Management/Field Engineering	% of Direct Project Cost	1.5	%			1,038,000
S-U/Commissioning	% of Direct Project Cost	1.0	%			692,000
Project Contingency	% of Direct & Indirect Project Cost	20.0	%			14,744,000
Total Construction Cost						**88,464,541**

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Capital Cost Estimate for Option 2: Rebuld ESP with SS Internals

Estimate No. : 23300B
Project No. : 11801-002
Issue Date : 04/25/2008
Preparer : RK
Reviewer : PG

Pacificorp
WYODAK Station ESP Rebuild
WITH STAINLESS STEEL INTERNALS

Description	Scope Definition	Quantity	Unit of Measure	Equipment & Material Cost	Installation Cost	Total Cost
CIVIL	NONE					
DRAINAGE, GRADING, PAVING, ROADWORK		0	LS	0	0	0
SUBTOTAL CIVIL				**0**	**0**	**0**
MECHANICAL						
DEMOLISH ESP CASING INSULATION & LAGGING		138,000	SF	0	835,000	835,000
INSTALL ESP INTERNALS		1	EA	21,092,000	22,446,000	43,538,000
INSTALL SS COLLECTOR PLATES		1	EA	13,579,000	0	13,579,000
INSULATION AND LAGGING		166,300	SF	1,713,000	3,321,000	5,034,000
SUBTOTAL MECHANICAL				**36,384,000**	**26,602,000**	**62,986,000**
ELECTRICAL						
SUBTOTAL ELECTRICAL				**999,000**	**399,000**	**1,398,000**
GENERAL SUPPORT						
EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	1 Crane With Crew - 6 Months	1	LT	0	400,000	400,000
SUBTOTAL GENERAL SUPPORT				**0**	**400,000**	**400,000**
Subtotal Equipment, Material and Install Costs				**37,383,000**	**27,401,000**	**64,784,000**
CONTRACTOR'S COST						
Craft Support During Startup	% of Installation Cost	3.0	%		822,000	822,000
Mobilization / Demobilization	% of Installation Cost	1.5	%		411,000	411,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	Working 6 -12 Hour Days	25.0	%		3,577,000	3,577,000
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	Working 6 -12 Hour Days	22.0	%		1,259,000	1,259,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	Working 5 -10 Hour Days	8.0	%		1,449,000	1,449,000
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	Working 5 -10 Hour Days	10.0	%		725,000	725,000
Per Diem		8.0	$/HOUR		3,394,041	3,394,041
Freight-ExWorks To Site	% of Equipment/Material Cost	4.0	%	108,000	0	108,000
Taxes - Sales	Not Included		%	0	0	0
Contractor's General and Administration Expense	% of Material/Install Cost	5.0	%	136,000	248,000	384,000
Contractor's Profit	% of Material/Install Cost	10.0	%	271,000	496,000	767,000
EPC Fee	% of Equipment/Material/Install Cost	10.0	%	3,738,300	2,740,100	6,478,400
SUB-TOTAL CONSTRACTOR'S COST				**4,253,300**	**15,121,141**	**19,374,441**
Total Direct Project Costs				**41,636,300**	**42,522,141**	**84,158,441**
Indirect Project Costs						
Engineering, Procurement, & Project Services	% of Direct Project Cost	4.0	%			3,366,000
Construction Management/Field Engineering	% of Direct Project Cost	1.5	%			1,262,000
S-U/Commissioning	% of Direct Project Cost	1.0	%			842,000
Project Contingency	% of Direct & Indirect Project Cost	20.0	%			17,926,000
Total Construction Cost						**107,554,441**

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Capital Cost Estimate for Option 3A: ESP to FF Conversion – Reuse Casing

Estimate No. : 23299F
Project No. : 11802-002
Issue Date : 04/28/2008
Preparer : RK/KSZ
Reviewer : PG

Pacificorp
Wyodak Station Install - Baghouse in Existing ESP Casing - Option 1

Sargent & Lundy

Description	Cost Type	Quantity	Unit of Measure	Equipment & Material Cost	Installation Cost	Total Cost
CIVIL						
DRAINAGE, GRADING, PAVING, ROADWORK	EST	0	LS	0	0	0
MECHANICAL, DUCTWORK ,FOUNDATIONS AND DEMOLITION						
DEMOLISH ESP CASING INSULATION & LAGGING	EST	124,000	SF	0	822,000	822,000
DEMO EXISTING ESP INTERNALS	EST	1	EA	0	1,260,000	1,260,000
INSTALL BAGHOUSE IN EXISTING ESP CASING	EST	1	EA	13,200,000	4,142,000	17,342,000
INSULATION AND LAGGING	EST	109,000	SF	1,123,000	2,384,000	3,507,000
BAGHOUSE CONCRETE FOUNDATION	EST	0	CY	0	0	0
BAGHOUSE CAISSONS	EST	0	EA	0	0	0
REPLACE ID FAN & MOTOR	EST	2	EA	2,630,000	903,000	3,533,000
ASH HANDLING SYSTEM UPGRADES		1	LS	1,400,000	700,000	2,100,000
DUCTWORK	EST					
GAS DUCTWORK BETWEEN BAGHOUSE OUTLET TO ID FAN INLET						
DUCTWORK	Est	700	TN	2,450,000	3023000	5473000
INSULATION & LAGGING	Est	75,000	SF	773,000	1342000	2115000
EXPANSION JOINTS	Est	1,500	LF	450,000	287000	737000
DAMPERS	Est	0	SF	0	0	0
TURNING VANES	Est	4	TN	12,000	17000	29000
TEST PORTS	Est	2	EA	10,000	10000	20000
SUPPORT STEEL	Est	400	TN	1,060,000	913000	1973000
GRATING	Est	1,200	SF	19,000	9000	28000
MISC. STEEL	Est	60	TN	186,000	164000	350000
HR & TP	Est	700	LF	35,000	27000	62000
LADDERS AND CAGES	Est	250	LF	13,000	10000	23000
STAIRS	Est	50	LF	5,000	4000	9000
FOUNDATIONS FOR DUCTS						
CAISSONS 2X12-30"DIA. X 30'	Est	1,500	LF	188,000	0	188000
CONCRETE	Est	850	CY	162,000	351000	513000
DEMOLITION OF DUCTS						
DEMOLISH DUCTS	Est	400	TN	0	316000	316000
DEMOLISH INSULATION AND LAGGING	Est	60,000	SF	0	5923000	5923000
DEMOLISH SUPPORT STEEL	Est	250	TN	0	197000	197000
SUBTOTAL MECHANICAL, DUCTWORK ,FOUNDATIONS AND DEMOLITION				**23,716,000**	**22,804,000**	**46,520,000**
ELECTRICAL						
EQUIPMENT	EST	1	LS	4,594,000	0	4,594,000
MATERIAL AND INSTALLATION	EST	1	LS	3,305,000	2,305,000	5,610,000
SUBTOTAL ELECTRICAL				**7,899,000**	**2,305,000**	**10,204,000**
GENERAL SUPPORT						
EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	Est	1	LT	0	400,000	400,000
SUBTOTAL GENERAL SUPPORT				**0**	**400,000**	**400,000**
Subtotal Equipment, Material and Install Costs				**31,615,000**	**25,509,000**	**57,124,000**
CONTRACTORS COSTS						
OUTAGE WORK						
NON OUTAGE WORK						
Craft support during startuip	EST	3	%		636,000	636,000
Mobilization / Demobilization		1.5	%		383,000	383,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	EST	25.0	%		2,702,000	2,702,000
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	EST	22.0	%		951,000	951,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	EST	8.0	%		1,513,000	1,513,000
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	EST	10.0	%		757,000	757,000
Per Diem	EST	8.0	$/hour		3,157,286	3,157,286

Description	Cost Type	Quantity	Unit of Measure	Equipment & Material Cost	Installation Cost	Total Cost
Freight-ExWorks To Site		4.0	%	631,000	0	631,000
Taxes - Sales			%	0	0	0
Contractor's General and Administration Expense		5.0	%	789,000	1,275,000	2,064,000
Contractor's Profit		10.0	%	1,579,000	2,551,000	4,130,000
EPC Fee		10.0	%	3,161,500	2,550,900	5,712,400
SUBTOTAL CONTRACTOR'S COST				**6,160,500**	**16,476,186**	**22,636,686**
Total Direct Project Costs				**37,775,500**	**41,985,186**	**79,760,686**
Indirect Project Costs						
Engineering, Procurement, & Project Services		8.0	%			6,381,000
Construction Management/Field Engineering		4.0	%			3,190,000
S-U/Commissioning		1.0	%			798,000
Subtotal Indirect Costs						**10,369,000**
Escalation						
AFUDC						
Sub-total Project Costs						**90,129,686**
Project Contingency		20.0	%			18,025,937
Total Construction Cost						**108,155,623**

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Capital Cost Estimate for Option 3B: ESP to FF Conversion – New Casing

Estimate No. : 24140C — Pacificorp — Sargent & Lundy
Project No. : 11802-002 Wyodak Station Install - Baghouse in Existing ESP Casing - Option 2 (Replace casing above hopper beam)
Issue Date : 04/28/2008
Preparer : RK/KSZ
Reviewer : PG

Description	Quantity	Unit of Measure	Equipment & Material Cost	Installation Cost	Total Cost
CIVIL					
DRAINAGE, GRADING, PAVING, ROADWORK	0	LS	0	0	0
MECHANICAL, DUCTWORK ,FOUNDATIONS AND DEMOLITION					
DEMOLISH INSULATION & LAGGING FROM HOPPERS	46,000	SF	0	305,000	305,000
DEMO EXISTING ESP INTERNALS AND CASING ABOVE HOPPER BEAM	1	EA	0	1,680,000	1,680,000
INSTALL BAGHOUSE IN EXISTING ESP CASING	1	EA	15,600,000	5,112,000	20,712,000
INSULATION AND LAGGING	109,000	SF	1,123,000	2,384,000	3,507,000
BAGHOUSE CONCRETE FOUNDATION	0	CY	0	0	0
BAGHOUSE CAISSONS	0	EA	0	0	0
REPLACE ID FAN & MOTOR	2	EA	2,630,000	903,000	3,533,000
ASH HANDLING SYSTEM UPGRADES	1	LS	1,400,000	700,000	2,100,000
DUCTWORK					
GAS DUCTWORK BETWEEN BAGHOUSE OUTLET TO ID FAN INLET					
DUCTWORK	700	TN	2,450,000	3023000	5473000
INSULATION & LAGGING	75,000	SF	773,000	1342000	2115000
EXPANSION JOINTS	1,500	LF	450,000	287000	737000
DAMPERS	0	SF	0	0	0
TURNING VANES	4	TN	12,000	17000	29000
TEST PORTS	2	EA	10,000	10000	20000
SUPPORT STEEL	400	TN	1,060,000	913000	1973000
GRATING	1,200	SF	19,000	9000	28000
MISC. STEEL	60	TN	186,000	164000	350000
HR & TP	700	LF	35,000	27000	62000
LADDERS AND CAGES	250	LF	13,000	10000	23000
STAIRS	50	LF	5,000	4000	9000
FOUNDATIONS FOR DUCTS					
CAISSONS 2X12-30"DIA. X 30'	1,500	LF	188,000	0	188000
CONCRETE	850	CY	162,000	351000	513000
DEMOLITION OF DUCTS					
DEMOLISH DUCTS	400	TN	0	316000	316000
DEMOLISH INSULATION AND LAGGING	60,000	SF	0	5923000	5923000
DEMOLISH SUPPORT STEEL	250	TN	0	197000	197000
SUBTOTAL MECHANICAL, DUCTWORK ,FOUNDATIONS AND DEMOLITION			**26,116,000**	**23,677,000**	**49,793,000**
ELECTRICAL					
EQUIPMENT	1	LS	4,594,000	0	4,594,000
MATERIAL AND INSTALLATION	1	LS	3,305,000	2,305,000	5,610,000
SUBTOTAL ELECTRICAL			**7,899,000**	**2,305,000**	**10,204,000**
GENERAL SUPPORT					
EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	1	LT	0	400,000	400,000
SUBTOTAL GENERAL SUPPORT			**0**	**400,000**	**400,000**
Subtotal Equipment, Material and Install Costs			**34,015,000**	**26,382,000**	**60,397,000**
CONTRACTORS COSTS					
OUTAGE WORK					
NON OUTAGE WORK					
Craft support during startuip	3	%		653,000	653,000
Mobilization / Demobilization	1.5	%		396,000	396,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	25.0	%		2,771,000	2,771,000
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	22.0	%		975,000	975,000
Labor Cost Due To Overtime Ineffiency - Specify % Inefficiency	8.0	%		1,536,000	1,536,000

Description	Quantity	Unit of Measure	Equipment & Material Cost	Installation Cost	Total Cost
Overtime Pay @ 1.5 - % Additional Hours Paid on Hours Worked	10.0	%		768,000	768,000
Per Diem	8.0	$/HR		3,244,199	3,244,199
Freight-ExWorks To Site	4.0	%	631,000	0	631,000
Taxes - Sales		%	0	0	0
Contractor's General and Administration Expense	5.0	%	789,000	1,319,000	2,108,000
Contractor's Profit	10.0	%	1,579,000	2,638,000	4,217,000
EPC Fee	10.0	%	3,401,500	2,638,200	6,039,700
SUBTOTAL CONTRACTOR'S COST			**6,400,500**	**16,938,399**	**23,338,899**
Total Direct Project Costs			**40,415,500**	**43,320,399**	**83,735,899**
Indirect Project Costs					
Engineering, Procurement, & Project Services	8.0	%			6,699,000
Construction Management/Field Engineering	4.0	%			3,349,000
S-U/Commissioning	1.0	%			837,000
Subtotal Indirect Costs					**10,885,000**
Escalation					0
AFUDC					0
Sub-total Project Costs					**94,620,899**
Project Contingency	20.0	%			18,924,180
Total Construction Cost					**113,545,079**

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Capital Cost Estimate for Option 4: New Stand-Alone Baghouse

Sargent & Lundy LLC
Chicago

Pacificorp
Wyodak Station
Fabric Filter Retrofit Study
Installation of a Stand Alone Baghouse
Conceptual EPC Cost Estimate
-CONFIDENTIAL-

Estimate No.: 23301B
Project No.: 11802-002
Date: 4/24/2008
Revision Number: 0
Revision Date:
Run Date: 4/28/2008
Preparer: RCK/KSZ
Reviewer: PG

Cost Type: Ett = Estimated, Bid = Specific Project Bid Received, OPB = Other Project Bid

Item No.	Description	Scope Definition	Cost Type	Quantity	Unit of Measure	Unit Equip./ Mat. Cost	Total Equipment or Material Cost	Total Construction & Erection Cost	Sub-Contracts	Total Projected Cost (Rounded)
DW	**DUCTWORK**									
DW-1	GAS DUCTWORK FROM EXISTING SDA OUTLET TO BAGHOUSE INLET						**1,301,200**	**1,632,700**		**2,933,900**
DW-2	GAS DUCTWORK BETWEEN BAGHOUSE OUTLET & NEW ID FAN INLET PANTLEGS						**792,400**	**1,000,600**		**1,793,000**
DW-3	GAS DUCTWORK - NEW ID FAN PANTLEGS						**526,000**	**660,600**		**1,186,600**
DW-4	600 LF OF STRAIGHT DUCT						**2,557,400**	**3,295,700**		**5,853,100**
DW-5	GAS DUCTWORK BETWEEN SPLIT AND ENTERING CHIMNEY						**330,300**	**416,100**		**746,400**
DW-6	DUCTWORK SUPPORT STRUCTURES						**2,496,000**	**1,248,800**		**3,744,800**
DW-7	FOUNDATIONS						**291,600**	**669,300**		**960,900**
DW-8	PILES						**580,000**	**194,400**		**774,400**
DW-9	ELECTRICAL **SEE AUX POWER SYSTEM**									
DW	**DUCTWORK SUBTOTAL**						**8,874,900**	**9,118,200**		**17,993,100**
BH	**BAGHOUSE**									
BH-1	BAGHOUSE, COMPLETE	3.5 fpm A/C Ratio g, 1,876,920 acfm @ 170 deg F	OPB	1	LS	13,550,000	13,550,000	10,378,900		23,928,900

Sargent & Lundy LLC
Chicago

Pacificorp
Wyodak Station
Fabric Filter Retrofit Study
Installation of a Stand Alone Baghouse
Conceptual EPC Cost Estimate
-CONFIDENTIAL-

Estimate No.: 23301B
Project No.: 11802-002
Date: 4/24/2008
Revision Number: 0
Revision Date:
Run Date: 4/28/2008
Preparer: RCK/KSZ
Reviewer: PG

Cost Type: Ett = Estimated, Bid = Specific Project Bid Received, OPB = Other Project Bid

Item No.	Description	Scope Definition	Cost Type	Quantity	Unit of Measure	Unit Equip./ Mat. Cost	Total Equipment or Material Cost	Total Construction & Erection Cost	Sub-Contracts	Total Projected Cost (Rounded)
BH-2	AIR COMPRESSORS & RECEIVERS (By Vendor)	Included in BH-1								Incl. In BH-1
BH-3	AIR PIPING & VALVES (By Vendor)	Included in BH-1								Incl. In BH-1
BH-4	BAGHOUSE SUPPORT STRUCTURES									**Incl. In BH-1**
	STRUCTURAL STEEL (By Vendor)	Included in BH-1								Incl. In BH-1
	GIRTS & PURLINS (By Vendor)	Included in BH-1								Incl. In BH-1
	ACCESS GALLERIES (By Vendor)	Included in BH-1								Incl. In BH-1
BH-5	INSULATION, SIDING, & ROOFING						**769,200**	**1,097,600**		**1,866,800**
	BAGHOUSE MODULE INSULATION & LAGGING		Est	24,000	SF	10	240,000	429,400		669,400
	BAGHOUSE MODULE ROOF	Insulation & Checkered Plate	Est	8,400	SF	13	109,200	179,000		288,200
	HOPPER INSULATION & LAGGING		Est	19,000	SF	10	190,000	340,000		530,000
	HOPPER ENCLOSURE INSULATED METAL SIDING		Est	6,500	SF	10	65,000	60,600		125,600
	PENTHOUSE ENCLOSURE INSULATED METAL SIDING		Est	3,500	SF	10	35,000	32,600		67,600
	PENTHOUSE ENCLOSURE INSULATED METAL ROOFING		Est	13,000	SF	10	130,000	56,000		186,000
BH-6	FOUNDATIONS (INCL. EXCAVATION AND BACKFILL)						**324,000**	**531,200**		**855,200**
	FOUNDATIONS FOR BAGHOUSE STRUCTURAL STEEL		Est	1,800	CY	180	324,000	531,200		855,200
BH-7	PILES						**250,000**	**0**		**250,000**
	STRAIGHT SHAFT DRILLED CAISSONS	Total 2,500 LF @ 20' Each, 30" DIA.	Est	125	EA	2,000	250,000	0	Yes	250,000
BH-8	ELECTRICAL/I&C **SEE AUX POWER SYSTEM**									

Sargent & Lundy LLC
Chicago

Pacificorp
Wyodak Station
Fabric Filter Retrofit Study
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Conceptual EPC Cost Estimate
-CONFIDENTIAL-

Estimate No.: 23301B
Project No.: 11802-002
Date: 4/24/2008
Revision Number: 0
Revision Date:
Run Date: 4/28/2008
Preparer: RCK/KSZ
Reviewer: PG

Cost Type: Ett = Estimated, Bid = Specific Project Bid Received, OPB = Other Project Bid

Item No.	Description	Scope Definition	Cost Type	Quantity	Unit of Measure	Unit Equip./ Mat. Cost	Total Equipment or Material Cost	Total Construction & Erection Cost	Sub-Contracts	Total Projected Cost (Rounded)
BH	**BAGHOUSE SUBTOTAL**						**14,893,200**	**12,007,700**		**26,900,900**
ASH	**ASH HANDLING & STORAGE SYSTEM**									
ASH-3	CONVEYOR PIPING & VALVES						**1,589,600**	**657,700**		**2,247,300**
	HOPPER VALVES AND PIPE UNDER BAGHOUSE	For (14) Ash Hoppers, 8" Pipe	Vendor Est.	1	LS	1,400,000	1,400,000	448,000		1,848,000
	TRANSPORT PIPE TO SILO	800' of 8" Pipe	Vendor Est.	1	LS	100,000	100,000	90,700		190,700
ASH-5	PIPE SUPPORTS FOR CONVEYOR PIPING		Vendor Est.	1	LS	70,000	70,000	52,900		122,900
ASH-6	SERVICE PIPING TO NEW ASH HANDLING EQUIPMENT	Allowance, 4" Sch. 40 GALV.	Est	700	LF	28	19,600	66,100		85,700
ASH-7	FOUNDATIONS						**14,400**	**33,100**		**47,500**
	ASH PIPING		Est	80	CY	180	14,400	33,100		47,500
ASH-8	PILES						**60,000**	**0**		**60,000**
	STRAIGHT SHAFT DRILLED CAISSONS	Total 600 LF @ 20' Each, 30" DIA.	Est	30	EA	2,000	60,000	0	Yes	60,000
ASH-9	ELECTRICAL/I&C **SEE AUX POWER SYSTEM**									
ASH	**ASH HANDLING & STORAGE SYSTEM SUBTOTAL**						**1,664,000**	**690,800**		**2,354,800**

Sargent & Lundy [LLC]
Chicago

Pacificorp
Wyodak Station
Fabric Filter Retrofit Study
Installation of a Stand Alone Baghouse
Conceptual EPC Cost Estimate
-CONFIDENTIAL-

Estimate No.: 23301B
Project No.: 11802-002
Date: 4/24/2008
Revision Number: 0
Revision Date:
Run Date: 4/28/2008
Preparer: RCK/KSZ
Reviewer: PG

Cost Type: Ett = Estimated, Bid = Specific Project Bid Received, OPB = Other Project Bid

Item No.	Description	Scope Definition	Cost Type	Quantity	Unit of Measure	Unit Equip./ Mat. Cost	Total Equipment or Material Cost	Total Construction & Erection Cost	Sub-Contracts	Total Projected Cost (Rounded)
ID	**ID FANS**									
ID-1	FANS & MOTORS	w/ 7,500 HP Motor	OPB	2	EA	1,200,000	2,400,000	644,000		3,044,000
ID-2	LUBE OIL	Included in ID-1								Incl. In ID-1
ID-3	VIBRATION MONITORS	Included in ID-1								Incl. In ID-1
ID-4	INSULATION & LAGGING		Est	1	LS	75,000	75,000	53,000		128,000
ID-5	FOUNDATION		Est	500	CY	150	75,000	206,600		281,600
ID-6	PILES									
	STRAIGHT SHAFT DRILLED CAISSONS	Total 800 LF @ 20' Each, 30" DIA.	Est	40	EA	2,000	80,000	0	Yes	80,000
ID-7	ID FAN ROTOR REMOVAL SYSTEM	See Ductwork Support Steel								Incl. In DW-5
ID	**ID FAN SUBTOTAL**						**2,630,000**	**903,600**		**3,533,600**
AP	**AUXILIARY POWER SUPPLY SYSTEM**									
AP-1	230 KV SWITCHYARD BREAKER	Including All Accessories, Buswork, etc.	Est	2	EA	450,000	900,000	1,088,200		1,988,200
AP-2	230KV 3 Ph. LINE - 250 MCM ALUMINUM	750' Per Phase, Overhead Transmission Lines	Est	2,250	LF	85	191,300	192,300		383,600
AP-3	ISO-PHASE BUS TAP IN EXISTING GENERATOR BUS		Est	1	LS	50,000	50,000	25,200		75,200

Sargent & Lundy LLC
Chicago

Pacificorp
Wyodak Station
Fabric Filter Retrofit Study
Installation of a Stand Alone Baghouse
Conceptual EPC Cost Estimate
-CONFIDENTIAL-

Estimate No.: 23301B
Project No.: 11802-002
Date: 4/24/2008
Revision Number: 0
Revision Date:
Run Date: 4/28/2008
Preparer: RCK/KSZ
Reviewer: PG

Cost Type: Ett = Estimated, Bid = Specific Project Bid Received, OPB = Other Project Bid

Item No.	Description	Scope Definition	Cost Type	Quantity	Unit of Measure	Unit Equip./ Mat. Cost	Total Equipment or Material Cost	Total Construction & Erection Cost	Sub-Contracts	Total Projected Cost (Rounded)
AP-4	ISO-PHASE BUS, 1200A, 27KV	In Single Phase Feet	Est	150	LF	1,000	150,000	33,700		183,700
AP-5	BAGHOUSE ID FAN TRANSFORMERS									
	230-13.8KV, 25 MVA		Est	1	EA	640,000	640,000	39,300		679,300
	23-13.8KV, 25 MVA		Est	1	EA	386,000	386,000	22,400		408,400
AP-6	TRANSFORMER RELAY & METERINGS	Serving 2 Transformers	Est	1	LS	170,000	170,000	11,200		181,200
AP-7	15KV CABLE BUS, 2000A	2 Runs @ 900'	Est	1,800	LF	780	1,404,000	807,700		2,211,700
AP-8	15KV SWITCHGEAR, 500 MVA, 2,000A, 7 SECTIONS WITH 10 BREAKERS, RELAYING AND METERING, OUTDOOR RATED.		Est	1	LT	540,000	540,000	56,100		596,100
AP-9	480V MCC, 1,600A, 6 SECTIONS		Est	2	EA	70,000	140,000	56,100		196,100
AP-10	13.8KV/480V TRANSFORMER, 750/1,000 KVA		Est	2	EA	50,000	100,000	22,400		122,400
AP-11	SWITCHGEAR & TRANSFORMER FOUNDATIONS									
	FOUNDATIONS		Est	80	CY	180	14,400	56,700		71,100
	STRAIGHT SHAFT DRILLED CAISSONS	Not Included	Est	0	EA	2,000	0	0	Yes	0
AP-12	GROUNDING									
	CABLE - 500 KCMIL GND		Est	1,000	LF	4	4,000	29,200		33,200
	GROUNDING RODS		Est	6	LF	200	1,200	1,300		2,500
AP-13	LIGHTING									
	40 FT. POLE		Est	10	EA	1,230	12,300	300		12,600

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	POLE FOUNDATION		Est	6	EA	560	3,400	1,400		4,800
	T2 FIXTURE - 400W HPS		Est	50	EA	340	17,000	1,300		18,300
AP-14	ELECTRICAL BUILDING									
	BUILDING	Pre-Fabricated, Complete	Est	1	EA	230,000	230,000	18,300		248,300
	FOUNDATION		Est	20	CY	180	3,600	14,200		17,800
	PLATFORMS		Est	5	TN	3,000	15,000	13,700		28,700
AP-15	CABLE									
	POWER CABLE 1/C 500 KCM, 15KV		Est	6,000	LF	7.80	46,800	134,500		181,300
	POWER CABLE 3/C #6, 600v		Est	10,000	LF	2.20	22,000	261,500		283,500
	POWER CABLE 3/C #10, 600v		Est	50,000	LF	1.10	55,000	186,800		241,800
AP-16	RACEWAY									
	CABLE TRAYS	36" X 6"	Est	1,600	LF	25	40,000	130,700		170,700
	CONDUIT, 1" RGS		Est	3,000	LF	2.50	7,500	122,600		130,100
AP-17	DCS SYSTEM ADDITIONS									
	CABINETS		Est	1	EA	30000.00	30,000	2,000		32,000
	CABLES	3/C #14, 600V	Est	40,000	LF	0.50	20,000	89,700		109,700
	COMMUNICATION CABLES	1 PR #16, 300V	Est	70,000	LF	0.05	3,500	141,200		144,700
AP-18	DCS PROGRAMMING/INTERFACE									
	PANEL BOARDS		Est	4	EA	40000.00	160,000	59,000		219,000
	PROGRAMMING LABOR		Est	1	LT	0.00	0	22,400		22,400
AP-19	MISCELLANEOUS ELECTRICAL									
	MISC. INSTRUMENTATION		Est	1	LT	17000.00	17,000	12,800		29,800
	MISC. FOUNDATIONS		Est	10	CY	180	1,800	7,100		8,900
	MISC. SUPPORT STEEL		Est	5	TN	3,000	15,000	11,000		26,000

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AP	**AUXILIARY POWER SYSTEM SUBTOTAL**						**5,390,800**	**3,672,300**		**9,063,100**
DEMO	**DEMOLITION**									
DEMO-4	DEMOLISH SPRAY DRYER OUTLET DUCTS, INCL. INSULATION & LAGGING	(2), Each Approx. 35' X 10' X 25' Long	Est	80	TN		0	118,500		118,500
DEMO-5	DEMOLISH EXISTING BOOSTER FAN OUTLET DUCTS, INCL. INSULATION & LAGGING	(2), Each Approx. 30' X 30' X 40' Long	Est	120	TN		0	177,700		177,700
DEMO	**DEMOLITION SUBTOTAL**						**0**	**296,200**		**296,200**
REIN	**REINFORCING OF EXISTING EQUIPMENT**									
REIN-1	BOILER	Not Included								Not Included
REIN-2	PRIMARY & SECONDARY AIR HEATERS	Not Included								Not Included
REIN-3	PRECIPITATOR	Not Included								Not Included
REIN-4	EXISTING DUCTWORK	Not Included								Not Included
REIN	**REINFORCING OF EXISTING EQUIPMENT SUBTOTAL**						**0**	**0**		**0**
MISC	**MISCELLANEOUS**									

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MISC-1	PAINTING	Touch-up and Field Finish	Est	1	LS	95,000	95,000	173,400		268,400
MISC-2	ROADWORK RESURFACING	20' Width X 1,000 LF Asphalt	Est	1	LS	95,000	95,000	66,000		161,000
MISC-3	STORM DRAINAGE		Est	1	LS	30,000	30,000	55,800		85,800
MISC-4	FINAL GRADING		Est	1	LS	-	0	124,500		124,500
MISC	**MISCELLANEOUS SUBTOTAL**						**220,000**	**419,700**		**639,700**
GS	**GENERAL SUPPORT**									
GS-1	MOBILIZATION / DEMOBILIZATION	% of labor cost	Est	1.5	%		0	379,000		379,000
GS-2	EQUIPMENT RENTAL SUPPLEMENT, LARGE CRANES	1 Crane With Crew - 6 Months	Est	1	LT			400,000		400,000
GS	**GENERAL SUPPORT SUBTOTAL**						**0**	**779,000**		**779,000**
	SUBTOTAL						**33,672,900**	**27,887,500**		**61,560,400**
	CRAFT SUPPORT DURING STARTUP	At 3% of Total Manhours						682,400		682,400
	MOB/DEMOB EXPENSE			1	LT			300,000		300,000
	LABOR COST DUE TO OVERTIME INEFFICIENCY	Allowance for Casual OT Only, @ 5% of Direct Labor - Not Extended OT						1,394,400		1,394,400
	PRODUCTIVITY LOSS DUE TO OVERTIME									Not Included
	PER DIEM EXPENSE			65	DAY			2,878,000		2,878,000
	PROJECT WRAP (EFFICACY) INSURANCE	Not Included - Labor Rates Include General Liability Only								Not Included

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	ERECTION CONTRACTOR'S GENERAL & ADMINISTRATIVE COSTS	% of Material and Labor Costs Excl'd Equipment		5	%		165,000	1,500,000		1,665,000
	ERECTION CONTRACTOR'S PROFIT	% of Material and Labor Costs Excl'd Equipment		10	%		330,000	3,000,000		3,330,000
	MANDATORY SPARE PARTS (START-UP/TESTING)	Included w\Equipment Costs								Incl. w\Equip. Costs
	SPECIAL TOOLS	Included w\Equipment Costs								Incl. w\Equip. Costs
	FREIGHT TO SITE	% of Equipment/Material Cost, Less Baghouse Costs (Included Above)		4	%		804,900			804,900
	TAXES - SALES/USE/VAT/BUSINESS/ETC.									Not Included
	SUBTOTAL DIRECT PROJECT COSTS						**34,972,800**	**37,642,300**		**72,615,100**
	ENGINEERING & PROCUREMENT	Based on % of total Direct Project Costs.		8	%					5,809,200
	CONSTRUCTION MANAGEMENT / FIELD ENGINEERING	Based on % of total Direct Project Costs.		4.0	%					2,904,600
	STARTUP & COMMISSIONING	Based on 1% of total Direct Project Costs.		1	%					726,200
	EPC CONTRACTOR'S ESCALATION ALLOWANCE	Not Included		0	%					0
	EPC CONTRACTOR'S FEE			10	%					8,205,500
	SUBTOTAL EPC PROJECT COST									**90,260,600**
	PERMITTING	Not Included								Not Included
	CLIENT INTERNAL COST	Not Included								Not Included

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	PROJECT CONTINGENCY	Based on % of All Above Costs		20	%					18,052,100
	OPERATING SPARE PARTS	Not Included								Not Included
	INTEREST DURING CONSTRUCTION (AFUDC)	Not Included								Not Included
	ESCALATION	Not Included								
	TOTAL PROJECT COST									**108,312,700**
	NOTE: Non Outage Non overtime job - casual O.T. only, Stand Aone Does not address ESP Demolition									