

Air Curtain Burner vs. Wood Grinder

Disposal of Wood Waste

A Comparison of Critical Emissions and a Basic Economic Discussion of Two Disposal Methods:

A. Overview:

The purpose of this paper is to provide details concerning a better environmental and economic method for the disposal of wood and vegetative waste. Technical details will be provided for comparing two machines typically used for the disposal of wood and vegetative waste: the Air Curtain FireBox and the Diesel powered Wood Grinder. For the disposal of accumulated wood and vegetative waste, an Air Curtain Burner (ACB) "FireBox" is a better choice for protecting the environment and it is also the most economical choice.

- 1) The ACB FireBox is an "end solution" and actually eliminates the wood waste, while a grinder is just a "handling process" where 100 tons of wood is ground-up into 100 tons of mulch.
- 2) The FireBox uses the waste as its fuel, where the grinder uses hundreds of gallons of Diesel fuel to grind wood in to mulch.
- 3) The FireBox creates a small amount of natural clean ash that is good for the soil, the grinder creates a huge amount of mulch that is bad for the soil and must be transported off-site.
- 4) The FireBox has less impact on the environment; the Grinder and associated transportation have a significantly negative impact on the environment.
- 5) The FireBox is significantly less costly to purchase and to operate than the grinder.
- 6) The FireBox can create energy from the waste, the grinder only consumes energy.

The Air Curtain FireBox follows the same natural process as has been happening on Earth for millions of years, but without the unwanted particulate matter or black carbon release. As we concern ourselves with the reduction of climate changing impacts on our environment, the FireBox is the best choice for immediate reduction in black carbon emissions. This paper will provide more details in comparing the two machines and outlining the path to achieving significantly lower emissions today.



B. Comparison of Critical Pollutants

The following critical emission components will be compared: PM and CO₂. These are emissions, either aerosol and gaseous, which are classified as harmful Greenhouse Gas Emissions within the framework of Global Warming and Climate Change discussions and concerns.



Grinder – Significant Visible PM Discharge

PM or Particulate Matter from a combustion process is Black Carbon (BC) consisting of clusters of carbon molecules. Usually sizes smaller than 10 μ (PM₁₀) are regulated. Black Carbon emissions constitute an aerosol and not a gas, because BC consists of pure carbon suspended in the atmosphere as tiny solids. BC tends to gravitate back to earth over time and it adversely affects “Global Warming” which is best noticeable on earth in the permafrost

regions. It is not an actual Greenhouse Gas and it remains in the atmosphere only a few days or weeks. Reducing BC would have a near immediate positive effect on Global Warming in contrast to CO₂ which remains in the atmosphere for 100 years or more, and any CO₂ mitigation efforts would yield results only for future generations. While we should work diligently towards the reduction of CO₂, immediate efforts should be made to mitigate or eliminate altogether BC releases from combustion processes, whether from wood burning or combustion of hydrocarbons in engines, due to the immediate positive impact on the effects of climate change. The FireBox can be an effective tool towards achieving the goal of BC reduction now.

PM from the chipping and grinding of wood waste and the subsequent handling, transporting and storage resulting in additional fugitive dust (PM), also is released in various sizes. Raw wood particles are a known carcinogen with obvious health implications, especially to a population close to the source, such as the site operators. It is obvious that raw wood PM emissions from grinders and chippers must be minimized and they are regulated by the authorities in the USA and elsewhere.

The gaseous emission of concern emitted in one form or another from both air curtain burners and grinders is the dangerous *non-biogenic* CO₂, because it is classified as one of the major undesirable Greenhouse Gases. Other releases from a process of incomplete combustion, such as organic gases (CH₄, etc.) are not addressed in this review, as they are inconsequential with regard to this FireBox-to-Grinder comparison study focusing on major environmental impacts of the two competing processes. Biogenic CO₂ also does not enter the comparison, because Biogenic CO₂ from wood is considered *carbon neutral* by the IPCC and USEPA and the biogenic carbon release ultimately is the same for the air curtain burner and the grinder.

It is interesting to note that the US authorities regulate grinders with an allowable maximum opacity for PM emissions of 20% whereas the limit for PM emissions from the air curtain burner is a mere 10%. Opacity is a measurement of the density or thickness of a PM emission plume rising up from a stationary source. This means that it is recognized by the authorities that a FireBox will release much fewer particulate emissions when operated properly than is practical and achievable for the grinder. It is inherently "dirtier" and pollutes more and cannot reasonably tolerate a 10% opacity limit.

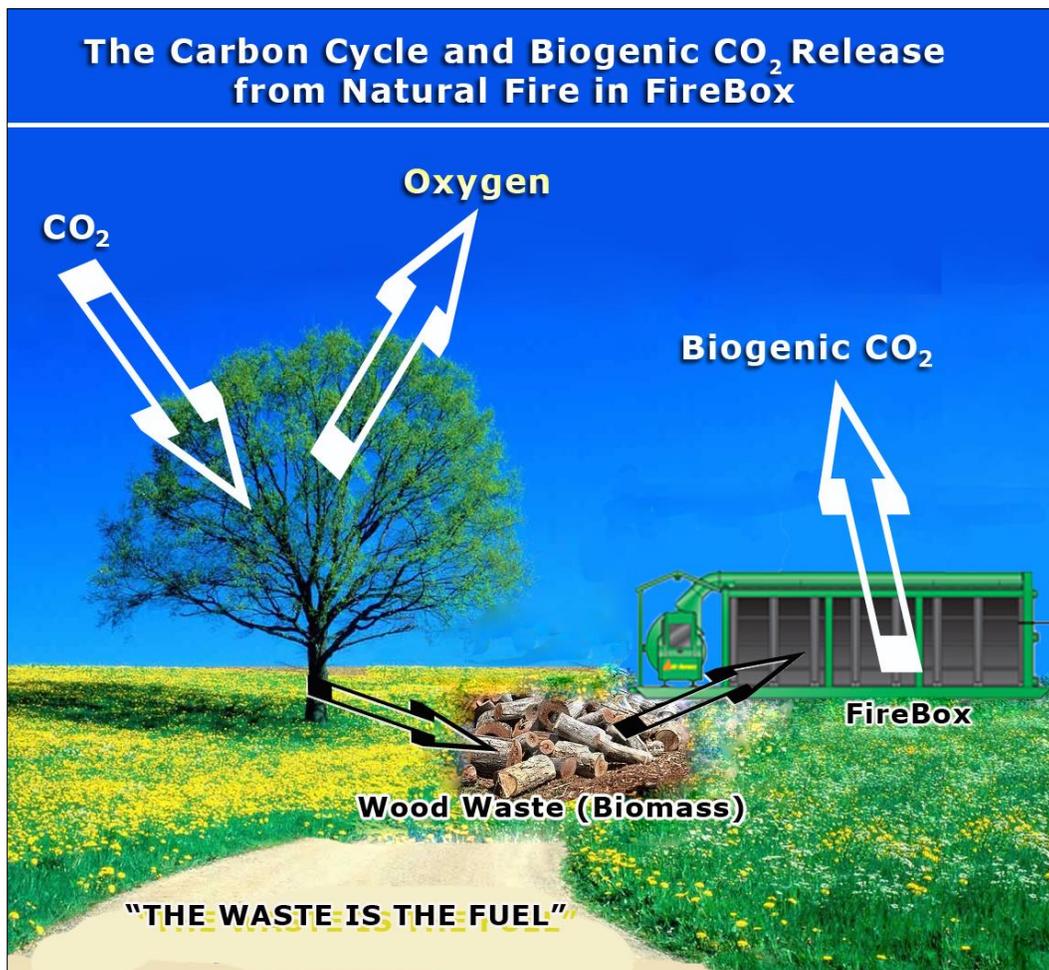
C. Carbon Cycle

This section is devoted to the understanding of "Biogenic CO₂ and the Carbon Cycle based on which the IPPC and other agencies have determined that the burning of woody biomass is CARBON NEUTRAL, that is the release of biogenic CO₂ is not considered a bad Greenhouse Gas in contrast to the carbon dioxide that is released into the atmosphere from the combustion of hydrocarbons such as petroleum or Diesel fuel. That CO₂ is the "bad" Non-biogenic CO₂.

The carbon that is released in this case was sequestered deep inside the Earth and it would have remained there forever, were it not harvested by man and combusted in Diesel engines of trucks, grinders, ocean ships, airplanes, etc.

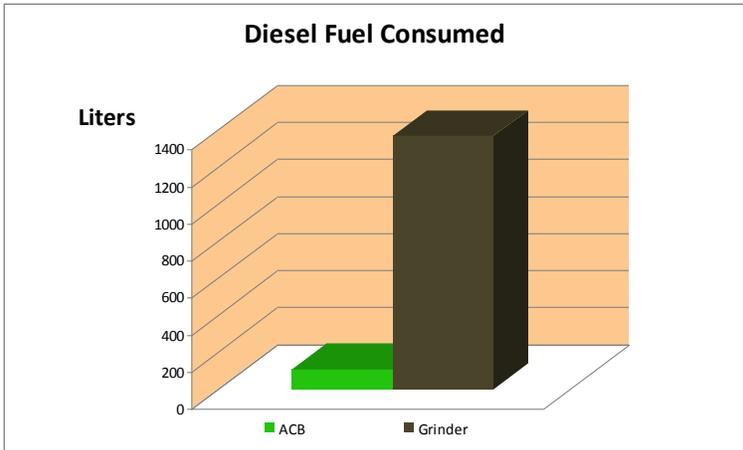
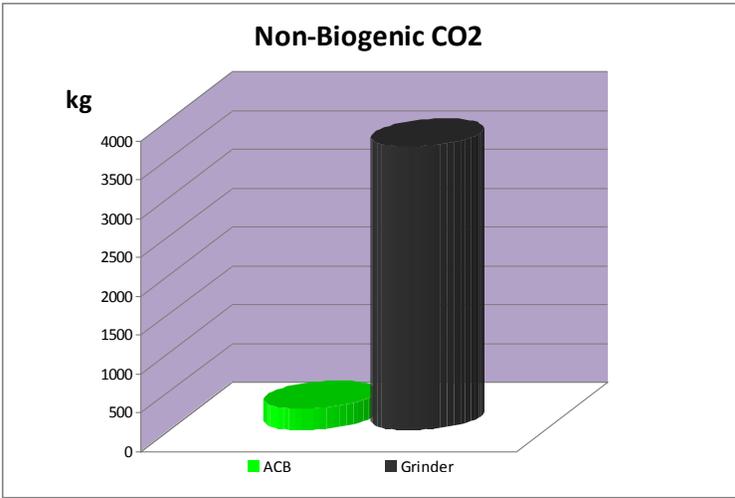
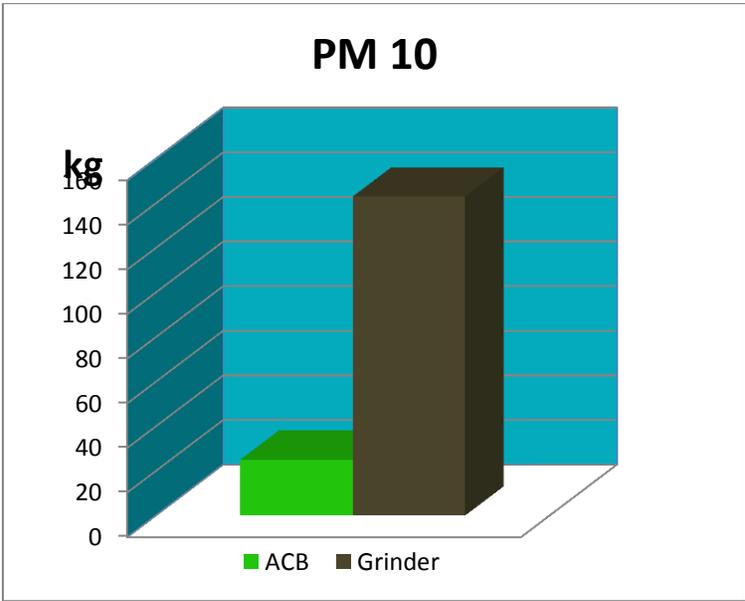
The Biogenic CO₂ from Biomass burning represents carbon that was absorbed by trees and taken from the surrounding CO₂ in the air as the result of nature's process of photo syntheses by which life is sustained on Earth. The carbon portion of the CO₂ remains sequestered in the woody tree or other vegetation and the oxygen is released into the surrounding atmosphere.

When the wood waste is burned in the air curtain burner at very high combustion efficiency, the carbon from the woody biomass again combines with oxygen and forms CO₂. The cycle is complete. No additional CO₂ was added to the atmosphere. The carbon cycle is depicted in the image on the following page and it is self-explanatory.



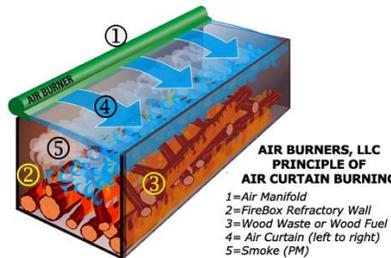
D. Quick Overview of the Results of this Review

The following bar graphs summarize the results for the review of the emissions from the disposal process of 100 tons of wood waste (typical amount for one day) for a quick comparison. The difference between the environmental performances of the FireBox versus the grinder is striking:



E. Brief Discussion of the Equipment and Operation

Air Curtain Burners are above ground refractory walled burn chambers that provide a high velocity curtain of air ("air curtain") over the top of the burn chamber. The air curtain acts like a lid trapping the PM rising from the fire with the intense hot gases and re-burning the PM until the particles are so small that they escape as a gas through the air curtain. (www.aircurtaintechnology.com).



The high velocity air curtain is created by an air fan powered by a small Diesel engine. Air curtain burners reach very high temperatures of 800° C - 1200° C thereby achieving virtually a complete combustion of the wood waste. The residue consists of 2%-3% or less of residual ash that has beneficial use and is usually applied to the surrounding land. (97% to 98% of the wood waste is being totally eliminated. A larger FireBox, such as model S-327, has been designed to eliminate 10-12 tons per hour.

Wood Grinders, such as horizontal or tub grinders were designed to facilitate the transportation of wood debris, not to eliminate it. It was the objective to grind or chip the wood debris into smaller pieces so more weight would fit onto a truck for hauling it to a location for final disposal or storage. The function of the grinders therefore is to provide an interim process, not a final disposal solution. Grinders are powered by large high horse power Diesel engines that drive massive mechanisms which cut or hammer the wood debris into small pieces, the chips or mulch. The mechanism is quite susceptible to breakdowns, because objects, such as chunks of stones or metal which often are inadvertently loaded with the wood waste cannot be tolerated well. Rocks, stones and metal are of no concern for the ACB. This is actually the main reasons why it is so preferred for getting rid of root balls.

For a comparison of the commercial or cost related aspects of the two methods, the most important single distinction is the fact that the air curtain burner offers an end solution for wood waste disposal whereas the grinder offers only an interim process facilitating the transport of the woody debris. This process does not eliminate the waste, as the air curtain burner does.

F. Overview of Emissions from Air Curtain Burner and Grinder

1. Air Curtain FireBox

The air curtain burner selected for this comparison is a mid-size Model S-220. It is equipped with a small Diesel engine that powers the air fan. The largest ACB machine, the S-327, is fitted with an 89HP Diesel engine. Emissions from the engine's exhaust will be considered.

The wood is burned inside the burn chamber where the wood waste is the only actual "fuel" that is combusted. PM emissions from the combustion process will be considered.

2. *Wood Grinder*

Grinders are powered by large Diesel engines, as large as 12 cylinders, 1000HP engines with high fuel consumption. Emissions from the engines exhaust will be considered. The wood waste grinding operations release PM in the form of wood dust (a) from the grinding process itself and (b) from the release of the chips or mulch from the machine via a conveyor belt or similar system. (c) Fugitive PM is released from the storage pile, the on-site staging by a machine (i.e., front-end loader) that pushes the material away from the conveyor belt outlet area, and also each time the material is loaded, transported and finally dumped at its ultimate disposal site, usually a landfill.

G. Quantitative Comparison of Selected Two Pollutants from FireBox and Grinder for 100 Ton of Wood Waste Disposal/Processing

1. *Air Curtain Burner (ACB) - 59HP S-220 by Air Burners, Inc.*

- a. PM from ACB Diesel engine
- b. CO₂ from ACB Diesel engine
- c. PM from wood combustion (processing)

2. *Grinder - 400HP Generic Grinder*

- a. PM from Grinder Diesel engine
- b. CO₂ from Grinder Diesel engine
- c. PM from wood chipping/grinding (processing)
- d. PM, fugitive releases from on-site handling
- e. CO₂ from Truck Diesel engines
- f. PM, fugitive releases from transporting and discharge
- g. PM, fugitive releases from remote/landfill site handling

3. *Basic Specifications of Air Curtain Burner (FireBox)*

Model: Air Burners, Inc. S-220

Engine: Kubota Model V2403-TE, 59 HP max.

Diesel fuel consumption: 8.5 L/hr average

FireBox through-put: 8 tons/hr (8000 kg/hr)

4. *Basic Specifications of Wood Grinder*

Model: Generic Model

Engine: Generic Diesel, 6 Cylinder, 400 HP max.

Diesel fuel consumption: 113.5 L/hr average

Grinder through-put: 16 tons/hr (16000 kg/hr)

5. *Notes*

- a. The loading equipment, such as an excavator, is not included in the comparison, because both the FireBox and the Grinder are assumed to use the same or a similar loading machine, albeit the FireBox for 10 hours and the Grinder for 6 hours. This is balanced by the use of the equipment for removing the beneficial ash from the FireBox and for pushing the chips away from the

grinder's conveyor belt discharge area, where the mulch has to be cleared out over a period of 6 hours, however, the ash can be removed from the FireBox in less than 15 minutes.

b. Calculation of number of dump trucks required to transport 100 tons of wood waste ground into mulch:

- 1) Weight: 100t fairly dry woody debris
- 2) Typical grinding and mulch handling/spillage losses (wood dust and moisture) by weight 2% or $\approx 2,000\text{kg}$ (2t)
- 3) As 1m^3 of mulch has a weight of 290kg, $100\text{t} - 2\text{t} = 98\text{t}$ (198000kg) of wood material ground has a volume of $198000/290 = 337\text{m}^3$
- 4) 1 dump truck can hold (legally) heaped 17m^3 (no weight consideration needed, load weighs only $\approx 5\text{t}$)
- 5) $337/17$ trucks ≈ 20 dump trucks are required

c. Assumption of travel distance to mulch disposal site is 40km one way, total travel distance for 20 loads would be $20 \times 80\text{km}$ (roundtrip) or 1600km; at an average speed of 48km/hr, truck engines would release emissions for $1600/48 = 33$ hrs for every 100 tons (100000kg) of ground wood waste hauled.

d. The fugitive PM emissions from road dust caused by the trucks are ignored, but could be significant in rural areas with unpaved roadways.

e. Emissions from the frequently needed Diesel fuel tanker to refuel the grinder and fleet of trucks are also ignored for this comparison.

PM & CO₂ Data for 100 Tons of Wood Waste Processed

Source	Pollutant	Units	Typical Emissions or Data		Air Burners S-220 59HP	Wood Grinder 400HP
			ACB	Grinder	100t Wood Waste	
Diesel Engine - Processing	PM10	kg/HP-hr	0.059	0.4	0.74kg	4.6kg
Wood Processing	PM10	kg/t	0.24kg/t	0.8kg/t Fed Limit 0.9kg/t	24kg	80kg
Handling of Chips on-site*	PM10	kg/t	0	0.1	0	10kg
Diesel Engine - Trucking 300 HP	PM10	kg/HP-hr	0	0.3kg	0	30kg
Handling of Chips Trucking*	PM10	kg/t	0	0.1kg/t	0	10kg
Handling of Chips Remote Discharge*	PM10	kg/t	0	0.08kg/t	0	8kg
Total PM10					24	142.6
Diesel Engine - Processing	CO ₂ Non-biogenic	kg/L	2.67kg/L	2.67kg/L	283kg	1893kg
Diesel Engine - Trucking 300 HP	CO ₂ Non-biogenic	kg/L	0	2.67kg/L	0	1762kg
Total Non-biogenic CO₂					283kg	3655kg
Diesel Engine - Processing Fuel Consumption	-	L	8.5/hr	113.5/hr	106L	709L
Truck -300HP Fuel Consumption		L	0	37.5L/100km		660L
Total Diesel Fuel					106L	1369L
Wood Processing - Particulate EPA Limit	PM Opacity	%	10	20	-	-
Summary of Totals (rounded)						
TOTAL PM10					25 kg	143 kg
TOTAL CO₂					283 kg	3655 kg
TOTAL Diesel Fuel Consumed					106 L	1369 L

When evaluating different wood waste disposal alternatives, it is often overlooked that a comparison of air curtain burners to grinders is really quite flawed: the FireBox offers an *end solution*; the waste is eliminated. The grinder in contrast thereto is only an *interim step*, a tool to facilitate the transport of the wood waste to the ultimate disposal location. Whenever the two methods are compared, whether from the standpoint of economics or environmental friendliness, the cost and the pollution from the transport vehicles must be factored into the equations. Only then a true and useful comparison can be drawn. The air curtain FireBox will be superior every time by margins so wide, that those voices wanting to argue the finer points of any comparison will be swiftly muted.

A quick discussion regarding the residual products of the two disposal methods is worthwhile. Forest fires burning vegetative waste represent a natural process that has been going on since the beginning of time. A lightning bolt strikes the ground, a wildfire starts and the forest floor is cleared of dead limbs, pathogens, insects and nutrient-robbing undergrowth. The ash becomes a beneficial soil amendment. The burning of wood waste in the FireBox replicates the burning of woody material by natural forest fires, but without the smoke, the FireBox ash becomes a beneficial soil amendment. Because the ashes have a high pH (approximately pH8), they are also useful as an additive to the daily landfill cover at a commercial landfill site further augmenting the overall cost savings enjoyed by the use of the FireBox.

The mulch from the grinder, on the other side, more often than not poses a real commercial and environmental problem. The grinding and hauling is expensive, tipping fees can be high and the mulch hardly ever has a beneficial (commercial) use. Typical mulch grindings may include seeds of invasive species plants, insect larvae, inorganics, mold spores and termites. The mulch is still a waste product, and it costs money to dispose of waste. For the environmentalist charged to safeguard our environment there are several concerns. First, a major problem across the US is the safety and pollution issue from the spontaneous combustion of larger mulch piles. They tend to smolder for many months with no good way to extinguish the fire. Second, the mulch will go septic from natural decomposition. That causes discharges of leachate that are undesirable, as they enter the ground drinking water table. Finally, mulch piles can attract rodents and other pests and when used as landscape material, the mulch can alter the ground ecosystem or even bring pests to homes, if scattered near them. The Forest Service has long recognized the detrimental effect of mulch deposited on the forest floor and heavily restricts the amount of mulch that can remain there from cutting operations.

H. Energy Recovery from the FireBox

The Air Burners FireBox has an optional heat recovery system that allows the operator to utilize waste heat for other purposes, such as kiln drying and heating facilities. Air Burners, Inc. PowerGen FireBox is now available. This self-contained Biomass power generating system will produce electricity from the waste wood. In addition, the system is portable allowing users to "follow the waste", again reducing the environmentally damaging and costly transportation component. You can read more about this exciting new product on our website at www.powergenfirebox.com.

I. Conclusion

The Air Burners FireBox is a well proven and tested technology that delivers benefits to both the corporate budget and the environment. From an environmental standpoint we need to embrace technology that incentivizes the user to protect our environment. From a corporate budget standpoint you can purchase the FireBox for less than a competing grinder and you now have the "end solution".

A comparison of two common methods for the disposal of wood debris has been: (1) Air Curtain FireBox versus (2) grinder and associated trucking option where the ground mulch is hauled to a remote location for ultimate disposal.

The air curtain option is superior both from the economics of the operation and the protection of the environment. In every instance, grinding the waste and hauling it away will be considerably more costly and will release a higher level of undesirable pollutants.

J. References

1. Diesel Engine Emissions Calculations:
US EPA AP42, Section 3.3 "Gasoline and Diesel Engines", Los Alamos National Laboratory (LANL/US Energy Dept.): "*Air Curtain Destructors, General Description of Source Category*".
2. Air Curtain Burner PM Emissions Calculations:
3. USDA-Forest Service: *Reducing PM2.5 Emissions Through Technology, Results from a Recent Study Evaluating the Effectiveness of an Air Curtain Incinerator.*
Fountainhead Engineering: *Air Burners S-327 Emissions Test Report*
US EPA Chalmette, Louisiana Air Curtain Burner Test (S-327)
4. Grinder PM Emissions Calculations:
State of California BAAQMD Regulation 6-301 and BAAQMD Condition #6385 part 4.
Ringelmann 1/20% opacity; BAAQMD Regulation 6-311:
 $E=0.026(P^{0.67})$ where E=allowable emission rate (PM, lb/hr) and P=wood process rate (lb/hr)
5. Air curtain Burner Technical Data:
www.airburners.com
6. Grinder Technical Data
Generic literature accessible at www.google.com

K. Appendix

1. Air Burners, Inc. FireBox Brochure
2. FireBox Specifications for S-327 and S-220

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