BART DETERMINATION FOR EASTALCO ALUMINUM COMPANY FREDERICK, MARYLAND

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ACRONYMS

acfm	actual cubic feet per minute
AWMA	Air and Waste Management Association
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
CAA	Clean Air Act
$CaSO_3$	Calcium Sulfite
$CaSO_4$	Calcium Sulfate
CFR	Code of Federal Regulations
CO_2	Carbon Dioxide
COS	Carbonyl Sulfide
dv	deciview
Eastalco	Eastalco Aluminum Company
ESP	Electrostatic Precipitator
°F	degrees Fahrenheit
FCCU	Fluidized-bed Catalytic Cracking Unit
FGD	Flue Gas Desulfurization
GHGs	Greenhouse Gases
kWh	Kilowatt hours
LAER	Lowest Achievable Emissions Rate
LoTOx™	Low Temperature Oxidation
LSFO	Limestone Slurry Forced Oxidation
LSNO	Limestone Slurry Natural Oxidation
MANE-VU	Mid-Atlantic/Northeast Visibility Union
Mg/Nm^3	milligrams per cubic meter
MMBtu/hr	million British thermal units per hour
MW	Megawatt
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_x	Nitrogen Oxides
O_2	Oxygen
PM	Particulate Matter
ppm	parts per million
ppmv	parts per million by volume
RACT	Reasonably Available Control Technology
RBLC	RACT/BACT/LAER Clearinghouse
RPO	Regional Planning Organization
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SO_2	Sulfur Dioxide
USEPA	United States Environmental Protection Agency
VISTAS	Visibility Improvement State and Tribal Association of the Southeast

EXECUTIVE SUMMARY

The Clean Air Act (CAA) requires the protection of visibility in 156 scenic areas across the United States. Under CAA Section 169A(b)(2)(A), states must require certain existing stationary sources to install Best Available Retrofit Technology (BART). Eastalco Aluminum Company (Eastalco) is a "BART-eligible" source. A BART determination is required because Eastalco emits air pollutants that may reasonably be anticipated to contribute to impairment of visibility in a Class I area using criteria established by the State of Maryland.

The BART analysis contained herein lists the individual BART-eligible emission units and evaluates visibility impacts, control option feasibility, cost effectiveness, and visibility improvement. The BART evaluation was completed according to guidance provided in 40 Code of Federal Regulations (CFR) 51, Appendix Y and guidance from the State of Maryland.

A baseline Class I area visibility impact analysis was performed on 53 BART-eligible emission units at Eastalco using the CALPUFF model. These sources include two potlines, an anode bake furnace, eight aluminum holding furnaces, three homogenizing furnaces, various material handling and transfer operations, natural gas and diesel combustion, and other small miscellaneous sources.

Modeled or projected 98th percentile visibility impacts were determined for five Class I areas: Brigantine Wilderness Area, Dolly Sods Wilderness Area, James River Face Wilderness Area, Otter Creek Wilderness Area, and Shenandoah National Park. The modeled facility-wide visibility impacts in all five Class I areas were below the United States Environmental Protection Agency's (USEPA's) recommended 0.5 deciview (dv) contribution threshold for "BART eligible" facilities. The modeled impacts in three Class I areas (Dolly Sods Wilderness Area, Otter Creek Wilderness Area, and Shenandoah National Park) exceed 0.1 dv, which the State of Maryland has suggested as an alternate contribution threshold to USEPA's recommended 0.5 dv threshold. The highest modeled facility-wide impact was forecast to be 0.42 dv in Shenandoah National Park. The modeled visibility impacts are primarily from the potlines, with a small amount from the anode bake furnace and rod shop. Other sources contribute negligible amounts to the total as described further below.

The highest modeled or projected 98th percentile visibility impact of the potlines is approximately 0.36 dv in Shenandoah National Park. The projected impacts in the other, more distant, Class I areas are lower. Nearly 73% of the projected impact from the potlines is attributable to emissions from the potroom primary control devices, with the remainder from the potroom wet roof scrubbers. Approximately 95% of the potroom primary control device impact is from emissions of sulfur dioxide (SO_2).

The analysis of control options for potroom emissions determined that BART for potline SO_2 emissions is a pollution prevention limit of 3% sulfur in the calcined petroleum coke used to manufacture anodes (i.e., coke), along with continued operation of existing potline SO_2 emission control systems. With this BART determination, Eastalco would limit total annual SO_2 emissions from the potlines and anode bake furnace to 3,781 tons per year. BART for other pollutants emitted from the potlines [particulate matter (PM) and nitrogen oxides (NO_x)] was determined to be the existing level of emission control.

The highest modeled or projected 98th percentile visibility impact from the anode bake furnace is approximately 0.045 dv in Shenandoah National Park, with lower projected impacts in other Class I areas. The analysis of control options for the anode bake furnace determined that BART for anode bake furnace SO_2 emissions is a pollution prevention limit of 3% sulfur in coke used to manufacture anodes. With this BART determination, Eastalco would limit total annual SO_2 emissions from the potlines and anode bake furnace to 3,781 tons per year. For anode bake furnace NO_x and PM emissions, BART was determined to be the existing level of emissions control.

Additional BART-eligible emission units at the Eastalco facility include aluminum holding furnaces, homogenizing furnaces, various material handling and transfer operations, natural gas and diesel combustion, and other small miscellaneous sources that support the primary aluminum ore reduction process. The projected impacts from the remaining 50 BART-eligible emission units combined (sources other than the potlines and anode bake furnace) are 0.067 dv in Shenandoah National Park, with lower projected impacts in other Class I areas. Considering the trivial contribution to visibility impairment (less than 0.07 dv) and the existing level of emissions control, these emission sources were excluded from further analysis and BART was determined to be the existing level of emissions control.

1.0 INTRODUCTION

The Clean Air Act (CAA) requires the protection of visibility in 156 scenic and wilderness areas (Class I areas) across the United States. Under CAA Section 169A(b)(2)(A), states must require certain existing stationary sources to install Best Available Retrofit Technology (BART) if they meet certain criteria. A "BART-eligible" source is a stationary source that is in one or more of 26 identified source categories, has the potential to emit greater than or equal to 250 tons per year of any visibility impairing air pollutant, and was put in place during the 15-year interval between August 7, 1962, and August 7, 1977. BART is required when any source meeting this definition emits any air pollutant that may reasonably be anticipated to cause or contribute to any impairment of visibility in any Class I area.

2.0 IDENTIFICATION OF BART-ELIGIBLE UNITS AT EASTALCO

Eastalco operates emission units that fall within the categories of primary aluminum ore reduction plants and secondary metal production facilities, two of the 26 identified source categories to which BART is applicable. The Eastalco facility was originally constructed in 1970. Therefore, the facility's emission units were in existence on August 7, 1977, but were not in operation before August 7, 1962. The facility has the potential to emit more than 250 tons per year of sulfur dioxide (SO_2) and particulate matter (PM), which are visibility impairing pollutants. As such, the Eastalco facility is defined as a BART-eligible source. Numerous emission units at Eastalco were constructed between August 7, 1962 and August 7, 1977 and are, therefore, BART-eligible. These emission units are summarized in **Table 2-1**. Emissions of SO_2, PM, and nitrogen oxides (NO_x) were evaluated as part of this process.

3.0 BART-ELIGIBLE EMISSION UNIT GROUP DESCRIPTION

3.1 PRIMARY ALUMINUM REDUCTION PROCESS DESCRIPTION

Eastalco's primary aluminum reduction operations include two center-worked prebake potlines and an electrode manufacturing operation made up of a paste production and anode baking operation.

The potline operation manufactures metallic aluminum by the electrolytic reduction of alumina in center-worked prebake cells. Direct electrical current, passing between anodes and the cathode, electrolytically reduces the alumina to metallic aluminum and oxygen. Molten aluminum is deposited and accumulates over time at the cathode beneath a layer of molten cryolite bath. Periodically the molten aluminum is siphoned from beneath the cryolite bath and processed to achieve specific metal properties or is retained as pure aluminum. The produced aluminum is solidified into intermediate products.

Anodes are manufactured in an ancillary on-site paste production plant. Calcined petroleum coke used to manufacture anodes (i.e., coke) is crushed and sized, reusable anode butt material is crushed and sized, and both are mixed together with pitch and formed into self-supporting carbonaceous blocks called "green anodes." The green anodes are then surrounded by packing coke and baked in furnaces before being used in the aluminum reduction process.

Table 2-1 presents the individual emission units that are included in the primary aluminum reduction and secondary metal production categories that were identified as being BART-eligible. Potlines A and B emit SO_2 and PM, and the anode bake furnace emits lesser amounts of SO_2, NO_x, and PM. These emission units are presently equipped with sophisticated emission control equipment for PM (i.e., baghouses), so the BART determination for these emission units focuses primarily on potential reductions for SO_2 and NO_x.

The remaining emission units identified in **Table 2-1** include aluminum holding furnaces, homogenizing furnaces, various material handling and transfer operations, natural gas and diesel combustion, and other small miscellaneous sources that support the potlines and anode bake furnace. Aside from the products of natural gas combustion, which result in very small amounts of PM, emissions from most of these support operations consist of relatively small amounts of PM that are controlled by fabric filter type control devices. Fabric filters effectively remove more than 99% of particulate emissions and, based on the control technology review in Section 5.0, represent the best available control for these types of material handling and transfer operations. Given the level of emissions, the fact that fabric filters represent the best available control, and the minimal impacts of these sources on visibility, these emission sources were excluded from further BART engineering analysis. BART for this grouping of support operations was determined to be the existing level of control.

3.1.1 Existing Potline Emissions Control

The potlines at Eastalco consist of four potroom groups [i.e., "…a group of potroom segments ducted to a common control system" (40 Code of Federal Regulations 60.191)] of electrolytic reduction cells connected in series that produce molten aluminum. There are two potroom groups per potline, designated A1 and A2 for Potline A and B1 and B2 for Potline B. Each potroom is comprised of 120 reduction cells (or pots) with 18 anodes per cell. All pots at Eastalco are hooded to capture emissions. Emissions captured by the hoods are abated by the primary control system, which consists of alumina dry injection scrubbers with baghouses for the control of fluoride and PM emissions. In addition, half of the Potline A emissions (pots in A1) are subsequently vented to modified wet roof scrubbers, which are equipped with alkaline injection systems for the control of SO_2 emissions. Six small wet roof scrubbers that were originally part of the secondary control system (described further below) were modified in 1995 in an effort to capture SO_2 in the potline exhaust gas. The facility typically operates four of these six scrubbers, with a nominal SO_2 control efficiency of approximately 20%. Sustained higher removal efficiencies are not possible for these scrubbers due to design limitations and demonstrated issues with scale formation and corrosion. The BART options for potline SO_2 control in Section 5.0 were therefore based on high efficiency scrubbing systems to treat SO_2 emissions from both potlines.

Each of Eastalco's primary control system centers consists of multi-compartment baghouse cells. Baghouse filter cleaning is performed offline periodically using sonic horn technology. The multiple compartment design allows for maintenance and troubleshooting of individual cells while the baghouse center is still operating. The PM control efficiency of the primary control system is estimated to be above 95% based on measured emissions.

Fugitive potroom emissions from primary aluminum smelters are typically not controlled due to the large volume of air exiting the potroom roof (approximately 4.5 million actual cubic feet per minute [acfm] per potline). However, Eastalco operates a secondary pollution control system on each of its potlines to abate fugitive fluoride, PM, and SO_2 emissions. The secondary control system consists of a series wet roof scrubbers for each of the two potlines. Each of the 89 wet roof scrubbers treats between 90,000 acfm and 108,000 acfm of potroom air. The wet roof scrubbers become inoperable and must be shutdown during sustained periods of below-freezing temperatures in order to avoid permanent damage. These shutdowns occur infrequently and only during the winter months. The PM control efficiency of the secondary control system is estimated to be approximately 20% based on source test data from the last five years of operation. The wet roof scrubbers also remove approximately 25% of fugitive potroom SO_2 emissions.

3.1.2 Anode Bake Furnace Emissions Control

Products of natural gas combustion, products of combustion from volatiles liberated during the baking of green anodes, and other emissions typically associated with anode baking are exhausted to a dry alumina scrubbing system. The anode bake furnace emission control equipment conditions the exhaust gases prior to alumina being injected. Fabric filtration modules located downstream of the alumina injection reduce PM emission by as much as 99%

3.1.3 Aluminum Holding Furnace Emissions Control

The holding furnaces at Eastalco vary in size, ranging from 12 to 16 million British thermal units per hour (MMBtu/hr). These furnaces are fueled by natural gas and are currently equipped with low-NO_x burners.

4.0 BASELINE CONDITIONS AND VISIBILITY IMPACTS FOR BART-ELIGIBLE UNITS

CALPUFF modeling was performed to evaluate the cumulative visibility impacts of BART-eligible emission units at Eastalco, and to compare the relative contribution of individual emission units to the total visibility impact. All modeling performed in association with this BART determination was done by Epsilon Associates, Inc. The complete Eastalco BART modeling report is contained in **Appendix A**.

4.1 CALPUFF MODEL AND BASELINE EMISSION INPUTS

CALPUFF and its meteorological model CALMET are designed to handle the complexities posed by complex terrain, long source receptor distances, chemical transformation and deposition, and other issues related to Class I impacts. The USEPA adopted the CALPUFF modeling system as a guideline model for source-receptor distances greater than 50 km and for use on a case-by-case basis in complex flow situations for shorter distances (Federal Register, April 15, 2003). CALPUFF was recommended for Class I impact assessments by the Federal Land Managers Workgroup in 2000 and the Interagency Workgroup on Air Quality Modeling in 1998. CALPUFF is recommended by USEPA (Federal Register, July 6, 2005) and the Mid-Atlantic/Northeast Visibility Union (MANE-VU) regional planning organization (RPO) for BART analyses.

Tables 4-1, 4-2, and 4-3 present the baseline modeling source input data for point sources, line sources, and volume sources, respectively, that were used in the CALPUFF model to forecast the visibility impacts. In accordance with Section IV of 40 CFR 51 Appendix Y, baseline emission rates used in the model were based on 24-hour average actual emissions from the highest emitting day. To represent the worst-case average emission rate, potline SO_2 emissions were modeled assuming that only two of the six wet SO_2 scrubbers for Potline A1 were operational, with the uncontrolled emissions exiting the A1 Bypass Stack (EU110-3 in **Table 4-1**). **Table 4-4** presents the modeled maximum daily emission rates of SO_2, PM, and NO_x for each emission unit.

4.2 BASELINE MODELING ANALYSIS

Baseline modeling runs were performed for 2001 through 2003 using the 4-km resolution Domain 5 CALMET meteorological data set prepared by the Visibility Improvement State and Tribal Association of the Southeast (VISTAS). Five Class I areas (Brigantine Wilderness Area, Dolly Sods Wilderness Area, James River Face Wilderness Area, Otter Creek Wilderness Area, and Shenandoah National Park) were included in the baseline visibility modeling.

Table 4-5 presents the modeled 98th percentile total source visibility impacts (reported as deciviews) for 2001, 2002, and 2003 in these five Class I areas. Baseline modeled visibility impacts in all five Class I areas were below the USEPA's recommended 0.5 dv contribution threshold, which has been adopted in most States and Regions across the United States to determine which sources are BART-eligible. Using this predominantly accepted contribution to visibility impact threshold, Eastalco would not be subject to BART, and would not be required to undertake either a costly source-specific BART analysis or implement BART for emission units having no appreciable effect on the haze in any Class I area.

The modeled impacts in three Class I areas (Dolly Sods Wilderness Area, Otter Creek Wilderness Area, and Shenandoah National Park) exceed 0.1 dv, a level which the State of Maryland has suggested as an alternate contribution threshold. The highest predicted visibility impacts were forecast to be in Shenandoah National Park.

Table 4-6 presents a source contribution analysis for Shenandoah National Park. Individual emission unit visibility impacts in Shenandoah National Park were used to identify which emission units were forecasted to have the most impact on visibility. The modeled or projected 98th percentile visibility impact from the combined potline emissions for the maximum year (2003) is approximately 0.357 dv in Shenandoah National Park. Nearly 73% of this projected impact from the potlines is attributable to emissions from the potroom primary control devices, with the remainder from the potroom wet roof scrubbers (27%). Approximately 95% of the forecast potroom primary control device impact is from SO_2 emissions.

The modeled or projected 98th percentile visibility impact in Shenandoah National Park from the anode bake furnace for the maximum year (2001) was 0.045 dv. For 2001, approximately 20% of the anode bake furnace impact is from SO_2 emissions and approximately 13% of the impact is from NO_x emissions, with the remainder being from PM emissions.

The modeled or projected 98th percentile visibility impact in Shenandoah National Park from the 51 non-potline BART-eligible sources for the maximum year (2003) are 0.067 dv. A reduction in emissions from individual units within this group would not result in perceptible visibility improvement in any of the Class I areas. For example, the modeled visibility impact from the aluminum holding furnaces (casthouse sources in **Table 4-6**) was 0.012 dv at Shenandoah National Park. The use of add-on controls for these furnaces would provide negligible visibility improvement at Shenandoah National Park, and less at the other Class I areas.

Based on results from the baseline modeling, the scope of the BART control analysis and engineering cost calculations were focused on the potlines and anode bake furnace.

5.0 BART ANALYSIS FOR BART-ELIGIBLE EMISSION UNITS

The results of the refined CALPUFF modeling show that Eastalco's potline reactors and anode bake furnace contribute to less than 0.5 dv, but greater than 0.1 dv visibility impairment in three Class I areas. The BART analysis completed for the BART-eligible emission sources is described in this section. The analysis included a review of available and technologically feasible BART technologies (Steps 1 and 2), the determination of control effectiveness for feasible options (Step 3), the evaluation of cost and secondary impacts for feasible alternatives (Step 4), and an analysis of impacts and visibility improvements (Step 5).

5.1 AVAILABLE AND TECHNICALLY FEASIBLE EMISSION CONTROL OPTIONS

Steps 1 and 2 of the BART analysis are to identify available emission control options and to evaluate the technical feasibility of these control technologies. Control options for the potline reactors and anode bake furnace are described separately in the following sections.

5.1.1 Potline Emissions and Existing Controls

Aluminum is manufactured in large electrolytic reduction cells called pots. Aluminum is produced from alumina in the pot as current is passed from a carbon anode to carbon blocks on the pot wall, which serve as the cathode. The anodes are made from calcined petroleum coke and pitch. The major pollutants emitted from the cells are PM, hydrogen fluoride, SO_2, carbonyl sulfide (COS), and carbon monoxide. PM includes particulate fluoride, carbon dust, and alumina. SO_2 and COS originate from the sulfur in the components used to make the anodes. NO_x emissions are minimal since there is no external fuel and there are no large sources of nitrogen in the raw materials.

Emissions from the pots are collected by capture hoods over each pot. The hoods enclose the pot as tightly as possible to collect off-gases, but sections are periodically removed to enable anodes to be exchanged. The off-gases are collected into manifolds that combine the gases from the individual pots. The temperature of the exhaust gases entering the control equipment is typically 150 to 300 degrees Fahrenheit (°F)[1]. The combined gases are routed to a dry alumina scrubber. The potline primary control systems for Eastalco's two potlines consist of dry scrubbers using alumina injection with fabric filtration for PM control. The system at Eastalco is large, treating approximately 1,620,000 acfm of 200°F exhaust gases.

[1] Air and Waste Management Association (AWMA). 2000. *Air Pollution Engineering Manual*, Second Edition.

5.1.2 Anode Bake Furnace Emissions and Existing Controls

The anode bake furnace structure is a series of interconnected refractory flues connected to side main exhaust manifolds. The furnace is fueled with natural gas. Exhaust gases are routed through the interconnecting flues so that the sections of unbaked anodes are preheated. Flue gases leaving the anode bake furnace contain PM, hydrogen fluoride, SO_2, carbon monoxide, and hydrocarbons.

The anode bake furnace control device used at Eastalco is similar to the potline primary control system, in that it consists of dry alumina injection with fabric filtration. The anode bake furnace gas stream is conditioned by a water spray to reduce the inlet temperature before it enters the alumina scrubber. Fresh and recycled alumina are injected into the gas stream, gaseous fluoride and hydrocarbons are adsorbed onto the alumina surface, and fabric filters on top of the reactor compartments collect entrained particulate matter present in the gas stream. The anode bake furnace control system at Eastalco treats approximately 140,000 acfm of 190°F exhaust gases.

5.1.3 Aluminum Holding Furnace Emissions and Existing Controls

Molten aluminum is transferred from the potlines to any of the eight holding furnaces. The holding furnaces maintain the molten aluminum in a liquid state while physical and chemical properties of the aluminum are adjusted to varying product specifications. Molten aluminum from the furnaces is cast and processed into intermediary products. The furnace stacks emit NO_x, SO_2, and PM.

The holding furnaces have inherently low emissions due to their size and the nature of the operations performed in each furnace. For example, the furnaces meet National Emission Standards for Hazardous Air Pollutants (NESHAP) emission limits for PM [40 CFR Part 63, Subpart RRR (Secondary Aluminum NESHAP)] without add-on controls and SO_2 emissions from the holding furnaces are due to the sulfur content of natural gas, which is minimal. In addition, the holding furnaces are already equipped with low-NO_x burners to reduce NO_x emissions from the natural gas combustion.

5.1.4 Potentially Applicable BART Control Options for SO_2

Sulfur in the anodes is oxidized, releasing SO_2 from the potlines as the anodes are consumed by the electrolytic reduction process. SO_2 is also released from the anode bake furnace during the baking process. Options for controlling SO_2 include both add-on controls and pollution prevention.

5.1.4.1 Add-on Emission Controls

Absorption and adsorption have been used for the control of SO_2 emissions from numerous power utility and industrial processes. As a result many commercialized control technologies have been used for SO_2 control. However, the practical application of these control systems to the potline reactors and anode bake furnace is limited by the very low inlet SO_2 concentrations, in the range of 100 parts per million by volume (ppmv), and the expected range of gas conditions, including temperature, oxygen content (O_2), humidity, SO_2/O_2 ratio, and gas impurities.

Eight different SO_2 control options were considered as having potential practical application as part of the BART analysis. Two of these technologies have been applied to the control of SO_2 emissions at aluminum smelters. Six of the control options use wet scrubbing and two use dry scrubbing technology. The eight potentially applicable control options are:

- Limestone slurry scrubbing with forced oxidation
- Limestone slurry scrubbing with natural oxidation
- Conventional lime wet scrubbing
- Seawater scrubbing
- Dual alkali sodium/lime scrubbing (dilute mode)
- Conventional sodium scrubbing
- Dry injection
- Semi-dry scrubbing

5.1.4.1.1 Wet Scrubbing

The primary development of SO_2 control technology occurred because of the need to control emissions from the coal-fired, electric utility power industry[2]. The large volumetric size of the potroom exhaust (approximately 1,620,000 acfm) would require a system similar to those used in the electric utility power industry.

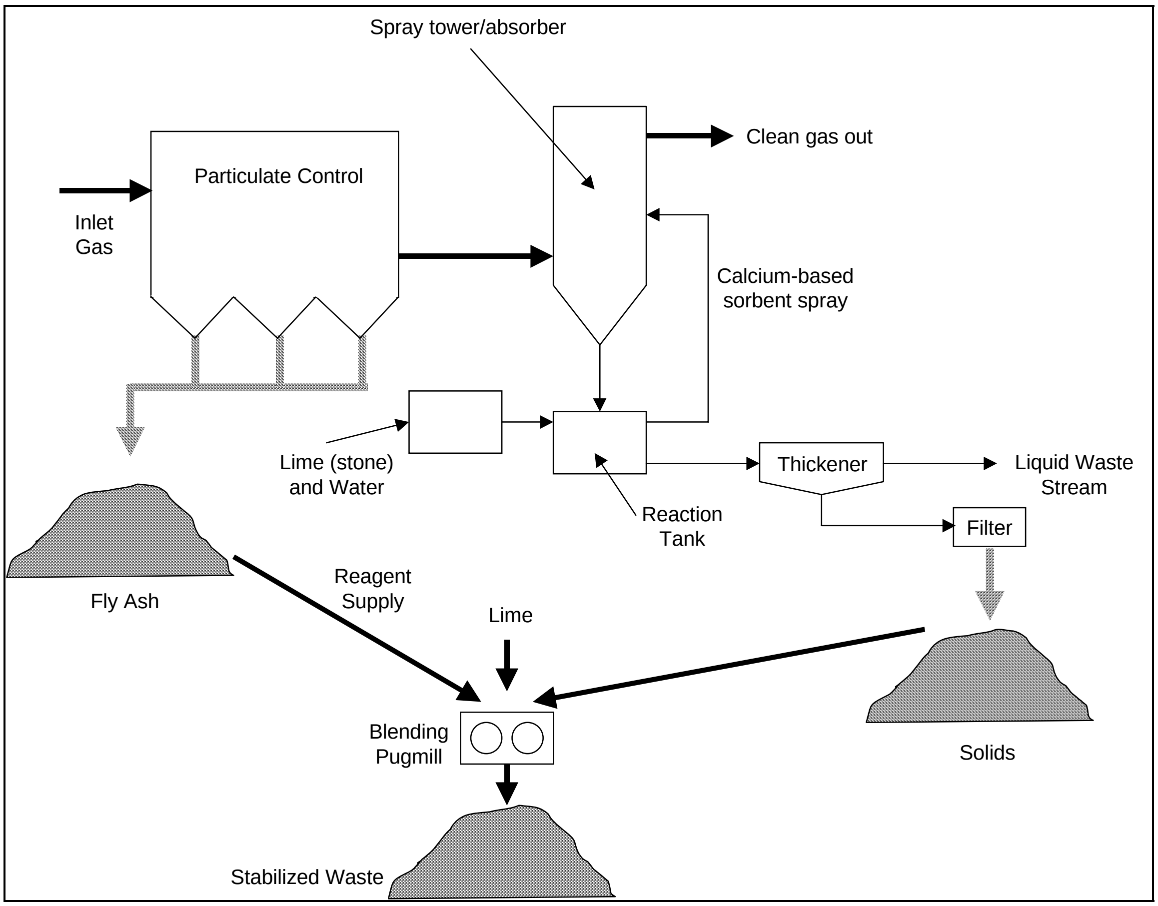
The typical temperature range for wet scrubbers is 300 to 700°F. For utility combustion units, wet scrubbing systems have been installed on systems as large as 1,500 megawatts (MW). Sodium compounds, lime, or limestone can be used. However, the high solubility of sodium complicates disposal of waste and wastewater. The typical sorbent material is lime or limestone. Lime is generally easier to manage on-site but is significantly more costly. Wet limestone scrubbing has a high capital and operating cost due to the handling of liquid reagent and waste, but is the preferred process for coal-fired utility power plants due to the low cost of limestone and high removal efficiencies. Typical removal efficiencies for wet scrubbers are between 80 and 95%. Approximately 85% of the flue gas

[2] AWMA. 2000. *Air Pollution Engineering Manual*, Second Edition.

desulfurization (FGD) systems installed in the United States are wet scrubber systems[3].

In wet scrubbers, the waste gas enters a large vessel (spray tower or absorber), where it is sprayed with water slurry. The calcium in the slurry reacts with SO_2 to form calcium sulfite ($CaSO_3$). A portion of the slurry from the reaction tank is pumped into the thickener, where the solids settle before going to a filter for final dewatering to about 50% solids. Figure 5-1 is a simplified process flow diagram of a conventional wet scrubber.

Figure 5-1. Wet scrubber process flow diagram



In the utility industry, the $CaSO_3$ waste product is usually mixed with fly ash (approximately 1:1 ratio) and fixative lime (approximately 5%) and typically disposed of in landfills. Alternately, the forced oxidation process oxidizes the spent slurry to gypsum. Gypsum crystals dewater more efficiently and reduce the size of

[3] USEPA. 2003. "Air Pollution Control Technology Fact Sheet – Flue Gas Desulfurization." EPA-452/F-03-034. August 8.

waste handling equipment. Depending on quality and demand, the gypsum may be commercially sold, eliminating the need for landfilling the waste product.

“Mist eliminators” installed at the spray tower outlet or downstream ductwork remove droplets from the gas. In some power plant installations, the gas is reheated to avoid corrosion downstream. Many scrubbers have gas bypassing capability, which can be used for gas reheating. If the wet scrubber is downstream of a high-efficiency particulate removal device [fabric filter or electrostatic precipitator (ESP)], the particulate concentration may be higher leaving the scrubber than entering due to the solids in mist droplets that are entrained and carried out of the scrubber.

Some disadvantages of using wet scrubbing techniques in many applications are the requirement to treat wastewater, the need to construct components from expensive alloys to resist corrosion, and much higher energy usage. A practical issue associated with a wet scrubber system is the complexity of the system. The space required for a wet system is substantial (i.e., large footprint), the systems require more maintenance due to their complexity, and more personnel are required for their operation.

5.1.4.1.1.1 Limestone Slurry Forced Oxidation

Limestone slurry forced oxidation (LSFO) is used extensively in the utility FGD market. The raw material is finely ground limestone. There are a number of suppliers of LSFO technology. The most commonly used equipment is an open, multi-level, countercurrent spray tower scrubber equipped with spray nozzles to inject the limestone slurry droplets into the gas stream. Liquor is collected at the bottom of the tower and sparged with air to oxidize the calcium sulfite to calcium sulfate to enhance the settling properties of the calcium sulfate. Recirculation pumps circulate the scrubbing liquor to the spray nozzles. SO_2 removal efficiencies of 90% have been achieved. The bleed from the scrubber is sent to a dewatering system to remove excess moisture. For an aluminum smelter, the process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive if a cement production facility is available and willing to accept the material. Only a very small purge or blowdown stream is required.

LSFO was determined to be a technically feasible retrofit control option for the potroom reactor and the anode bake furnace exhausts even though it is not ideally suited for scrubbing SO_2 concentrations that are less than or equal to 105 parts per million (ppm).

5.1.4.1.1.2 Limestone Slurry Natural Oxidation

Limestone slurry natural oxidation (LSNO) is very similar to LSFO. The major difference is the absence of an oxidation stage. The gypsum/calcium sulfite product is essentially a waste product with limited possibilities of use for agricultural purposes.

5.1.4.1.1.3 Conventional Lime Wet Scrubbing

Conventional lime wet scrubbing is also similar to LSFO except that the raw material is hydrated lime or quick lime that is either slaked on-site or purchased in the slaked form. The system typically uses forced oxidation, although natural oxidation is possible. The process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive if a cement production facility is available and willing to accept the material.

5.1.4.1.1.4 Seawater Scrubbing

Seawater scrubbing is a method for controlling SO_2 emissions in which seawater is used to absorb SO_2 in exhaust gases. Seawater is slightly alkaline (with a pH of approximately 8) and SO_2 has a high solubility in it. Absorbed SO_2 is subsequently oxidized to sulfates by the use of aeration and the pH is adjusted by the addition of additional seawater.

A global review of feasible control technologies identified seawater scrubbing as having been installed at seven aluminum smelters, none of which are in the United States[4]. Even though this technology has been identified as a control technology in operation at six primary aluminum ore reduction plants in Norway and one primary aluminum ore reduction plant in Sweden[5], this technology is not feasible at Eastalco based on physical location of the facility.

5.1.4.1.1.5 Dual Alkali Sodium/Lime Scrubbing (Dilute Mode)

Dual alkali sodium/lime scrubbing (dilute mode) uses a caustic sodium solution in the scrubber tower. A portion of the scrubbing liquid is discharged to a neutralization stage where lime slurry is used to regenerate the caustic, which is returned to the scrubber. The bleed from the scrubber is sent to a dewatering system to produce a gypsum byproduct. The process will produce either solid gypsum waste or commercial-grade gypsum suitable for reuse as a cement additive. It should be noted, however, that dual alkali sodium/lime scrubbing

[4] The HATCH Group. 2006. *"Analysis of Options for BART Compliance"*. April 18. Page 4.
[5] Ibid. Page 9.

(dilute mode) is not currently marketed by major FGD vendors because the system is too complicated and expensive.

5.1.4.1.1.6 Conventional Sodium Scrubbing

Globally, conventional sodium scrubbing has been installed in at least 12 aluminum smelters. An alkaline solution of either soda ash or sodium hydroxide is pumped into the scrubbing tower and recirculated through a network of spray nozzles. Atomized droplets contact the up-flowing gas containing SO_2. Where this technology has been deployed, the liquid effluent containing dissolved salts, including sodium and fluorides, has generally been discharged into a large receiving stream or an open body of water without treatment.

5.1.4.1.2 Dry Scrubbing

5.1.4.1.2.1 Dry Injection

In dry injection, a reactive alkaline powder is injected into a furnace, ductwork, or a dry reactor. Typical removal efficiencies with calcium adsorbents are 50 to 60% and up to 80% with sodium base adsorbents. However, as with wet scrubbing, disposal of wastes from systems using sodium adsorbents must consider their high solubility in water compared to those from calcium adsorbents. The temperature range over which scrubbing has been used is 300 to 1,800°F; the minimum temperature is 300 to 350°F. Dry systems are rarely used and according to USEPA only 3% of FGD systems installed in the United States are dry systems[6]. The dry waste material is removed using particulate control devices such as a fabric filter or an ESP.

Dry scrubbing downstream of the potline reactors and anode bake furnace fabric filters is not technically feasible because of the low temperatures (less than or equal to 205°F) and low SO_2 concentrations (less than or equal to 105 ppm).

5.1.4.1.2.2 Semi-Dry Scrubbing (Spray Dryer)

Semi-dry scrubbing is more commonly referred to as spray drying. Calcium hydroxide slurry (lime mixed with water) is introduced into a spray dryer tower. Sodium compounds can be used, but as with the dry scrubber, the high solubility of the sodium-based waste products in water complicates disposal of the waste. The slurry is atomized and injected into a reactor with the exhaust gases, where droplets react with SO_2 as the liquid evaporates. This system is categorized as a semi-dry system because the end product of the SO_2 conversion reaction is a dry

[6] USEPA. 2003. "Air Pollution Control Technology Fact Sheet – Flue Gas Desulfurization." EPA-452/F-03-034.

material. The dry waste product is collected in the bottom of the spray dryer reactor and a fabric filter or ESP downstream of the spray dryer removes the $CaSO_3$, calcium sulfate ($CaSO_4$), and unreacted lime. This air pollution control system uses water for evaporative cooling and for the SO_2 reaction. It operates in a temperature range of 300 to 350°F because the temperature of the gases must be high enough to evaporate the water portion of the slurry. Approximately 12% of the FGD systems installed in the United States are spray dry systems[7] with typical SO_2 removal efficiencies in the range of 80 to 90%. Unlike a wet scrubbing system there is no liquid blow-down stream from the dry system and the collected solids are typically landfilled.

Spray dry scrubbing downstream of the potline reactors and anode bake furnace fabric filters is not technically feasible because of the low temperatures (less than or equal to 205°F) and low SO_2 concentrations (less than or equal to 105 ppm).

5.1.4.2 Pollution Prevention

The guidelines for BART determinations under the Regional Haze Rule recommend consideration of pollution prevention options in addition to add-on controls. The primary pollution prevention opportunity for minimizing SO_2 emissions in the smelting process is through limitations on the sulfur content of the coke used in the manufacture of green anodes. The practical limitation on SO_2 from the potline and anode bake furnace emission units is dictated by the maximum production capacity of the potlines/anode bake furnace and a maximum sulfur content of 3.5% in the incoming coke. This level of sulfur in the coke is a general upper limit for producing good quality anodes. One potential option to reduce SO_2 emissions from the facility would be to reduce the sulfur content of coke used to produce anodes.

During the BART process, Eastalco evaluated the current levels of sulfur in coke used by other aluminum smelters to determine whether a pollution prevention option using lower sulfur content coke would be a feasible BART option. This analysis indicated that certain smelters currently utilize coke with sulfur contents as low as 2%. Given that sulfur contents lower than the current Eastalco specification are utilized, Eastalco undertook a low sulfur coke availability analysis to determine whether coke at lower sulfur levels would be available beyond 2013 when BART requirements are anticipated. Confidential research information belonging to the market analysts assisting with the coke availability analysis has been provided separately and is referenced as **Appendix B**.

August 8.

[7] Ibid.

The primary conclusions from this analysis indicate that:

- Coke is a byproduct of the oil refining process. The sulfur content of the world's crude oil supply has been and will continue increasing in sulfur content. Those refiners with coking capacity are minimizing their raw material costs by maximizing use of high sulfur crude oils and oil sands to the optimal extent for their overall refinery design. The result will be a continuing increase in the sulfur content of available coke.
- Coke is a relatively small, low revenue component of the refinery's product profile. As such, the aluminum industry has little influence in controlling the quantity, quality, and price of the coke produced by refineries.
- Anode grade (or anode quality) coke is a small subset of the total coke produced world-wide. Growth in the aluminum industry has increased the demand for the limited quantities of anode grade coke and has driven prices for coke to unprecedented levels. Refining higher sulfur crude oils and oil sands further shrinks this small subset of anode grade coke.
- Prices for coke nearly doubled from 1994 to 2006.
- The increased global growth in aluminum production will continue to outpace the production of coke.
- Primary aluminum production is expected to grow at the rate of 3 to 4% annually, resulting in a commensurate growth in demand for anode grade coke.
- Removal or reduction of the sulfur content of the coke once it has been received is not feasible.
- Aluminum smelters are experimenting with alternative cokes and technologies that are outside of the traditional specifications to ensure continued aluminum production in the face of the changing characteristics of this key raw material.
- The deterioration in coke quality and the tightness of supply is expected to continue for the foreseeable future.
- The increased demand for coke will force the aluminum industry to accept lower quality coke with higher sulfur contents.

Based on the market and availability analysis of the future coke supply, Eastalco determined that it is infeasible to consider coke at sulfur contents below 3% as a BART pollution prevention option because a supply of coke with sulfur contents below 3% cannot be ensured beyond 2013. These same market pressures are expected to force facilities currently using coke with sulfur contents below 3% to begin using higher sulfur content coke in the future. Although coke at sulfur contents below 3% is considered infeasible due to availability concerns, a pollution prevention option using coke with a sulfur content of 3% was determined to be technically feasible.

5.1.4.3 Feasible Control Options from RBLC Database

A review of USEPA's RACT/BACT/LAER Clearinghouse (RBLC) database was also completed to determine which control technologies or techniques have been utilized by primary aluminum ore reduction plants. The results from the RBLC database search are summarized in **Table 5-1**.

The data in the RBLC database support the approach of limiting raw material sulfur content as a control option for the potlines and the anode bake furnace. Many facilities have limited sulfur content in coke to affect SO_2 emissions. Two facilities have limits of 3% sulfur content in coke and one has a 2.95% sulfur content limit. One facility is shown in the RBLC to have a wet scrubber to control potline SO_2 emissions; however, an investigation revealed that the wet scrubber was not required as part of a best available control technology (BACT) determination and that the facility currently does not operate a wet scrubber to control SO_2 emissions. That facility's current Title V permit for "Potline 5" simply limits coke sulfur content to 3% and coal tar pitch sulfur to 0.8%.

Dry alumina scrubbers (with fabric filters) are the controls that have been considered BACT for PM.

5.1.5 Potentially Applicable BART Control Options for PM

Potentially applicable PM emission controls are discussed in the following sections.

5.1.5.1 Fabric Filters

Fabric filters generally provide high collection efficiencies for both coarse and fine (submicron) particles. They are relatively insensitive to fluctuations in gas stream conditions. Efficiency is relatively unaffected by large changes in inlet dust loadings and the effluent is very clean[8]. Collected material is dry, which usually simplifies processing or disposal. Fabric filters are currently applied for controlling PM emissions from the potrooms and the anode bake furnace at Eastalco.

5.1.5.2 Electrostatic Precipitators (ESPs)

ESPs are capable of very high removal efficiencies for large and small particles[9] and offer control efficiencies that are comparable to fabric filters. Because of their modular

[8] USEPA. 2003. "Air Pollution Control Technology Fact Sheet – Fabric Filter." EPA-452/F-03-025. August 7.
[9] USEPA. 2003. "Air Pollution Control Technology Fact Sheet – Dry Electrostatic Precipitator." EPA-452/F-03-

design, ESPs, like fabric filters, can be applied to a wide range of system sizes. The operating parameters that influence ESP performance include particulate mass loading, particle size distribution, electrical resistivity of the particles, and precipitator voltage and current. Dusts with high resistivities are not well-suited for collection in dry ESPs because the particles are not easily charged. This also affects the layers of particulate on the collecting electrodes. An ESP is technically feasible for control of PM from the potrooms and the anode bake furnace at Eastalco.

5.1.5.3 Cyclones, Inertial Separators, and Wet Scrubbers

Cyclones and inertial separators are used for collection of medium-sized and coarse particles. Wet scrubbers generally remove large particles but can remove small particles with the use of high pressure drops. However, none of these devices are as effective at removing small and submicron particles as fabric filters and ESPs[10].

5.1.6 Potentially Applicable BART Control Options for NO_x

Potentially applicable NO_x emission controls include combustion controls and post-combustion controls.

5.1.6.1 Combustion Controls

The concentration of NO_x in the potroom reactor exhaust is extremely low (less than 1 ppm) because there are no external fuels combusted and there are no large sources of nitrogen in the raw materials. Traditional methods of preventing NO_x formation using staged combustion or low NO_x burners are not applicable to the potlines at Eastalco.

NO_x emissions from anode baking depend on operating practices and burner controls. The traditional methods of preventing NO_x formation using staged combustion or low NO_x burners are not applicable because of the unique configuration of an anode bake furnace, where fuel is injected at several points along narrow flues. However, advanced firing systems that precisely measure and regulate fuel flow using a computerized control system can reduce NO_x emissions by reducing total fuel usage. Prevention of NO_x formation using advanced firing control has already been implemented on the anode bake furnace.

Traditional methods of preventing NO_x formation using staged combustion or low NO_x burners are applicable to the secondary aluminum furnaces at Eastalco and have already been implemented. The aluminum holding furnaces are equipped with low NO_x burners to limit NO_x emissions from natural gas combustion.

028. August 7.

[10] AWMA. 2000. *Air Pollution Engineering Manual*, Second Edition.

5.1.6.2 Post-Combustion NO_x Controls

Selective non-catalytic reduction (SNCR), selective catalytic reduction (SCR), and low temperature oxidation (LoTOx™) controls are discussed in this section.

5.1.6.2.1 Selective Non-Catalytic Reduction

SNCR is an add-on technique that involves injecting ammonia or urea into a specific temperature zone in a furnace or boiler. The ammonia or urea reacts with NO_x in the gas to produce nitrogen and water. SNCR typically provides a NO_x reduction of 30 to 50%. The effectiveness of SNCR depends on the temperature where reagents are injected, mixing of the reagent in the gas, residence time of the reagent within the required temperature window, and the ratio of reagent to NO_x. The required temperature window is 1,600 to 2,100°F. Typical uncontrolled NO_x levels where this technology has been applied vary from 200 to 400 ppm. SNCR is less effective at lower levels of uncontrolled NO_x[11].

The temperature (approximately 200°F) and NO_x concentration (less than 1 ppm) of the potroom emission exhaust are outside the ranges where SNCR could be used. Thus, SNCR is not technically feasible for the potlines at Eastalco.

The temperature of the anode bake furnace exhaust (300 to 450°F) is also below the temperature where SNCR could be used. Downstream of the existing control device, the temperature is approximately 190°F, which is also below the appropriate range. In addition, the NO_x concentration (less than 20 ppm) is below the level where SNCR could be used. Thus, SNCR is not technically feasible for the anode bake furnace at Eastalco.

5.1.6.2.2 Selective Catalytic Reduction

SCR is an add-on technique similar to SNCR that involves injecting ammonia into flue gas in the presence of a metal-based catalyst to convert NO_x emissions to elemental nitrogen and water. The catalyst allows SCR systems to operate at much lower temperatures than SNCR; typical temperatures for SCR are 500 to 800°F, compared with 1,600 to 2,100°F for SNCR. The optimum temperature range is 700 to 750°F[12]. SCR is capable of NO_x reduction efficiencies in the range of 70 to 90% and can be used with NO_x concentrations as low as 20 ppm. However, higher NO_x levels result in increased performance[13].

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[11] USEPA. 2003. "Air Pollution Control Technology Fact Sheet – Selective Non-Catalytic Reduction." EPA-452/F-03-031. August 8.

[12] USEPA. 2002. *EPA Air Pollution Control Cost Manual*, Sixth Edition. EPA/452/B-02-001. January.

[13] USEPA. 2003. "Air Pollution Control Technology Fact Sheet – Selective Catalytic Reduction." EPA-452/F-03-032. August 8.

The temperature of the potroom emission exhaust (approximately 200°F) and NO_x concentration (less than 1 ppm) of the potroom emission exhaust are outside the levels where SCR could be used. Thus, SCR is not technically feasible for the potlines at Eastalco.

The temperature of the anode bake furnace exhaust (300 to 450°F) is also below the temperature where SCR could be used. Downstream of the existing control device, the temperature is approximately 190°F, which is also below the appropriate range. In addition, the NO_x concentration (less than 20 ppm) is below the level where SCR could be used. Thus, SCR is not technically feasible for the anode bake furnace at Eastalco.

5.1.6.2.3 Low-temperature Oxidation (LoTOx™) System

The LoTOx™ system is the patented technology of BOC Gases. In this NO_x removal system, ozone is injected into the exhaust gas stream to oxidize insoluble NO_x into soluble nitrogen compounds, including N_2O_5. N_2O_5 is highly soluble and reacts with moisture in the gas stream to form nitric acid. A wet scrubber is required downstream of the LoTOx™ system to remove the nitric acid formed by the reaction of N_2O_5 and moisture in the gas stream. The ozone is typically generated on site and on demand. Since LoTOx™ is a low temperature system it does not require heat input and the low operating temperature (150 to 250°F) allows for stable and consistent control even with variations in flow, load, and NO_x concentrations[14].

Use of the LoTOx™ system has not been demonstrated at an aluminum plant. Research indicates that application of the LoTOx™ technology has been limited to a sulfuric acid regeneration plant, a reverbatory furnace at a lead plant, a stainless steel plant, a coal-fired electric generation unit, and two fluidized-bed catalytic cracking units (FCCU) at refineries[15,16]. Reported NO_x removal efficiencies for the LoTOx™ system are on the order of 90% to 95%.

The temperature of the anode bake furnace exhaust (approximately 190°F) is within the temperature range where LoTOx™ could be used. Although this technology has not been demonstrated on an anode bake furnace, low-temperature oxidation technology may be technically feasible for reducing anode bake furnace NO_x emissions.

[14] BOC Process Gas Solutions. 2001. *Low Temperature Oxidation System Demonstration at RSR Quemetco, Inc., City of Industry, California.* June 28. (www.arb.ca.gov/research/icat/projects/boc.pdf)
[15] USEPA. 2005. "Using Non-Thermal Plasma to Control Air Pollutants". EPA-456/R-05-001. February. www.epa.gov/ttn/catc/dir1/fnonthrm.pdf,
[16] USEPA RACT/BACT/LAER Clearinghouse (RBLC) database.

5.1.7 Summary of Technically Feasible BART Control Options

5.1.7.1 Feasible BART Control Options for SO_2

Two technically feasible options were identified for controlling SO_2 emissions from the potlines and anode bake furnace:

- Adding a wet scrubber to the potline and/or anode bake furnace exhausts, and
- A pollution prevention option limiting the sulfur content in the coke used to produce anodes.

These two options were evaluated further as part of the BART determination analysis.

5.1.7.2 Feasible BART Control Options for PM

Cyclones, inertial separators, wet scrubbers, ESPs, and fabric filters are all technically feasible for controlling potroom PM emissions. However, ESPs and fabric filters are superior devices for controlling fine PM.

Fabric filtration with dry alumina scrubbing has been widely used in the primary aluminum industry. Most smelters constructed within the past 20 years have used dry alumina scrubbing with fabric filters to control emissions from potlines. A few plants use control systems consisting of ESPs to collect PM followed by spray towers to scrub gaseous fluoride. Wet systems have many disadvantages, such as corrosion by hydrofluoric acid, scaling, and the requirement to treat wastewater. ESPs and wet systems are no longer installed on new smelters[17].

Dry scrubbers are widely used on anode bake furnaces because they provide effective removal of hydrocarbons, fluorides, and PM. Wet systems have the same disadvantages for anode bake furnaces as for potlines: corrosion by hydrofluoric acid, scaling, and the requirement to treat wastewater. Dry scrubbers with fabric filters are a superior choice for anode bake furnaces.

Given that fabric filters are already used for PM control and that these high-efficiency devices are superior or equal to other feasible control options, no further analysis of PM controls was performed.

5.1.7.3 Feasible BART Control Options for NO_x

Since there is no external fuel combusted in the smelting cells, there are no technically feasible pre-combustion NO_x controls for the potlines. Likewise, there are no technically

[17] AWMA. 2000. *Air Pollution Engineering Manual*, Second Edition.

feasible add-on controls because of the temperature of the potroom exhaust (approximately 200°F) and extremely low NO_x concentration (less than 1 ppm).

Eastalco has already installed an advanced firing system to lower NO_x formation and reduce natural gas usage from the anode bake furnace. Add-on SCR and SNCR controls are not feasible at the furnace exhaust because of the temperature (less than 450°F) and presence of tar vapor. SCR and SNCR are not feasible downstream of the reactor because of the temperature (approximately 190°F) and low NO_x concentration (less than 20 ppm). The use of low temperature oxidation (LoTOx™) may be a viable option for further reducing anode bake furnace NO_x emissions if a wet scrubber were installed on the anode bake furnace for SO_2 control. This option was given further consideration as part of the BART analysis.

The aluminum holding furnaces are already equipped with low NO_x burners to limit NO_x emissions from natural gas combustion.

5.2 CONTROL EFFECTIVENESS OF FEASIBLE OPTIONS

Step 3 of the BART analysis is to evaluate the control effectiveness of the technically feasible control technologies.

5.2.1 SO_2 Wet Scrubbing

A wet scrubber was identified as a technically feasible add-on pollution control option to reduce SO_2 from the potline reactors. Typical removal efficiencies are 80 to 95%. Capital cost estimates and control efficiencies for wet scrubbers at Eastalco were developed by scaling costs from two vendor quotes obtained for retrofitting LSFO scrubbing technology at Alcoa's facility in Alcoa, Tennessee. Each of the vendors that provided proposals for the Tennessee facility indicated that a 95% SO_2 removal was achievable. Accordingly, an SO_2 removal efficiency of 95% was used in the Eastalco BART analysis for the wet scrubber control option.

Mist droplets will be a component of the gas stream emitted from the scrubber. Solids in the droplets will become airborne PM when the droplets evaporate. The PM concentration in the outlet of the wet scrubber was quoted to be 20 milligrams per cubic meter (mg/Nm^3) by one of the vendors. This compares to a concentration of less than 2 mg/Nm^3 emitted from the existing potline control system. Consequently, the wet scrubber option would cause a collateral increase in PM from the potlines.

A wet scrubber was also identified as a technically feasible add-on pollution control option for the anode bake furnace since it has an SO_2 concentration and a temperature similar to the potline reactor exhaust. However, the anode bake furnace is a smaller source than the potlines because of the lower exhaust gas flow rate (1,620,000 acfm versus 140,000 acfm). A separate vendor cost proposal was not obtained for the anode bake furnace, but an SO_2 removal efficiency of 95% is assumed to be feasible. Wet scrubber costs for the anode bake furnace were also scaled from the LSFO potline wet scrubber vendor quotes.

Table 5-2 summarizes the SO_2, NO_x, and PM emission levels under the control scenarios considered for BART. The emissions represent the combined total emissions from the primary and secondary potline control systems and the anode bake furnace for each scenario. Control scenario #1 is the addition of a wet scrubber to the potline reactors. Control scenario #2 is the addition of a wet scrubber to the anode bake furnace. The emission reductions achievable for each of the scenarios were compared to maximum potline and anode bake furnace annual emissions (based on continuous operation at maximum 24-hour average emission rate).

5.2.2 SO_2 Pollution Prevention

The pollution prevention option considered in this analysis represents a 3.0% sulfur limit in the coke used to produce anodes, combined with operation of the facility's existing SO_2 controls for potroom primary and secondary (roof) SO_2 emissions. Under this option, Eastalco would limit total annual SO_2 emissions from the potlines and anode bake furnace to 3,781 tons per year.

5.2.3 Anode Bake Furnace LoTOx™ System

NO_x emissions from the anode bake furnace could potentially be reduced by using the LoTOx™ system for post-combustion control. This technology has a control efficiency of 90% for NO_x emissions when combined with wet scrubbing, resulting in a potential reduction in NO_x emissions of approximately 44.2 tons/year.

5.3 EVALUATION OF COSTS AND OTHER IMPACTS

Step 4 of the BART analysis involves evaluation of cost and other impacts, including energy impacts, greenhouse gas generation, non-air quality environmental impacts, and remaining useful life. Costs of control, energy impacts, greenhouse gas generation impacts, non-air quality environmental impacts, and remaining useful life are evaluated in this section.

5.3.1 Cost Impacts for Feasible Controls

5.3.1.1 Wet Scrubbers

The exhaust gases from each potline are routed to dry alumina reactors. Potline gases currently exhaust to the atmosphere from stacks above the fabric filters in each of the four baghouse scrubbing centers, which are located in courtyards between the potrooms.

Wet scrubber costs for Eastalco were estimated based on cost quotes received by Alcoa from two flue gas desulphurization equipment vendors. The cost quotes were originally provided as part of the BART analysis for Alcoa's Tennessee Operations in Alcoa, TN. Both vendors provided cost proposals for wet scrubbing systems based on LSFO SO_2 scrubbers. Lime- or sodium-based scrubbers could also be used for potlines, but lime and sodium are less desirable reagents considering that these reagents are much more expensive. Therefore, a LFSO scrubber was determined to be the most appropriate control device for the cost analysis. The vendor's proposals contain confidential business information and are, therefore, included along with other confidential information that is being provided separately. The confidential information that is being provided separately is referenced in **Appendix B**.

Neither of the two vendors provided a comprehensive installed cost estimate. Both preliminary designs were based on a central scrubbing center as the least cost approach, where exhaust from all dry scrubbing systems would be ducted to a centralized scrubbing system. Both design estimates were based on systems that would provide 100% availability of emissions control on each day of the year, given that potlines cannot be easily shutdown and restarted for control system outages.

One vendor provided an estimate of the scrubber equipment only. The other provided an "indicative price," with an installed cost assumed equal to the equipment cost. Important retrofit considerations for installing a potline wet scrubbing system include: (1) that gases must be collected from multiple individual baghouse stacks, (2) the system must simultaneously maintain balanced flow from multiple potline control devices, and (3) the system installation would require transport of new components through narrow passages in the existing potline. Coordination of the equipment delivery and the daily work schedule of the potline operation would also affect the control system installation. One of the vendors recognized the complexity of this type of project, pointing out in their proposal that an extensive engineering effort was needed because of space limitations, access limitations, uncertainty as to laydown areas, and uncertainty of ductwork and supports. These retrofit issues would apply equally to the Alcoa, TN facility and Eastalco.

The vendor cost proposals for the Tennessee facility were based on a total scrubber exit gas volume of approximately 1,580,000 acfm at 101^oF compared to an exit gas volume of approximately 1,460,000 acfm at 100^oF for Eastalco. Vendor equipment cost proposals for the Alcoa, TN facility therefore had to be adjusted to account for differences in exhaust gas volume and other design parameters.

Hatch, an engineering firm contracted by Alcoa, prepared a pre-feasibility report for Alcoa's Intalco Works facility in Ferndale, Washington in which equipment costs provided by one of the vendors for the Alcoa, TN facility were scaled or adjusted to estimate LSFO equipment costs for Intalco. The procedure used by Hatch adjusted equipment cost estimates using appropriate exponential factors for equipment type (reagent feed, SO_2 removal, gas handling, etc.), along with differences in system exhaust gas volume, limestone consumption, and gypsum by-product generation. ENVIRON used the cost adjustment approach developed by Hatch to prepare an average equipment cost for Eastalco based on both vendor quotations for the Alcoa Tennessee facility. In addition, ENVIRON estimated limestone usage and gypsum by-product generation for Eastalco based on the corresponding values Hatch developed in its pre-feasibility report for Alcoa's Intalco Works facility. The values for Intalco were scaled based on the ratio of SO_2 reductions for the two facilities. The equipment cost scaling procedures are outlined in the Hatch report in **Appendix C** and ENVIRON's parallel calculations based on the average of the two vendor quotes are provided in **Appendix D**.

The average scrubber equipment cost was used with factors from the *EPA Air Pollution Cost Control Manual*[18] to determine installation costs and total capital costs. Utility and raw material requirements provided by Hatch for Alcoa's Intalco Works facility were scaled for Eastalco as described above. Limestone usage, water usage, compressed air usage, and gypsum by-product generation were assumed to scale based on the ratio of SO_2 reductions. Electricity usage was assumed to scale based on the ratio of scrubber exhaust flow rates. Operating costs were calculated based on the estimated utility and raw material requirements, along with unit cost information provided by Eastalco and other cost assumptions from the *EPA Air Pollution Cost Control Manual*. Complete cost calculations and assumptions are provided in **Appendix D**.

Separate vendor cost quotes were not obtained for installing a wet SO_2 scrubbing system on the anode bake furnace. Instead, the potline SO_2 scrubber equipment costs were scaled to estimate Eastalco anode bake furnace control equipment costs using the same approach discussed above for the potlines. The anode bake furnace wet scrubber design was based on a scrubber exhaust gas volume of 123,800 acfm at 100^oF. The vendor equipment costs were adjusted using exponential factors that account for differences in exhaust gas volume, limestone consumption, and gypsum by-product generation.

Table 5-3 summarizes the cost of installing and operating an LSFO wet scrubber on the Eastalco potlines and anode bake furnace to remove 95% of the SO_2. The capital and

[18] USEPA. 2000. *EPA Air Pollution Cost Control Manual*, Sixth Edition. EPA-452/B-02-001. January 2002 (and updates).

total annualized costs for a potline wet scrubber are high at approximately $203.4 million and $40.4 million per year, respectively. The wet scrubber cost effectiveness is also high at $9,400 per ton of SO_2 removed.

The estimated installed capital cost to add a wet scrubber to remove 95% of the SO_2 from the anode bake furnace exhaust would be approximately $25.1 million with an annualized cost of $5.5 million per year. The wet scrubber cost effectiveness is also high at $21,600 per ton of SO_2 removed.

5.3.1.2 SO_2 Pollution Prevention

Eastalco is not currently constrained by a sulfur limit in the coke used to make anodes. Significant additional cost to the business is forecast as lower sulfur coke becomes more difficult to procure. Additional information regarding low sulfur coke availability and cost is included in the confidential information referenced in **Appendix B**.

5.3.1.3 Anode Bake Furnace LoTOx™ System

Cost data for the LoTOx™ system is not readily available. However, as demonstrated above in Section 5.3.1.1 for the control of SO_2 emissions from the anode bake furnace, the cost of the downstream scrubber, an integral component required as part of a LoTOx™ system, makes this option cost prohibitive. NO_x emissions are lower than SO_2 emissions for the anode bake furnace, so the cost per ton values for NO_x would be even higher than the $21,600 per ton of removal estimated for SO_2.

5.3.2 Energy Impacts

A wet scrubber removes SO_2 by forcing the exhaust gas through a spray tower or absorber where it contacts water droplets that contain the un-reacted lime or limestone. Energy is required to overcome the resistance of the scrubber components as well as falling water droplets. A substantial amount of energy would be associated with fans to move the potline and anode bake furnace exhaust streams through scrubbers. Other energy is required for the slurry pumps, instrumentation, and miscellaneous items (e.g., lighting). The total energy required[19] would be approximately 5,550 kilowatt-hours (kWh)/hr for the potline scrubber and 460 kWh/hr for the anode bake furnace scrubber. As listed in **Table 5-3**, this is equivalent to approximately 48,579,000 kWh of electricity per year for the potline scrubber and 4,016,000 kWh per year for an anode bake furnace wet scrubber.

5.3.3 Greenhouse Gas Generation

Greenhouse gases (GHGs) are gaseous compounds that are known to provide a warming effect to the atmosphere. The predominant GHG is carbon dioxide (CO_2). Other GHGs include nitrous oxide and methane. The proposed SO_2 control devices would increase overall emissions of GHGs via three mechanisms: (1) as a byproduct of the reaction chemistry in the scrubbers, (2) as indirect emissions from the generation of electricity required to power the scrubbing systems, and (3) as direct emissions from vehicle travel for the additional personnel that will be required at the facility to maintain and operate the scrubbing systems. The details of the GHG emission calculations for each of these mechanisms are presented in the **Appendix E**.

The total GHGs (in CO_2 equivalents) generated by the implementation of the proposed scrubbing system for the potline fumes were estimated to be 189,253 pounds per day, or 34,536 tons per year. The total GHGs (in CO_2 equivalents) generated by the implementation of the proposed scrubbing system for the anode bake furnace were estimated to be 15,350 pounds per day, or 2,800 tons per year.

5.3.4 Non-Air Quality Environmental Impacts

Both of the wet scrubber proposals were based on the LSFO process. This process oxidizes the spent slurry to gypsum, which may be landfilled or commercially sold. There is no way to know at this time whether the gypsum would have commercial value or whether there would be any demand for it. Therefore, it must be assumed that 18,680 tons of waste from the potline wet scrubber and 941.6 tons of waste from the anode bake furnace wet scrubber would need to be landfilled each year.

It is estimated that approximately 125.7 million gallons of water would be required annually to operate the potline wet scrubber at a cost of approximately $628,000. This would significantly impact the community infrastructure in that it would increase Eastalco's daily water demand by approximately 30%[20].

It is also estimated that a total of approximately 52.6 million kWh would be needed to operate the potline and anode bake furnace scrubbers annually. This would impact power demand in the community and would also have an environmental impact due to power production equivalent to adding approximately 4,936 new households in the community[21].

5.3.5 Remaining Useful Life

Operation of the Eastalco facility is currently curtailed. This curtailment is due to high local energy costs experienced by the plant once its long-term power contract expired. Any requirement for significant new controls under an air quality requirement such as BART would

[19] Hatch. 2007. *SO_2 Scrubbing for the INTALCO Primary Aluminum Smelter: Pre-Feasibility Report.* July 26.
[20] Percent increase in daily water demand calculated based on additional water demand and average facility-wide water usage for 2001 to 2005.
[21] Calculated based on 2001 average energy usage per household of 10,656 kWh/yr for the United States as reported by the Department of Energy (http://www.eia.doe.gov/emeu/reps/enduse/er01_us_tab1.html).

be detrimental to the facility's projected energy and operating costs, its global cost competitiveness, and, thereby, its future operation. The Eastalco smelter operated between 1970 and 2005, and remains one of Alcoa's important primary aluminum production assets in the United States. Efforts to secure affordable energy for Eastalco's future operation continue. Should reasonably available and affordable energy be secured, it is Alcoa's intention for Eastalco to operate throughout the period of the Regional Haze Program.

5.4 EVALUATE VISIBILITY IMPACTS

Step 5 of the BART analysis involves evaluation of visibility impacts. More specifically, this is an evaluation of the potential improvement in visibility resulting from application of feasible pollution prevention/add-on control options. Refined CALPUFF modeling was performed for a control scenario with wet SO_2 scrubbing applied to the potline. This modeling was accomplished using the VISTA's meteorological data. In general, this modeling was the same as the baseline modeling except stack data and emission data associated with the application of the feasible add-on control were used as model inputs. **Table 5-4** presents the post-control modeling source input data that were used in the CALPUFF model to forecast visibility impacts for the control option.

Table 5-5 presents the results of modeling with the scrubber SO_2 control scenario along with baseline impacts. As shown in **Table 5-5**, the addition of a potline wet scrubber reduced modeled visibility impacts in all five Class I areas to between 0.024 and 0.29 dv for the three years modeled. For example, the baseline modeling results indicate that the highest 98^{th} percentile visibility impact from Eastalco's BART-eligible sources at Shenandoah National Park was 0.42 dv. The post-control modeling results indicate that the highest 98^{th} percentile visibility impact from Eastalco's BART-eligible sources at Shenandoah National Park with wet scrubbers installed on the potlines was 0.29 dv in 2003. This represents a 0.13 dv reduction in total facility visibility impacts at Shenandoah National Park with the addition of wet scrubbers on the potlines.

Adding a wet scrubber to the anode bake furnace would not produce perceptible changes to visibility in the Class I areas. The base case impact analysis showed a maximum total impact of 0.045 dv from the anode bake furnace, with approximately 20% of this impact, or 0.009 dv, from SO_2 emissions. To minimize costs and maximize available resources, visibility improvement resulting from the installation of anode bake furnace SO_2 controls was not modeled.

For NO_x, the use of LoTOx™ technology for the anode bake furnace would also result in only minimal improvements in visibility. The baseline visibility modeling indicated that the highest 98^{th} percentile visibility impact due to anode bake furnace NO_x emissions was approximately 0.0045 dv (10.8% of 0.042 dv). Therefore, a 90% reduction with the use of LoTOx™ would reduce the impacts by approximately 0.0041 dv.

6.0 DETERMINATION OF BART

6.1 ALUMINUM POTLINES

For potline SO_2 emissions, BART was determined to be a coke sulfur content limit of 3% sulfur and the continued use of existing SO_2 control equipment. With this BART determination, Eastalco would limit total annual SO_2 emissions from the potlines and anode bake furnace to 3,781 tons per year. Use of wet scrubbing technology to reduce potline SO_2 emissions was rejected as BART due to excessive costs: total cost effectiveness of $9,400 per ton of SO_2 removed and capital and total annualized costs of $203.4 million and $40.4 million per year, respectively. A potline wet scrubber would also have substantial secondary impacts, including increased energy usage of approximately 48,579,000 kWh of electricity per year, added water consumption of 125.7 million gallons per year, and solid waste generation of 18,680 tons per year.

For PM emissions, BART was determined to be the current level of control: the use of baghouses to control PM emissions from the alumina dry scrubbers and the use of wet roof scrubbers to control secondary PM emissions from the potroom roofs.

There are no feasible technologies for control of NO_x from the potlines; thus, BART for NO_x was determined to be no controls.

6.2 ANODE BAKE FURNACE

BART for anode bake furnace SO_2 emissions was determined to be a pollution prevention limit of 3% sulfur in coke used to manufacture anodes. With this BART determination, Eastalco would limit total annual SO_2 emissions from the potlines and anode bake furnace to 3,781 tons per year. Use of wet scrubbing technology to reduce anode bake furnace SO_2 emissions was rejected as BART due to both excessive costs and negligible opportunity for visibility improvement. Modeled visibility impacts from anode bake furnace SO_2 emissions for the highest year were less than 0.02 dv and the cost effectiveness of add-on controls is $21,600 per ton of SO_2 removed.

The existing level of control (based on baghouses on the alumina dry scrubbers) was determined to be BART for PM emissions.

BART for anode bake furnace NO_x emissions was determined to be the existing level of control, which uses an advanced firing system to minimize natural gas usage. The use of a LoTOx™ system was rejected as BART because the cost of the technology would be excessive and result in negligible visibility improvement.

6.3 ALUMINUM HOLDING FURNACES

The deployment of additional controls on aluminum holding furnaces was rejected because baseline visibility impacts from these emission units are trivial and any improvement would be negligible. Accordingly, BART for the Eastalco aluminum holding furnaces was determined to be the existing low-NO_x burner technology.

6.4 MATERIAL HANDLING AND TRANSFER OPERATIONS

PM emissions from the BART-eligible material handling and transfer operations are all controlled using fabric filter technology. This existing level of emissions control was determined to be BART for these material handling and transfer operations.

TABLES

Table 2-1
BART-Eligible Primary Aluminum Reduction Emission Units
Eastalco Aluminum Company
Frederick, Maryland

Process	Emission Unit ID	Emission Unit Description	Visibility Impairing Pollutants	Existing Pollution Controls	Modeling Source Type
Ladle Shop	EU023-1	Ladle cleaning	PM	D/C	Point
	EU023-3	Burners	PM, SO_x, NO_x, CO, VOC		Volume
Process Water Treatment	EU033-3	Boiler	PM, SO_x, NO_x, CO, VOC		Point
Potlines	EU110-1	Potline A dry scrubbers	PM, SO_x, CO	D/C	Point
	EU110-2a	Potline A wet scrubbers	PM, SO_x, CO	Wet scrubber	Line
	EU110-2b	Potline A SO_2 scrubbers	PM, SO_x, CO	SO_2 scrubber	Line
	EU110-3	Potline A1 bypass	PM, SO_x, CO		Point
	EU111-1	Potline B dry scrubbers	PM, SO_x, CO	D/C	Point
	EU111-2	Potline B wet scrubbers	PM, SO_x, CO	Wet scrubber	Line
Material Handling	EU112-1	Alumina railcar unloading	PM	D/C	Point
	EU112-2	Alumina silo A	PM	D/C	Point
	EU112-3	Alumina silo B	PM	D/C	Point
	EU112-4	Reacted ore conversion	PM	D/C	Point
	EU112-6	Aluminum fluoride silo N	PM	D/C	Point
	EU112-7	Aluminum fluoride silo S	PM	D/C	Point
	EU112-9	Pet coke	PM	D/C	Point
Rod Shop	EU113-1	Butts and bath separation	PM	D/C	Point
	EU113-2	Bath conversion	PM	D/C	Point
	EU113-3	Primary butts crusher	PM	D/C	Point
	EU113-5	Butts storage silo	PM	D/C	Point
	EU113-6	Shot blast	PM	D/C	Point
	EU113-7	Rod preheater and dryer	PM, SO_x, NO_x, CO, VOC		Volume
	EU113-8	Cast iron furnaces	PM		Volume
	EU113-9	Aluminum spray furnaces	PM, SO_x, NO_x, CO, VOC	D/C	Point
	EU113-10	Spent anode cooling	PM		Volume
Casthouse	EU114-1	Dross skimming station	PM	D/C	Point
	EU114-5	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-6	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-7	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-8	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-9	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-10	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-11	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-12	Aluminum holding furnace	PM, SO_x, NO_x, CO, VOC		Point
	EU114-14a	Homogenizing furnace A	PM, SO_x, NO_x, CO, VOC		Point
	EU114-14a	Homogenizing furnace B	PM, SO_x, NO_x, CO, VOC		Point
	EU114-17	Casthouse roof vent	PM/VOC		Volume
Cathode Plant	EU115-1	Anthracite crusher	PM	D/C	Point
	EU115-2	Cast iron furnaces	PM		Point
	EU115-3	Cathode bar shot blast	PM	D/C	Point
	EU115-4	Cathode dry-out heater	PM, SO_x, NO_x, CO, VOC		Volume
	EU115-5	Anthracite railcar unloading	PM		Volume

Table 2-1
BART-Eligible Primary Aluminum Reduction Emission Units
Eastalco Aluminum Company
Frederick, Maryland

Process	Emission Unit ID	Emission Unit Description	Visibility Impairing Pollutants	Existing Pollution Controls	Modeling Source Type
Paste Plant	EU116-1	Roll crusher	PM	D/C	Point
	EU116-2	Feed bin system	PM	D/C	Point
	EU116-3	Ball mill	PM	D/C	Point
	EU116-4	Weigh feeder	PM	D/C	Point
	EU116-5	Pitch fume	PM, SO_x, NO_x, VOC	D/C	Point
	EU116-6	Boiler	PM, SO_x, NO_x, CO, VOC		Point
	EU116-7	Pet coke silos	PM	D/C	Point
Bake Oven	EU117-1	Bake oven dry scrubber	PM, SO_x, NO_x, CO, VOC	D/C	Point
	EU117-3	Anode coring	PM	D/C	Point
	EU117-4a	Refractory mixer 1	PM	D/C	Point
	EU117-4a	Refractory mixer 2	PM	D/C	Point
	EU117-5	Bake oven roof vents	PM, SO_x, NO_x, CO, VOC		Volume
Miscellaneous	EU205-1	Admin boiler	PM, SO_x, NO_x, CO, VOC		Point
	EU206-1	East gate boiler	PM, SO_x, NO_x, CO, VOC		Point
	EU208-1	Tech boiler	PM, SO_x, NO_x, CO, VOC		Point

Table 4-1
Source Input Data for Baseline Modeling - Point Sources
Eastalco Aluminum Company
Frederick, Maryland

Emission Unit ID	Source Description	Lambert Conformal Coordinate X (km)	Lambert Conformal Coordinate Y (km)	Stack Height (m)	Effective Stack Diameter (m)	Exit Velocity (m/s)	Flow Rate (m^3/s)	Exit Temperature (°K)
EU023-1	Ladle cleaning	1657.153	104.946	5.05	0.20	49.48	1.6	300
EU033-3	Process water treatment boiler	1656.870	104.533	14.33	0.31	11.23	0.85	339
EU110-1	Potline A dry scrubbers (SE combined)	1657.037	104.791	24.38	3.73	16.82	184.1	366
EU110-3	Potline A1 bypass	1656.923	104.677	12.19	3.66	17.97	188.8	355
EU111-1	Potline B dry scrubbers (NW combined)	1656.832	104.857	26.82	4.03	15.52	198.2	355
EU111-1	Potline B dry scrubbers (NE combined)	1656.927	104.931	26.82	4.03	15.52	198.2	355
EU112-1	Alumina railcar unloading	1657.115	104.506	12.71	0.86	20.41	11.8	300
EU112-2	Alumina silo A	1657.120	104.549	38.10	0.24	20.90	0.94	300
EU112-3	Alumina silo B	1657.120	104.549	38.10	0.24	31.35	1.4	300
EU112-4	Reacted ore conversion	1657.084	104.559	15.65	0.57	18.29	4.7	300
EU112-6	Aluminum fluoride silo N	1657.487	104.940	21.56	0.20	17.73	0.57	300
EU112-7	Aluminum fluoride silo S	1657.492	104.932	25.18	0.20	17.73	0.57	300
EU112-9	Pet coke	1657.371	104.757	13.72	0.43	19.59	2.8	300
EU113-1	Butts and bath separation	1657.189	104.786	8.53	1.19	16.93	18.9	300
EU113-2	Bath conversion	1657.266	104.787	10.06	0.76	25.77	11.8	300
EU113-3	Primary butts crushers	1657.271	104.794	16.46	0.71	19.01	7.6	300
EU113-5	Butts storage silo	1657.315	104.810	23.52	0.17	26.45	0.57	300
EU113-6	Shot blast	1657.177	104.775	4.27	0.38	19.51	2.3	300
EU113-9	Aluminum spray furnace 1	1657.201	104.771	15.24	1.22	0.61	0.71	311
EU113-9	Aluminum spray furnace 2	1657.204	104.767	15.24	1.22	0.61	0.71	311
EU114-1	Dross skimming station	1657.293	105.017	3.66	0.42	20.32	2.8	300
EU114-5	Aluminum holding furnace B	1657.191	105.176	33.53	0.86	1.61	0.94	325
EU114-6	Aluminum holding furnace 6	1657.268	105.052	24.08	0.91	1.08	0.71	311
EU114-7	Aluminum holding furnace 7	1657.243	105.113	33.53	1.22	0.61	0.71	311
EU114-8	Aluminum holding furnace 8	1657.237	105.122	33.53	1.22	0.61	0.71	311
EU114-9	Aluminum holding furnace 9	1657.225	105.125	33.53	1.22	0.61	0.71	311
EU114-10	Aluminum holding furnace 10	1657.217	105.136	33.53	1.22	0.61	0.71	311
EU114-11	Aluminum holding furnace 11	1657.200	105.144	33.53	1.22	0.61	0.71	311
EU114-12	Aluminum holding furnace 12	1657.191	105.155	33.53	1.22	0.61	0.71	311
EU114-14	Homogenizing furnace A	1657.246	105.155	24.38	0.86	1.61	0.94	325
	Homogenizing furnace B	1657.249	105.150	24.38	0.86	1.61	0.94	325
EU115-1	Anthracite crusher	1657.461	104.987	16.76	0.37	23.95	2.6	300
EU115-2	Cast iron furnaces	1657.424	104.996	3.05	0.42	11.85	1.7	311
EU115-3	Cathode bar shot blast	1657.421	105.000	9.14	0.91	0.74	0.49	311
EU116-1	Roll crusher	1657.325	104.791	10.67	0.41	33.47	4.3	300
EU116-2	Feed bin system	1657.331	104.791	31.85	0.42	20.40	2.7	300
EU116-3	Ball mill	1657.306	104.800	30.78	0.26	16.14	0.84	300
EU116-4	Weigh feeder	1657.336	104.784	19.81	0.37	19.25	2.1	300
EU116-5	Pitch fume	1657.307	104.752	15.24	1.02	16.12	13.1	339
EU116-6	Boiler	1657.319	104.785	32.00	0.61	2.43	0.71	311
EU116-7	Pet coke silo A	1657.383	104.762	30.48	0.15	17.90	0.33	300
	Pet coke silo B	1657.397	104.774	30.48	0.15	17.90	0.33	300
EU117-1	Bake oven dry scrubber	1657.080	104.595	30.48	2.06	19.87	66.1	361
EU117-3	Anode coring	1657.232	104.718	3.76	0.43	26.13	3.8	300
EU117-4a	Refractory mixer 1	1657.115	104.646	3.05	0.15	54.33	0.99	300
EU117-4b	Refractory mixer 2	1657.147	104.603	3.05	0.15	54.33	0.99	300
EU205-1	Admin boiler	1657.008	105.280	7.62	0.61	2.43	0.71	311
EU206-1	East gate boiler	1657.105	105.237	7.62	0.61	2.43	0.71	311
EU208-1	Tech boiler	1657.177	105.017	15.24	0.61	2.43	0.71	311

Table 4-2
Source Input Data for Baseline Modeling - Line Sources
Eastalco Aluminum Company
Frederick, Maryland

Source Description	Lambert Conformal Coordinates				Release Height	Base Elevation
	Beginning X (km)	Beginning Y (km)	Ending X (km)	Ending Y (km)	(m)	(m)
Potline A1 West (wet/SO_2 scrubber)	1656.836	104.582	1656.995	104.708	16.76	101.5
Potline A1 East (wet scrubber)	1656.995	104.708	1657.192	104.860	16.76	101.5
Potline A2 (wet scrubber)	1656.786	104.647	1657.141	104.925	16.76	101.5
Potline B1 (wet scrubber)	1656.728	104.722	1657.083	105.000	16.76	101.5
Potline B2 (wet scrubber)	1656.679	104.785	1657.034	105.062	16.76	101.5

Additional Parameters	
Average Building Length (m)	454.3
Average Building Height (m)	16.76
Average Building Width (m)	40.0
Average Line Source Width (m)	5.73
Average Separation Between Buildings (m)	40.95
Average Buoyancy Parameter - Bypass (m^4/s^3)	3,335.49

Table 4-3
Source Input Data for Baseline Modeling - Volume Sources
Eastalco Aluminum Company
Frederick, Maryland

Source Description	Emission Unit IDs	Lambert Conformal Coordinate X (km)	Lambert Conformal Coordinate Y (km)	Release Height (m)	Initial σ_y (m)	Initial σ_z (m)	Base Elevation (m)
Bake Oven A Roof Vent 1	EU117-5	1657.192	104.627	22.60	22.57	10.51	101.5
Bake Oven A Roof Vent 2		1657.201	106.616	22.60	22.57	10.51	101.5
Bake Oven B Roof Vent 1		1657.158	104.672	22.56	22.57	10.49	101.5
Bake Oven B Roof Vent 2		1657.167	104.659	22.56	22.57	10.49	101.5
Casthouse Roof Vent 1	EU114-17	1657.258	105.044	15.85	0.21	7.37	101.5
Casthouse Roof Vent 2		1657.247	105.123	23.16	0.21	10.77	101.5
Casthouse Roof Vent 3		1657.237	105.136	23.16	0.21	10.77	101.5
Casthouse Roof Vent 4		1657.228	105.150	23.16	0.21	10.77	101.5
Casthouse Roof Vent 5		1657.218	105.162	23.16	0.21	10.77	101.5
Casthouse Roof Vent 6		1657.208	105.175	23.16	0.21	10.77	101.5
Rod Shop Fugitives 1	EU113-7, EU113-8, & EU113-10	1657.174	104.773	0	0.71	2.84	101.5
Rod Shop Fugitives 2		1657.200	104.740	0	0.71	2.84	101.5
Rod Shop Fugitives 3		1657.299	104.844	0	9.51	6.10	101.5
Cathode Plant Fugitives	EU115-4	1657.455	104.973	0	0.71	2.84	101.5
Ladle Shop Fugitives 1	EU023-3	1657.160	104.960	0	0.71	2.84	101.5
Ladle Shop Fugitives 2		1657.187	104.925	0	0.71	2.84	101.5
Anthracite Rail Unloading 1	EU115-5	1657.469	105.007	0	2.13	5.67	101.5
Anthracite Rail Unloading 2	EU115-5	1657.480	104.993	0	2.13	5.67	101.5

Table 4-4
Modeled Maximum Daily Emission Rates
Eastalco Aluminum Company
Frederick, Maryland

Process	Emission Unit ID	Emission Unit Description	PM_{10} Emission Rate (g/s)	SO_2 Emission Rate (g/s)	NO_x Emission Rate (g/s)
Ladle Shop	EU023-1	Ladle cleaning	1.4E-02		
	EU023-3	Burners	6.6E-04	5.2E-05	8.7E-03
Process Water Treatment	EU033-3	Boiler	1.8E-06	1.5E-07	1.9E-04
Potlines	EU110-1	Potline A dry scrubbers	0.29	24.8	
	EU110-2a	Potline A wet scrubbers	6.8	1.2	
	EU110-2b	Potline A SO_2 scrubbers	5.0E-02	9.8	
	EU110-3	Potline A1 bypass	0.15	12.6	
	EU111-1	Potline B dry scrubbers	0.61	49.9	
	EU111-2	Potline B wet scrubbers	6.5	2.4	
	N/A	Potline SO_2 scrubber[1]	13.0	6.5	
Material Handling	EU112-1	Alumina railcar unloading	3.8E-02		
	EU112-2	Alumina silo A	5.6E-03		
	EU112-3	Alumina silo B	5.6E-03		
	EU112-4	Reacted ore conversion	5.3E-02		
	EU112-6	Aluminum fluoride silo N	2.3E-03		
	EU112-7	Aluminum fluoride silo S	2.3E-03		
	EU112-9	Pet coke	2.9E-02		
Rod Shop	EU113-1	Butts and bath separation	0.20		
	EU113-2	Bath conversion	0.12		
	EU113-3	Primary butts crusher	0.19		
	EU113-5	Butts storage silo	6.0E-03		
	EU113-6	Shot blast	2.4E-02		
	EU113-7	Rod preheater and dryer	1.1E-03	8.8E-05	1.5E-02
	EU113-8	Cast iron furnaces	8.6E-03		
	EU113-9	Aluminum spray furnaces	2.9E-03	1.2E-04	2.0E-02
	EU113-10	Spent anode cooling	4.9E-03		
Casthouse	EU114-1	Dross skimming station	3.2E-02		
	EU114-5	Aluminum holding furnace	3.5E-02	2.9E-04	6.8E-02
	EU114-6	Aluminum holding furnace	3.5E-02	2.9E-04	6.8E-02
	EU114-7	Aluminum holding furnace	3.5E-02	3.9E-04	9.1E-02
	EU114-8	Aluminum holding furnace	3.5E-02	3.9E-04	9.1E-02
	EU114-9	Aluminum holding furnace	3.5E-02	2.9E-04	6.8E-02
	EU114-10	Aluminum holding furnace	3.5E-02	2.9E-04	6.8E-02
	EU114-11	Aluminum holding furnace	3.5E-02	2.9E-04	6.8E-02
	EU114-12	Aluminum holding furnace	3.5E-02	2.9E-04	6.8E-02
	EU114-14a	Homogenizing furnace A	6.1E-03	4.9E-04	0.11
	EU114-14a	Homogenizing furnace B	8.6E-03	6.8E-04	0.16
	EU114-17	Casthouse roof vent	8.2E-03		
Cathode Plant	EU115-1	Anthracite crusher	1.2E-02		
	EU115-2	Cast iron furnaces	1.3E-03		
	EU115-3	Cathode bar shot blast	2.2E-03		
	EU115-4	Cathode dry-out heater	1.5E-03	1.2E-04	1.9E-02
	EU115-5	Anthracite railcar unloading	5.4E-05		
	EU116-1	Roll crusher	4.7E-02		

Table 4-4
Modeled Maximum Daily Emission Rates
Eastalco Aluminum Company
Frederick, Maryland

Process	Emission Unit ID	Emission Unit Description	PM_{10} Emission Rate (g/s)	SO_2 Emission Rate (g/s)	NO_x Emission Rate (g/s)
Paste Plant	EU116-2	Feed bin system	2.9E-02		
	EU116-3	Ball mill	9.0E-03		
	EU116-4	Weigh feeder	2.2E-02		
	EU116-5	Pitch fume	0.12	5.1E-02	7.9E-02
	EU116-6	Boiler	1.8E-03	1.5E-04	2.4E-02
	EU116-7	Pet coke silos	7.0E-03		
Bake Oven	EU117-1	Bake oven dry scrubber	1.3	7.7	1.4
	EU117-3	Anode coring	4.2E-02		
	EU117-4a	Refractory mixer 1	1.1E-02		
	EU117-4a	Refractory mixer 2	1.1E-02		
	EU117-5	Bake oven roof vents	0.15	7.8E-05	2.9E-02
Miscellaneous	EU205-1	Admin boiler	3.9E-04	3.1E-05	5.1E-03
	EU206-1	East gate boiler	3.9E-04	3.1E-05	5.1E-03
	EU208-1	Tech boiler	7.5E-04	5.9E-05	9.9E-03

Note:

[1] These emissions represent the potline control scenario of adding an SO_2 scrubber. This source replaces emission units EU110-1, EU110-2b, EU110-3, and EU111-1 in the control scenario visibility modeling.

Table 4-5
Baseline Visibility Modeling Results
Eastalco Aluminum Company
Frederick, Maryland

Class I Area	2001		2002		2003	
	Modeled 98th Percentile (deciview)	Number of Days Exceeding 0.5 dv	Modeled 98th Percentile (deciview)	Number of Days Exceeding 0.5 dv	Modeled 98th Percentile (deciview)	Number of Days Exceeding 0.5 dv
Brigantine Wilderness Area	0.091	0	0.068	0	0.065	0
Dolly Sods Wilderness Area	0.074	0	**0.116**	0	**0.173**	0
James River Face Wilderness Area	0.095	0	0.087	0	0.077	0
Otter Creek Wilderness Area	0.041	0	0.084	0	**0.111**	0
Shenandoah National Park	**0.309**	2	**0.307**	3	**0.420**	3

Note:
Modeled visibility impacts that exceed the 0.1 dv contribution threshold are presented in bold in this table.

Table 4-6
Culpability Analysis for Baseline Visibility Modeling Results in Shenandoah National Park
Eastalco Aluminum Company
Frederick, Maryland

Year	Source Group	Modeled 98th Percentile (deciview)	Percentage of Species Contribution		
			SO_4	NO_3	PM_{10}
2001	**Total of all sources**	**0.309**	**32.9%**	**2.6%**	**64.5%**
	Potline primary emission controls	0.080	85.4%	0%	14.6%
	Potline secondary emission controls	0.119	9.3%	0%	90.7%
	Anode bake furnace	0.045	19.8%	13%	67.0%
	Rod shop sources	0.043	0%	0.44%	99.6%
	Paste plant sources	0.007	1.1%	8.0%	90.9%
	Ladle shop sources	0.004	84.4%	6.6%	8.9%
	Casthouse sources	0.012	0.04%	34.6%	65.4%
	Cathode plant sources	0.001	0.03%	21.3%	78.7%
	Boilers	0	0%	0%	0%
	Material handling	0	0%	0%	100%
2002	**Total of all sources**	**0.307**	**33.1%**	**2.7%**	**64.3%**
	Potline primary emission controls	0.100	87.7%	0%	12.3%
	Potline secondary emission controls	0.140	5.1%	0%	94.9%
	Anode bake furnace	0.042	34.8%	10.8%	54.5%
	Rod shop sources	0.023	0%	0.52%	99.5%
	Paste plant sources	0.004	3.2%	9.9%	87.0%
	Ladle shop sources	0.002	84.8%	7.3%	8.0%
	Casthouse sources	0.008	0.10%	37.5%	62.4%
	Cathode plant sources	0	0%	0%	0%
	Boilers	0	0%	0%	0%
	Material handling	0.002	0%	0%	100%
2003	**Total of all sources**	**0.420**	**67.8%**	**1.2%**	**31.0%**
	Potline primary emission controls	0.260	95.3%	0%	4.7%
	Potline secondary emission controls	0.097	18.0%	0%	82.0%
	Anode bake furnace	0.036	49.1%	7.2%	43.7%
	Rod shop sources	0.019	0%	0.50%	99.5%
	Paste plant sources	0.003	3.2%	8.6%	88.3%
	Ladle shop sources	0.003	89.6%	4.7%	5.8%
	Casthouse sources	0.005	0.13%	37.0%	62.9%
	Cathode plant sources	0	0%	0%	0%
	Boilers	0	0%	0%	0%
	Material handling	0.001	0%	0%	100%

Table 5-1
RBLC Database Search Results for Primary Aluminum Facilities
Eastalco Aluminum Company
Frederick, Maryland

RBLC ID	Facility	Last Update	Process	Pollutant	Control Option	Percent Efficiency	Emission Limit
KY-0070	NSA - A Division of Southwire Company	3/2/2004	Potline 5	SO_2	Wet scrubber[1]	93%	25.51 lb/hr
SC-0037	Alumax of South Carolina	9/17/2002	Potroom Groups (4)	PM	Existing dry alumina scrubbers (fabric filter)		5.9 lb/hr
SC-0037	Alumax of South Carolina	9/17/2002	Potroom Groups (4)	SO_2	Limit maximum % sulfur of anode coke to 2.95%; limit maximum % sulfur of anode pitch to		271 lb/hr
SC-0037	Alumax of South Carolina	9/17/2002	Anode Bake Plant	SO_2	No upgrade; limit maximum % sulfur of anode coke to 2.95%; limit maximum % sulfur of anode pitch to 1.2%		85.5 lb/hr
SC-0037	Alumax of South Carolina	9/17/2002	Anode Bake Plant	PM	No upgrade; limit sulfur content of raw materials		4.8 lb/hr
SC-0037	Alumax of South Carolina	9/17/2002	Anode Bake Plant	NO_x	No upgrade; limit sulfur content of raw materials		9 lb/hr
KY-0041	Arco Metals Co.	12/18/2001	Primary Aluminum Reduction Potline	PM	Baghouse, hooding for raw material handling	98%	0.02 gr/dscf
KY-0041	Arco Metals Co.	12/18/2001	Primary Aluminum Reduction Potline	SO_2	Fuel spec: low sulfur coke and pitch (calc. 3% sulfur)		388 lb/hr
OR-0002	Alumax Pacific Corp.	12/18/2001	Entire Plant	PM	Baghouse		5.4 lb/t (monthly ave.); 5.0 lb/ton (annual ave.)
OR-0002	Alumax Pacific Corp.	12/18/2001	Anode Coke	SO_2	Fuel spec: sulfur limit in coke		3% S in coke
WA-0003	Alcoa	12/18/2001	Potlines 1, 2, and 3	SO_2	Fuel spec: limit S content in coke, raw		3% S in coke
NC-0003	Alcoa	1/28/2002	Potline 3	PM	Fabric filter		26 lb/hr
NC-0003	Alcoa	1/28/2002	Potline 3	SO_2			321 lb/hr
NC-0003	Alcoa	1/28/2002	Anode Production	SO_2			13 lb/hr
NC-0003	Alcoa	1/28/2002	Anode Production	PM			9 lb/hr
MO-0036	Noranda Aluminum, Inc.	5/9/2006	Carbon Baking Furnace for Potline 3	PM_{10}			98.5999 tons/yr
MO-0036	Noranda Aluminum, Inc.	5/9/2006	Potline 1	PM_{10}	Coated filter dry scrubber		56.76 tons/yr
MO-0036	Noranda Aluminum, Inc.	5/9/2006	Potline 3	PM_{10}	Coated filter dry scrubber		68.8 tons/yr

Notes:

[1] This wet scrubber is not actually used or required by permit.

Table 5-2
Post Control Emission Rates[1]
Eastalco Aluminum Company
Frederick, Maryland

Control Scenario	SO_2 Control Technology	SO_2		NO_x		PM_{10}	
		Emissions (tons/yr)	% Reduction (Increase)[2]	Emissions (tons/yr)	% Reduction (Increase)[2]	Emissions (tons/yr)	% Reduction (Increase)[2]
1	LSFO Scrubber for Potlines	653	83	49	0	956	(76)
2	LSFO Scrubber for Anode Bake Furnace	3,512	7	49	0	537	1
Maximum Annual Potline and Anode Bake Furnace Emissions[3]	Current controls (A1 SO_2 Scrubber and Potroom Roof Scrubbers)	3,781		49		544	

Notes:

[1] Emission rates include the potline primary control system, the potline secondary control system emissions, and the anode bake furnace emissions.

[2] Compared with maximum annual emissions.

[3] Based on continuous operation at maximum 24-hour average emission rate.

Table 5-3
Summary of the Impacts Analysis for SO_2 Control Scenarios
Eastalco Aluminum Company
Frederick, Maryland

Control Scenario	Control Technology Evaluated	Controlled SO_2 Emission Rate[1] (tons/year)	SO_2 Emission Reductions[2] (tons/year)	Installed Capital Cost	Total Annualized Control Costs	Cost Effectiveness (per ton SO_2 removed)	Energy Impact (kW-hr/yr)	Collateral Increase in Other Pollutants	Non-Air Quality Environmental Impacts
1	LSFO Scrubber for Potlines	653	4,285	$203,388,702	$40,420,000	$9,400	48,578,588	412 tons/yr PM_{10} 34,536 tons/yr GHG[3]	18,680 tons/year of solid waste disposal 125.7 million gallons/year makeup water
2	LSFO Scrubber for Anode Bake Furnace	3,512	254	$25,118,252	$5,490,000	$21,600	4,016,126	-6 tons/yr PM_{10} 2,800 tons/yr GHG[3]	941.6 tons/year of solid waste disposal 18.8 million gallons/year makeup water
Maximum Annual Potline and Anode Bake Furnace Emissions[4]	Current controls (A1 SO_2 Scrubber and Potroom Roof Scrubbers)	3,781							

Notes:

[1] Emission rates include the potline primary control system, the potline secondary control system emissions, and the anode bake furnace emissions.

[2] Compared with maximum annual emissions.

[3] Greenhouse gas (GHG) emissions are presented as CO_2 equivalent emissions. The GHG emission calculations are presented in **Appendix E**.

[4] Based on continuous operation at maximum 24-hour average emission rate.

Table 5-4
Source Input Data for Post Control SO_2 Modeling[1]
Eastalco Aluminum Company
Frederick, Maryland

Control Scenario	SO_2 Control Technology	Source Description	Lambert Conformal Coordinate X (km)	Lambert Conformal Coordinate Y (km)	Stack Height (m)	Effective Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (°K)	PM_{10} Emission Rate (g/s)	SO_2 Emission Rate (g/s)	NO_x Emission Rate (g/s)
1	LSFO Scrubber for Potlines	Potline Wet Scrubber[2]	1656.893	104.573	38.1	6.9	18.4	311	13.0	6.5	0

Notes:
[1] Source input data for all other sources are the same as listed in Table 4-1 through 4-3 for the baseline modeling.
[2] Potline wet scrubber source replaces sources EU110-1, EU110-3, and EU111-1 in Table 4-1 from the baseline modeling.

Table 5-5
SO_2 Post Control Visibility Modeling Results
Eastalco Aluminum Company
Frederick, Maryland

Control Scenario	**SO_2 Control Technology Evaluated**	**Class I Area**	**2001**		**2002**		**2003**	
			Modeled 98th Percentile (deciview)	**Number of Days Exceeding 0.5 dv**	**Modeled 98th Percentile (deciview)**	**Number of Days Exceeding 0.5 dv**	**Modeled 98th Percentile (deciview)**	**Number of Days Exceeding 0.5 dv**
1	LSFO Scrubber for Potlines	Brigantine Wilderness Area	0.051	0	0.050	0	0.042	0
		Dolly Sods Wilderness Area	0.032	0	0.049	0	0.059	0
		James River Face Wilderness Area	0.044	0	0.038	0	0.040	0
		Otter Creek Wilderness Area	0.024	0	0.034	0	0.046	0
		Shenandoah National Park	**0.282**	1	**0.235**	1	**0.290**	3
Current Allowable Emissions	Facility-wide Annual SO_2 Emission Cap	Brigantine Wilderness Area	0.091	0	0.068	0	0.065	0
		Dolly Sods Wilderness Area	0.074	0	**0.116**	0	**0.173**	0
		James River Face Wilderness Area	0.095	0	0.087	0	0.077	0
		Otter Creek Wilderness Area	0.041	0	0.084	0	**0.111**	0
		Shenandoah National Park	**0.309**	2	**0.307**	3	**0.420**	3

Note:
Modeled visibility impacts that exceed the 0.1 dv contribution threshold are presented in bold in this table.

APPENDICES

APPENDIX A:

BART MODELING RESULTS

BART Modeling Analysis
for
Alcoa Eastalco Works
Frederick, Maryland

February 8, 2008

Prepared for:

Alcoa
201 Isabella St at 7th St Bridge
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Prepared by:

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Ref. No. 2281

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1.0 INTRODUCTION

1.1 Background

Epsilon Associates, Inc. (Epsilon) on behalf of Alcoa has performed a visibility modeling analysis of the existing Alcoa Eastalco Works in Frederick County, Maryland in conformance with the EPA Best Available Retrofit Technology (BART) Regional Haze Regulations. Eastalco has been identified by the Maryland Department of the Environment (MDE) as a BART eligible facility. The facility performs electrolytic reduction of alumina to aluminum to produce various alloys of aluminum. The visibility modeling was conducted in support of the facility's BART assessment.

BART, required by the EPA Regional Haze Regulations, is designed to improve visibility in the Federal Class I Areas. A BART-eligible unit is a source at a stationary facility that:

1. falls into any of the 26 source categories identified under the Regional Haze Regulations [40 CFR 51, July 6, 2005];

2. began operation after August 7, 1962, and was still in existence on August 7, 1977; and

3. has the potential to emit 250 tpy or more of any visibility impairing pollutant [including sulfur dioxide (SO_2), oxides of nitrogen (NO_x), particulate matter (PM_{10}), and volatile organic compounds (VOCs)].

The modeling approach was based on the application of the CALMET/CALPUFF meteorological and dispersion modeling system. The Mid-Atlantic/Northeast Visibility Union (MANE-VU) regional Planning Organization recommends the use of CALPUFF for BART modeling (NESCAUM, 2006). CALPUFF is the EPA guideline model recommended for assessing long range transport impacts in Class I Areas. CALPUFF is a non-steady state Gaussian puff model that uses three-dimensional meteorological data and incorporates complex terrain algorithms, building downwash, and other effects. Three years of the 4 km CALMET meteorological files provided by VISTAS were used in this analysis. The VISTAS Modeling Protocol (VISTAS, 2005) was used as guidance on visibility modeling methodology. Visibility impacts were assessed in the five closest Class I Areas, all within the recommended distance of 300 km of the facility. The nearest Class 1 area, the Shenandoah National Park, is located approximately 100 km southwest of the Facility in Virginia. Brigantine National Wildlife Refuge is the furthest away. It is located along the New Jersey coast approximately 260 km to the northeast of the facility.

The purpose of the modeling analysis was two-fold:

- Model all facility sources to determine a baseline. During this step a culpability analysis was performed to see which sources at the Facility are the largest contributors to the visibility impacts in the Class I areas.

- Assess the improvement in visibility expected from a proposed control option for the Potlines (largest contributor).

1.2 Outline of Report

This modeling report describes the air quality modeling approach and visibility results for the Class I area analysis. In this report, Section 2 describes the Eastalco Facility and the proposed control option. The source exhaust parameters, emission estimates and building downwash analysis are discussed. Section 3 discusses the CALMET modeling provided by VISTAS and the modeling domain. Section 4 details the CALPUFF model options and inputs are discussed along with the CALPOST processing to obtain the predicted visibility impacts. The modeling results are presented in Section 5. References are provided in Section 6.

2.0 FACILITY DESCRIPTION

2.1 Eastalco Facility

The Facility is located on a 2,200 acre site in Buckeystown, Maryland which is approximately 11 kilometers (km) south-southwest of Frederick, Maryland. The Universal Transverse Mercator (UTM) coordinates (zone 18) of the center of the Facility are 286.736 km east, 4356.323 km north. Figure 2.1-1 shows the Eastalco Works property and facility.

The Facility is a primary aluminum smelter. Aluminum is produced continuously in large electrolytic cells called pots by the electrolysis of alumina (Al_2O_3) in a molten cryolite-based electrolyte (Na_3AlF_6). This method is known as the Hall-Heroult process. In this process, alumina is separated into aluminum and oxygen by applying an electric current.

The Facility is a center-work prebake plant with two potlines, Potlines A and B. Each of the Facility's 480 pots is equipped with 18 carbon anodes. On a periodic basis, alumina is added to the pots, aluminum metal is removed from the pots, and consumed anodes are removed. Anodes are made from coke and pitch, which are mixed, pressed, and baked in an on-site facility.

All pots at the Facility are hooded to control gaseous and particulate emissions. Emissions captured by the hoods are drawn through the primary control system, which consists of an alumina dry injection system for the control of fluorides. In addition, a portion of the Potline A emissions are subsequently vented through wet scrubbers, which are equipped with alkaline injection systems that can be used to control SO_2 emissions. A small fraction of the pot emissions escape capture by the hoods and are released into the potrooms. These emissions are drawn through a secondary control system on the roof. The secondary control system consists of wet roof scrubbers that control SO_2, PM and total fluoride emissions.

2.2 Source Data

The Facility is comprised of a complex arrangement of emission sources. The potrooms are parallel, low-level buoyant line sources. There are many point sources emitting to the atmosphere at the Facility as well. Some of the point sources have emissions released through horizontal openings while others are emitted from vertical stacks. Both stack orientations were addressed in the CALPUFF analysis. Some of the buildings at the Facility have fugitive emissions that escape through doors and windows. These sources were modeled as volume sources. Buildings with fugitive emissions include the Rod Shop, Cathode Plant, Ladle Shop, and Athracite Rail Unloading Area at the Cathode Plant. Emissions from individual sources inside each building were combined and then converted into an emission rate for each opening of the building (emissions were computed in proportion to the relative size of the opening).

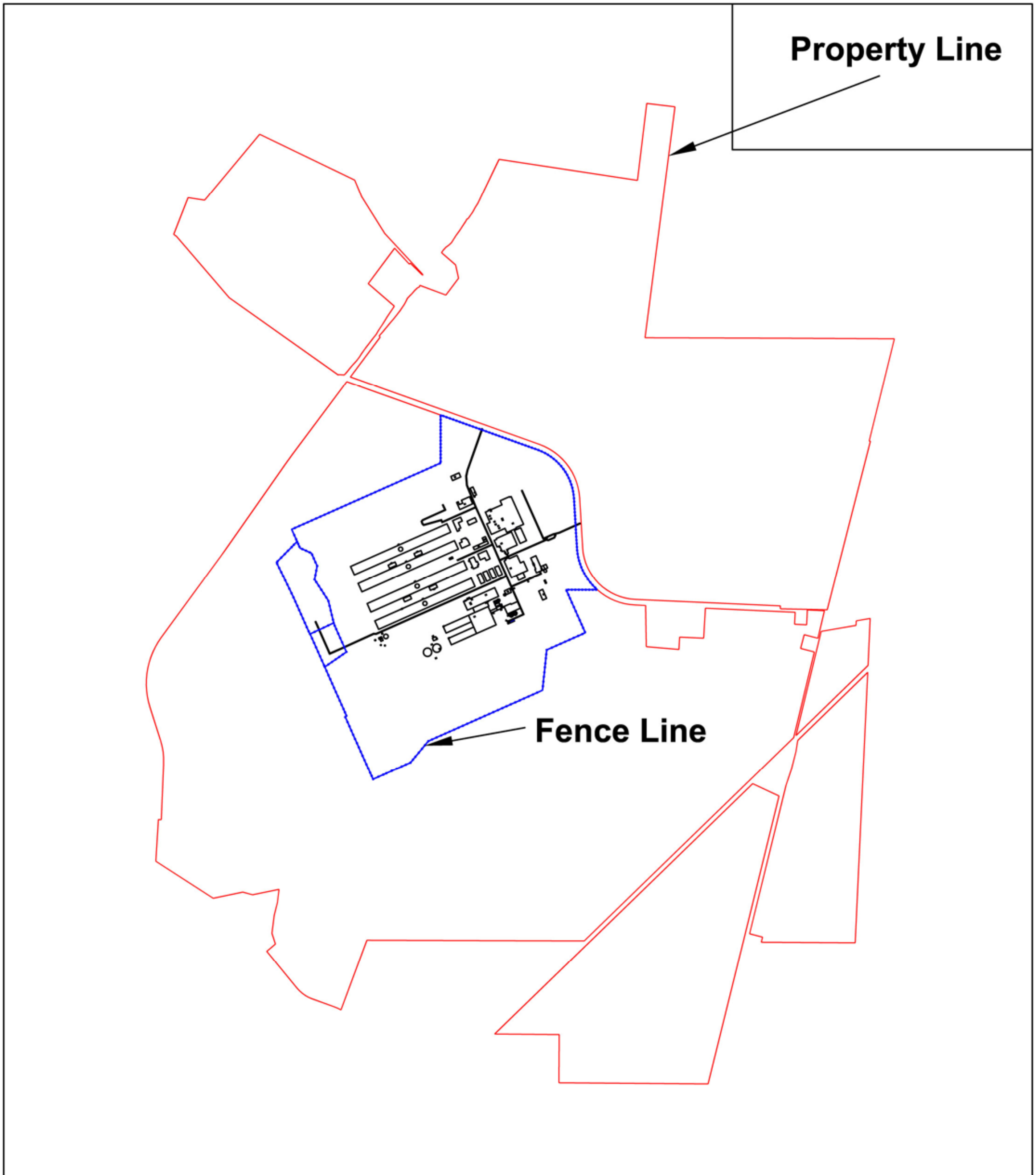

FIGURE 2.1-1

Epsilon
ASSOCIATES INC.

Eastalco Facility Site Plan

\\Hendrick\Projects\ealco\Graphics\siteplan-report.dwg

The Casthouse and Bake Oven have emissions from roof vents. These sources were also treated as volume sources.

The potrooms are equipped with wet roof scrubbers for secondary (fugitive) emission control. In addition to the wet roof scrubbers, the west end of Potline A1 is equipped with six SO_2 wet scrubbers to provide additional SO_2 control. The SO_2 scrubber systems are typically shut down for short periods throughout a given year for maintenance purposes. During the SO_2 scrubber shutdown periods, the effluent is discharged through a bypass vent. In the base case modeling scenario, short-term (24-hour) impacts were determined assuming the bypass vent was in use. The Facility source parameters used in the CALPUFF modeling are presented in Tables 2.2-1 through 2.2-3 for the point sources, line sources and volume sources, respectively.

The baseline emissions for the visibility impact modeling are based on maximum 24-hour average emission rates which are presented for each source in Table 2.2-4. The particulate matter emissions were provided as PM_{10} only, therefore it was conservatively assumed that all the particulate emissions were organic condensable in the submicron size categories. This follows the recommendation of VISTAS concerning the procedure for speciation of emissions (VISTAS, 2006) which states that the default assumption is that organics is the highest reasonable extinction category (elemental carbon is considered overly conservative). Condensable emissions are assumed to be evenly distributed across two PM size categories (i.e. 50 % in PM081 and 50 % in PM056).

A potline SO_2 scrubber control option was also modeled with CALPUFF. In this scenario the emissions routed to the potline dry scrubbers are now vented out a new potline SO_2 scrubber stack. The potline roof top SO_2 scrubbers are not in operation during this scenario. The bypass stack is also not necessary for this alternative operating scenario. All other sources remain unchanged. Table 2.2-5 lists the emission rates associated with the changes to emissions associated with the potline SO_2 scrubber control scenario.

Table 2.2-1 Source Parameters for the Eastalco Facility Point Sources

Baseline Source Data BART									
EU Number	Source	Location				Stack	Diameter	Exit velocity	Temperature
		UTM E	UTM N	Lambert Conformal		height	(m)	(m/s)	(K)
		(km)	(km)	x (km)	y (km)	(m)			
	Pot Line A								
EU110-1 (D7)	Dry Scrubber SE					24.38	1.52	16.82	366
EU110-1 (D8)						24.38	1.52	16.82	366
EU110-1 (D9)						24.38	1.52	16.82	366
EU110-1 (D10)						24.38	1.52	16.82	366
EU110-1 (D11)						24.38	1.52	16.82	366
EU110-1 (D12)						24.38	1.52	16.82	366
	Dry Scrubber Stacks Combined	286.668	4356.292	1657.037	104.791	24.38	3.73	16.82	366
EU110-3	Potline A1 Bypass	286.529	4356.208	1656.923	104.677	12.19	3.66	17.97	355
	Pot Line B								
EU111-1- (D1)	Dry Scrubber NW					26.82	1.52	15.52	355
EU111-1- (D2)						26.82	1.52	15.52	355
EU111-1- (D3)						26.82	1.52	15.52	355
EU111-1- (D4)						26.82	1.52	15.52	355
EU111-1- (D5)						26.82	1.52	15.52	355
EU111-1- (D6)						26.82	1.52	15.52	355
EU111-1- (D7)						26.82	1.52	15.52	355
	Dry Scrubber Stacks Combined	286.484	4356.405	1656.832	104.857	26.82	4.03	15.52	355
EU111-1- (D8)	Dry Scrubber NE					26.82	1.52	15.52	355
EU111-1- (D9)						26.82	1.52	15.52	355
EU111-1- (D10)						26.82	1.52	15.52	355
EU111-1- (D11)						26.82	1.52	15.52	355
EU111-1- (D12)						26.82	1.52	15.52	355

Table 2.2-1 Source Parameters for the Eastalco Facility Point Sources (Continued)

Baseline Source Data BART									
EU Number	**Source**	**Location**				**Stack**	**Diameter**	**Exit velocity**	**Temperature**
		UTM E	**UTM N**	**Lambert Conformal**		**height**	**(m)**	**(m/s)**	**(K)**
		(km)	**(km)**	**x (km)**	**y (km)**	**(m)**			
EU111-1- (D13)						26.82	1.52	15.52	355
EU111-1- (D14)						26.82	1.52	15.52	355
	Dry Scrubber Stacks Combined	286.595	4356.455	1656.927	104.931	26.82	4.03	15.52	355
	Bake Oven								
EU117-3	Anode Coring	286.842	4356.174	1657.232	104.718	3.76	0.43	26.13	300
EU117-1	Bake Oven Dry Scr.	286.663	4356.090	1657.080	104.595	30.48	2.06	19.87	361
EU117-4a	Refractory Mixer 1	286.709	4356.132	1657.115	104.646	3.05	0.15	54.33	300
EU117-4b	Refractory Mixer 2	286.731	4356.082	1657.147	104.603	3.05	0.15	54.33	300
	Rod Shop								
EU113-1	Butts & Bath Separation	286.816	4356.251	1657.189	104.786	8.53	1.19	16.93	300
EU113-2	Bath Conv.	286.891	4356.233	1657.266	104.787	10.06	0.76	25.77	300
EU113-3	Butts Primary and Secondary Crusher	286.898	4356.238	1657.271	104.794	16.46	0.71	19.01	300
EU113-6	Shot Blast (s.b..)	286.802	4356.242	1657.177	104.775	4.27	0.38	19.51	300
EU113-5	Butts Storage Silo	286.945	4356.243	1657.315	104.810	23.52	0.17	26.45	300
EU113-9	Al Spray Furnace 1	286.824	4356.233	1657.201	104.771	15.24	1.22	0.61	311
EU113-9	Al Spray Furnace 2	286.826	4356.228	1657.204	104.767	15.24	1.22	0.61	311
	Material Handling								
EU112-6	Aluminum F Silos N	287.145	4356.329	1657.487	104.940	21.56	0.20	17.73	300
EU112-7	Aluminum F Silos S	287.148	4356.320	1657.492	104.932	25.18	0.20	17.73	300
EU112-1	Alumina RR Unload	286.676	4355.995	1657.115	104.506	12.71	0.86	20.41	300
EU112-2&3	Alumina Silos A and B	286.691	4356.036	1657.120	104.549	38.10	0.24	20.90	300
EU112-9	Pet Coke	286.987	4356.178	1657.371	104.757	13.72	0.43	19.59	300
EU112-4	Reacted Ore Conv.	286.658	4356.054	1657.084	104.559	15.65	0.57	18.29	300

Table 2.2-1 Source Parameters for the Eastalco Facility Point Sources (Continued)

Baseline Source Data BART									
EU Number	Source	Location				Stack	Diameter	Exit velocity	Temperature
		UTM E	UTM N	Lambert Conformal		height	(m)	(m/s)	(K)
		(km)	(km)	x (km)	y (km)	(m)			
	Casthouse								
EU114-6	Furnace-6	286.958	4356.490	1657.268	105.052	24.08	0.91	1.08	311
EU114-7	Furnace-7	286.948	4356.556	1657.243	105.113	33.53	1.22	0.61	311
EU114-8	Furnace-8	286.944	4356.566	1657.237	105.122	33.53	1.22	0.61	311
EU114-12	Furnace-12	286.907	4356.609	1657.191	105.155	33.53	1.22	0.61	311
EU114-5	B-Fur.	286.912	4356.630	1657.191	105.176	33.53	0.86	1.61	325
EU114-14	A-Homo Fur.	286.961	4356.596	1657.246	105.155	24.38	0.86	1.61	325
EU114-14	B-Homo Fur.	286.963	4356.591	1657.249	105.150	24.38	0.86	1.61	325
EU114-1	Dross Skimming Station	286.974	4356.450	1657.293	105.017	3.66	0.42	20.32	300
EU114-9	Furnace-9	286.933	4356.572	1657.225	105.125	33.53	1.22	0.61	311
EU114-10	Furnace-10	286.928	4356.584	1657.217	105.136	33.53	1.22	0.61	311
EU114-11	Furnace-11	286.913	4356.597	1657.200	105.144	33.53	1.22	0.61	311
	Cathode Plant								
EU115-1	Anthracite Crusher	287.131	4356.381	1657.461	104.987	16.76	0.37	23.95	300
EU115-3	Cathode Bar S.B.	287.095	4356.403	1657.421	105.000	9.14	0.91	0.74	311
EU115-2	Cast Iron Furnace (2)	287.097	4356.398	1657.424	104.996	3.05	0.42	11.85	311
	Paste Plant								
EU116-1	Roll Crusher	286.950	4356.222	1657.325	104.791	10.67	0.41	33.47	300
EU116-2	Feed Bin System (Plant D.C.)	286.956	4356.220	1657.331	104.791	31.85	0.42	20.40	300
EU116-3	Ball Mill	286.933	4356.236	1657.306	104.800	30.78	0.26	16.14	300
EU116-5	Pitch Fume	286.923	4356.189	1657.307	104.752	15.24	1.02	16.12	339

Table 2.2-1 Source Parameters for the Eastalco Facility Point Sources (Continued)

Baseline Source Data BART									
EU Number	**Source**	**Location**				**Stack**	**Diameter**	**Exit velocity**	**Temperature**
		UTM E	**UTM N**	**Lambert Conformal**		**height**	**(m)**	**(m/s)**	**(K)**
		(km)	**(km)**	**x (km)**	**y (km)**	**(m)**			
EU116-4	Weigh Feeder	286.959	4356.213	1657.336	104.784	19.81	0.37	19.25	300
EU116-6	Boiler	286.943	4356.218	1657.319	104.785	32.00	0.61	2.43	311
EU116-7	Pet Coke Silo A	287.000	4356.180	1657.383	104.762	30.48	0.15	17.90	300
EU116-7	Pet Coke Silo B	287.017	4356.188	1657.397	104.774	30.48	0.15	17.90	300
	Ladle Shop								
EU023-1	Ladle Cleaning	286.819	4356.415	1657.153	104.946	5.05	0.20	49.48	300
	Boilers								
EU033-3	Process Water Treatment Boiler	286.442	4356.080	1656.870	104.533	14.33	0.31	11.23	339
EU205-1	Admin Boiler	286.758	4356.776	1657.008	105.280	7.62	0.61	2.43	311
EU206-1	E. Gate Boiler	286.843	4356.710	1657.105	105.237	7.62	0.61	2.43	311
EU208-1	Tech Boiler	286.860	4356.478	1657.177	105.017	15.24	0.61	2.43	311
Potline SO2 Control Case Source Data BART									
NEW	Potline SO_2 Scrubber	286.475	4356.113	1656.893	104.573	38.1	6.9	18.4	311
	(No Roof Top SO_2 scrubbers - No Bypass)								

Table 2.2-2 Source Parameters for the Eastalco Facility Line Sources

Baseline Source Data BART						
Potroom Description	**Potroom Coordinates (Lambert Conformal)**				**Release**	**Base**
	Beginning X	**Beginning Y**	**Ending X**	**Ending Y**	**Height**	**Elevation**
	(km)	**(km)**	**(km)**	**(km)**	**(m)**	**(m)**
Potline A1 West (wet/SO_2 scr.)	1656.836	104.582	1656.995	104.708	16.76	101.5
Potline A1 East (wet scr.)	1656.995	104.708	1657.192	104.860	16.76	101.5
Potline A2 (wet scr.)	1656.786	104.647	1657.141	104.925	16.76	101.5
Potline B1 (wet scr.)	1656.728	104.722	1657.083	105.000	16.76	101.5
Potline B2 (wet scr.)	1656.679	104.785	1657.034	105.062	16.76	101.5

Additional Variables	
Average Building Length (m)	454.3
Average Building Height (m)	16.76
Average Building Width (m)	40.0
Average Line Source Width (m)	5.73
Average Separation Between Buildings (m)	40.95
Average Buoyancy Parameter - Bypass (m^4/s^3)	3335.49

Table 2.2-3 Source Parameters for the Eastalco Facility Volume Sources

Baseline Source Data BART								
Source Description	Location				Effective	Base	Initial	Initial
	UTM E	UTM N	Coordinates (Lambert Conformal)		Height	Elevation	Sigma y	Sigma z
	(km)	(km)	X (km)	Y (km)	(m)	(m)	(m)	(m)
Bake Oven A Roof Vent 1	286.780	4356.095	1657.192	104.627	22.60	101.5	22.57	10.51
Bake Oven A Roof Vent 2	286.787	4356.081	1657.201	104.616	22.60	101.5	22.57	10.51
Bake Oven B Roof Vent 1	286.758	4356.146	1657.158	104.672	22.56	101.5	22.57	10.49
Bake Oven B Roof Vent 2	286.764	4356.132	1657.167	104.659	22.56	101.5	22.57	10.49
Casthouse Roof Vent 1	286.946	4356.485	1657.258	105.044	15.85	101.5	0.21	7.37
Casthouse Roof Vent 2	286.955	4356.565	1657.247	105.123	23.16	101.5	0.21	10.77
Casthouse Roof Vent 3	286.948	4356.580	1657.237	105.136	23.16	101.5	0.21	10.77
Casthouse Roof Vent 4	286.942	4356.595	1657.228	105.150	23.16	101.5	0.21	10.77
Casthouse Roof Vent 5	286.935	4356.610	1657.218	105.162	23.16	101.5	0.21	10.77
Casthouse Roof Vent 6	286.928	4356.625	1657.208	105.175	23.16	101.5	0.21	10.77
Rod Shop Fugitives 1	286.798	4356.241	1657.174	104.773	0	101.5	0.71	2.84
Rod Shop Fugitives 2	286.815	4356.203	1657.200	104.740	0	101.5	0.71	2.84
Rod Shop Fugitives 3	286.937	4356.280	1657.299	104.844	0	101.5	9.51	6.10
Cathode Plant Fugitives	287.121	4356.369	1657.455	104.973	0	101.5	0.71	2.84
Ladle Shop Fugitives 1	286.829	4356.427	1657.160	104.960	0	101.5	0.71	2.84
Ladle Shop Fugitives 2	286.847	4356.386	1657.187	104.925	0	101.5	0.71	2.84
Anthracite Rail Unloading 1	287.144	4356.398	1657.469	105.007	0	101.5	2.13	5.67
Anthracite Rail Unloading 2	287.151	4356.382	1657.480	104.993	0	101.5	2.13	5.67

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
	Ladle Shop						
EU023-1	Ladle Cleaning	0.00	0.00E+00	4.89E-01	1.41E-02	0.00	0.00E+00
EU023-3	Burners	1.82E-03	5.24E-05	2.31E-02	6.64E-04	3.04E-01	8.74E-03
	Process H2O Treat.						
EU033-3	Boiler	5.06E-06	1.45E-07	6.40E-05	1.84E-06	8.43E-04	1.92E-04
	Pot Line A						
EU110-1 (D7)	Dry Scrubber SE	143.84	4.14E+00	1.70	4.89E-02	0.00	0.00E+00
EU110-1 (D8)		143.84	4.14E+00	1.70	4.89E-02	0.00	0.00E+00
EU110-1 (D9)		143.84	4.14E+00	1.70	4.89E-02	0.00	0.00E+00
EU110-1 (D10)		143.84	4.14E+00	1.70	4.89E-02	0.00	0.00E+00
EU110-1 (D11)		143.84	4.14E+00	1.70	4.89E-02	0.00	0.00E+00
EU110-1 (D12)		143.84	4.14E+00	1.70	4.89E-02	0.00	0.00E+00
EU110-2 (W1)	Wet Scr. (Large Stk)	0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W2)	+	0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W3)	SO_2 Scr. (Large Stk)	0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W4)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W5)	47 total stacks	0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W6)	41 wet scrub, 6 so2	56.61	1.63E+00	0.29	8.28E-03	0.00	0.00E+00

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU110-2 (W7)	25 on A1	56.61	1.63E+00	0.29	8.28E-03	0.00	0.00E+00
EU110-2 (W8)	22 on A2	56.61	1.63E+00	0.29	8.28E-03	0.00	0.00E+00
EU110-2 (W9)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W10)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W11)		56.61	1.63E+00	0.29	8.28E-03	0.00	0.00E+00
EU110-2 (W12)		56.61	1.63E+00	0.29	8.28E-03	0.00	0.00E+00
EU110-2 (W13)		56.61	1.63E+00	0.29	8.28E-03	0.00	0.00E+00
EU110-2 (W14)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W15)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W16)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W17)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W18)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W19)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W20)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W21)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W22)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W23)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W24)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W25)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W26)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W27)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W28)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU110-2 (W29)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W30)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W31)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W32)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W33)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W34)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W35)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W36)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W37)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W38)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W39)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W40)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W41)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W42)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W43)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W44)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W45)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W46)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU110-2 (W47)		0.99	2.86E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-3	Potline A1 Bypass	438.48	1.26E+01	5.18	1.49E-01	0.00	0.00E+00
	Pot Line B						
EU111-1- (D1)	Dry Scrubber NW	123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D2)		123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D3)		123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D4)		123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D5)		123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D6)		123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D7)		123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
						0.00	0.00E+00
EU111-1- (D8)	Dry Scrubber NE	123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D9)		123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D10)		123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D11)		123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D12)		123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D13)		123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D14)		123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-2 (W1)	Wet Scr.	1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W2)	(48 total)	1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W3)	(19 small stk)	1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W4)	(29 large stk)	1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W5)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W6)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU111-2 (W7)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W8)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W9)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W10)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W11)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W12)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W13)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W14)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W15)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W16)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W17)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W18)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W19)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W20)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W21)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W22)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W23)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W24)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W25)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W26)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W27)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W28)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W29)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W30)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W31)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU111-2 (W32)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W33)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W34)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W35)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W36)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W37)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W38)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W39)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W40)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W41)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W42)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W43)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W44)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W45)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W46)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W47)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W48)		1.71	4.91E-02	4.69	1.35E-01	0.00	0.00E+00
	Material Handling						
EU112-1	Alumina RR Unload	0.00	0.00E+00	1.31	3.76E-02	0.00	0.00E+00
EU112-2	Alumina Silos A	0.00	0.00E+00	0.20	5.64E-03	0.00	0.00E+00
EU112-3	Alumina Silos B	0.00	0.00E+00	0.20	5.64E-03	0.00	0.00E+00
EU112-4	Reacted Ore Conv.	0.00	0.00E+00	1.84	5.28E-02	0.00	0.00E+00
EU112-6	Aluminum Fluoride Silos N	0.00	0.00E+00	0.08	2.33E-03	0.00	0.00E+00
EU112-7	Aluminum Fluoride Silos S	0.00	0.00E+00	0.08	2.33E-03	0.00	0.00E+00
EU112-9	Pet Coke Conveyor	0.00	0.00E+00	1.01	2.89E-02	0.00	0.00E+00

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
	Rod Shop						
EU113-1	Butts & Bath Separation	0.00	0.00E+00	6.97	2.01E-01	0.00	0.00E+00
EU113-2	Bath Conv.	0.00	0.00E+00	4.34	1.25E-01	0.00	0.00E+00
EU113-3	Butts Primary Crusher	0.00	0.00E+00	6.71	1.93E-01	0.00	0.00E+00
EU113-5	Butts Storage Silo	0.00	0.00E+00	0.21	6.02E-03	0.00	0.00E+00
EU113-6	Shot Blast (s.b..)	0.00	0.00E+00	0.84	2.41E-02	0.00	0.00E+00
EU113-7	Rod Preheater & Dryer	0.003	8.78E-05	0.04	1.11E-03	0.51	1.46E-02
EU113-8	Cast Iron Furnace (3)	0.00	0.00E+00	0.30	8.61E-03	0.00	0.00E+00
EU113-9	Al Spray Furnace 1	0.002	6.07E-05	0.05	1.44E-03	0.35	1.01E-02
EU113-9	Al Spray Furnace 2	0.002	6.07E-05	0.05	1.44E-03	0.35	1.01E-02
EU113-10	Spent Anode Cooling	0.00	0.00E+00	0.17	4.94E-03	0.00	0.00E+00
	Casthouse						
EU114-1	Dross Skimming Station	0.00	0.00E+00	1.10	3.17E-02	0.00	0.00E+00
EU114-5	B-Fur.	0.01	2.91E-04	1.23	3.55E-02	2.36	6.79E-02
EU114-6	Furnace-6	0.01	2.91E-04	1.23	3.55E-02	2.36	6.79E-02
EU114-7	Furnace-7	0.01	3.88E-04	1.23	3.55E-02	3.15	9.06E-02
EU114-8	Furnace-8	0.01	3.88E-04	1.23	3.55E-02	3.15	9.06E-02
EU114-9	Furnace-9	0.01	2.91E-04	1.23	3.55E-02	2.36	6.79E-02
EU114-10	Furnace-10	0.01	2.91E-04	1.23	3.55E-02	2.36	6.79E-02
EU114-11	Furnace-11	0.01	2.91E-04	1.23	3.55E-02	2.36	6.79E-02
EU114-12	Furnace-12	0.01	2.91E-04	1.23	3.55E-02	2.36	6.79E-02
EU114-14	A-Homo Fur.	0.02	4.85E-04	0.21	6.15E-03	3.94	1.13E-01
EU114-14	B-Homo Fur.	0.02	6.79E-04	0.30	8.61E-03	5.51	1.59E-01
EU114-17	Casthouse Roof Vent	0.00	0.00E+00	0.28	8.20E-03	0.00	0.00E+00

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
	Cathode Plant						
EU115-1	Anthracite Crusher	0.00	0.00E+00	0.42	1.22E-02	0.00	0.00E+00
EU115-2	Cast Iron Furnace(2)	0.00	0.00E+00	0.04	1.26E-03	0.00	0.00E+00
EU115-3	Cathode Bar S.B.	0.00	0.00E+00	0.08	2.20E-03	0.00	0.00E+00
EU115-4	Cathode Dry-Out Heater	0.004	1.16E-04	0.05	1.48E-03	0.67	1.94E-02
EU115-5	Anthracite Rail Unloading	0.00	0.00E+00	0.002	5.40E-05	0.00	0.00E+00
	Paste Plant						
EU116-1	Roll Crusher	0.00	0.00E+00	1.62	4.66E-02	0.00	0.00E+00
EU116-2	Feed Bin System (Plant D.C.)	0.00	0.00E+00	1.02	2.94E-02	0.00	0.00E+00
EU116-3	Ball Mill	0.00	0.00E+00	0.31	9.05E-03	0.00	0.00E+00
EU116-4	Weigh Feeder	0.00	0.00E+00	0.78	2.24E-02	0.00	0.00E+00
EU116-5	Pitch Fume	1.76	5.05E-02	4.32	1.24E-01	2.75	7.90E-02
EU116-6	Boiler	0.01	1.46E-04	0.06	1.84E-03	0.84	2.43E-02
EU116-7	Pet Coke Silo A	0.00	0.00E+00	0.12	3.50E-03	0.00	0.00E+00
EU116-7	Pet Coke Silo B	0.00	0.00E+00	0.12	3.50E-03	0.00	0.00E+00
	Bake Oven						
EU117-1	Bake Oven Dry Scr.	267.2	7.69E+00	44.5	1.28E+00	49.09	1.41E+00
EU117-3	Anode Coring	0.00	0.00E+00	1.47	4.22E-02	0.00	0.00E+00
EU117-4a	Refractory Mixer 1	0.00	0.00E+00	0.39	1.11E-02	0.00	0.00E+00
EU117-4b	Refractory Mixer 2	0.00	0.00E+00	0.39	1.11E-02	0.00	0.00E+00
EU117-5	Bake Oven Roof Vents	0.0013	3.88E-05	2.52	7.25E-02	0.50	1.43E-02
EU117-5	Bake Oven Roof Vents	0.0013	3.88E-05	2.52	7.25E-02	0.50	1.43E-02

Table 2.2-4 Maximum Short Term Emission Rates for the Eastalco Facility Baseline Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
	Boilers						
EU205-1	Admin Boiler	0.001	3.06E-05	0.01	3.87E-04	0.18	5.10E-03
EU206-1	E. Gate Boiler	0.001	3.06E-05	0.01	3.87E-04	0.18	5.10E-03
EU208-1	Tech Boiler	0.002	5.95E-05	0.03	7.53E-04	0.34	9.91E-03

Note: Shading indicates the emissions are treated as fugitive and modeled as volume sources.

Table 2.2-5 Maximum Short Term Emission Rates for the Eastalco Facility Potline SO_2 Control Case

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
NEW	**Potlines SO_2 Scrubber**	225.5	6.49E+00	450.9	13.0	0.00E+00	0.00E+00
	Pot Line A						
~~EU110-1 (D7)~~	~~Dry Scrubber SE~~	~~143.84~~	~~4.14E+00~~	~~1.70~~	~~4.89E-02~~	~~0.00~~	~~0.00E+00~~
~~EU110-1 (D8)~~	-	~~143.84~~	~~4.14E+00~~	~~1.70~~	~~4.89E-02~~	~~0.00~~	~~0.00E+00~~
~~EU110-1 (D9)~~	-	~~143.84~~	~~4.14E+00~~	~~1.70~~	~~4.89E-02~~	~~0.00~~	~~0.00E+00~~
~~EU110-1 (D10)~~	-	~~143.84~~	~~4.14E+00~~	~~1.70~~	~~4.89E-02~~	~~0.00~~	~~0.00E+00~~
~~EU110-1 (D11)~~	-	~~143.84~~	~~4.14E+00~~	~~1.70~~	~~4.89E-02~~	~~0.00~~	~~0.00E+00~~
~~EU110-1 (D12)~~	-	~~143.84~~	~~4.14E+00~~	~~1.70~~	~~4.89E-02~~	~~0.00~~	~~0.00E+00~~
EU110-2 (W1)	Wet Scr. (Large Stk)	1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W2)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W3)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00

Table 2.2-5 Maximum Short Term Emission Rates for the Eastalco Facility Potline SO_2 Control Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU110-2 (W4)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W5)	47 total stacks	1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
~~EU110-2 (W6)~~	~~41 wet scrub, 6 so2~~	~~56.61~~	~~1.63E+00~~	~~0.29~~	~~8.28E-03~~	~~0.00~~	~~0.00E+00~~
~~EU110-2 (W7)~~	~~25 on A1~~	~~56.61~~	~~1.63E+00~~	~~0.29~~	~~8.28E-03~~	~~0.00~~	~~0.00E+00~~
~~EU110-2 (W8)~~	~~22 on A2~~	~~56.61~~	~~1.63E+00~~	~~0.29~~	~~8.28E-03~~	~~0.00~~	~~0.00E+00~~
EU110-2 (W9)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W10)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
~~EU110-2 (W11)~~	-	~~56.61~~	~~1.63E+00~~	~~0.29~~	~~8.28E-03~~	~~0.00~~	~~0.00E+00~~
~~EU110-2 (W12)~~	-	~~56.61~~	~~1.63E+00~~	~~0.29~~	~~8.28E-03~~	~~0.00~~	~~0.00E+00~~
~~EU110-2 (W13)~~	-	~~56.61~~	~~1.63E+00~~	~~0.29~~	~~8.28E-03~~	~~0.00~~	~~0.00E+00~~
EU110-2 (W14)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W15)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W16)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W17)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W18)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W19)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W20)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W21)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W22)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W23)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W24)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W25)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00

Table 2.2-5 Maximum Short Term Emission Rates for the Eastalco Facility Potline SO_2 Control Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU110-2 (W26)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W27)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W28)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W29)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W30)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W31)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W32)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W33)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W34)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W35)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W36)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W37)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W38)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W39)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W40)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W41)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W42)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W43)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W44)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00

Table 2.2-5 Maximum Short Term Emission Rates for the Eastalco Facility Potline SO_2 Control Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU110-2 (W45)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W46)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-2 (W47)		1.30	3.70E-02	5.75	1.65E-01	0.00	0.00E+00
EU110-3	Potline A1 Bypass	438.48	1.26E+01	5.18	1.49E-01	0.00	0.00E+00
	Pot Line B						
EU111-1- (D1)	Dry Scrubber NW	123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D2)		123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D3)	-	123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D4)	-	123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D5)	-	123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D6)	-	123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
EU111-1- (D7)	-	123.90	3.56E+00	2.32	6.69E-02	0.00	0.00E+00
						0.00	0.00E+00
EU111-1- (D8)	Dry Scrubber NE	123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D9)		123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D10)	-	123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D11)	-	123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D12)	-	123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D13)	-	123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-1- (D14)	-	123.90	3.56E+00	0.73	2.09E-02	0.00	0.00E+00
EU111-2 (W1)	Wet Scr.	2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W2)	(48 total)	2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W3)	(19 small stk)	2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W4)	(29 large stk)	2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00

Table 2.2-5 Maximum Short Term Emission Rates for the Eastalco Facility Potline SO_2 Control Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU111-2 (W5)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W6)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W7)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W8)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W9)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W10)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W11)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W12)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W13)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W14)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W15)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W16)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W17)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W18)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W19)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W20)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W21)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W22)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W23)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W24)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W25)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W26)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W27)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W28)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W29)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00

Table 2.2-5 Maximum Short Term Emission Rates for the Eastalco Facility Potline SO_2 Control Case (Continued)

EU Number	Source	SO_2		PM		NOx	
		Actual	Actual	Actual	Actual	Actual	Actual
		tons/yr	g/sec	tons/yr	g/sec	tons/yr	g/sec
EU111-2 (W30)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W31)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W32)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W33)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W34)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W35)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W36)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W37)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W38)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W39)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W40)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W41)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W42)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W43)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W44)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W45)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W46)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W47)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00
EU111-2 (W48)		2.22	6.40E-02	4.69	1.35E-01	0.00	0.00E+00

Note: Shading indicates the emissions have changed from the baseline case.

2.3 Building Downwash Analysis

The building downwash analysis for the Facility point sources was conducted using the USEPA Building Profile Input Program (BPIP). BPIP employs the methodology described in the USEPA's revised *Guidelines for Determination of Good Engineering Practice Stack Height* (USEPA 1985) to produce the building heights and projected building widths that affect the dispersion of pollutants from the source in question. The aerodynamic downwash caused by a building's wake has a direct effect on the dispersion of a pollutant. The area of influence of a structure extends five times L (5L) directly downwind from the trailing edge of the structure, where L is the lesser of the building's height or direction-specific projected building width. The area of influence extends 2L in the upwind direction and 0.5L in the crosswind direction. A building's wake effect height, or Good Engineering Practice (GEP) stack height, as defined by the USEPA guidelines is:

$H_{GEP} = H_b + 1.5L$

Where,

H_{GEP} = GEP stack height,

H_b = Height of adjacent or nearby structures,

L = Lesser of height or maximum projected width of adjacent or nearby building (i.e., the critical dimension), and

Nearby = Within 5L of the stack from downwind (trailing edge) of the building.

The building with the largest wake effect height, whose area of influence encompasses a stack, is the dominant influential building to that stack. A complete description of BPIP can be found in the *User's Guide to the Building Profile Input Program* (USEPA 1993).

The plumes from each point source at the Facility are affected by downwash, and therefore the wind direction specific building dimensions generated by BPIP were input into the CALPUFF model.

3.0 METEOROLOGICAL AND MONITORED DATA

3.1 CALMET Meteorological Data

The Visibility Improvement State and Tribal Association of the Southeast (VISTAS) has created three years (2001-2003) of CALMET meteorological data sets for use in BART analysis. They created a large domain with 12 km spacing, and five smaller sub-domains with 4 km spacing. Although Maryland is a member of the Mid-Atlantic/Northeast Visibility Union (MANE-VU), and not part of VISTAS, the VISTAS' Domain 5 extends into the MANE-VU region beyond Maryland. MANE-VU has also processed CALMET files for use in BART modeling analyses, but for only one year (2002) and the grid spacing is coarser, 36km and 12km. Knowing that the closest Class I area to Eastalco Works is Shenandoah National Park (SNP), and that the long thin terrain features that characterize SNP is best resolved with 4 km grid spacing, the VISTAS CALMET computational Domain 5 is used for this analysis. Figure 3.1-1 shows the region included in VISTAS Domain 5. The Class I Areas in the region are also shown.

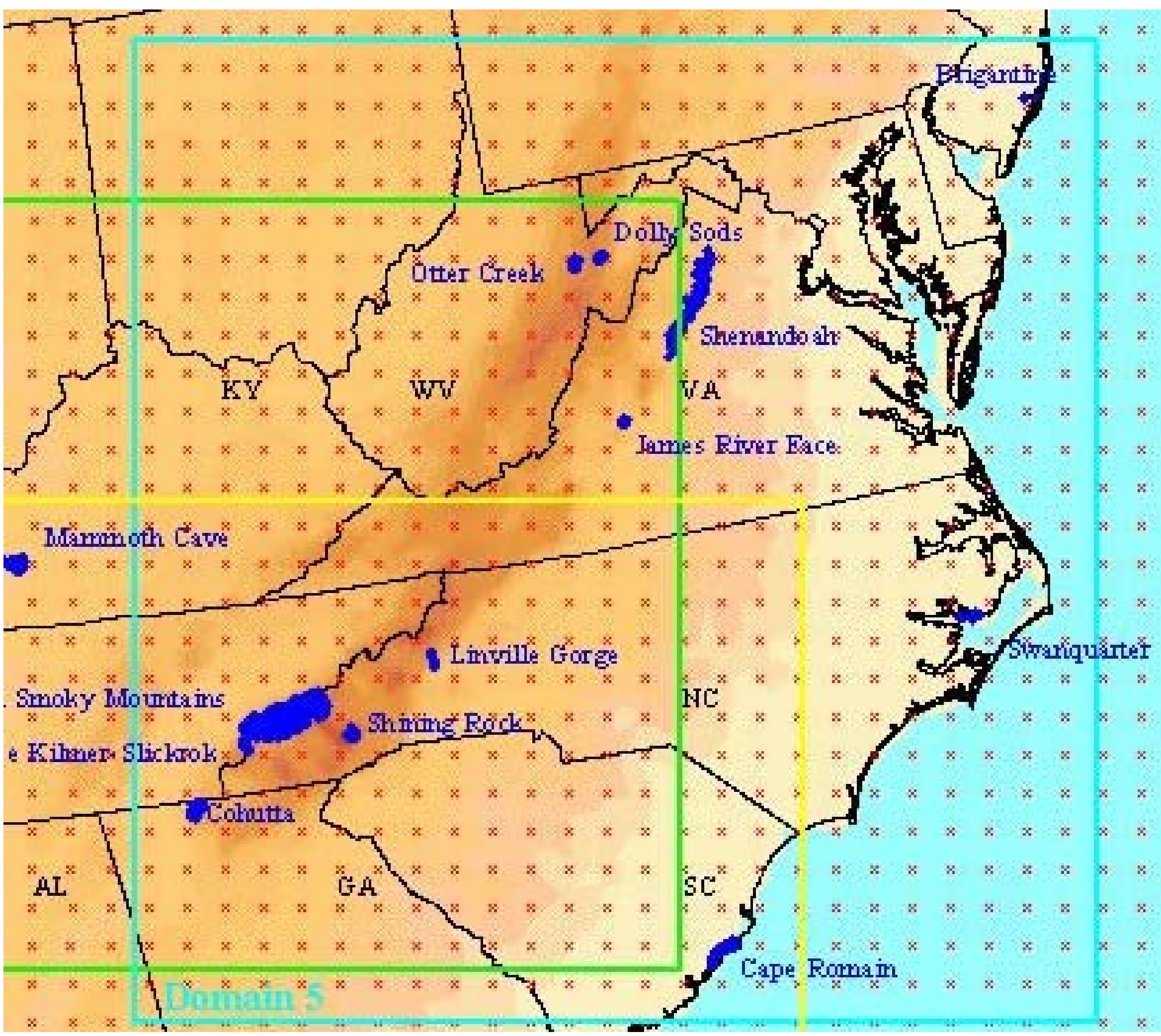

Figure 3.1-1 VISTAS 4 km CALMET Domain 5.

Domain 5 covers an area of 912 km by 928 km (228 by 232 4 km grid cells), which extends from southern Pennsylvania and New Jersey south to Georgia and South Carolina, and west to eastern Tennessee and Kentucky. A Lambert Conformal projection is used with an origin of 40.0N, 97.0W and standard parallels at 33N and 45N. The NWS-84 datum is used. In addition to SNP, four other closest Class I areas to Eastalco Works are included in the BART analysis; i.e., Otter Creek Wilderness, Dolly Sods Wilderness, Brigantine National Wildlife Refuge and James River Face Wilderness area.

The meteorological data used as input to CALMET include the Penn State/NCAR Mesoscale Modeling System (MM5). Hourly MM5 data consists of wind speed and direction, temperature and pressure on a grid of spatial resolution of 12 km for 2001 and 2002, and 36 km for 2003. In addition to the MM5 data, available observations from surface, upper air, precipitation and buoy stations were used as input to CALMET. A total of 232 surface observation stations, 9 upper air stations, 3 overwater stations and 347 precipitations stations were used in CALMET. A description of the CALMET modeling can be obtained from VISTAS at www.vistas-sesarm.org/BART.

3.2 Ozone Monitoring Data

CALPUFF uses measured hourly ozone concentrations in the chemical transformation scheme (conversion of SO_2 to SO_4 and NOx to HNO_3 and NO_3). Ambient monitoring data from the AIRS and CASTNET datasets was used to develop an hourly ozone data set. The standard ozone data file is made available by TRC for each year of the VISTAS CALMET data. These files were downloaded and processed with the SUBDOMN program in CALPRO to create a new ozone file for a user specified extraction domain. The user specifies the minimum and maximum x and y coordinates for the extraction domain. The extracted "ozone.dat" file used in this modeling consisted of data from 293 ozone stations. For the BART modeling the following Lambert Conformal coordinates were used to define the extraction domain.

Xmin = 1016 km

Xmax = 2028 km

Ymin = -736 km

Ymax = 292 km

4.0 CALPUFF MODELING

The USEPA approved air quality model used for this analysis is CALPUFF. The air quality analysis employed the CALPUFF modeling system in refined mode using CALMET generated meteorological data. The CALPUFF dispersion model along with the CALPOST postprocessor was used to evaluate the visibility impacts.

4.1 Model Selection

For this analysis, the CALPUFF modeling system (CALPUFF Version 5.8, Level 070623 and CALPOST Version 5.6394, Level 070622) was used to evaluate visibility impacts in Class I areas due to emissions of SO_2, NOx, and PM from the Facility. CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model, which can simulate the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation, and removal. The postprocessors, POSTUTIL and CALPOST, were used to combine the PM species, sum impacts from multiple source groups and predict the visibility impacts.

CALPUFF contains algorithms for long range effects such as pollutant removal (wet scavenging and dry deposition), chemical transformation, vertical wind shear, over-water transport and coastal interaction effects.

4.2 Modeling Domains

The CALMET VISTAS Domain 5 is described in Section 3.1. The CALPUFF computational domain is a subset in the northeast corner of the CALMET domain. The computational grid is sufficiently large and extends beyond the receptor locations to allow for the recirculation of puffs. The grid spacing of the computational grid is the same as the meteorological grid (i.e., 4 km resolution). Figure 4.2-1 shows the terrain elevations of the CALMET modeling domain and the CALPUFF computational domain, the Eastalco Facility location and the Class I areas of interest in this analysis. Ten vertical layers were used to resolve the mixed layer of the atmosphere with a finer resolution near the surface and coarser resolution aloft. Ten vertical levels at heights of 10 meters (m), 30 m, 60 m, 120 m, 240 m, 480 m, 920 m, 1600 m, 2500 m, and 3500 m were used.

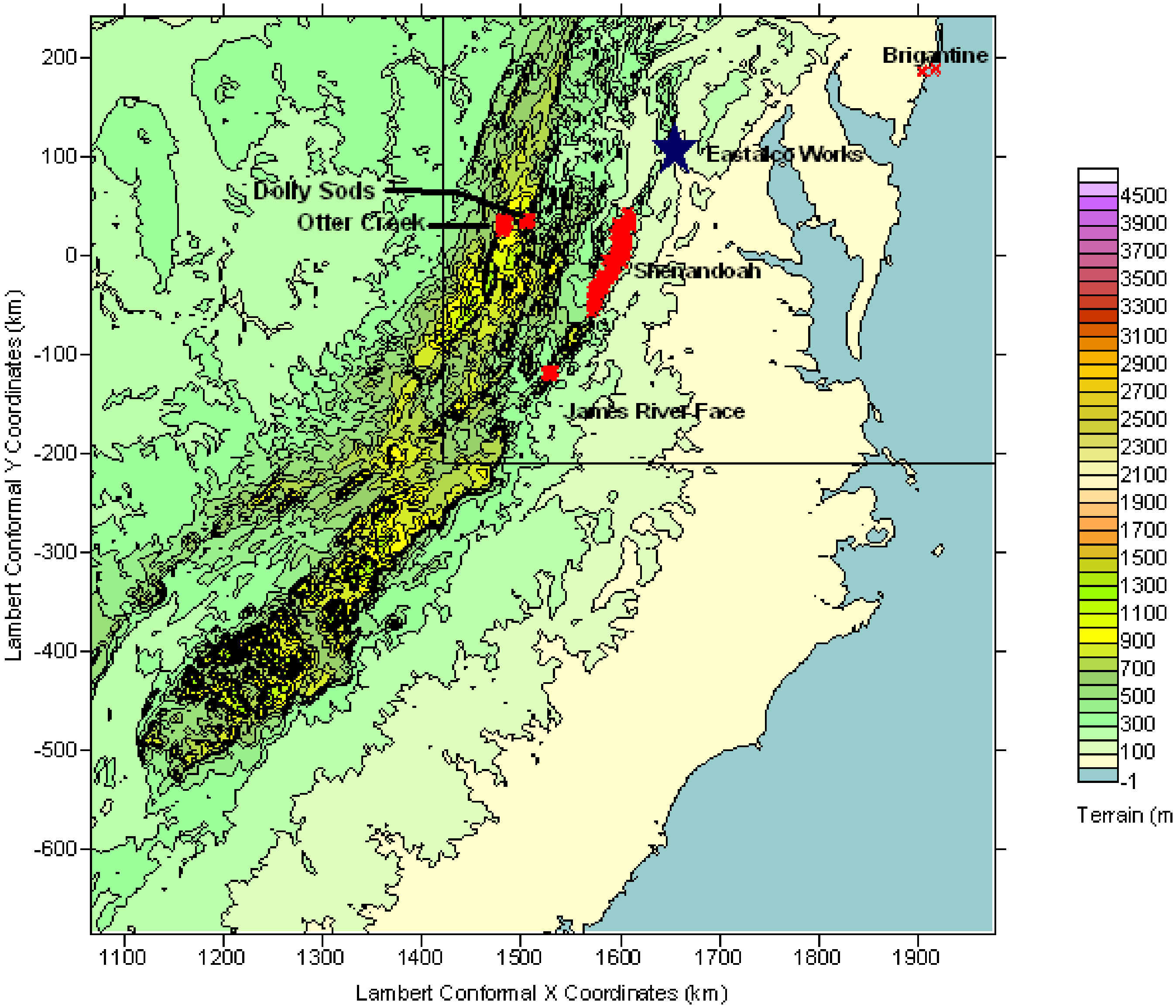

Figure 4.2-1; CALMET/CALPUFF Modeling Domains. Terrain Elevations, Source and Class I Receptor Locations Shown.

4.3 CALPUFF Model Options

The CALPUFF model was run in refined mode using the CALMET meteorological fields. The CALPUFF model options corresponding to those specified in the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 report (USEPA, 1998) as defaults were invoked. The following options were used:

- Gaussian distribution,
- Near field puffs are modeled as puffs (no slugs),

- Chemical transformation rates computed using the MESOPUFF II scheme
- Model dry and wet deposition,
- Stack tip downwash,
- Pasquill-Gifford dispersion coefficients for rural areas and McElroy-Pooler coefficients for urban areas,
- Building downwash.

The point source stack heights are less than the calculated GEP stack heights; therefore they are affected by aerodynamic downwash. Wind-direction specific building information was input into CALPUFF for each stack to allow for the simulation of the downwash effects. These inputs were generated from the BPIP analysis discussed in Section 2.4

4.4 Class I Receptors

The National Park Service has developed a database of Class I receptors to be used in modeling analyses. The receptor data sets are available from the following NPS website (http://www2.nature.nps.gov/air/Maps/Receptors/index.cfm). The receptor locations (latitude/longitude) and elevations for the five Class I areas evaluated in this study were obtained along with a conversion utility to convert the latitude/longitude to Lambert Conformal coordinates. A total of 553 receptors were modeled. Table 4.4-1 shows the number of receptors in each Class I Area.

Table 4.4-1 Number of Receptors in Each Class I Area

Class I Area	Number of Receptors
Shenandoah National Park	298
Dolly Sods Wilderness Area	65
Otter Creek Wilderness Area	122
James River Face Wilderness Area	52
Brigantine Wilderness within Edwin B. Forsythe National Wildlife Refuge	16

4.5 Post processing

Postprocessors, POSTUTIL and CALPOST, which are part of the CALPUFF Modeling System were used to postprocess the CALPUFF results and predict the visibility impacts in each of the Class I Areas. Each group of sources representing a process at the Facility was modeled in a separate CALPUFF run. Eleven CALPUFF runs were for the base case. The first post processing step involved combining the PM081 and PM056 impacts into one species of secondary organic aerosols (SOA) for each of the CALPUFF runs. Once that was accomplished, the predicted concentrations from individual source groups were summed to obtain a facility impact. The POSTUTIL program was used for these combining steps of the post processing.

CALPOST Method 6 was used to compute the extinction change in deciviews at each Class I area, which is consistent with the procedures outlined in the VISTAS modeling protocol. Table 4.5-1 provides the default natural beta extinctions, the annual average haze index and the background extinction coefficient that was input to CALPOST for the application of Visibility Method 6. These values are location specific; therefore values are presented for each Class I Area included in the analysis. Table 4.5-2 provides the monthly f(rh) values based on the centroid of the Class I area as required for application of Visibility Method 6.

Table 4.5-1 Default Natural Beta Extinctions

Class I Area	Bext (Mm-1)	Annual Avg. Haze Index (dv)	Background Extinction Coefficient (dv) (input into CALPOST)
Shenandoah NP	20.98	7.41	10.98
Dolly Sods WA	21.13	7.48	11.13
Otter Creek WA	21.14	7.49	11.14
James River Face WA	20.96	7.40	10.96
Brigantine NWR	21.05	7.44	11.05

Source: Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule (2003), Appendix B

Table 4.5-2 Monthly f(RH) values based on the Centroid of the Area

Class I Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shenandoah NP	3.1	2.8	2.8	2.5	3.1	3.4	3.5	3.9	3.9	3.2	3.0	3.1
Dolly Sods WA	3.0	2.8	2.8	2.8	3.1	3.4	3.5	3.9	3.9	3.3	3.0	3.1
Otter Creek WA	3.0	2.8	2.8	2.6	3.2	3.5	3.7	4.1	4.0	3.3	3.0	3.1
James River Face	2.8	2.6	2.7	2.4	3.0	3.3	3.4	3.7	3.6	3.2	2.8	3.0
Brigantine NWR	2.8	2.8	2.7	2.6	3.0	3.2	3.4	3.7	3.6	3.3	2.9	2.8

Source: Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule (2003), Appendix A

5.0 CALPUFF MODELING RESULTS

5.1 Baseline Case

Tables 5.1-1 through 5.1-5 summarize the predicted extinction changes at each of the Class I Area due to the baseline emissions from the Eastalco Works Facility for 2001, 2002, and 2003 meteorological data. These tables provide the ranked highest 8 values of the extinction change along with the days when the impacts occurred. The 8th highest values (98th percentile) for each year modeled is shown in bold. The largest extinction change is seen in Shenandoah National Park, ranging from 0.307 to 0.420 ddv. Table 5.1-6 presents the source group contributions to the 98th percentile extinction change for each of the three years in Shenandoah NP. It is shown that between 64% - 85% of the visibility impact is due to the potline sources.

Table 5.1-1 Eastalco Baseline Case Change in Visibility Impacts at Shenandoah National Park

		2001		2002		2003	
Shenandoah NP	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.729	347	1.041	203	1.204	280
	2	0.512	141	0.638	73	0.893	32
	3	0.474	167	0.625	246	0.842	284
	4	0.372	201	0.478	302	0.488	294
	5	0.338	40	0.453	243	0.477	33
	6	0.313	13	0.398	240	0.460	221
	7	0.310	80	0.348	245	0.441	291
	8	**0.309**	64	**0.307**	270	**0.420**	254

Table 5.1-2 Eastalco Baseline Case Change in Visibility Impacts at Otter Creek Wilderness

		2001		2002		2003	
Otter Creek Wilderness	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.076	347	0.233	244	0.319	221
	2	0.072	64	0.167	240	0.259	284
	3	0.068	201	0.128	303	0.199	232
	4	0.067	178	0.126	253	0.183	227
	5	0.062	167	0.116	321	0.162	253
	6	0.062	166	0.098	207	0.121	78
	7	0.056	343	0.094	287	0.118	258
	8	**0.041**	202	**0.084**	254	**0.111**	256

Table 5.1-3 Eastalco Baseline Case Change in Visibility Impacts at Dolly Sods Wilderness

		2001		2002		2003	
Dolly Sods Wilderness	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.143	347	0.245	244	0.428	221
	2	0.135	64	0.215	321	0.311	284
	3	0.100	80	0.186	240	0.216	156
	4	0.079	141	0.141	253	0.189	253
	5	0.079	92	0.138	303	0.180	227
	6	0.076	178	0.137	287	0.176	258
	7	0.075	167	0.119	243	0.174	33
	8	**0.074**	343	**0.116**	299	**0.173**	232

Table 5.1-4 Eastalco Baseline Case Change in Visibility Impacts at James River Face Wilderness Area

		2001		2002		2003	
James River Face Wilderness	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.151	201	0.415	246	0.212	231
	2	0.126	238	0.221	286	0.164	251
	3	0.112	209	0.167	243	0.126	244
	4	0.112	14	0.167	215	0.106	228
	5	0.104	332	0.111	287	0.098	252
	6	0.103	13	0.109	79	0.091	340
	7	0.098	95	0.108	203	0.083	294
	8	**0.095**	346	**0.087**	242	**0.077**	47

Table 5.1-5 Eastalco Baseline Case Change in Visibility Impacts at Brigantine Wilderness within Edwin B. Forsythe NWR

		2001		2002		2003	
Brigantine NWR	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.243	219	0.128	225	0.248	283
	2	0.182	179	0.120	247	0.130	166
	3	0.163	241	0.099	184	0.095	208
	4	0.127	220	0.079	230	0.086	229
	5	0.112	125	0.077	201	0.080	41
	6	0.110	226	0.073	248	0.070	26
	7	0.097	86	0.071	163	0.066	191
	8	**0.091**	17	**0.068**	185	**0.065**	275

Table 5.1-6 Eastalco Source Group and Species Contributions to 98th Percentile Change in Visibility at Shenandoah NP (delta deciview)

Year	Source Group	Contrib. to Total ddv Change(%)	Modeled ddv Change	Species Contribution to Total Change in Visibility					
				SO_4 (ddv)	NO_3 (ddv)	Organics (ddv)	SO_4 %	NO_3 %	Organics %
Baseline run, receptor 285, day ending 64 hr0									
2001	All Groups	100	0.31	0.102	0.008	0.199	32.91	2.58	64.51
2001	Potrooms Roof Scrubbers	38.5	0.12	0.011	0.000	0.108	9.31	0.00	90.69
2001	Potline Dry Scrubbers	25.2	0.08	0.068	0.000	0.012	85.38	0.00	14.62
2001	Bake Oven	14.6	0.05	0.009	0.006	0.030	19.75	13.25	67.00
2001	Rod Shop	13.9	0.04	0.000	0.000	0.043	0.00	0.44	99.56
2001	Paste Plant	2.3	0.01	0.000	0.001	0.006	1.07	8.03	90.91
2001	Ladle Shop	1.3	0.00	0.003	0.000	0.000	84.42	6.64	8.93
2001	Casthouse	3.9	0.01	0.000	0.004	0.008	0.04	34.60	65.36
2001	Cathode Plant	0.3	0.00	0.000	0.000	0.001	0.03	21.26	78.67
2001	Boilers	0.0	0.00	0.000	0.000	0.000	0.00	0.00	0.00
2001	Material Handling	0.0	0.00	0.000	0.000	0.000	0.00	0.00	100.00
Baseline run, receptor 298, day ending 270 hr0									
2002	All Groups	100	0.31	0.102	0.008	0.197	33.07	2.69	64.25
2002	Potrooms Roof Scrubbers	45.6	0.14	0.007	0.000	0.133	5.13	0.00	94.87
2002	Potline Dry Scrubbers	29.6	0.10	0.088	0.000	0.012	87.66	0.00	12.35
2002	Bake Oven	13.7	0.04	0.015	0.005	0.023	34.80	10.75	54.45
2002	Rod Shop	7.5	0.02	0.000	0.000	0.023	0.00	0.52	99.49

Table 5.1-6 Eastalco Source Group and Species Contributions to 98th Percentile Change in Visibility at Shenandoah NP (delta deciview) (Continued)

Year	Source Group	Contrib. to Total ddv Change(%)	Modeled ddv Change	Species Contribution to Total Change in Visibility					
				SO_4 (ddv)	NO_3 (ddv)	Organics (ddv)	SO_4 %	NO_3 %	Organics %
2002	Paste Plant	1.3	0.00	0.000	0.000	0.003	3.21	9.86	86.99
2002	Ladle Shop	0.7	0.00	0.002	0.000	0.000	84.79	7.34	8.04
2002	Casthouse	2.6	0.01	0.000	0.003	0.005	0.10	37.54	62.38
2002	Cathode Plant	0.0	0.00	0.000	0.000	0.000	0.00	0.00	0.00
2002	Boilers	0.0	0.00	0.000	0.000	0.000	0.00	0.00	0.00
2002	Material Handling	0.7	0.00	0.000	0.000	0.002	0.00	0.00	100.13
Baseline run, receptor 297, day ending 254 hr0									
2003	All Groups	100	0.42	0.285	0.005	0.130	67.79	1.19	31.02
2003	Potrooms Roof Scrubbers	23.1	0.10	0.017	0.000	0.080	18.00	0.00	82.00
2003	Potline Dry Scrubbers	62.2	0.26	0.248	0.000	0.012	95.32	0.00	4.68
2003	Bake Oven	8.6	0.04	0.018	0.003	0.016	49.10	7.22	43.69
2003	Rod Shop	4.5	0.02	0.000	0.000	0.019	0.00	0.50	99.50
2003	Paste Plant	0.7	0.00	0.000	0.000	0.003	3.17	8.59	88.26
2003	Ladle Shop	0.7	0.00	0.003	0.000	0.000	89.56	4.68	5.79
2003	Casthouse	1.2	0.01	0.000	0.002	0.003	0.13	37.01	62.86
2003	Cathode Plant	0.0	0.00	0.000	0.000	0.000	0.00	0.00	0.00
2003	Boilers	0.0	0.00	0.000	0.000	0.000	0.00	0.00	0.00
2003	Material Handling	0.2	0.00	0.000	0.000	0.001	0.00	0.00	99.98

Note: There were no contributions from PM-coarse, PM-fine or Elemental Carbon, since all PM modeled was conservatively assumed to be organic condensables.

5.2 Potline SO_2 Control Case

Tables 5.2-1 through 5.2-5 summarize the predicted extinction changes at each Class I Area due to the emissions from the Eastalco Works Facility operating under the new potline SO_2 scrubber control conditions for 2001, 2002, and 2003 meteorological data. These tables provide the ranked highest 8 values of the extinction change along with the days when the impacts occurred. The 8th highest values (98th percentile) for each year modeled are shown in bold.

Table 5.2-6 presents a comparison of the 98th percentile visibility impact for the baseline case and the potline SO_2 scrubber control case. The control case impacts are lower than the baseline case impacts at all of the Class I areas.

Table 5.2-1 Eastalco Control Case Change in Visibility Impacts at Shenandoah National Park

		2001		2002		2003	
Shenandoah NP	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.591	347	0.629	203	0.890	280
	2	0.440	13	0.358	194	0.601	32
	3	0.414	201	0.354	246	0.583	284
	4	0.375	40	0.328	270	0.490	294
	5	0.334	14	0.282	244	0.321	47
	6	0.319	141	0.260	302	0.320	231
	7	0.299	168	0.248	240	0.291	67
	8	**0.282**	304	**0.235**	85	**0.290**	66

Table 5.2-2 Eastalco Control Case Change in Visibility Impacts at Otter Creek Wilderness

		2001		2002		2003	
Otter Creek Wilderness	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.069	64	0.127	244	0.120	284
	2	0.046	347	0.085	303	0.085	221
	3	0.026	201	0.053	321	0.082	253
	4	0.026	127	0.052	240	0.070	78
	5	0.026	80	0.048	253	0.059	232
	6	0.025	343	0.046	298	0.052	256
	7	0.025	167	0.041	207	0.046	99
	8	**0.024**	178	**0.034**	245	**0.046**	32

Table 5.2-3 Eastalco Control Case Change in Visibility Impacts at Dolly Sods Wilderness

		2001		2002		2003	
Dolly Sods Wilderness	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.154	64	0.160	244	0.156	284
	2	0.099	347	0.103	303	0.118	253
	3	0.072	80	0.101	321	0.117	221
	4	0.048	127	0.061	240	0.087	78
	5	0.040	305	0.056	253	0.080	99
	6	0.036	343	0.054	207	0.069	32
	7	0.032	167	0.049	299	0.059	58
	8	**0.032**	92	**0.049**	298	**0.059**	33

Table 5.2-4. Eastalco Control Case Change in Visibility Impacts at James River Face Wilderness Area

		2001		2002		2003	
James River Face Wilderness	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.088	13	0.135	246	0.088	294
	2	0.071	14	0.081	286	0.072	231
	3	0.067	201	0.064	193	0.070	314
	4	0.059	209	0.052	215	0.055	251
	5	0.057	238	0.047	243	0.053	244
	6	0.057	95	0.041	287	0.051	22
	7	0.046	343	0.041	79	0.050	291
	8	**0.044**	260	**0.038**	295	**0.040**	252

Table 5.2-5 Eastalco Control Case Change in Visibility Impacts at Brigantine Wilderness within Edwin B. Forsythe NWR

		2001		2002		2003	
Brigantine NWR	**Rank**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**	**Change in Vis (ddv)**	**Julian Day hr 0**
	1	0.072	241	0.069	329	0.077	283
	2	0.068	219	0.060	11	0.071	41
	3	0.063	340	0.059	277	0.058	26
	4	0.063	86	0.053	211	0.051	166
	5	0.059	220	0.053	30	0.046	240
	6	0.056	179	0.053	6	0.046	191
	7	0.053	132	0.051	212	0.043	229
	8	**0.051**	278	**0.050**	230	**0.042**	275

Table 5.2-6 Comparison of Baseline and Control Scenario 98th Percentile Change in Visibility Impacts

	2001		2002		2003	
Ckass I Area	**Baseline Change in Vis (ddv)**	**Control Change in Vis (ddv)**	**Baseline Change in Vis (ddv)**	**Control Change in Vis (ddv)**	**Baseline Change in Vis (ddv)**	**Control Change in Vis (ddv)**
Shenandoah NP	0.309	0.282	0.307	0.235	0.420	0.290
Otter Creek	0.041	0.024	0.084	0.034	0.111	0.056
Dolly Sods	0.074	0.032	0.116	0.049	0.173	0.059
James River Face	0.095	0.044	0.087	0.038	0.077	0.040
Brigantine NWR	0.091	0.051	0.068	0.050	0.065	0.042

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APPENDIX B:

BUSINESS CONFIDENTIAL INFORMATION

APPENDIX C:

PRE-FEASIBILITY REPORT FOR ALCOA INTALCO WORKS

Alcoa Primary Metals
USA

Pre-Feasibility Report

SO2 Scrubbing for the INTALCO Primary Aluminum Smelter

H-325640
2
November 5, 2007

Project Report

PR325640.10001
Rev. 2, Page 1

November 5, 2007

Alcoa Primary Metals

SO2 Scrubbing for the INTALCO Primary Aluminum Smelter

DISTRIBUTION

Alcoa	**Hatch**
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James Schon	Don Wilson
	Stephan Broek

Pre-Feasibility Report

Table of Contents

1. Summary

This report is a pre-feasibility study for the implementation of flue gas desulphurisation (FGD) systems at the primary aluminum smelter of Intalco Works in Ferndale, Washington. The study focus is on controlling the SO_2 emissions from the potrooms and from the baking furnace. The target removal is set for 95% of the released SO_2 at the emissions sources.

For both solutions the well known Limestone/Gypsum Forced Oxidation (LSFO) process is applied. This widely used process uses limestone as a reagent and produces gypsum as a by-product. This product can either be reused or safely stored in a landfill.

Potlines

For the potlines the selected configuration is a gas collection system that connects to each dry scrubbing system and redirects all fumes to a central FGD system. The FGD system comprises of two large open spray tower type absorbers in which the fumes are washed and cleaned. One such unit is operating while the second is on standby. The limestone handling as well as the gypsum recovery is done in a single plant serving both absorbers. Appropriate redundancy is built-in to ensure the 100% availability that is required in a smelter that operates 24 hrs a day, every day of the year.

The FGD system is designed to handle 1,814,880 SCFM of fumes from the potrooms. This equates to an annual SO2 emission reduction of 7,875 tpa. The associated limestone consumption is 14,244 tpa while the water intake is 500,000 US Gallons per day. The annual gypsum production is 27,130 ton.

The cost estimate is a factored cost estimate using information derived from previous studies and cost databases. The following table presents the results for the potline FGD system.

Table 1: Capital cost estimate for the potline FGD system

All values in million USD	POTLINE FGD		
	Equipment	Installation	Subtotal
Reagent feed system	$6.98	$6.98	$13.96
SO2 removal system	$25.24	$25.24	$50.49
Flue gas system	$21.64	$21.64	$43.27
Byproduct handling	$7.17	$7.17	$14.33
General support equipment	$10.11	$10.11	$20.23
TOTAL PROCESS CAPITAL	$71.14	$71.14	$142.28

Anode Baking Furnace

A smaller source of SO_2 emissions are the fumes from the anode baking furnace. In this case a single collector duct is tied into the existing dry scrubbing system to connect to the FGD system. This FGD system is much smaller but has the same configuration as the potline FGD system. It provides for 100% available scrubbing.

The FGD system is designed to handle 172,510 SCFM of fumes from the potrooms. This equates to an annual SO_2 emission reduction of 175 tpa. The associated limestone consumption is 342 tpa while the water intake is 35,000 US Gallons per day. The annual gypsum production is 640 ton.

The cost estimate is a factored cost estimate using information derived from previous studies and cost databases. The following table presents the results for the potline FGD system.

Table 2: Capital cost estimate for the baking furnace FGD system

All values in million USD	**BAKING FURNACE FGD**		
	Equipment	Installation	Subtotal
Reagent feed system	$0.36	$0.36	$0.72
SO2 removal system	$4.13	$4.13	$8.25
Flue gas system	$3.54	$3.54	$7.07
Byproduct handling	$0.36	$0.36	$0.71
General support equipment	$0.50	$0.50	$1.01
TOTAL PROCESS CAPITAL	$8.88	$8.88	$17.76

2. Introduction

This report presents a pre-feasibility study on the implementation of FGD systems at the Intalco primary aluminum smelter in Ferndale, Washington.

The aluminum smelter has two primary sources of sulphur emissions, one is the pot rooms and the second is the anode baking furnace. This report includes the design and cost information on a dedicated FGD system for each of these main sources.

2.1 Process Selection

In previous studies Best Available Technologies were identified. For studies at the Alcoa Tennessee smelter the limestone-gypsum forced oxidation (LSFO) process was selected for further evaluation .

2.2 FGD System Configuration

2.2.1 Pot room system

The FGD system is designed to capture fumes from the potrooms under fully operational conditions.

A comprehensive evaluation was done to see what configuration would be more effective: a set of scrubbing towers per potline (equal to two potrooms) or one central system with long collector ducts feeding into the central system.

Two main criteria were used to decide what configuration to apply: 1) The sum of all fumes must be treated in one scrubbing tower and 2) maintenance must be minimized.

The first criteria was met after calculations showed that the sum of all flows would result in a scrubbing tower with a diameter of 60 feet. A large diameter tower is not uncommon and several FGD wet scrubbing towers with diameters of this size have been constructed world-wide. Having many smaller scrubbing towers versus one large tower design combined with collector ducts made of regular gauge steel is considered to be less cost effective than the latter case.

The second criteria concerns maintenance. The LSFO process basically is the circulation of a slurry of water, limestone and gypsum. It is abrasive and to a certain extent corrosive. Therefore, a lot of maintenance activity is associated with the circulation pumps and the scrubbing tower. Based on the design criteria of minimized maintenance, the selected system configuration was based on a single large scrubbing tower that would treat all of the pot room ventilation flows. Potroom flow would be combined into a single stream by a network of ducts, collecting fume from the current dry gas cleaning systems. .

An additional consideration was the continuous operation of a smelter. A single scrubbing tower must be taken down for service five to ten days per year (conservatively). This means that during periods of maintenance, there would be no scrubbing of SO_2 if a single scrubbing tower were installed. To provide 100 percent scrubbing availability during maintenance periods, a second scrubbing tower of the same size would be added to the design to ensure continuous SO_2 treatment during periods when the first scrubbing tower is taken out of service.

2.2.2 *Baking furnace system*

The FGD system for the baking furnace is of a simpler concept. The baking furnace is currently operated with an evaporative cooling tower followed by a dry gas cleaning system. The new FGD system will be connected downstream to the dry gas cleaning unit.

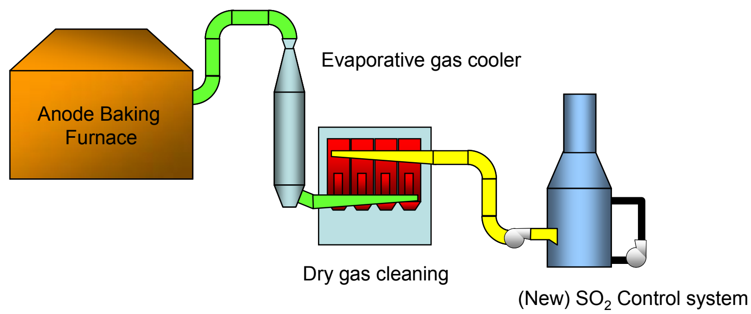


Figure 1: Overall gas cleaning concept for the anode baking furnace.

3. FGD System for the Potrooms

3.1 Design Basis

The design basis for both scrubbing systems has been based on technical process information provided by Alcoa. The information is based on actual operating conditions and operating information for Intalco Works.

The following table presents the design basis for the FGD system serving the potlines.

Table 3: Design basis for the potline FGD system at Intalco Works

Design parameter	Unit	Value
Number of potrooms in service	-	6
Number of GTCs per potroom	-	1
Total number of GTCs connected	-	6
No. of reduction cells per potroom	-	120
Ventilation flow for one reduction cell	ACFM	3,000 (@212 °F)
	SCFM (70 °F)	2,354
Air addition in each dry gas cleaning unit	SCFM	20,000 (Estimate)
Total flow of fumes to the FGD system	SCFM	1,814,880
Nominal fume temperature	°F	180
Composition of the fumes at the inlet of the FGD system		
Sulphur dioxide (SO_2)	ppmv	105 (300 mg/Nm^3)
Hydrogen fluoride (HF_g)	mg/Nm^3	5
Water vapour (H_2O)	vol%	3
Particulates	mg/Nm^3	10

In addition, the following system requirements are applied in the design of the system.

Table 4: Design requirements

Aspect	Unit	Requirement
Desulphurization efficiency	%	Min. 95
Removal efficiency of particulates and fluorides	-	No increment
Residual droplets	mg/Nm^3	Max. 100

Spare scrubbing capacity	%	100 (1 full scrubbing tower stand-by/no spare spray layers inside one scrubbing tower)
Limestone properties: - CaCO3 content - Reactivity - Particle size distribution	 % Microns	 Min. 85 Must comply with vendor specification. 96% < 75 microns (To be verified with vendor)
Gypsum by-product: - Application - Sulfate / Sulfite ratio - Residual moisture	 - - %	 Disposal 99 / 1 (Full oxidation) 15
Chloride concentration in the slurry	ppm	5,500
Waste water requirements	-	None.

3.2 Process description

The fumes from the potrooms are extracted from the stack of the existing dry gas cleaning systems (GTCs). Each stack will be provided with an adaptor and a valve that connects to the collector duct for the FGD system. This design allows for the GTCs to continue operation as it is today. The goal is that the GTCs do not "see" the additional FGD system. To achieve this, pressure control is applied in the collector duct whereby the pressure at the GTCs is maintained constant by a dedicated fan in the collector duct.

The collector ducts go over the potrooms and come together at the central FGD system. In each collector duct a damper is added in order to isolate an individual duct.

The combined fumes are blown into the scrubbing tower. The tower is an open spray design and has two spray layers installed. Each layer has a dedicated recycle pump. Because there is a second scrubbing tower in standby there is no need to have additional spray layers installed.

Above the spray layers are two chevron type horizontal mist eliminators. Below the lower mist eliminator is the main wash system and between the two mist eliminators is a second wash system. There is no need for a third wash system at the top of the stack as this can be washed manually once a year.

The two scrubbing towers vent to a combined stack that emits cleaned gases at a level approximately 150 feet above the ground.

Two slurry pumps recycle the slurry through the spray levels with the appropriate nozzles. These can be either hollow cone or full cone nozzles. The slurry is semi-atomized into a spray of droplets that mix with the incoming fumes.

The bottom of the scrubbing tower fulfills several functions. It has to provide enough liquid head for the pumps, it provides for enough retention time for the gypsum to grow into a desirable particle size distribution so that is can be dewatered properly, it is used for pH control, and it provides for the means to oxidize all the sulphite into sulphate.

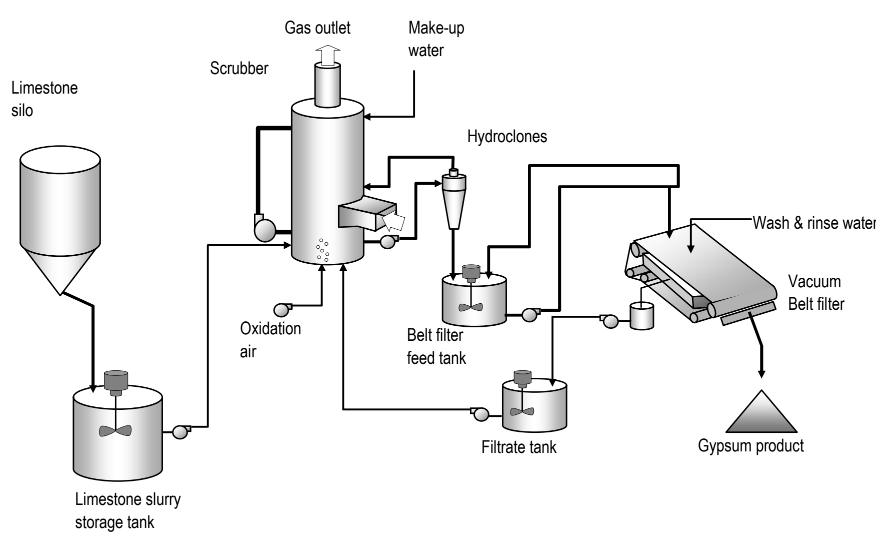
The fumes from the potroom contain close to 20 volume percent of oxygen. Experience with similar scrubbing systems of this type shows that 20 volume percent of oxygen is enough to provide full oxidation of sulphite into sulphate. However, for safety reasons (one wants to have the slurry fully oxidized at all times), a small amount of compressed air is introduced by a small blower.

A bleed system withdraws slurry from the scrubbing tower. A loop is used to measure the pH while the rest is fed to a hydroclone battery. This is the first stage of solids dewatering. The overflow of the hydroclones is returned to the scrubbing tower while the underflow is collected and fed to a vacuum filter. The system is engineered such that the underflow can be fed directly onto the filter.

The thickened slurry is dewatered on the vacuum filter to about 85 percent dry solids. The filtrate and wash/rinse water is collected and returned to the scrubbing tower. The gypsum is left with 15 percent moisture which prevents the need for a liquid purge stream otherwise needed to purge impurities from the process. The gypsum is moist enough to be stored in semi open warehouse and can be loaded into dump trucks and taken to a third party.

Limestone is delivered in powder form and added to the process water and fed from the slurry tank to the scrubbing tower via a pH control system.

3.3 Mass balance of an FGD system treating the fumes from the potrooms



GAS (lb/hr)	Fumes from one potroom	Fumes from 6 potrooms	Oxidation air	Clean gases	
N2	1,025,647	6,153,884	4,514	6,158,398	
O2	285,454	1,712,725	1,368	1,713,645	
CO2	413	2,479	3	3,751	
H2O	25,375	152,251	82	324,134	
H20 (l)	-	-	-	653	
SO2	316	1,893	-	95	
SO3	-	-	-	-	
HCl	-	-	-	-	
HF	5	32	-	1	
Particulate	5	32	-	11	
Mass flow (lb/hr)	1,337,216	8,023,295	5,967	8,200,687	
Volume flow (ACFM)	369,114	2,214,685	1,365	1,984,246	
Volume flow (SCFM)	302,481	1,814,887	1,343	1,877,773	
Temperature (°F)	189	189	77	98	
Pressure (Inch WG)	407.7	407.7	405.3	405.3	

LIQUID / SOLIDS (lb/hr)	Absorber recycle	Absorber bleed	pH loop	Hydroclone overflow	Hydroclone underflow
Liquid	30,849,560	78,847	25,708	46,671	6,467
Solids	5,444,040	13,914	4,537	4,086	5,291
Total	36,293,600	92,761	30,245	50,757	11,759
Solids concentration	15	15	15	8	45
Density (SG)	1.10	1.10	1.10	1.05	1.34
Flow (GPM)	66,050	169	55	96	18

LIQUID / SOLIDS (lb/hr)	Vacuum filter feed	Filter wash water	Rinse water	Filtrate	Gypsum
Liquid	6,467	-	10,530	16,068	929
Solids	5,291	-	-	26	5,265
Total	11,759	-	10,530	16,095	6,194
Solids concentration	45	-	-	0.2	85
Density (SG)	1.34	1.00	1.00	1.01	1.50
Flow (GPM)	18	-	21	32	-

LIQUID / SOLIDS (lb/hr)	Limestone	Process water	Limestone slurry to absorber		
Liquid	-	9,757	9,757		
Solids	3,252	-	3,252		
Total	3,252	9,757	13,009		
Solids concentration	100	-	25		
Density (SG)	2.80	1.00	1.19		
Flow (GPM)	-	-	-		

LIQUID / SOLIDS (lb/hr)	Process water intake	Water to absorber	Water to limestone preparation	Water to gypsum dewatering	Water for oxidation air cooling
Liquid	174,362	152,973	9,757	10,530	1,102
Solids	-	-	-	-	-
Total	174,362	152,973	9,757	10,530	1,102
Solids concentration	-	-	-	-	-
Density (SG)	1.00	1.00	1.00	1.00	1.00
Flow (GPM)	348	306	19	21	2

3.4 Consumables

The following list presents the main consumables for the FGD system treating the fumes from the potrooms.

Table 5: Consumables

Consumable	Unit	Value
Process water	US Gallons per day	500,000
Limestone	Short tons per day	39
Compressed air	SCFM	150
Electric power	kWh/h	7,400

3.5 Scope of work

The following is the scope of work used to develop the cost estimates. The overall basis is a lump sum contract with a single vendor/contractor.

<u>GTC connections</u>

All GTC stacks will be equipped with an adaptor that connect them to common scrubber ducts. The adaptors fit on the stacks and a valve is included.

<u>Collector ducts</u>

Each GTC will be connected to a collector duct and fan system. There are six collector ducts and fan systems, including isolation valves. The work includes structural steel work needed to position the collector ducts over the potrooms and to the central FGD system.

<u>Scrubbing tower</u>

Two scrubbing towers are included and they both are identical in size and have the same equipment and controls so that they can be operated independently from each other.

On the bottom, two 48-inch diameter pipes are connected to the tower and the suction of the recycle pumps. Each suction pipe has included a butterfly type valve to isolate a pump. Each recycle pump operates at 33,000 GPM. The discharge is also 48 inches in diameter and goes up the spray levels. Inside the scrubbing tower two spray levels are installed that form a network of smaller diameter pipes in order to provide equal distribution of the slurry over the cross section of the tower.

A common water supply system (tank and pumps) serves both scrubbing towers. It will connect to the three wash levels above the mist eliminators.

A common air compressor is included for the supply of oxidation air. To prevent clogging of the line where air is injected, water is injected to saturate the air before it hits the slurry in the scrubbing tower.

Primary dewatering

A first dewatering step is needed to create the right slurry density for final dewatering. A set of hydroclones is included to thicken the slurry from 15 percent solids to about 45 percent. The hydroclone set has included a chute to intercept the thickened slurry in case of a line blockage. In that case all slurry is returned.

Secondary dewatering

A vacuum belt filter is included for the dewatering of the gypsum slurry. This has included a vacuum system, wash & rinse system and discharge chute. In order to provide limited redundancy, two 75 percent capacity filters are included.

A filtrate collection system is incorporated to return any liquids to the scrubbing tower.

The vacuum filters are elevated in a building and the lower section has a dump & storage area for the gypsum. A front loader picks up the gypsum and dumps it into a dump truck for disposal.

Limestone system

The scope of work also includes an integrated silo and slurry preparation tank. Trucks are equipped with unloading equipment to deliver the limestone powder into the tank. The tank is provided with an agitator and pump set. The pumps are connected to a loop that passes both scrubbing towers. Slurry is drawn from the loop based on pH control. Dosing valves are included.

General systems and facilities

To prevent any uncontrolled releases into the environment, a slurry collection system is included in and around the central system to collect spills and overflows. A sump with a submerged pump is included and all slurry is transferred to the operating scrubbing tower.

The vendor will provide all automation and control systems to minimize manual intervention required from operating personnel.

Chemical sampling and analysis is added to the current work load of the laboratory staff. Some new equipment like slurry analysers will be provided.

4. FGD System for the Baking Furnace

4.1 Design basis

The following table presents the design basis for the FGD system serving the baking furnace.

Table 6: Design basis for the baking furnace FGD system – Intalco Works

Design parameter	**Unit**	**Value**
Number of fires in service	-	All
Total flow of fumes in the existing stack	ACFM	216,000
Nominal fume temperature	°F	205
Composition of the baking furnace fumes at the inlet of the FGD system		
Sulphur dioxide (SO_2)	ppmv	25 (5.33 grams/sec)
Hydrogen fluoride (HF_g)	mg/Nm^3	5
Water vapour (H_2O)	vol%	20.7
Particulates	mg/Nm^3	<5 (0.35 grams/sec)

In addition, the following system requirements are applied in the design of the system.

Table 7: Design requirements for the baking furnace FGD system

Aspect	**Unit**	**Requirement**
Desulphurization efficiency	%	Min. 95
Removal efficiency of particulates and fluorides	-	No increment
Residual droplets	mg/Nm^3	Max. 100
Spare scrubbing capacity	%	100 (1 full scrubbing tower stand-by/no spare spray layers inside one scrubbing tower)
Limestone properties:		
- CaCO3 content	%	Min. 85
- Reactivity		Must comply with vendor specification.
- Particle size distribution	Microns	96% < 75 microns (To be verified with vendor)

Gypsum by-product: - Application - Sulfate / Sulfite ratio - Residual moisture	 - - %	 Disposal 99 / 1 (Full oxidation) 15
Chloride concentration in the slurry	ppm	7,500
Waste water requirements	-	None.

4.2 Process description

The fumes from the ring duct are passed on to the evaporative cooling tower to cool the fumes and to precipitate some of the tars. The fumes are led into the dry gas cleaning system in which alumina is injected for particulate, tar, and fluoride removal. The fumes pass the bag filters and enter the plenum outlet.

The combined fumes are blown into the scrubbing tower. The tower is an open spray design and has two spray layers. Each layer has a dedicated recycle pump. Because there is a second scrubbing tower in standby there is no need to have additional spray layers.

Above the spray layers are two chevron type horizontal mist eliminators. Below the lower mist eliminator is the main wash system and between the two mist eliminators is a second wash system. There is no need for a third wash system at the top of the stack as this can be washed manually once a year.

The scrubbing tower has an integrated stack that emits the clean gases at a level approximately 150 feet above the ground.

Two slurry pumps recycle the slurry through the spray levels with the appropriate nozzles. These can be either hollow cone or full cone nozzles. The slurry is semi-atomized into a spray of droplets and washes the incoming fumes.

The bottom of the scrubbing tower fulfills several functions. It has to provide enough liquid head for the pumps, it provides for enough retention time for the gypsum to grow into a desirable particle size distribution so that is can be dewatered properly, it is used for pH control, and it provides for the means to oxidize all the sulphite into sulphate. All this is incorporated within the design.

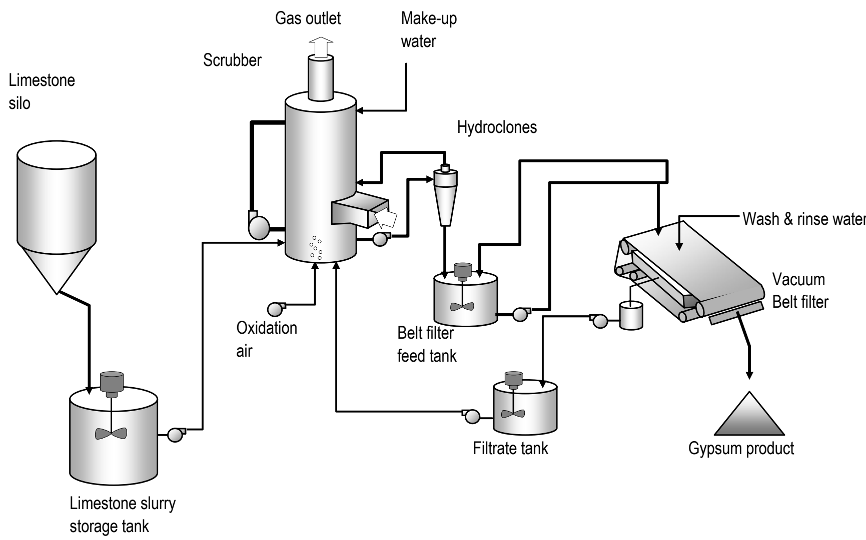
Air is injected under the liquid level of the scrubber tower bottom to provide for the required oxidation sulphites into sulphates. A small blower is used to inject the air.

A bleed system withdraws slurry from the scrubbing tower. A loop is used to measure the pH while the rest is fed to a hydroclone battery. This is the first stage of solids dewatering. The overflow of the hydroclones is returned to the scrubbing tower while the underflow is collected and fed to a vacuum filter. The system is engineered such that the underflow can be fed directly onto the filter.

The thickened slurry is dewatered on the vacuum filter to about 85 percent dry solids. The filtrate and wash/rinse water is collected and returned to the scrubbing tower. The gypsum is left with 15 percent moisture which will prevents the need for a liquid purge stream otherwise needed to purge impurities from the process. The gypsum is moist enough to be stored in semi open warehouse and can be loaded into dump trucks and taken to a third party.

Limestone is delivered in powder form and added to the process water and fed from the slurry tank to the scrubbing tower via a pH control system.

4.3 Mass balance for an FGD system to treat the fumes from the baking furnace



GAS (lb/hr)	Fumes from dry gas cleaning system	Oxidation air	Clean gases		
N2	516,752	224	516,977		
O2	24,683	68	24,741		
CO2	88,656	0	88,687		
H2O	99,881	4	111,652		
H20 (l)	-	-	61		
SO2	42	-	2		
SO3	-	-	-		
HCl	-	-	-		
HF	3	-	0		
Particulate	3	-	1		
Mass flow (lb/hr)	730,020	297	742,121		
Volume flow (ACFM)	218,111	68	202,525		
Volume flow (SCFM)	172,510	67	176,787		
Temperature (°F)	212	77	145		
Pressure (Inch WG)	407.7	405.3	405.3		

LIQUID / SOLIDS (lb/hr)	Absorber recycle	Absorber bleed	pH loop	Hydroclone overflow	Hydroclone underflow
Liquid	1,616,844	26,676	25,427	1,097	152
Solids	285,325	4,707	4,487	96	124
Total	1,902,170	31,383	29,914	1,193	276
Solids concentration	15	15	15	8.05	45
Density (SG)	1.09	1.09	1.09	1.02	1.31
Flow (GPM)	3,500	58	55	2.3	0.4

LIQUID / SOLIDS (lb/hr)	Vacuum filter feed	Filter wash water	Rinse water	Filtrate	Gypsum
Liquid	152	-	247	378	22
Solids	124	-	-	1	124
Total	276	-	247	378	146
Solids concentration	45	-	-	0	85
Density (SG)	1.33	1.00	1.00	1.00	1.50
Flow (GPM)	0.4	-	0.5	0.8	-

LIQUID / SOLIDS (lb/hr)	Limestone	Process water	Limestone slurry to absorber		
Liquid	-	235	235		
Solids	78	-	78		
Total	78	235	314		
Solids concentration	100	-	25		
Density (SG)	2.80	1.19	1.00		
Flow (GPM)	-	0.5	0.5		

LIQUID / SOLIDS (lb/hr)	Process water intake	Water to absorber	Water to limestone preparation	Water to gypsum dewatering	Water for oxidation air cooling
Liquid	11,865	10,279	235	247	1,102
Solids	-	-	-	-	-
Total	11,865	10,279	235	247	1,102
Solids concentration	-	-	-	-	-
Density (SG)	1.00	1.00	1.00	1.00	1.00
Flow (GPM)	24	21	0.5	0.5	2.2

4.4 Consumables

The following list presents the main consumables for the control system.

Table 8: Baking furnace FGD consumables

Consumable	Unit	Value
Process water	US Gallons per day	35,000
Limestone	Short tons per day	1.0
Compressed air	SCFM	50
Electric power	kWh/h	750

4.5 Scope of work

The following is the scope of work used to develop the cost estimates. The overall basis is a lump sum contract with a single vendor/contractor.

GTC connection

New fans will be installed to replace the existing fans downstream of the dry gas cleaning system. The fans are provided with an inlet manifold that connects to the scrubbing towers. Isolation dampers are included to separate one scrubbing tower from operation.

Scrubbing tower

Two scrubbing towers are included and they both are identical in size and have the same equipment and controls so that they can operate independently from each other.

The bottom two 4 inch diameter pipes are connected to the tower and the suction of the recycle pumps. Each suction pipe has included a butterfly type valve to isolate the pump. Each recycle pump operates at 1,750 GPM. The discharge is also 4 inches in diameter and goes to the spray levels. Inside the scrubbing tower two spray levels are installed and form a network of smaller diameter pipes in order to provide equal distribution of the slurry over the cross section of the tower.

A common water supply system (tank and pumps) serves both scrubbing towers. It will connect to the three wash levels around the mist eliminators.

A common air compressor is included for the supply of oxidation air. To prevent clogging of the line where air is injected, water is injected to saturate the air before it hits the slurry in the scrubbing tower.

Primary dewatering

A first dewatering step is needed to create the right slurry density for final dewatering. A set of hydroclones is included to thicken the slurry from 15 percent solids to about 45 percent. The hydroclone set has included a chute to intercept the thickened slurry in case nothing can go to the filter. In that case all slurry is returned.

Secondary dewatering

A vacuum belt filter is included for the dewatering of the gypsum slurry. This has included a vacuum system, wash & rinse system and discharge chute. In order to provide limited redundancy two 75 percent capacity filters are included.

A filtrate collection system is incorporated to return any liquids to the scrubbing tower.

The vacuum filters are elevated in a building and the lower section has a dump & storage area for the gypsum. A front loader picks up the gypsum and dumps it into a dump truck for disposal.

Limestone system

The scope of work also includes an integrated silo and slurry preparation tank. Trucks are equipped with unloading equipment to deliver the limestone powder into the tank. The tank is provided with an agitator and pump set. The pumps are connected to a loop that passes both scrubbing towers. Slurry is drawn from the loop based on pH control. Dosing valves are included.

General systems and facilities

To prevent any uncontrolled releases into the environment, a slurry collection system is included in and around the central system to collect spills and overflows. A sump with a submerged pump is included and all slurry is transferred to the operating scrubbing tower.

The vendor will provide all automation and control systems to minimize manual intervention required from operating personnel.

Chemical sampling and analysis is added to the current work load of the laboratory staff. Some new equipment like slurry analysers will be provided.

5. Capital cost estimates

In this section are provided all capital cost estimates for both the potroom FGD system and the baking furnace FGD system.

All equipment cost estimates are based on cost proposals provided by Alstom Power and Babcock Power for Alcoa's smelter in Alcoa, TN and a pre-feasibility study prepared by Hatch for the Alcoa TN smelter, entitled "SO_2 Scrubber for Alcoa Tennessee" (June 7, 2007 (Hatch report number PRH322820.0001).

5.1 Methodology

For this high level study, costs have been scaled based on specific design and operational aspects of FGD systems. The key three scaling parameters are the volume of gases going through, the amount of limestone consumed and the amount of gypsum by-product produced. These three parameters help scale certain parts of the FGD system scale properly; however, to apply such method a break down is required for the cost provided in the study for Alcoa Tennessee works. This was not presented in the previous study and as such it has been included here.

Based on Hatch' experience with cost analysis of FGD systems the following break down is derived and applied in this study:

Table 9: Break down of FGD sub system costs

Sub system	Fraction of cost of the total
Reagent feed system	10% of TPC
SO_2 removal system	35% of TPC
Flue gas system	30% of TPC
By-product handling	10% of TPC
General support equipment	15% of TPC
TOTAL PROCESS CAPITAL (TPC)	100%

Table 10: Cost break down of the Alcoa Tennessee works FGD system.

All values in million USD	TENNESSEE POTLINE FGD		
	Equipment	Installation	Subtotal
Reagent feed system	$6.50	$6.50	$13.00
SO2 removal system	$22.75	$22.75	$45.50
Flue gas system	$19.50	$19.50	$39.00
Byproduct handling	$6.50	$6.50	$13.00
General support equipment	$9.75	$9.75	$19.50
TOTAL PROCESS CAPITAL	$65.00	$65.00	$130.00

This table is used as a basis for the tables that follow and represent the results for the Intalco smelter.

Next step in the methodology is to convert the sub system costs from one case to another. For this the general formula of cost scaling is applied:

$$P_2 = P_1 \times \left(\frac{Q_2}{Q_1} \right)^n$$

From the Hatch database of cost information related to large FGD systems is further derived:

Table 11: Exponent n for scaled cost estimation.

Sub system	Exponent n
Reagent feed system	0.33
SO_2 removal system	0.50
Flue gas system	0.50
By-product handling	0.40
General support equipment	0.15

These exponents apply to large scale FGD units. For the baking furnace, which is much smaller, in the report is applied an exponent of 0.8 for all sub systems. This is consistent with earlier work prepared by the Alcoa team.

In order to scale costs between the different cases the following scaling factors have been applied:

Table 12: Scaling parameters.

Parameter	Scaling value		
	Tennessee *(Q_1)*	*Intalco Potline* *(Q_2)*	*Intalco Baking Furnace* *(Q_2)*
Clean flue gas flow (ACFM)	1,582,432	1,948,246	202,525
Limestone consumption (tpa)	10,407	12,921	315
Gypsum production (tpa)	19,272	24,607	578

Example:

$$P_2 = 8.93x\left(\frac{12{,}921}{10{,}407}\right)^{0.33} = 9.59$$

This example shows that for Intalco the estimate costs for the reagent (limestone) feed system is 9.59 million USD.

5.2 Cost estimate for the potline FGD system

The following table presents the results from the cost estimation for the FGD system, servicing the potline ventilation fumes at Intalco.

Table 13: Cost estimate for the Intalco Works potline FGD system

All values in million USD	POTLINE FGD		
	Equipment	Installation	Subtotal
Reagent feed system	$6.98	$6.98	$13.96
SO2 removal system	$25.24	$25.24	$50.49
Flue gas system	$21.64	$21.64	$43.27
Byproduct handling	$7.17	$7.17	$14.33
General support equipment	$10.11	$10.11	$20.23
TOTAL PROCESS CAPITAL	$71.14	$71.14	$142.28

5.3 Cost estimate for the baking furnace FGD system

The following table presents the results from the cost estimation for the FGD system, servicing the potline ventilation fumes at Intalco.

Table 14: Cost estimate for the Intalco Works baking furnace FGD system.

All values in million USD	BAKING FURNACE FGD		
	Equipment	Installation	Subtotal
Reagent feed system	$0.36	$0.36	$0.72
SO2 removal system	$4.13	$4.13	$8.25
Flue gas system	$3.54	$3.54	$7.07
Byproduct handling	$0.36	$0.36	$0.71
General support equipment	$0.50	$0.50	$1.01
TOTAL PROCESS CAPITAL	$8.88	$8.88	$17.76

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APPENDIX D:

WET SCRUBBER ECONOMIC AND ENERGY IMPACT

Scaling of Capital Equipment Costs Based on Vendor Proposals
Eastalco Aluminum Company
Frederick, Maryland

Scrubber Component	Fraction of Total Equipment Cost	Scaling Equation Exponent		Tennessee Potline Scrubber Equipment Costs			Eastalco Scrubber Equipment Cost Estimates	
		Potlines	Anode Bake Furnace	Vendor Quote #1	Vendor Quote #2	Average	Potlines	Anode Bake Furnace
Reagent feed system	10%	0.33	0.80	$6,500,000	$8,200,000	$7,350,000	$6,979,333	$656,939
SO_2 removal system	35%	0.50	0.80	$22,750,000	$28,700,000	$25,725,000	$24,709,803	$3,432,128
Flue gas system	30%	0.50	0.80	$19,500,000	$24,600,000	$22,050,000	$21,179,831	$2,941,824
By-product handling system	10%	0.40	0.80	$6,500,000	$8,200,000	$7,350,000	$6,980,899	$637,832
General support equipment	15%	0.15	0.80	$9,750,000	$12,300,000	$11,025,000	$10,814,031	$988,059
TOTAL				**$65,000,000**	**$82,000,000**	**$73,500,000**	**$70,663,896**	**$8,656,783**

Scaling of Material Usage Based on Intalco Data
Eastalco Aluminum Company
Frederick, Maryland

Parameter	Intalco Potlines	Intalco Anode Bake Furnace	Eastalco Potlines	Eastalco Anode Bake Furnace
Scrubber SO_x reduction (tpy)	6,223	172	4,285	254
Clean flue gas flow rate (acfm)	1,948,246	202,525	1,460,000	123,800
Water usage (gal/day)	500,000	35,000	344,269	51,537
Limestone usage (tons/yr)	12,921	315	8,897	464
Compressed air usage (scfm)	150	50	103	74
Gypsum generation rate (lb/hr)	6,194	146	4,265	215
Electricity usage (kWh/hr)	7,400	750	5,546	458

Captial Investment Cost Analysis for SO_2 Control Using a Wet Scrubber

Potlines

Eastalco Aluminum Company

Frederick, Maryland

	Value	Notes/References
Capital Investment Costs		
Direct Capital Costs (DCC)		
Purchased Equipment Costs (PEC)		
Adsorber vessels with internals	$70,663,896	Based on vendor quotations for Tennessee Alcoa smelter, adjusted for scrubber exhaust gas flow rate, limestone consumption, and gypsum generation per Pre-feasability Report (Hatch 2007)
Pumps	Included	
Limestone prep	Included	
Dewatering systems	Included	
Fans	Included	
Inlet ductwork	Included	
Stacks	Included	
Continuous Emission Monitoring system (2 stacks)	$80,000	
Subtotal (EC)	$70,743,896	
Instrumentation	$3,537,195	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of EC; adjusted from 10% since basic instrumentation is included in proposal)
Sales tax	$3,537,195	State sales tax rate for Maryland is 5%
Freight	$3,537,195	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of EC)
Total Purchased Equipment Costs (PEC)	**$81,355,481**	
Direct Installation Costs (DIC)		
Foundations and supports	$9,762,658	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (12% of PEC)
Handling and erection	$65,084,385	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (80% of PEC; adjusted from 40% to account for retrofit of existing plant and onsite fabrication)
Electrical	$813,555	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Piping	$24,406,644	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (30% of PEC)
Insulation	$813,555	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Painting	$813,555	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Total Direct Installation Costs (DIC)	**$101,694,351**	
Total Direct Capital Costs	**$183,049,832**	Sum of PEC and DIC
Indirect Capital Costs (ICC)		
Engineering	$4,067,774	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of PEC; adjusted from 10% since vendor proposal includes an allowance for engineering)
Construction and field expenses	$8,135,548	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (10% of PEC)
Contractor fees	$4,067,774	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of PEC; adjusted from 10% based on assumption that vendor will oversee scrubber installation)
Start-up	$813,555	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Performance test	$813,555	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Contingencies	$2,440,664	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (3% of PEC)
Total Indirect Capital Costs	**$20,338,870**	
Total Capital Investment Costs (TCIC)	**$203,388,702**	Sum of DCC and ICC

References:

Hatch. 2007. *SO_2 Scrubbing for the INTALCO Primary Aluminum Smelter: Pre-Feasibility Report* . July 26.

USEPA. 2002. *EPA Air Pollution Control Cost Manual* , Sixth Edition. EPA/452/B-02-001. January.

Operation and Maintenance Cost Analysis for SO_2 Control Using a Wet Scrubber
Potlines
Eastalco Aluminum Company
Frederick, Maryland

	Value	Units	Notes/References
Annual Operation and Maintenance Costs			
Direct Annual Costs (DAC)			
Operating labor			
Operator	$306,600		Assumes $35 per hour with one full-time operator, 3 shifts per day
Supervisor	$45,990		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (15% of operator costs)
Water	$628,291		
Water usage	344,269	gal/day	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of water	$0.00500	$/gal	Facility data
Limestone	$195,725		
Limestone usage	8,897	tons/yr	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of limestone	$22	$/ton	Based on limestone costs from BART determination prepared for Alcoa facility in Tennessee
Compressed air	$13,028		
Compressed air usage	103	scfm	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of compressed air	$0.24	$/1000 scf	Average compressed air generation cost for industrial facilities (http://www1.eere.energy.gov/industry/bestpractices/pdfs/compressed_air1.pdf)
Gypsum disposal	$3,175,575		
Gypsum generation rate	4,265	lb/hr	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of gypsum disposal	$170	$/ton	Non-hazardous waste disposal and transportation costs
Maintenance			
Labor	$539,136		Assumes $36 per hour with 4 full-time maintenance personnel, one shift per day, 5 days per week and 1 maintenance personnel for all other shifts
Material	$1,303,000		Cost for low sulfur boiler system with 1.7 macfm inlet/1.5 macfm outlet, which is smaller than the potline system with 2.2 macfm inlet/2.0 macfm outlet (Sargent & Lundy LLC 2003)
Electricity	$2,428,929		
Electricity usage	5,546	kWh/hr	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative exhaust flow rates
Electricity cost	$0.05	$/kWh	Facility data
Total Direct Annual Costs	**$8,636,275**		
Indirect Annual Costs (IAC)			
Overhead	$1,316,836		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (60% of total labor and maintenance material costs)
General and administrative costs	$4,067,774		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (2% of TCIC)
Property tax	$2,033,887		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (1% of TCIC)
Insurance	$2,033,887		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (1% of TCIC)
Total Indirect Annual Costs	**$9,452,384**		Sum of PEC and DIC
Total Annual Operating and Maintenance Costs	**$18,088,659**		Sum of DAC and IAC

References:

Hatch. 2007. *SO_2 Scrubbing for the INTALCO Primary Aluminum Smelter: Pre-Feasibility Report*. July 26.

Sargent & Lundy LLC. 2003. *Wet Flue Gas Desulfurization Technology Evaluation*. Prepared for National Lime Association. January.

USEPA. 2002. *EPA Air Pollution Control Cost Manual*, Sixth Edition. EPA/452/B-02-001. January.

Installation of Wet Scrubber on Potline Exhaust

				Reference
Primary potline control system uncontrolled SO_x emission rate		4,510	tpy	
SO_x control efficiency		95%		
Controlled annual SO_x emissions		226	tpy	
SO_x reduction		4,285	tpy	
Direct capital costs (DCC)	$	183,049,832		
Indirect capital costs (ICC)	$	20,338,870		
Total capital costs	**$**	**203,388,702**		
Interest rate		7%		USEPA 2002, Section 1, Chapter 2.4.2
Period of annualization		15	years	Assumption
Capital recovery discount factor		0.11		USEPA 2002, Section 1, Chapter 2.4.4.4, Equation 2.8a
Annualized capital cost	**$**	**22,331,000**		USEPA 2002, Section 1, Chapter 2.4.4.4, Equation 2.8
Operating labor costs	$	306,600		
Supervisory labor costs	$	45,990		
Maintenance labor costs	$	539,136		
Maintenance material costs	$	1,303,000		
Electricity costs	$	2,428,929		
Water costs	$	628,291		
Limestone costs	$	195,725		
Compressed air costs	$	13,028		
Gypsum disposal costs	$	3,175,575		
Overhead	$	1,316,836		
Property tax	$	2,033,887		
Insurance	$	2,033,887		
General and administrative costs	$	4,067,774		
Total annual cost estimate	**$**	**40,420,000**		
Cost of option per ton SO_x reduced	***$***	***9,400***		

Captial Investment Cost Analysis for SO_2 Control Using a Wet Scrubber
Anode Bake Furnace
Eastalco Aluminum Company
Frederick, Maryland

	Value	Notes/References
Capital Investment Costs		
Direct Capital Costs (DCC)		
Purchased Equipment Costs (PEC)		
Adsorber vessels with internals	$8,656,783	Based on vendor quotations for Tennessee Alcoa smelter, adjusted for exhaust gas flow rate per Pre-feasability Report (Hatch 2007)
Pumps	Included	
Limestone prep	Included	
Dewatering systems	Included	
Fans	Included	
Inlet ductwork	Included	
Stacks	Included	
Continuous Emission Monitoring system (2 stacks)	$80,000	
Subtotal (EC)	$8,736,783	
Instrumentation	$436,839	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of EC; adjusted from 10% since basic instrumentation is included in proposal)
Sales tax	$436,839	State sales tax rate for Maryland is 5%
Freight	$436,839	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of EC)
Total Purchased Equipment Costs (PEC)	**$10,047,301**	
Direct Installation Costs (DIC)		
Foundations and supports	$1,205,676	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (12% of PEC)
Handling and erection	$8,037,841	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (80% of PEC; adjusted from 40% to account for retrofit of existing plant and onsite fabrication)
Electrical	$100,473	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Piping	$3,014,190	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (30% of PEC)
Insulation	$100,473	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Painting	$100,473	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Total Direct Installation Costs (DIC)	**$12,559,126**	
Total Direct Capital Costs	**$22,606,427**	Sum of PEC and DIC
Indirect Capital Costs (ICC)		
Engineering	$502,365	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of PEC; adjusted from 10% since vendor proposal includes an allowance for engineering)
Construction and field expenses	$1,004,730	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (10% of PEC)
Contractor fees	$502,365	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (5% of PEC; adjusted from 10% based on assumption that vendor will oversee scrubber installation)
Start-up	$100,473	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Performance test	$100,473	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (1% of PEC)
Contingencies	$301,419	USEPA 2002, Section 5.2, Chapter 1, Table 1.3 (3% of PEC)
Total Indirect Capital Costs	**$2,511,825**	
Total Capital Investment Costs (TCIC)	**$25,118,252**	Sum of DCC and ICC

References:
Hatch. 2007. *SO_2 Scrubbing for the INTALCO Primary Aluminum Smelter: Pre-Feasibility Report*. July 26.
USEPA. 2002. *EPA Air Pollution Control Cost Manual*, Sixth Edition. EPA/452/B-02-001. January.

Operation and Maintenance Cost Analysis for SO_2 Control Using a Wet Scrubber
Anode Bake Furnace
Eastalco Aluminum Company
Frederick, Maryland

	Value	Units	Notes/References
Annual Operation and Maintenance Costs			
Direct Annual Costs (DAC)			
Operating labor			
Operator	$306,600		Assumes $35 per hour with one full-time operator, 3 shifts per day
Supervisor	$45,990		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (15% of operator costs)
Water	$94,055		
Water usage	51,537	gal/day	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of water	$0.005	$/gal	Facility data
Limestone	$10,204		
Limestone usage	464	tons/yr	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of limestone	$22	$/ton	Based on limestone costs from BART determination prepared for Alcoa facility in Tennessee
Compressed air	$9,287		
Compressed air usage	74	scfm	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of compressed air	$0.24	$/1000 scf	Average compressed air generation cost for industrial facilities (http://www1.eere.energy.gov/industry/bestpractices/pdfs/compressed_air1.pdf)
Gypsum disposal	$160,077		
Gypsum generation rate	215	lb/hr	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative SO_x reductions
Cost of gypsum disposal	$170	$/ton	Non-hazardous waste disposal and transportation costs
Maintenance			
Labor	$269,568		Assumes $36 per hour with 2 full-time maintenance personnel, one shift per day, 5 days per week and a half-time maintenance personnel equivalent for all other shifts
Material	$160,919		Calculated based on estimated maintenance material costs for potline scrubber and ratio of purchased equipment costs for the anode bake furnace and potline scrubbers
Electricity	$200,806		
Electricity usage	458	kWh/hr	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative exhaust flow rates
Electricity cost	$0.05	$/kWh	Facility data
Total Direct Annual Costs	**$1,257,507**		
Indirect Annual Costs (IAC)			
Overhead	$469,846		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (60% of total labor and maintenance material costs)
General and administrative costs	$502,365		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (2% of TCIC)
Property tax	$251,183		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (1% of TCIC)
Insurance	$251,183		USEPA 2002, Section 5.2, Chapter 1, Table 1.4 (1% of TCIC)
Total Indirect Annual Costs	**$1,474,576**		Sum of PEC and DIC
Total Annual Operating and Maintenance Costs	**$2,732,083**		Sum of DAC and IAC

References:

Hatch. 2007. *SO_2 Scrubbing for the INTALCO Primary Aluminum Smelter: Pre-Feasibility Report*. July 26.

USEPA. 2002. *EPA Air Pollution Control Cost Manual*, Sixth Edition. EPA/452/B-02-001. January.

Installation of Wet Scrubber on Anode Bake Furnace Exhaust

				Reference
Uncontrolled SO_x emission rate		267	tpy	
SO_x control efficiency		95%		
Controlled annual SO_x emissions		13.4	tpy	
SO_x reduction		253.7	tpy	
Direct capital costs (DCC)	$	22,606,427		
Indirect capital costs (ICC)	$	2,511,825		
Total capital costs	**$**	**25,118,252**		
Interest rate		7%		USEPA 2002, Section 1, Chapter 2.4.2
Period of annualization		15	years	Assumption
Capital recovery discount factor		0.11		USEPA 2002, Section 1, Chapter 2.4.4.4, Equation 2.8a
Annualized capital cost	**$**	**2,758,000**		USEPA 2002, Section 1, Chapter 2.4.4.4, Equation 2.8
Operating labor costs	$	306,600		
Supervisory labor costs	$	45,990		
Maintenance labor costs	$	269,568		
Maintenance material costs	$	160,919		
Electricity costs	$	200,806		
Water costs	$	94,055		
Limestone costs	$	10,204		
Compressed air costs	$	9,287		
Gypsum disposal costs	$	160,077		
Overhead	$	469,846		
Property tax	$	251,183		
Insurance	$	251,183		
General and administrative costs	$	502,365		
Total annual cost estimate	**$**	**5,490,000**		
Cost of option per ton SO_x reduced	***$***	***21,600***		

APPENDIX E:

GREENHOUSE GAS EMISSION CALCULATIONS

BART Determination
Eastalco Aluminum Company
Frederick, Maryland
Greenhouse Gas Emission Calculations

Greenhouse gases (GHGs) are gaseous compounds that are considered to act as heat trapping constituents of the atmosphere. Although there are many gases that may trap heat in the atmosphere, there are six GHGs recognized by international and domestic regulations on climate change: carbon dioxide (CO_2), nitrous oxide (N_2O), methane, hydrofluorocarbons (HFCs), chlorinated fluorocarbons (CFCs), and sulfur hexafluoride. More than 80% of the global warming potential results from CO_2 emissions.

The proposed sulfur dioxide (SO_2) control devices will contribute to the facility's overall emissions of GHGs via three mechanisms: (1) as a byproduct of the reaction chemistry in the scrubbers, (2) as indirect emissions from the generation of electricity required to power the scrubbing systems, and (3) as direct emissions from vehicle travel for the additional personnel that will be required at the facility to maintain and operate the scrubbing systems.

The estimate of carbon dioxide emissions resulting from the reaction of limestone with the sulfur dioxide in the exhaust streams is based on the theoretical reaction chemistry, assuming no other byproducts resulting from incomplete reaction. Consistent with the BART analysis, we assumed that 95% of the incoming sulfur dioxide reacts with the limestone, and hence is removed from the exhaust stream. There are three reactions taking place in the scrubber:

1) Dissolution of the limestone in the scrubbing water:

$$CaCO_3 + H_2O \rightarrow Ca^{+2} + HCO_3^{-} + OH^{-}$$

2) Dissolution of the sulfur dioxide in the scrubbing water:

$$SO_2 + H_2O \rightarrow 2H^{+} + SO_3^{-2}$$

3) Oxidation of the sulfite ions to sulfate ions (and hence, formation of gypsum or calcium sulfate):

$$Ca^{+2} + HCO_3^{-} + OH^{-} + 2H^{+} + SO_3^{-2} + \frac{1}{2} O_2 \rightarrow CaSO_4 + CO_2 + 2\,H_2O$$

Consistent with the chemical balance shown above, for every mole of SO_2 reacted, a mole of carbon dioxide is formed.

The inlet sulfur dioxide molar flowrates were estimated based on the uncontrolled SO_x emission rates for the potline primary control system and the anode bake furnace, as provided by Eastalco. Assuming a minimum 95% sulfur dioxide control efficiency (that is, assuming that 95% of the sulfur dioxide reacts with the limestone), the mass of carbon dioxide evolved was calculated based on the reaction chemistry presented above.

The implementation of the proposed scrubbing systems would also generate GHGs indirectly, as a result of consuming electricity. The generation of electricity at some off-site location would produce GHGs. The methodology described in the *California Climate Action Registry General Reporting Protocol (CCARGRP)*[1], for estimating indirect emissions of GHGs from electricity use was followed. The daily electricity usage of each scrubber (potline fumes scrubber and the anode bake furnace scrubber) were multiplied by a state-specific carbon dioxide emission factor. The state-specific emission factor was found in the USEPA *Emissions and Generation Resource Integrated Database for 2006* (eGrid2006)[2] for Maryland. To estimate the emissions of nitrous oxide and methane (two minor GHG components from combustion sources), the default emission factors provided in the CCARGRP[3] were used. To convert the estimated nitrous oxide and methane emissions to carbon dioxide equivalents, the CCARGRP provides an estimate of each compound's global warming potential (GWP)[4]. For example, methane has a GWP of 21 times that of carbon dioxide; therefore, to convert the methane emission rate to carbon dioxide equivalents, we multiply the methane emission rate by its GWP.

The last potential source of GHGs resulting from the implementation of the proposed scrubbing systems is from vehicle travel to and from the facility by additional personnel necessary for the operation and maintenance of the scrubbing systems. Based on facility estimates, the potline fumes scrubbing system would require nine additional employees per day on weekdays and six additional personnel per day on weekends. Similarly, the anode baking furnace scrubbing system would require six additional employees per day on weekdays and 4.5 additional personnel equivalents per day on weekends. It was assumed that each person would drive a roundtrip distance of 16 miles per day. This is approximately the roundtrip distance between the facility and downtown Frederick, Maryland. The emission estimates of carbon monoxide, nitrous oxide, and methane in the vehicle exhaust were based on assuming an average fuel economy. The fleet average (1988 to 2007) fuel economy from the USEPA[5] was used. The emission factor for carbon dioxide was provided in the CCARGRP for non-California gasoline[6]. The emission factors for nitrous oxide and methane from vehicles were based on the average of the 1988 to present emission factors provided in the CCARGRP[7]. To convert the nitrous oxide and methane emission rates to carbon dioxide equivalents, the GWP for each compound was applied as discussed above.

The GHG emission calculations described above are presented in the attached tables. The total GHGs (in carbon dioxide equivalents) generated by the implementation of the proposed scrubbing system for the potline fumes was estimated to be 189,253 pounds per day, or 34,536 tons per year. The total GHGs (in carbon dioxide equivalents) generated by the implementation of the proposed scrubbing system for the anode baking furnace was estimated to be 15,350 pounds per day, or 2,800 tons per year.

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[1] California Climate Action Registry.   2007. *California Climate Action Registry General Reporting Protocol (CCARGRP): Reporting Entity-Wide Greenhouse Gas Emissions*. Version 2.2. March. Chapter 6.
[2] United States Environmental Protection Agency (USEPA). 2007. Emissions and Generation Resource Integrated Database for 2006 (eGrid2006). Version 2.1. April. Year 2004 summary tables.
[3] California Climate Action Registry.   2007. *California Climate Action Registry General Reporting Protocol (CCARGRP): Reporting Entity-Wide Greenhouse Gas Emissions*. Version 2.2. March. Table C-2
[4] Ibid. Table III.6-1.
[5] United States Environmental Protection Agency (USEPA). 2007. Light-Duty Automotive Technology and Fuel Economy Trends: 1975 to 2007 (Table 1 – Cars and Trucks).
[6] California Climate Action Registry.   2007. *California Climate Action Registry General Reporting Protocol (CCARGRP): Reporting Entity-Wide Greenhouse Gas Emissions*. Version 2.2. March. Table C-3.
[7] Ibid. Table C-4 (used weighted average of the factors provided for various spans of model years).

Greenhouse Gases Emissions
Eastalco (Frederick, MD)

***Scope*:**
Calculation of greenhouse gases from the implementation of a flue gas desulfurization system. There will be one scrubbing system for the potrooms and one for the anode baking furnace. The scrubbing system consists of a limestone-gypsum forced oxidation (LSFO) process.

***Assumptions*:**
CO_2 is the primary greenhouse gas evolved. Other components, such as methane or nitrous oxide are in de minimus quantities. These will be included where there is sufficient information for their estimate.

***Sources of Greenhouse Gases*:**
- Reaction chemistry of the limestone and sulfur dioxide (LSFO)
- Energy consumption of the scrubbing systems
- The addition of personnel as a result of the operation of the scrubbing systems (vehicle travel)

***Summary of Potline Wet Scrubber GHG Emission Estimates*:**

Mass of CO_2 evolved from scrubbing potroom emissions	16,140	lb/day
Mass of GHGs (in CO_2 equivalents) evolved from electricity production for scrubbing system	172,971	lb/day
Mass of GHGs (in CO_2 equivalents) evolved from vehicle travel for additional personnel	142.3	lb/day
TOTAL GHGs (CO_2 equivalents)	**189,253**	**lb/day**
	34,536	**tons/yr**

***Summary of Anode Bake Furnace Wet Scrubber GHG Emission Estimates*:**

Mass of CO_2 evolved from scrubbing anode bake furnace emissions	955.5	lb/day
Mass of GHGs (in CO_2 equivalents) evolved from electricity production for scrubbing system	14,300	lb/day
Mass of GHGs (in CO_2 equivalents) evolved from vehicle travel for additional personnel	94.9	lb/day
TOTAL GHGs (CO_2 equivalents)	**15,350**	**lb/day**
	2,800	**tons/yr**

GHG Emissions from Scrubbing Potline Emissions

Scrubbing Reaction Chemistry:

1) $CaCO_3 + H_2O$ ------> $Ca^{+2} + HCO_3^- + OH^-$

2) $SO_2 + H_2O$ -----------> $2H^+ + SO_3^{-2}$

3) $Ca^{+2} + HCO_3^- + OH^- + SO_3^{-2} + 2H^+ + 1/2\ O_2$ ----------------> $CaSO_4 + CO_2 + 2H_2O$

So, for every one mole of SO_2 (64 grams) removed, one mole of CO_2 (44 grams) is evolved.

Parameter	Value	Reference
SO_2 at inlet of FGD system	129.7 grams/second	Calculated based on annual primary potline control system uncontrolled SO_x emission rate
	2.03 moles SO_2/second	Based on molar mass of SO_2 of 64 grams/mole
Removal efficiency	95% minimum	
Moles of SO_2 reacted	1.93 moles SO_2/second	
Moles of CO_2 evolved	1.93 moles CO_2/second	
Mass of CO_2 evolved	84.7 grams CO_2/second	Based on molar mass of CO_2 of 44 grams/mole
	7,321,084 grams CO_2/day	
	16,140 lb CO_2/day	

GHG Emissions from Scrubbing Anode Baking Furnace Emissions

Scrubbing Reaction Chemistry:

1) $CaCO_3 + H_2O$ ------> Ca^{+2} + HCO_3^- + OH^-

2) $SO_2 + H_2O$ -----------> $2H^+$ + SO_3^{-2}

3) Ca^{+2} + HCO_3^- + OH^- + SO_3^{-2} + $2H^+$ + 1/2 O_2 ----------------> $CaSO_4 + CO_2 + 2H_2O$

So, for every one mole of SO_2 (64 grams) removed, one mole of CO_2 (48 grams) is evolved.

Parameter	Value		Reference
SO_2 at inlet of FGD system	7.7	grams/second	Calculated based on annual anode bake furnace uncontrolled SO_x emission rate
	0.120	moles SO_2/second	Based on molar mass of SO_2 of 64 grams/mole
Removal efficiency	95%	minimum	
Moles of SO_2 reacted	0.114	moles SO_2/second	
Moles of CO_2 evolved	0.114	moles CO_2/second	
Mass of CO_2 evolved	5.0	grams CO_2/second	Based on molar mass of CO_2 of 44 grams/mole
	433,421	grams CO_2/day	
	956	lb CO_2/day	

GHGs resulting from electricity generation associated with potline scrubber system[1]

Parameters			**Reference**
Electricity usage for potline wet scrubber	5,546	kWh/h	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative exhaust flow rates
Electricity usage for potline wet scrubber	133,092	kWh/day	Assumes continuous operation of wet scrubber
N_2O global warming potential (GWP)	310		Table III.6.1 - CCARGRP
Methane GWP	21		Table III.6.1 - CCARGRP

Emission Factors			**Reference**
CO_2	1,293	lb/MWh	Emission factors for Maryland (eGrid 2006 Version 2.1, April 2007)
N_2O	0.0206	lb/MWh	Default emission factor for Maryland (Table C.2, CCARGRP)
Methane	0.0118	lb/MWh	Default emission factor for Maryland (Table C.2, CCARGRP)

Emission Estimates		
CO_2	172,088	lb/day
N_2O	2.7	lb/day
Methane	1.6	lb/day

Conversion of non-CO_2 GHGs to CO_2 equivalents		
CO_2	172,088	lb/day
N_2O - CO_2 equivalents	850	lb/day
Methane - CO_2 equivalents	33	lb/day
Total CO_2 equivalents	**172,971**	**lb/day**

Notes:

[1]Based on methodology described in the *California Climate Action Registry General Reporting Protocol (CCARGRP)* (March 2007) and the data in the USEPA *Emissions & Generation Resource Integrated Database* (eGrid2006).

GHGs resulting from electricity generation associated with anode bake furnace scrubber system[1]

Parameters			**Reference**
Electricity usage for anode bake furnace wet scrubber	458	kWh/h	Usage data from Pre-feasability Report (Hatch 2007) for Intalco, scaled based on relative exhaust flow rates
Electricity usage for anode bake furnace wet scrubber	11,003	kWh/day	Assumes continuous operation of wet scrubber
N_2O global warming potential (GWP)	310		Table III.6.1 - CCARGRP
Methane GWP	21		Table III.6.1 - CCARGRP

Emission Factors			**Reference**
CO_2	1,293	lb/MWh	Emission factors for Maryland (eGrid 2006 Version 2.1, April 2007)
N_2O	0.0206	lb/MWh	Default emission factor for Maryland (Table C.2, CCARGRP)
Methane	0.0118	lb/MWh	Default emission factor for Maryland (Table C.2, CCARGRP)

Emission Estimates		
CO_2	14,227	lb/day
N_2O	0.23	lb/day
Methane	0.13	lb/day

Conversion of non-CO_2 GHGs to CO_2 equivalents		
CO_2	14,227	lb/day
N_2O - CO_2 equivalents	70	lb/day
Methane - CO_2 equivalents	3	lb/day
Total CO_2 equivalents	**14,300**	**lb/day**

Notes:

[1]Based on methodology described in the *California Climate Action Registry General Reporting Protocol (CCARGRP)* (March 2007) and the data in the USEPA *Emissions & Generation Resource Integrated Database* (eGrid2006).

GHGs resulting from vehicle travel for additional personnel associated with potline scrubber system[1]

Parameters			**Reference**
Additional operating personnel	3		One additional full-time operator per shift, three shifts per day (assumption)
Additional maintenance personnel (weekdays)	6		Four additional full-time maintenance personnel, one shift per day, plus one additional full-time maintenance personnel for off-shifts (assumption)
Additional maintenance personnel (weekends)	3		One additional full-time maintenance personnel for off-shifts (assumption)
Total additional personnel (weekdays)	9		
Total additional personnel (weekends)	6		
Daily round trip distance	16	miles/trip	Assumption (distance from plant to downtown Frederick, MD is approximately 8 miles)
Total daily mileage (weekdays)	144	miles/day	
Total daily mileage (weekends)	96	miles/day	
Average fuel economy	20.3	miles/gallon	Fleet average (1988 to 2007 model years); USEPA, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 to 2007, Table 1 (Cars and Trucks)
N_2O global warming potential (GWP)	310		Table III.6.1 - CCARGRP
Methane GWP	21		Table III.6.1 - CCARGRP

Emission Factors			**Reference**
CO_2 emission factor	8.78	kg/gallon	Non-CA gasoline; Table C.3, CCARGRP
N_2O emission factor	0.050	grams/mile	Weighted average of 1988 to present automobile model years; Table C.4, CCARGRP
Methane emission factor	0.049	grams/mile	Weighted average of 1988 to present automobile model years; Table C.4, CCARGRP

Emission Estimates		
CO_2 (weekdays)	137.1	lb/day
N_2O (weekdays)	0.016	lb/day
Methane (weekdays)	0.015	lb/day
CO_2 (weekends)	91.4	lb/day
N_2O (weekends)	0.011	lb/day
Methane (weekends)	0.010	lb/day

Conversion of non-CO_2 GHGs to CO_2 equivalents		
CO_2 (weekdays)	137.1	lb/day
N_2O - CO_2 equivalents (weekdays)	4.9	lb/day
Methane - CO_2 equivalents (weekdays)	0.3	lb/day
Total CO_2 equivalents (weekdays)	**142.3**	**lb/day**
CO_2 (weekends)	91.4	lb/day
N_2O - CO_2 equivalents (weekends)	3.3	lb/day
Methane - CO_2 equivalents (weekends)	0.2	lb/day
Total CO_2 equivalents (weekends)	**94.9**	**lb/day**
CO_2 (annual)	22.6	tons/yr
N_2O - CO_2 equivalents (annual)	0.8	tons/yr
Methane - CO_2 equivalents (annual)	0.1	tons/yr
Total CO_2 equivalents (annual)	**23.4**	**tons/yr**

Notes:

[1]Based on methodology described in the *California Climate Action Registry General Reporting Protocol (CCARGRP)* (March 2007).

GHGs resulting from vehicle travel for additional personnel associated with anode bake furnace scrubber system[1]

Parameters			**Reference**
Additional operating personnel	3		One additional full-time operator per shift, three shifts per day (assumption)
Additional maintenance personnel (weekdays)	3		Two additional full-time maintenance personnel, one shift per day, plus one additional half-time equivalent maintenance personnel for off-shifts (assumption)
Additional maintenance personnel (weekends)	1.5		One additional half-time equivalent maintenance personnel for off-shifts (assumption)
Total additional personnel (weekdays)	6		
Total additional personnel (weekends)	4.5		
Daily round trip distance	16	miles/trip	Assumption (distance from plant to downtown Frederick, MD is approximately 8 miles)
Total daily mileage (weekdays)	96	miles/day	
Total daily mileage (weekends)	72	miles/day	
Average fuel economy	20.3	miles/gallon	Fleet average (1988 to 2007 model years); USEPA, Light-Duty Automotive Technology and Fuel Economy Trends: 1975 to 2007, Table 1 (Cars and Trucks)
N_2O global warming potential (GWP)	310		Table III.6.1 - CCARGRP
Methane GWP	21		Table III.6.1 - CCARGRP

Emission Factors			**Reference**
CO_2 emission factor	8.78	kg/gallon	Non-CA gasoline; Table C.3, CCARGRP
N_2O emission factor	0.050	grams/mile	Weighted average of 1988 to present automobile model years; Table C.4, CCARGRP
Methane emission factor	0.049	grams/mile	Weighted average of 1988 to present automobile model years; Table C.4, CCARGRP

Emission Estimates		
CO_2 (weekdays)	91.4	lb/day
N_2O (weekdays)	0.011	lb/day
Methane (weekdays)	0.010	lb/day
CO_2 (weekends)	68.6	lb/day
N_2O (weekends)	0.0079	lb/day
Methane (weekends)	0.0077	lb/day

Conversion of non-CO_2 GHGs to CO_2 equivalents		
CO_2 (weekdays)	91.4	lb/day
N_2O - CO_2 equivalents (weekdays)	3.3	lb/day
Methane - CO_2 equivalents (weekdays)	0.2	lb/day
Total CO_2 equivalents (weekdays)	**94.9**	**lb/day**
CO_2 (weekends)	68.6	lb/day
N_2O - CO_2 equivalents (weekends)	2.5	lb/day
Methane - CO_2 equivalents (weekends)	0.2	lb/day
Total CO_2 equivalents (weekends)	**71.2**	**lb/day**
CO_2 (annual)	15.4	tons/yr
N_2O - CO_2 equivalents (annual)	0.6	tons/yr
Methane - CO_2 equivalents (annual)	0.04	tons/yr
Total CO_2 equivalents (annual)	**16.0**	**tons/yr**

Notes:

[1]Based on methodology described in the *California Climate Action Registry General Reporting Protocol (CCARGRP)* (March 2007).