

OFFICE OF AIR, WASTE, AND TOXICS +

## MAY 08 2014

## **MEMORANDUM**

**SUBJECT:** Non-HAP Potential to Emit Emission Factors for Biomass Boilers Located in Pacific Northwest Indian Country

FROM: Dan Meyer, Environmental Engineer

**THRU:**Donald A. Dossett, P.E., ManagerAir Permits & Diesel Unit

TO: Permit File

EPA Region 10 has compiled the attached list of non-hazardous air pollutant ("non-HAP") emission factors ("EFs") for use in determining the potential emissions, more commonly referred to as potential to emit ("PTE"), for biomass boilers located in Pacific Northwest Indian Country. The EFs are presented in units of pounds of pollutant per million British thermal units heat input or "Ib/MMBtu." PTE generally represents the maximum capacity of a source to emit a pollutant under its physical and operational design taking into consideration restrictions that are federally enforceable. Non-HAP PTE is used to determine applicability of the Title V operating permit program and the Prevention of Significant Deterioration construction permit program.

For each of the 11 pollutants addressed in the attachment, a list of EFs is presented from which one will ultimately be selecting on a case-by-case basis to determine PTE for a particular boiler. From the list, it is generally the one that is (a) derived from an underlying applicable enforceable limit, and (b) the least numerical value among the group that is selected. The Federal Air Rules for Reservations ("FARR"), the New Source Performance Standards ("NSPS") and the National Emission Standards for Hazardous Air Pollutants ("NESHAP")<sup>1</sup> are all federal regulations that restrict certain non-HAP emissions from biomass boilers. For each pollutant-specific limit, a corresponding EF has been derived. Similarly, greenhouse gas EFs have been derived from those appearing in the Mandatory Greenhouse Gas Reporting Rule. In addition to these regulatoryderived EFs, the attachment presents EFs appearing in Section 1.6 of EPA's AP-42 (September 2003); a compilation of average emission factors.<sup>2</sup> In general, it is appropriate to employ an AP-42 EF to determine PTE for a particular pollutant only when (a) no federal regulation or permit is limiting, and (b) a more representative emission factor is not available.

<sup>&</sup>lt;sup>1</sup> Biomass boiler emissions of particulate matter may consist partially of trace metal HAPs, and those particulate matter emissions are limited in both the major and area source boiler NESHAPs. The major source boiler NESHAP also limits carbon monoxide as a surrogate for organic HAP.

<sup>&</sup>lt;sup>2</sup> "Average" in this context means arithmetic average for a set of values upon which the EF is based. It is not meant to be descriptive of the relative quality of the EF.

## EPA Region 10 Non-HAP Potential to Emit Emission Factors for Biomass Boilers Located in Pacific Northwest Indian Country, May 2014

Criteria Pollutant	EF Reference
Carbon Monoxide (CO)	1
Lead (Pb)	2
Nitrogen Oxides (NO <sub>X</sub> )	3
Particulate (PM)	4
Respirable Particulate (PM <sub>10</sub> )	5
Fine Particulate (PM <sub>2.5</sub> )	6
Sulfur Dioxide (SO <sub>2</sub> )	7
Volatile Organic Compounds (VOC)	8

EF Reference
9
10
11

1

<sup>1</sup> The DC Circuit Court of Appeals on July 12, 2013 vacated EPA regulations that delayed until July 21, 2014 consideration of CO<sub>2</sub> emissions resulting from biomass combustion in determining PSD and Title V applicability pursuant to 40 CFR 52.21(b)(49)(ii)(a) and 40 CFR 71.2 definition of "subject to regulation." See explanation for exemption provided by EPA at 76 FR 43490. See DC Circuit Court of Appeals July 12, 2013 ruling vacating the exemption at http://www.cadc.uscourts.gov/internet/opinions.nsf/F523FF129C06ECA85257BA6005397B5/\$file/11-1101-1446222.pdf

EF Reference	Description								
	Option 1: 0.6 lb/MMBtu								
	Basis: AP-42, September 2003. Table 1.6-2.								
	Option 2: 0.243 - 2.281 lb/MMBtu (EPA Reference Method 10, 10A or 10B) Basis: Major Source Boiler MACT ("NESHAP DDDDD") In order to create an EF in units of "lb/MMBtu heat input" based upon NESHAP DDDDD CO emission limits expressed in units of "ppm @3%O <sub>2</sub> ," the following equation must be employed: EF (lb/MMBtu) = NESHAP DDDDD CO Limit (ppmvd@3%O <sub>2</sub> ) X CF <sub>3-0%O2</sub> X CF <sub>ppm-lb/dscfCO</sub> X F <sub>d</sub> (dscf/MMBtu) • NESHAP DDDDD specifies a range of different CO emission limits based upon (a) the date the boiler commenced construction or reconstruction, (b) the design of the boiler and (type of fuel combusted. For the purpose of this PTE EF exercise, only the emission limits in units of "ppm" will be employed here. The alternative "lb/MMBtu steam output" or "lb/MV								
	Maximum Design	Date Construction		NESHAP DDDDD	Regulatory Citation				
	Heat Input Capacity, X	or Reconstruction	Boiler Design	CO Emission Limit	40 CFR 63.7500(a)(1)				
	(MMBtu/hr)	Commenced, Y	Ŭ	(ppmvd@3%O <sub>2</sub> )	and NESHAP DDDDD				
	()	,	Stokers/sloped grate/others designed to burn wet	1,500 (3-run avg)					
			biomass fuel	720 (30-day rolling avg)	Table 2, Row 7				
			Stokers/sloped grate/others designed to burn kiln-dried biomass fuel	460 (3-run avg)	Table 2, Row 8				
			Fluidized bed units designed to burn biomass/bio-based	470 (3-run avg)	<b>T</b>     0 D 0				
			solid	310 (30-day rolling avg)	Table 2, Row 9				
		X = 00/04/40	Suspension burners designed to burn biomass/bio-based	2,400 (3-run avg)	Table 0. Days 40				
		Y ≤ 06/04/10	solid	2,000 (10-day rolling avg)	Table 2, Row 10				
			Dutch ovens/pile burners designed to burn biomass/bio-	770 (3-run avg)	<b>T</b>     0 <b>D</b>   11				
			based solid	520 (10-day rolling avg)	Table 2, Row 11				
			Fuel cell units designed to burn biomass/bio-based solid	1,100 (3-run avg)	Table 2, Row 12				
			Hybrid suspension grate boiler designed to burn	2,800 (3-run avg)	Table 2 Day 12				
	10 ≤ X		biomass/bio-based solid	900 (30-day rolling avg)	Table 2, Row 13				
	10 S X		Stokers/sloped grate/others designed to burn wet	620 (3-run avg)	Table 4 Daw 7				
			biomass fuel	390 (30-day rolling avg)	Table 1, Row 7				
			Stokers/sloped grate/others designed to burn kiln-dried biomass fuel	460 (3-run avg)	Table 1, Row 8				
			Fluidized bed units designed to burn biomass/bio-based	230 (3-run avg)	Table 1, Row 9				
			solid	310 (30-day rolling avg)	Table 1, Now 9				
		06/04/10 < Y	Suspension burners designed to burn biomass/bio-based	2,400 (3-run avg)	Table 1, Row 10				
		00/04/10 < 1	solid	2,000 (10-day rolling avg)					
			Dutch ovens/pile burners designed to burn biomass/bio- based solid	330 (3-run avg) 520 (10-day rolling avg)	Table 1, Row 11				
			Fuel cell units designed to burn biomass/bio-based solid	910 (3-run avg)	Table 1, Row 12				
			Hybrid suspension grate boiler designed to burn biomass/bio-based solid	1,100 (3-run avg) 900 (30-day rolling avg)	Table 1, Row 13				

• CF<sub>3-0%02</sub> (unitless) = (20.9 - X<sub>02Fd</sub>) / (20.9 - X<sub>02NESHAP5D</sub>). To create a conversion factor that adjusts the basis of the NESHAP DDDDD CO emission limit from 3% O<sub>2</sub> to 0% O<sub>2</sub> (the basis for F<sub>d</sub>), X<sub>02Fd</sub> = 0 and X<sub>02NESHAP5D</sub> = 3. The value 20.9 is the percent by volume of the ambient air that is O<sub>2</sub>. Decreasing the O<sub>2</sub> from the NESHAP DDDDD CO baseline increases the pollutant concentration. See Equation 19-1 of EPA Method 19 at Appendix A-7 to 40 CFR Part 60.

•  $CF_{ppm-ubidsetCO}$  (lb CO/dscf / ppm CO) = [CO Concentration (ppm)] X [CF<sub>ppm-unitiess</sub> (1/ppm)] X [MW CO (g/mol)] X [Ideal Gas Constant @ EPA Standard Conditions (L/mol)]<sup>-1</sup> X [CF<sub>L-ft3</sub> (L/ft<sup>3</sup>)] X [CF<sub>g-ub</sub> (g/lb)]<sup>-1</sup>. This factor converts CO concentration from units "ppm" to "lb/dscf." To create the conversion factor, start by assuming CO concentration of 1 ppm and dividing by 1,000,000 to create a volumetric ratio of CO to exhaust gas. The molecular weight of CO is 28.010 g/mol. EPA standard conditions for reference method testing are a temperature of 20°C and a pressure of 1 atm. See Footnote 1 of Table 19-2 of EPA Method 19. The ideal gas constant is 0.08205746 L-atm/°K-mol. At EPA standard conditions, the value for ideal gas constant becomes 24.05514 L/mol through the following calculation: (0.08205746 L-atm/°K-mol) X (1 atm)<sup>-1</sup> X (293.15°K). Note that °K = [°C] + 273.15. There are around 28.32 liters (L) in a cubic foot (ft<sup>3</sup>) and around 453.6 grams (g) in a pound (lb).

The calculation to determine  $\mathsf{CF}_{\mathsf{COvolume}}$  is presented in the following table:

The calculation to determine CF <sub>COvolum</sub>		ollowing table:	22			
CF <sub>ppm→lb/dscfCO</sub>	CO Concentration	CE	CO Molecular Weight	Ideal Gas Constant	CF <sub>L→ft3</sub>	CF <sub>g→lb</sub>
ppm→lb/dsctCO	(ppm)	CF <sub>ppm→unitless</sub> (1/ppm)	(g/mol)	(L/mol)	$(L/ft^3)$	(g/lb)
7.27E-08	1	1.E-06	28.010	24.05514	28.3168466	453.5923
$F_d = 9,240 \text{ dscf/MMBtu for combustio}$	n of "wood" or 9,600					
Returning to the equation, EF (Ib/MMB						
EF can now be calculated assuming co						
For "Existing" Units (Commencing Con	struction or Reconstr	uction on or before June 4, 2010	0)			
		NESHAP DDDDD CO	NESHAP DDDDD CO			
Boiler	Fuel	Calculated EF	Emission Limit <sup>1</sup>	$CF_{3\rightarrow0\%O2}$	CF <sub>ppm→lb/dscfCO</sub>	F <sub>d</sub>
Design	i dei	(Ib/MMBtu)	(ppmvd@3%O <sub>2</sub> )	(unitless)	(lb/dscf / ppm)	(dscf/MMB
Stokers/sloped grate/others designed	Wood	1.176	1500			9240
to burn wet biomass fuel	Bark	1.222	1500			9600
Stokers/sloped grate/others designed	Wood	0.361	460			9240
to burn kiln-dried biomass fuel	Bark	0.375	460			9600
Fluidized bed units designed to burn	Wood	0.369	470			9240
biomass/bio-based solids	Bark	0.383	470			9600
Suspension burners designed to burn	Wood	1.882	2400			9240
biomass/bio-based solids	Bark	1.956	2400	1.168	7.27E-08	9600
Dutch ovens/pile burners designed to	Wood	0.604	770			9240
burn biomass/bio-based solids	Bark	0.627	770			9600
Fuel cell units designed to burn	Wood	0.863	1100			9240
biomass/bio-based solids	Bark	0.896	1100			9600
Hybrid suspension grate boiler	Wood	2.196	2800			9240
designed to burn biomass/bio-based	Bark	2.281	2800			9600
solids				are then one		9000
Least stringent emission limit selected For "New" Units (Commencing Constru			ce to choose from among me	ne than one.		
c		NESHAP DDDDD CO	NESHAP DDDDD CO			
Boiler		Calculated EF	Emission Limit <sup>1</sup>	CF <sub>3→0%O2</sub>	CF <sub>ppm→lb/dscfCO</sub>	Fd
Design	Fuel	(lb/MMBtu)	(ppmvd@3%O <sub>2</sub> )	(no units)	(lb/dscf / ppm)	(dscf/MMB
Stokers/sloped grate/others designed	Wood	0.486	620	(no anno)	(10/00017 ppin)	9240
to burn wet biomass fuel	Bark	0.505	620			9600
Challenge de grate (athere de signed	Weed	0.361	460			9240
Stokers/sloped grate/others designed to burn kiln-dried biomass fuel	Wood					
	Bark	0.375	460			9600
Fluidized bed units designed to burn	Wood	0.243	310			9240
biomass/bio-based solids	Bark	0.253	310			9600
Suspension burners designed to burn biomass/bio-based solids	Wood	1.882	2400	1.168	7.27E-08	9240
	Bark	1.956	2400			9600
Dutch ovens/pile burners designed to burn biomass/bio-based solids	Wood Bark	0.408	520 520			9240 9600
Fuel cell units designed to burn	Wood	0.714	910			9000
biomass/bio-based solids	Bark	0.741	910			9600
Hybrid suspension grate boiler		0.863	1100			9240
designed to burn biomass/bio-based	Wood					
solids	Bark	0.896	1100			9600
Least stringent emission limit selected	to calculate EF whe	n NESHAP DDDDD allows source	ce to choose from among me	ore than one.		
Dption 1: 4.8x10 <sup>-5</sup> lb/MMBtu Basis: AP-42, September 2003. Table	4.0.4					
	1 H A					
Option 1: 0.22 lb/MMBtu	1.6-4.					
<u>Option 1</u> : 0.22 lb/MMBtu Basis: AP-42, September 2003, Table		ed boiler				
<u>Option 1</u> : 0.22 lb/MMBtu Basis: AP-42, September 2003. Table Option 2: 0.49 lb/MMBtu		ed boiler				
Basis: AP-42, September 2003. Table	1.6-2 for wet wood-fir					
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir	ed boiler				
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir	ed boiler				
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir	ed boiler		NSPS		
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir	ed boiler ) Date Action	ACF	PM Emissi	on Limit	-
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr)	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action	ed boiler Date Action Commenced, Y				Citation
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M	ed boiler Date Action Commenced, Y 06/19/84 < Y ≤ 02/28/05		PM Emissi (lb/MMBtu) 0.10	on Limit (% removal) N/A	Citation 60.43b(c)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X ≤ 250	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M	ed boiler Date Action Commenced, Y 06/19/84 < Y ≤ 02/28/05 06/19/84 < Y ≤ 02/28/05		PM Emissi (Ib/MMBtu) 0.10 0.20	on Limit (% removal) N/A N/A	Citation 60.43b(c)( 60.43b(c)(
Basis: AP-42, September 2003. Table <u>Dotion 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Dotion 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M	ed boiler Date Action Commenced, Y 06/19/84 < Y ≤ 02/28/05 06/19/84 < Y ≤ 02/28/05 02/28/05 < Y	30% < Z 30% ≥ Z N/A	PM Emissi (Ib/MMBtu) 0.10 0.20 0.030	on Limit (% removal) N/A N/A N/A	Citation 60.43b(c)( 60.43b(c)( 60.43b(c)(
Basis: AP-42, September 2003. Table <u>Dotion 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Dotion 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z 30% ≥ Z N/A N/A	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051	on Limit (% removal) N/A N/A N/A 99.8	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z 30% ≥ Z N/A N/A 30% < Z	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051 0.10	on Limit (% removal) N/A N/A N/A 99.8 N/A	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 100 < X 250 < X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z 30% ≥ Z N/A N/A	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051	on Limit (% removal) N/A N/A N/A 99.8	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X $\leq$ 250 100 < X 100 < X 250 < X C - construction, R - reconstruction an	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z 30% ≥ Z N/A N/A 30% < Z	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051 0.10	on Limit (% removal) N/A N/A N/A 99.8 N/A	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 250 250 < X C - construction, R - reconstruction an <u>Option 2</u> : 0.030 - 0.30 lb/MMBtu (EPA	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z 30% ≥ Z N/A N/A 30% < Z	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051 0.10	on Limit (% removal) N/A N/A N/A 99.8 N/A	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table Dption 2: 0.49 lb/MMBtuBasis: AP-42, September 2003. Table Dption 1: 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows:Maximum Design Heat Input Capacity, X (MMBtu/hr)100 < X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M 	ed boiler Date Action Commenced, Y 06/19/84 < Y ≤ 02/28/05 06/19/84 < Y ≤ 02/28/05 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y	30% < Z 30% ≥ Z N/A N/A 30% < Z	PM Emissi (Ib/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085	on Limit (% removal) N/A N/A 99.8 N/A N/A	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 250 < X C - construction, R - reconstruction an <u>Option 2</u> : 0.030 - 0.30 lb/MMBtu (EPA Basis: NSPS Subpart Dc as follows: Maximum Design	1.6-2 for wet wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M M M M Reference Method 5)	ed boiler Date Action Commenced, Y 06/19/84 < Y ≤ 02/28/05 06/19/84 < Y ≤ 02/28/05 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y	30% < Z 30% ≥ Z N/A N/A 30% < Z 30% < Z	PM Emissi (Ib/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085 NSPS	on Limit (% removal) N/A N/A 99.8 N/A N/A Dc	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table <u>Dotion 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Dotion 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 100 < X C - construction, R - reconstruction an <u>Dotion 2</u> : 0.030 - 0.30 lb/MMBtu (EPA Basis: NSPS Subpart Dc as follows: Maximum Design Heat Input Capacity, X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M	ed boiler Date Action Commenced, Y 06/19/84 < Y ≤ 02/28/05 06/19/84 < Y ≤ 02/28/05 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y 02/28/05 < Y	30% < Z 30% ≥ Z N/A N/A 30% < Z	PM Emissi (Ib/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085 NSPS PM Emissi	on Limit (% removal) N/A N/A 99.8 N/A N/A Dc on Limit	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 250 < X C - construction, R - reconstruction an <u>Option 2</u> : 0.030 - 0.30 lb/MMBtu (EPA Basis: NSPS Subpart Dc as follows: Maximum Design	1.6-2 for wet wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M M M M M Action Action	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z 30% ≥ Z N/A N/A 30% < Z 30% < Z	PM Emissi (Ib/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085 NSPS PM Emissi (Ib/MMBtu)	on Limit (% removal) N/A N/A 99.8 N/A N/A N/A Dc on Limit (% removal)	Citation 60.43b(c)( 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 80.43b(h)())))))))))))))))))))))))))))))))))
Basis: AP-42, September 2003. Table <u>Dotion 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Dotion 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 100 < X C - construction, R - reconstruction an <u>Dotion 2</u> : 0.030 - 0.30 lb/MMBtu (EPA Basis: NSPS Subpart Dc as follows: Maximum Design Heat Input Capacity, X	1.6-2 for wet wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M M M M M M M Action C, R, M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z	PM Emissi (Ib/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085 NSPS PM Emissi (Ib/MMBtu) 0.10	on Limit (% removal) N/A N/A N/A 99.8 N/A N/A Dc on Limit (% removal) N/A	60.43c(b)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 100 < X C - construction, R - reconstruction an <u>Option 2</u> : 0.030 - 0.30 lb/MMBtu (EPA Basis: NSPS Subpart Dc as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr)	1.6-2 for wet wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M M M M Action Reference Method 5) Action C, R, M C, R, M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085 PM Emissi (lb/MMBtu) 0.10 0.30	on Limit (% removal) N/A N/A N/A 99.8 N/A N/A Dc on Limit (% removal) N/A N/A N/A	Citation 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43b(b)(b)( 60.43b(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)
Basis: AP-42, September 2003. Table <u>Dotion 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Dotion 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 100 < X C - construction, R - reconstruction an <u>Dotion 2</u> : 0.030 - 0.30 lb/MMBtu (EPA Basis: NSPS Subpart Dc as follows: Maximum Design Heat Input Capacity, X	1.6-2 for wet wood-fir 1.6-2 for dry wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M M M Action C, R, M C, R, M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	$\begin{array}{c c} 30\% < Z \\ \hline 30\% \geq Z \\ \hline N/A \\ \hline N/A \\ \hline 30\% < Z \\ \hline 30\% \geq Z \\ \hline N/A \\ \end{array}$	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085 PM Emissi (lb/MMBtu) 0.10 0.30 0.030	on Limit (% removal) N/A N/A N/A 99.8 N/A N/A Dc on Limit (% removal) N/A N/A N/A N/A N/A N/A	Citation 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(b)( 60.43c(b)( 60.43c(b)( 60.43c(c)( 60.43c(c)(
Basis: AP-42, September 2003. Table <u>Option 2</u> : 0.49 lb/MMBtu Basis: AP-42, September 2003. Table <u>Option 1</u> : 0.030 - 0.20 lb/MMBtu (EPA Basis: NSPS Subpart Db as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr) 100 < X 100 < X 100 < X 100 < X 100 < X 100 < X C - construction, R - reconstruction an <u>Option 2</u> : 0.030 - 0.30 lb/MMBtu (EPA Basis: NSPS Subpart Dc as follows: Maximum Design Heat Input Capacity, X (MMBtu/hr)	1.6-2 for wet wood-fir Reference Method 5) Action C, R, M C, R, M C, R, M M M M M M M M Action Reference Method 5) Action C, R, M C, R, M	Date           Action           Commenced, Y           06/19/84 < Y ≤ 02/28/05	30% < Z	PM Emissi (lb/MMBtu) 0.10 0.20 0.030 0.051 0.10 0.085 PM Emissi (lb/MMBtu) 0.10 0.30	on Limit (% removal) N/A N/A N/A 99.8 N/A N/A Dc on Limit (% removal) N/A N/A N/A	Citation 60.43b(c)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(h)( 60.43b(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43c(b)( 60.43b(b)(b)( 60.43b(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)(b)

1

Option 3: 0.03 - 0.07 lb/MMBtu (EPA Reference Method 5)

Basis: Area Source Boiler MACT ("NESHAP JJJJJJ") as follows:									
Maximum Design	Date Construction	NESHAP JJJJJJ	Regulatory Citation						
Heat Input Capacity, X	or Reconstruction	PM Emission Limit	40 CFR 63.11201(a)						
(MMBtu/hr)	Commenced, Y	(lb/MMBtu)	and NESHAP 5D						
30 ≤ X	06/04/10 < Y	0.03	Table 1, Row 3						
10 ≤ X < 30	06/04/10 < Y	0.07	Table 1, Row 4						

Option 4: 0.0032 - 0.44 lb/MMBtu (EPA Reference Method 5)

## Basis: NESHAP DDDDD as follows:

4

• NESHAP DDDDD specifies a range of different PM emission limits based upon (a) the date the boiler commenced construction or reconstruction, (b) the design of the boiler and (c) type of fuel combusted. For the purpose of this PTE EF exercise, only the emission limits in units of "lb/MMBtu heat input" will be employed here. The source may choose to comply with an alternative "lb/MMBtu heat input" emission limit for total selected metals (TSM). Because TSM constitutes only a fraction of total PM, TSM emission limits will not be considered in determining PM PTE EF. TSM is limited to arsenic, beryllium, cadmium, chromium, lead, manganese, nickel and selenium.

Maximum Design Heat Input Capacity, X (MMBtu/hr)	Date Construction or Reconstruction Commenced, Y	Boiler Design	NESHAP DDDDD PM Emission Limit (Ib/MMBtu; 3-run avg)	Regulatory Citation 40 CFR 63.7500(a)(1) and NESHAP 5D
		Stokers/sloped grate/others designed to burn wet biomass fuel		Table 2, Row 7
		Stokers/sloped grate/others designed to burn kiln-dried biomass fuel	0.32	Table 2, Row 8
		Fluidized bed units designed to burn biomass/bio-based solid	0.11	Table 2, Row 9
	Y ≤ 06/04/10	Suspension burners designed to burn biomass/bio-based solid	0.051	Table 2, Row 10
		Dutch ovens/pile burners designed to burn biomass/bio- based solid	0.28	Table 2, Row 11
		Fuel cell units designed to burn biomass/bio-based solid	0.02	Table 2, Row 12
10 ≤ X		Hybrid suspension grate boiler designed to burn biomass/bio-based solid	0.44	Table 2, Row 13
10 5 X		Stokers/sloped grate/others designed to burn wet biomass fuel	0.03	Table 1, Row 7
		Stokers/sloped grate/others designed to burn kiln-dried biomass fuel	0.03	Table 1, Row 8
		Fluidized bed units designed to burn biomass/bio-based solid	0.0098	Table 1, Row 9
	06/04/10 < Y	Suspension burners designed to burn biomass/bio-based solid	0.03	Table 1, Row 10
		Dutch ovens/pile burners designed to burn biomass/bio- based solid	0.0032	Table 1, Row 11
		Fuel cell units designed to burn biomass/bio-based solid	0.02	Table 1, Row 12
		Hybrid suspension grate boiler designed to burn biomass/bio-based solid	0.026	Table 1, Row 13

Option 5: 0.397 lb/MMBtu for wood and 0.412 lb/MMBtu for bark (EPA Reference Method 5)

Basis: FARR wood-fired boiler stack PM emission limit of 0.2 gr/dscf corrected to 7% O<sub>2</sub> at 40 CFR 49.125(d)(2)

EF (Ib/MMBtu) = FARR PM Limit (gr/dscf@7%O<sub>2</sub>) X CF<sub>7 $\rightarrow$ 0%O2</sub> X F<sub>d</sub> (dscf/MMBtu) / CF<sub>gr $\rightarrow$ 1b</sub>

•  $CF_{7-0\%O2} = (20.9 - X_{O2Fd}) / (20.9 - X_{O2FARR})$ . To create a correction factor that adjusts the basis of the FARR emission limit from 7% O<sub>2</sub> to 0% O<sub>2</sub> (the basis for F<sub>d</sub>), X<sub>O2Fd</sub> = 0 and X<sub>O2FARR</sub> = 7. The value 20.9 is the percent by volume of the ambient air that is O<sub>2</sub>. Decreasing the O<sub>2</sub> from the FARR baseline increases the pollutant concentration. See Equation 19-1 of EPA Method 19 at Appendix A-7 to 40 CFR Part 60.

• F<sub>d</sub> = 9,240 dscf/MMBtu for combustion of "wood" or 9,600 dscf/MMBtu for combustion of "wood bark." See Table 19-2 of EPA Method 19 at Appendix A-7 to 40 CFR Part 60.

		FARR PM	FARR						
	Fuel	Calculated EF	PM Emission Limit	CF <sub>7→0%O2</sub>	Fd	CF <sub>gr→lb</sub>			
		(Ib/MMBtu)	(gr/dscf @7%O <sub>2</sub> )	(unitless)	(dscf/MMBtu)	(gr/lb)			
	Wood	0.397	0.2	1.504	9240	7000			
Bark		0.412	0.2	1.504	9600	7000			
	Option 6: 0.35 lb/MMBtu (EPA Referen	ce Method 5)							
	Basis: (a) AP-42, September 2003. Tal	ole 1.6-1. (b) Fuel ble	nding and installation of mechar	nical collectors to comply w	vith FARR PM limit.				
	bark and wet wood together without co CFR 49.152(d)(2)) if controls are not in collectors and blending bark with wood	stalled (0.40 and 0.3	3 ~ 0.397), combustion of bark a	nd wet wood together will					
	Option 1: 0.047 - 0.217 lb/MMBtu								
	Basis: NSPS Subpart Db (0.03 - 0.20 II	o/MMBtu) as noted at	pove for PM plus 0.017 lb/MMBtu	u condensible portion as no	oted in AP-42.				
	Option 2: 0.047 - 0.317 lb/MMBtu	(MADeu) on poted of	ere for DM plue 0.047 lb/MMD4	, condensible notion on n	atad in AD 42				
	Basis: NSPS Subpart Dc (0.03 - 0.30 II Option 3: 0.047 - 0.087 lb/MMBtu	o/wiwibiu) as noted at		a condensible portion as no	Died III AP-42.				
	Basis: NESHAP JJJJJJ (0.03 - 0.07 lb/	MMbtu) as noted abo	ve for PM plus 0.017 lb/MMRtu (	condensible portion as not	ed in AP-42				
	Option 4: 0.0202 - 0.457 lb/MMBtu	www.ull.as noted abo		condensible portion as not	eu ill Ar -42.				
	Basis: NESHAP DDDDD (0.0032 - 0.44	1 lb/MMBtu) as noted	above for PM plus 0.017 lb/MM	Btu condensible portion as	noted in AP-42.				
	Option 5: 0.429 lb/MMBtu	,							
	Basis: FARR wood-fired boiler stack P	M emission limit of 0.2	2 gr/dscf corrected to 7% O2 at 4	0 CFR 49.125(d)(2) for filt	erable portion and AP-42 for	or condensible portio	n.		
	Basis: FARR wood-fired boiler stack PM emission limit of 0.2 gr/dscf corrected to 7% O <sub>2</sub> at 40 CFR 49.125(d)(2) for filterable portion and AP-42 for condensible portion. As stated previously in analysis of PM EF, an EF of 0.412 is calculated assuming compliance with FARR PM limit and combustion of bark. EPA Reference Method 5 is the test meth employed to determine compliance with the limit. EPA Reference Method 5 measures only filterable PM, but PM <sub>10</sub> consists of both a filterable and condensible portion. AP-42 estim- the condensible contribution to be 0.017 lb/MMBtu. Adding the two together. 0.412 + 0.017 = 0.429 lb/MMBtu.								

	lb/MMBtu) as noted at	pove for PM plus 0.017 lb/MMBtu	condensible portion as no	ted in AP-42.			
<u>Option 2</u> : 0.047 - 0.317 lb/MMBtu							
Basis: NSPS Subpart Dc (0.03 - 0.30 lb/MMBtu) as noted above for PM plus 0.017 lb/MMBtu condensible portion as noted in AP-42.							
Option 3: 0.047 - 0.087 lb/MMBtu							
Basis: NESHAP JJJJJJ (0.03 - 0.07 lb	/MMbtu) as noted abo	ve for PM plus 0.017 lb/MMBtu o	ondensible portion as note	d in AP-42.			
Option 4: 0.0202 - 0.457 lb/MMBtu							
Basis: NESHAP DDDDD (0.0032 - 0.4	4 lb/MMBtu) as noted	above for PM plus 0.017 lb/MME	Btu condensible portion as	noted in AP-42.			
Option 5: 0.429 lb/MMBtu							
Basis: FARR wood-fired boiler stack F	M emission limit of 0.2	2 gr/dscf corrected to 7% O2 at 4	0 CFR 49.125(d)(2) for filte	erable portion and AP-42	for condensible portion.		
As stated previously in analysis of PM		• -		•			
employed to determine compliance wi the condensible contribution to be 0.0	th the limit. EPA Refer	ence Method 5 measures only fil	terable PM, but PM <sub>2.5</sub> cons				
Option 1: 1.153 lb/MMBtu for wood an	d 1.198 lb/MMBtu for I	bark					
Basis: FARR combustion source stack	SO <sub>2</sub> emission limit of	500 parts per million by volume	dry basis (ppmvd) correcte	d to 7% O2 at 40 CFR 49	.129(d)(1)		
EF (lb/MMBtu) = FARR SO <sub>2</sub> Limit (ppr		6O2 X CFnom→lb/dscfSO2 X Fd (dscf/M	IMBtu)				
• CF <sub>7→0%O2</sub> = (20.9 - X <sub>O2Fd</sub> ) / (20.9 - X <sub>O</sub>				imit from 7% O <sub>2</sub> to 0% O <sub>2</sub>	(the basis for F <sub>4</sub> ). X <sub>one</sub>		
= 7. The value 20.9 is the percent by							
Method 19 at Appendix A-7 to 40 CFR				·			
• CF <sub>ppm→lb/dscfSO2</sub> = 1.660 X 10 <sup>-7</sup> lb SO <sub>2</sub>	/dscf / ppm SO <sub>2</sub> . See <sup>-</sup>	Table 19-1 of EPA Method 19 at	Appendix A-7 to 40 CFR P	art 60.			
• $F_d = 9,240  dscf/MMBtu for combustic$					endix A-7 to 40 CFR Pa		
	FARR 500 ppm	FARR		······			
Fuel	Calculate SO <sub>2</sub> EF	SO <sub>2</sub> Emission Limit	CF <sub>7→0%O2</sub>	CF <sub>ppm→lb/dscfSO2</sub>	Fd		
1 001	(Ib/MMBtu)	(ppmvd@7%O <sub>2</sub> )	(unitless)	(lb/dscf / ppm)	(dscf/MMBtu)		
Mand.	(ID/MINIBLU) 1.153		()	1.66E-07			
Wood		500	1.504		9240		
Bark Option 2: 4.615 lb/MMBtu for wood an	1.198	500 bark	1.504	1.66E-07	9600		
Basis: FARR solid fuel sulfur limit of 2							
EF (Ib/MMBtu) = {[FARR Fuel S Limit				aduat 00 / 10 0			
• $CF_{S \rightarrow SO2} = 2 \text{ lb } SO_2/\text{lb } S. S + O_2 \rightarrow S$							
• HV (heating value) wood (dry) = 8,66			4500/(1-0.5)). See page A	-5 of Appendix A to AP-42	2, September 1985.		
<b>-</b> ·	FARR Fuel S	FARR	05		0.5		
Fuel	Calculate SO <sub>2</sub> EF	Fuel Sulfur Limit	$CF_{S \rightarrow SO2}$	HV <sub>fuel</sub>	CF <sub>Btu→MMBtu</sub>		
	(Ib/MMBtu)	(% by weight)	(lb SO <sub>2</sub> /lb S)	(Btu/lb)	(Btu/MMBtu)		
Wood	4.615	2	2	8667	1.0E+06		
Bark	4.444	2	2	9000	1.0E+06		
Option 3: 0.462 lb/MMBtu for wood an	d 0.444 lb/MMBtu for I	bark					
Basis: Bark upper bound sultur estima to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor	uel, Journal of the Air Oglesby and Blosser,	Pollution Control Association, 3 conservatively assume all sulfur	introduced to boiler is exh	/00022470.1980.1046510			
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S	Fuel, Journal of the Air Oglesby and Blosser, ntent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S	Pollution Control Association, 3 conservatively assume all sulfur s-S02 / HV <sub>tuel</sub> (Btu/lb)} X CF <sub>Btu-M</sub> (16 lb/lb-mol) reactant, there is	D:7, 769-772, DOI:10.1080, introduced to boiler is exh <sub>MBtu</sub> (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro	/00022470.1980.1046510 austed as SO <sub>2</sub> . oduct. 32 / 16 = 2.	7		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S	Fuel, Journal of the Air Oglesby and Blosser, ntent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S	$ \begin{array}{l} \label{eq:pollution Control Association, 30 conservatively assume all sulfur $$_{S}-SO2$ / HV_{fuel} (Btu/lb) $$ CF_{Blu-HM}$ (16 lb/lb-mol) reactant, there is $$)). HV bark (dry) = 9,000 Btu/lb. \end{tabular} $	0:7, 769-772, DOI:10.1080 introduced to boiler is exh <sub>MBtu</sub> (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A	/00022470.1980.1046510 austed as SO <sub>2</sub> . oduct. 32 / 16 = 2.	7		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor $CF_{S\rightarrow SO2} = 2 \text{ lb } SO_2/\text{lb } S. S + O_2 \rightarrow S$ HV (heating value) wood (dry) = 8,66	Euel, Journal of the Air Oglesby and Blosser, Intent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S 57 Btu/lb. (5200/(1-0.4	$\begin{array}{l} \label{eq:solution} \mbox{Pollution Control Association, 30} \\ \mbox{conservatively assume all sulfur} \\ \mbox{s_{JSO2}} / \mbox{HV}_{fuel} \mbox{(Btu/lb)} X \mbox{CF}_{Blu-M} \\ \mbox{(16 lb/lb-mol) reactant, there is} \\ \mbox{)). HV bark (dry) = 9,000 \mbox{Btu/lb}. \\ \hline \mbox{Reasonable Upper Bound} \end{array}$	0:7, 769-772, DOI:10.1080, introduced to boiler is exh <sub>MBlu</sub> (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A 100% Conversion	/00022470.1980.1046510 austed as SO <sub>2</sub> . oduct: 32 / 16 = 2. -5 of Appendix A to AP-42	7 2, September 1985.		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor $CF_{S \rightarrow SO2} = 2  b SO_2/ b S. S + O_2 \rightarrow S$	Euel, Journal of the Air Oglesby and Blosser, ntent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S S7 Btu/lb. (5200/(1-0.4 Calculate SO <sub>2</sub> EF	Pollution Control Association, 3 conservatively assume all sulfur <sub>S→SO2</sub> / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>Btu→M</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content	0:7, 769-772, DOI:10.1080, introduced to boiler is exh MBtu (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A 100% Conversion CF <sub>S-SO2</sub>	/00022470.1980.1046510 austed as SO <sub>2</sub> . oduct. 32 / 16 = 2. -5 of Appendix A to AP-42 HV <sub>fuel</sub>	7 2, September 1985. CF <sub>Btu→MMBtu</sub>		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S HV (heating value) wood (dry) = 8,66 Fuel	Euel, Journal of the Air Oglesby and Blosser, Intent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S 57 Btu/lb. (5200/(1-0.4 Calculate SO <sub>2</sub> EF (lb/MMBtu)	Pollution Control Association, 3 conservatively assume all sulfur <sub>S→SO2</sub> / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>Btu→M</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight)	0:7, 769-772, DOI:10.1080, introduced to boiler is exh Metu (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A 100% Conversion CF <sub>SSO2</sub> (lb SO <sub>2</sub> /lb S)	/00022470.1980.1046510 austed as SO <sub>2</sub> . oduct. 32 / 16 = 2. -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb)	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu)		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S • HV (heating value) wood (dry) = 8,66	Cuel, Journal of the Air Oglesby and Blosser, Intent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S S7 Btu/lb. (5200/(1-0.4 Calculate SO <sub>2</sub> EF (lb/MMBtu) 0.462	Pollution Control Association, 3 conservatively assume all sulfur sso2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>Btu</sub> M (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,} \\ \text{introduced to boiler is exh} \\ \text{MBIU} (Btu/MMBtu) \\ 1 \ \text{mol SO}_2 (32 \ \text{lb/lb-mol) product} \\ (4500/(1-0.5)). \ \text{See page A} \\ \hline 100\% \ \text{Conversion} \\ \ \text{CF}_{S \rightarrow SO2} \\ (\text{lb SO}_2/\text{lb S}) \\ \hline 2 \end{array}$	/00022470.1980.1046510 austed as SO <sub>2</sub> . bduct. 32 / 16 = 2. -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb) 8667	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor $\circ$ CF <sub>S502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S $\circ$ HV (heating value) wood (dry) = 8,66 Fuel Wood Bark	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           B7 Btu/lb. (5200/(1-0.4           Calculate SO2 EF           (lb/MMBtu)           0.462           0.444	Pollution Control Association, 30 conservatively assume all sulfur sso2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2	0:7, 769-772, DOI:10.1080, introduced to boiler is exh Metu (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A 100% Conversion CF <sub>SSO2</sub> (lb SO <sub>2</sub> /lb S)	/00022470.1980.1046510 austed as SO <sub>2</sub> . oduct. 32 / 16 = 2. -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb)	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu)		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor $\bullet$ CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S $\bullet$ HV (heating value) wood (dry) = 8,66 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (lb/MMBtu)           0.462           0.444           dd 0.0444	Pollution Control Association, 30 conservatively assume all sulfur sSO2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,} \\ \text{introduced to boiler is exh} \\ \text{_MBtu} (Btu/MMBtu) \\ 1 \mbox{ mol SO}_2 (32 \mbox{ lb/lb-mol) pri} \\ (4500/(1-0.5)). See page A \\ \hline 100\% \mbox{ Conversion } \\ \mbox{ CF}_{S \rightarrow SO2} \\ \mbox{ (lb SO_2/lb S) } \\ \hline 2 \\ \hline 2 \\ \end{array}$	/00022470.1980.1046510 austed as SO <sub>2</sub> . oduct. 32 / 16 = 2. -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb) 8667 9000	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor $\cdot$ CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S $\cdot$ HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima	Fuel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4           Calculate SO2 EF           (Ib/MMBtu)           0.442           d 0.044 Ib/MMBtu for I           the of 0.2% by weight (	Pollution Control Association, 30 conservatively assume all sulfur s_SO2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. ( Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub>	0:7, 769-772, DOI:10.1080, introduced to boiler is exh <sub>MBtu</sub> (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A 100% Conversion CF <sub>S-S02</sub> (lb SO <sub>2</sub> /lb S) 2 2 . See H. S. Oglesby & R. C	/00022470.1980.1046510 austed as SO <sub>2</sub> . -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb) <u>8667</u> 9000 D. Blosser (1980) Informat	7 2, September 1985. CF <sub>Btu→MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor $\cdot$ CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S $\cdot$ HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima	Fuel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4           Calculate SO2 EF           (Ib/MMBtu)           0.442           d 0.044 Ib/MMBtu for I           the of 0.2% by weight (	Pollution Control Association, 30 conservatively assume all sulfur s_SO2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. ( Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub>	0:7, 769-772, DOI:10.1080, introduced to boiler is exh <sub>MBtu</sub> (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A 100% Conversion CF <sub>S-S02</sub> (lb SO <sub>2</sub> /lb S) 2 2 . See H. S. Oglesby & R. C	/00022470.1980.1046510 austed as SO <sub>2</sub> . -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb) <u>8667</u> 9000 D. Blosser (1980) Informat	7 2, September 1985. CF <sub>Btu→MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor $\circ$ CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S $\circ$ HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.462           0.444           d 0.044 Ib/MMBtu for I           ate of 0.2% by weight (	Pollution Control Association, 30 conservatively assume all sulfur s_SO2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. ( Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub> nal of the Air Pollution Control A	0:7, 769-772, DOI:10.1080 introduced to boiler is exh <sub>MBtu</sub> (Btu/MMBtu) 1 mol SO <sub>2</sub> (32 lb/lb-mol) pro (4500/(1-0.5)). See page A 100% Conversion CF <sub>S-S02</sub> (lb SO <sub>2</sub> /lb S) 2 2 . See H. S. Oglesby & R. C ssociation, 30:7, 769-772,	/00022470.1980.1046510 austed as SO <sub>2</sub> . -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb) <u>8667</u> 9000 D. Blosser (1980) Informat	7 2, September 1985. CF <sub>Btu→MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter		
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to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S • HV (heating value) wood (dry) = 8,66 Fuel Wood Bark Qption 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.462           0.444           dd 0.044 lb/MMBtu for I           the of 0.2% by weight (           Burned as a Fuel, Journ           assume that only 10%           net (%S) / 100] X CF           SO2. For every 1 mol S	Pollution Control Association, 3 conservatively assume all sulfur s_JSO2 / HV <sub>tuel</sub> (Btu/lb)} X CF <sub>Btu-HM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark dry) and 10% conversion to SO2 mal of the Air Pollution Control A of sulfur introduced to boiler is s_JSO2 / HV <sub>tuel</sub> (Btu/lb)} X CF <sub>Btu-HM</sub> (16 lb/lb-mol) reactant, there is	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,}\\ \text{introduced to boiler is exh}\\ \text{MBtu} (Btu/MMBtu)\\ 1 \mbox{mod} \ DOS_2 (32 \mbox{ lb/lb-mol}) \mbox{prod}\\ 100\% \ Conversion \ CF_{S-so2} \ (lb \ SO_2/lb \ S)\\ \hline 2 \ 2 \ Conversion \ CF_{S-so2} \ (lb \ SO_2/lb \ S)\\ \hline 2 \ Conversion \ CO$	/00022470.1980.1046510 austed as SO <sub>2</sub> . -5 of Appendix A to AP-42 HV <sub>fuel</sub> (Btu/lb) 8667 9000 D. Blosser (1980) Informat DOI:10.1080/00022470.1	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter 980.10465107		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S • HV (heating value) wood (dry) = 8,66 Fuel Wood Bark Qption 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4           Calculate SO2 EF           (Ib/MMBtu)           0.462           0.444           dd 0.044 lb/MMBtu for I           te of 0.2% by weight (           Burned as a Fuel, Jour           assume that only 10%           net (%S) / 100] X CF           SO2. For every 1 mol S           as SO2. The balance p	$\begin{array}{c} \label{eq:solution} \mbox{Control Association, 3i} \\ \mbox{conservatively assume all sulfur} \\ \mbox{solution} so$	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,}\\ \text{introduced to boiler is exh}\\ \text{MBhu} (Btu/MMBtu)\\ 1 \mbox{mol SO}_2 (32 \mbox{ lb/lb-mol}) \mbox{prod}\\ 100\% \mbox{ Conversion}\\ \hline CF_{S-so2}\\ (\mbox{ lb SO}_2/\mbox{ lb S})\\ \hline 2\\ \hline 2\\ \hline \\ \mbox{seciation, 30:7, 769-772,}\\ \mbox{exhausted as SO}_2.\\ \hline \text{MBhu} (Btu/MMBtu)\\ 1 \mbox{ mol SO}_2 (32 \mbox{ lb/lb-mol}) \mbox{ prod}\\ \mbox{mol sh} Multiplying \mbox{ by 0.1, res}\\ \end{array}$	$\begin{array}{c} \text{r00022470.1980.1046510} \\ \text{austed as SO}_2. \\ \text{oduct. 32 / 16 = 2.} \\ \text{-5 of Appendix A to AP-42} \\ \\ \hline \text{HV}_{\text{fuel}} \\ \\ \hline \text{(Btu/lb)} \\ \hline \text{8667} \\ \hline \text{9000} \\ \hline \text{OBIOSSER (1980) Informat} \\ \hline \text{DOI:10.1080/00022470.1} \\ \hline \text{oduct. 32 / 16 = 2. But eminimation CF}_{\text{S}\rightarrow\text{SO2}} = 0.2 \ \text{Ib S} \\ \hline \end{array}$	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter 980.10465107 piral data suggests that $O_2/lb$ S.		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S • HV (heating value) wood (dry) = 8,66 Fuel Wood Bark Qption 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (Ib/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S of sulfur is exhausted to atmosphere a	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4           Calculate SO2 EF           (Ib/MMBtu)           0.462           0.444           dd 0.044 lb/MMBtu for I           te of 0.2% by weight (           Burned as a Fuel, Jour           assume that only 10%           net (%S) / 100] X CF           SO2. For every 1 mol S           as SO2. The balance p	$\begin{array}{c} \label{eq:solution} \mbox{Control Association, 3i} \\ \mbox{conservatively assume all sulfur} \\ \mbox{solution} so$	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,}\\ \text{introduced to boiler is exh}\\ \text{MBhu} (Btu/MMBtu)\\ 1 \mbox{mol SO}_2 (32 \mbox{ lb/lb-mol}) \mbox{prod}\\ 100\% \mbox{ Conversion}\\ \hline CF_{S-so2}\\ (\mbox{ lb SO}_2/\mbox{ lb S})\\ \hline 2\\ \hline 2\\ \hline \\ \mbox{seciation, 30:7, 769-772,}\\ \mbox{exhausted as SO}_2.\\ \hline \text{MBhu} (Btu/MMBtu)\\ 1 \mbox{ mol SO}_2 (32 \mbox{ lb/lb-mol}) \mbox{ prod}\\ \mbox{mol sh} Multiplying \mbox{ by 0.1, res}\\ \end{array}$	$\begin{array}{c} \text{r00022470.1980.1046510} \\ \text{austed as SO}_2. \\ \text{oduct. 32 / 16 = 2.} \\ \text{-5 of Appendix A to AP-42} \\ \\ \hline \text{HV}_{\text{fuel}} \\ \\ \hline \text{(Btu/lb)} \\ \hline \text{8667} \\ \hline \text{9000} \\ \hline \text{OBIOSSER (1980) Informat} \\ \hline \text{DOI:10.1080/00022470.1} \\ \hline \text{oduct. 32 / 16 = 2. But eminimation CF}_{\text{S}\rightarrow\text{SO2}} = 0.2 \ \text{Ib S} \\ \hline \end{array}$	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter 980.10465107 piral data suggests that $O_2/lb$ S.		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor $CF_{S\rightarrow SO2} = 2 \text{ Ib SO}_2/\text{Ib S. S} + O_2 \rightarrow S$ HV (heating value) wood (dry) = 8,66 Fuel Wood Bark Detion 4: 0.046 Ib/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (Ib/MMBtu) = {[Upper bound S Cor $CF_{S\rightarrow SO2} = 2 \text{ Ib SO}_2/\text{Ib S. S} + O_2 \rightarrow S$ of sulfur is exhausted to atmosphere a	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4           Calculate SO2 EF           (Ib/MMBtu)           0.462           0.444           dd 0.044 lb/MMBtu for I           te of 0.2% by weight (           Burned as a Fuel, Jour           assume that only 10%           net (%S) / 100] X CF           SO2. For every 1 mol S           as SO2. The balance p	Pollution Control Association, 30 conservatively assume all sulfur $s_{3-302}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark dry) and 10% conversion to SO <sub>2</sub> mal of the Air Pollution Control A of sulfur introduced to boiler is a s-so <sub>2</sub> / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb.	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,}\\ \text{introduced to boiler is exh}\\ \text{MBIU} (Btu/MMBtu)\\ 1 \mbox{mod} SO_2 (32 \mbox{lb/lb-mol}) \mbox{pr}\\ (4500/(1-0.5)). See page A\\ \hline 100\% \ Conversion \ CF_{S \to SO2} \ (lb \ SO_2/lb \ S)\\ \hline 2 \ 2 \ 2 \ 2 \ 2 \ 2 \ 2 \ 2 \ 2 \ 2$	$\begin{array}{c} \text{r00022470.1980.1046510} \\ \text{austed as SO}_2. \\ \text{oduct. 32 / 16 = 2.} \\ \text{-5 of Appendix A to AP-42} \\ \\ \hline \text{HV}_{\text{fuel}} \\ \\ \hline \text{(Btu/lb)} \\ \hline \text{8667} \\ \hline \text{9000} \\ \hline \text{OBIOSSER (1980) Informat} \\ \hline \text{DOI:10.1080/00022470.1} \\ \hline \text{oduct. 32 / 16 = 2. But eminimation CF}_{\text{S}\rightarrow\text{SO2}} = 0.2 \ \text{Ib S} \\ \hline \end{array}$	7 2, September 1985. $CF_{Btu \rightarrow MMBtu}$ (Btu/MMBtu) 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 2, September 1985.		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor $CF_{S\rightarrow SO2} = 2 \text{ Ib SO}_2/\text{Ib S. S} + O_2 \rightarrow S$ HV (heating value) wood (dry) = 8,66 Fuel Wood Bark Detion 4: 0.046 Ib/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (Ib/MMBtu) = {[Upper bound S Cor $CF_{S\rightarrow SO2} = 2 \text{ Ib SO}_2/\text{Ib S. S} + O_2 \rightarrow S$ of sulfur is exhausted to atmosphere a	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (lb/MMBtu)           0.462           0.444           dd 0.044 lb/MMBtu for It           te of 0.2% by weight (           Burned as a Fuel, Jour           assume that only 10%           thetn (%S) / 100] X CF           SO2. For every 1 mol S           as SO2. The balance p           ST Btu/lb. (5200/(1-0.4)           Calculate SO2 EF	Pollution Control Association, 30 conservatively assume all sulfur $_{S \rightarrow SO2}$ / HV <sub>fuel</sub> (Btu/lb) X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub> mal of the Air Pollution Control A 5 of sulfur introduced to boiler is $_{S \rightarrow SO2}$ / HV <sub>fuel</sub> (Btu/lb) X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,} \\ \text{introduced to boiler is exh} \\ \text{_MBtu} (Btu/MMBtu) \\ 1 \mbox{ mol SO}_2 (32 \mbox{ lb/lb-mol}) \mbox{ prival} \\ 100\% \mbox{ Conversion} \\ \mbox{ CF}_{S \rightarrow SO2} \\ \mbox{ (lb SO}_2/\mbox{ lb S)} \\ \mbox{ 2 } \\ \mb$	$\begin{array}{l} \label{eq:2} \mbox{(20022470.1980.1046510)} \\ \mbox{austed as SO}_2. \\ \mbox{oduct. 32 / 16 = 2.} \\ \mbox{-5 of Appendix A to AP-42} \\ \mbox{HV}_{tuel} \\ \mbox{(Btu/lb)} \\ \mbox{8667} \\ \mbox{9000} \\ \mbox{2000} \\ \mbox$	7 2, September 1985. CF <sub>Btu→MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor $CF_{S\rightarrow SO2} = 2 \text{ lb } SO_2/\text{lb } S. S + O_2 \rightarrow S$ +HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor $CF_{S\rightarrow SO2} = 2 \text{ lb } SO_2/\text{lb } S. S + O_2 \rightarrow S$ of sulfur is exhausted to atmosphere a +HV (heating value) wood (dry) = 8,60	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           S02. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (lb/MMBtu)           0.462           0.444           d0.0441 lb/MMBtu for It           te of 0.2% by weight (           Sume that only 10%           thet (%S) / 100] X CF           SO2. For every 1 mol S           as SO2. The balance p           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (lb/MMBtu)	$\begin{array}{c} \label{eq:solution} \mbox{Control Association, 30} \\ \mbox{conservatively assume all sulfur} \\ conser$	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,} \\ \text{introduced to boiler is exh} \\ \text{_MBtu} (Btu/MMBtu) \\ 1 \mbox{ mol SO}_2 (32 \mbox{ lb/lb-mol}) \mbox{ prival} \\ 100\% \ Conversion \\ CF_{S-MS02} \\ (lb \ SO_2/lb \ S) \\ \hline 2 \\ \hline 2 \\ \hline 2 \\ \hline \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$\begin{array}{c} \text{(00022470.1980.1046510)} \\ \text{austed as SO}_2. \\ \text{oduct. 32 / 16 = 2.} \\ \text{-5 of Appendix A to AP-42} \\ \text{(Btu/lb)} \\ $	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu)		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S • HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,60	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           S02. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.462           0.444           d0.044 lb/MMBtu for           tte of 0.2% by weight (           3urned as a Fuel, Jour           assume that only 10%           ntent (%S) / 100] X CF           SO2. For every 1 mol S           as SO2. The balance p           37 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.046	$\begin{array}{c} \label{eq:solution} \mbox{Control Association, 30} \\ \mbox{conservatively assume all sulfur} \\ conser$	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,} \\ \text{introduced to boiler is exh} \\ \text{MBtu} (Btu/MMBtu) \\ 1 \mbox{mod} \ DOI \$	$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter 980.10465107 piral data suggests that O <sub>2</sub> /lb S. 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S • HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,60 Wood Bark	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SQ2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.462           0.444           d 0.044 lb/MMBtu for I           the of 0.2% by weight (           Burned as a Fuel, Jour           assume that only 10%           ntent (%S) / 100] X CF           SO2. The balance p           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.046           0.044	$\begin{array}{c} \label{eq:pollution} \mbox{Control Association, 30} \\ \mbox{conservatively assume all sulfur} \\ \mbox{conservatively all sulfur} \\ \mbo$	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,} \\ \text{introduced to boiler is exh} \\ \text{_MBtu} (Btu/MMBtu) \\ 1 \mbox{ mol SO}_2 (32 \mbox{ lb/lb-mol}) \mbox{ prival} \\ 100\% \ Conversion \\ CF_{S-MS02} \\ (lb \ SO_2/lb \ S) \\ \hline 2 \\ \hline 2 \\ \hline 2 \\ \hline \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$\begin{array}{c} \text{(00022470.1980.1046510)} \\ \text{austed as SO}_2. \\ \text{oduct. 32 / 16 = 2.} \\ \text{-5 of Appendix A to AP-42} \\ \text{(Btu/lb)} \\ $	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu)		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (Ib/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S • HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,60 Wood Bark Option 5: 0.069 lb/MMBtu for wood an	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           SO2. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.444           d 0.044 Ib/MMBtu for I           atte of 0.2% by weight (           Burned as a Fuel, Jour           assume that only 10%           ttent (%S) / 100] X CF           SO2. For every 1 mol S           as SO2. The balance p           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (Ib/MMBtu)           0.046           0.044           0.066	Pollution Control Association, 3 conservatively assume all sulfur $_{S\rightarrow SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub> mal of the Air Pollution Control A 5 of sulfur introduced to boiler is $G_{S\rightarrow SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080},\\ \text{introduced to boiler is exh}\\ \text{MBtu} (Btu/MMBtu)\\ 1 \mbox{mod} \ DOS (32 \mbox{lb/lb-mol}) \mbox{prd} \\ 100\% \ Conversion \ CF_{SS02} \ (lb \ SO_2/lb \ S) \\ \hline 2 \\ 2 \\$	$\label{eq:constraint} \begin{array}{l} & \text{MO022470.1980.1046510} \\ \text{austed as SO}_2. \\ & \text{soduct. 32 / 16 = 2.} \\ & -5 \text{ of Appendix A to AP-42} \\ & \text{HV}_{\text{fuel}} \\ & (\text{Btu/lb}) \\ & & 8667 \\ & 9000 \\ \hline \\ \text{OBIOSSER (1980) Informat DOI:10.1080/00022470.11 \\ & \text{DOI:10.1080/00022470.11} \\ \hline \\ & soduct. 32 / 16 = 2. But emmediate the second second$	7 2, September 1985. CF <sub>Btu→MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 ion on the Sulfur Conter 980.10465107 piral data suggests that O <sub>2</sub> /lb S. 2, September 1985. CF <sub>Btu→MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S-502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S • HV (heating value) wood (dry) = 8,66 Fuel Wood Bark <u>Option 4</u> : 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S-502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,66 Wood Bark <u>Wood</u> Bark <u>Option 5</u> : 0.069 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima	Fuel, Journal of the Air Oglesby and Blosser, thent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S 67 Btu/lb. (5200/(1-0.4 Calculate SO <sub>2</sub> EF (lb/MMBtu) 0.462 0.444 d 0.044 lb/MMBtu for I ate of 0.2% by weight ( Burned as a Fuel, Jour assume that only 10% thent (%S) / 100] X CF SO <sub>2</sub> . For every 1 mol S as SO <sub>2</sub> . The balance p 67 Btu/lb. (5200/(1-0.4 Calculate SO <sub>2</sub> EF (lb/MMBtu) 0.046 0.044 d 0.067 lb/MMBtu for I the of 0.2% by weight (	Pollution Control Association, 30 conservatively assume all sulfur $s_{-SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark dry) and 10% conversion to SO <sub>2</sub> mal of the Air Pollution Control A of Sulfur introduced to boiler is $s_{-SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark dry) and 15% conversion to SO <sub>2</sub>	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,}\\ \text{introduced to boiler is exh}\\ \text{MBILU} (Btu/MMBtu)\\ 1 \mbox{mod} \ DOS (32 \mbox{lb/lb-mol}) \mbox{pr}\\ 2 \mbox{c}\\ 2 \mbox{mod} \mbox{pr}\\ 2 \mbox{c}\\ 2 \mbox{c}\ 2 \mbox{c}\\ 2 \mbox{c}\ 2 \mbox{c}$	$00022470.1980.1046510$ austed as SO2.         oduct. 32 / 16 = 2.         -5 of Appendix A to AP-42 $HV_{tuel}$ (Btu/lb)         8667         9000         D. Blosser (1980) Informat         DOI:10.1080/00022470.11         oduct. 32 / 16 = 2. But em         vultant CF <sub>SS02</sub> = 0.2 lb S         -5 of Appendix A to AP-42         HV <sub>fuel</sub> (Btu/lb)         8667         9000	7 2, September 1985. CF <sub>Btu-MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 CF <sub>Btu-MMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S • HV (heating value) wood (dry) = 8,66 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,66 Wood Bark Option 5: 0.069 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E	$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	Pollution Control Association, 30 conservatively assume all sulfur $s_{s-SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub> mal of the Air Pollution Control A of sulfur introduced to boiler is a s-so <sub>2</sub> / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 15% conversion to SO <sub>2</sub> mal of the Air Pollution Control A	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080,}\\ \text{introduced to boiler is exh}\\ \text{MBILU} (Btu/MMBtu)\\ 1 \mbox{mod}\ SO_2(32\ lb/lb-mol)\ prives (4500/(1-0.5)). See page A\\ \hline 100\%\ Conversion \ CF_{S \to SO2} \ (lb\ SO_2/lb\ S)\\ \hline 2\\ \hline 2\\ \hline 2\\ \hline \\ \text{See H. S. Oglesby & R. C}\\ \text{ssociation, 30:7, 769-772,}\\ \text{(lb\ SO_2/lb\ S)}\\ \hline \\ 1 \ mol\ SO_2(32\ lb/lb-mol)\ prives page A\\ \hline 10\%\ Conversion \ CF_{S \to SO2} \ (lb\ SO_2/lb\ S)\\ \hline \\ 0.2\\ \hline 0.2\\ \hline \\ 0.2\\ \hline \\ 0.2\\ \hline \\ 0.2\\ \hline 0.2\\ $	$00022470.1980.1046510$ austed as SO2.         oduct: 32 / 16 = 2.         -5 of Appendix A to AP-42 $HV_{tuel}$ (Btu/lb)         8667         9000         D. Blosser (1980) Informat         DOI:10.1080/00022470.11         bduct. 32 / 16 = 2. But em         bduct. 32 / 16 = 3. But em	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 1.0E+06 1.0E+06 CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06 1.0E+06		
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to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S • HV (heating value) wood (dry) = 8,60 Fuel Wood Bark Option 4: 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,60 Wood Bark Option 5: 0.069 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Assuming that 15 percent of sulfur intr conversion factor is a reasonable upp Oglesby and Blosser. EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S→SO2</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> → S of sulfur is exhausted to atmosphere a	Euel, Journal of the Air           Oglesby and Blosser,           ntent (%S) / 100] X CF           S02. For every 1 mol S           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (lb/MMBtu)           0.462           0.444           d0.044 lb/MMBtu for It           GS02. For every 1 mol S           as SO2. The balance p           S7 Btu/lb. (5200/(1-0.4)           Calculate SO2 EF           (lb/MMBtu)           0.046           0.046           0.047           d0.067 lb/MMBtu for It           te of 0.2% by weight (           Burned as a Fuel, Jour           roduced to boiler is ext           orduced to boiler is ext           er bound estimate give           thet of (%S) / 100] X CF           So2. The balance p           Sta SO2. The balance p           Sta SO2. The balance p           Sta SO2. The b	Pollution Control Association, 30 conservatively assume all sulfur $s_{-SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>Blu-M</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. ( Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub> mal of the Air Pollution Control A of sulfur introduced to boiler is $s_{-SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>Blu-M</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. ( Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 15% conversion to SO <sub>2</sub> mal of the Air Pollution Control A hausted as SO <sub>2</sub> strikes a balance en that Option 4's 10% conversion recipitates out as sulfates in the is recipitates out as sulfates in the bark (dry) and 15% conversion to SO <sub>2</sub> mal of the Air Pollution Control A hausted as SO <sub>2</sub> strikes a balance en that Option 4's 10% conversion (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. ( Reasonable Upper Bound Fuel Sulfur Content (W bark (dry) = 9,000 Btu/lb.) Reasonable Upper Bound Fuel Sulfur Content	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080},\\ \text{introduced to boiler is exh}_{\text{MBtu}} (Btu/MMBtu) \\ 1 \mbox{mod} mol SO_2 (32 lb/lb-mol) prives (4500/(1-0.5)). See page A \\ \hline 100\% Conversion CF_{SSO2} (lb SO_2/lb S) \\ \hline 2 \\ 2 \\$	$00022470.1980.1046510$ austed as SO2.         oduct. 32 / 16 = 2.         -5 of Appendix A to AP-42 $HV_{tuel}$ (Btu/lb)         8667         9000         D. Blosser (1980) Informat         DOI:10.1080/00022470.11         cduct. 32 / 16 = 2. But em         utant CF <sub>SS02</sub> = 0.2 lb S         -5 of Appendix A to AP-42         HV <sub>fuel</sub> (Btu/lb)         8667         9000         DOI:10.1080/00022470.11         8667         9000         D. Blosser (1980) Informat         DOI:10.1080/00022470.11         and Option 4's 10% sulfamited amount of data from         cduct. 32 / 16 = 2. Assumment         sultant CF <sub>SS02</sub> = 0.3 lb 15         -5 of Appendix A to AP-42 $HV_{fuel}$ -5 of Appendix A to AP-42 $HV_{fuel}$	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E		
to SO <sub>2</sub> Emissions when Burned as a F Despite evidence to the contrary from EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S-:502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S • HV (heating value) wood (dry) = 8,66 Fuel <u>Wood</u> Bark <u>Option 4</u> : 0.046 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Consistent with Oglesby and Blosser, EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S-:502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,66 <u>Wood</u> Bark <u>Option 5</u> : 0.069 lb/MMBtu for wood an Basis: Bark upper bound sulfur estima Contribution to SO <sub>2</sub> Emissions when E Assuming that 15 percent of sulfur intr conversion factor is a reasonable upp Oglesby and Blosser. EF (lb/MMBtu) = {[Upper bound S Cor • CF <sub>S-:502</sub> = 2 lb SO <sub>2</sub> /lb S. S + O <sub>2</sub> $\rightarrow$ S of sulfur is exhausted to atmosphere a • HV (heating value) wood (dry) = 8,66	$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	Pollution Control Association, 3 conservatively assume all sulfur $s_{-SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark (dry) and 10% conversion to SO <sub>2</sub> mal of the Air Pollution Control A 5 of sulfur introduced to boiler is $s_{-SO2}$ / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight) 0.2 0.2 bark dry) and 15% conversion to SO <sub>2</sub> mal of the Air Pollution Control A hausted as SO <sub>2</sub> strikes a balance en that Option 4's 10% conversion (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the is-so2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the is-so2 / HV <sub>fuel</sub> (Btu/lb)} X CF <sub>BtuM</sub> (16 lb/lb-mol) reactant, there is recipitates out as sulfates in the )). HV bark (dry) = 9,000 Btu/lb. Reasonable Upper Bound Fuel Sulfur Content (% by weight)	$\begin{array}{c} \text{D:7, 769-772, DOI:10.1080},\\ \text{introduced to boiler is exh}_{\text{MBIu}} (Btu/MMBtu) \\ 1 \mbox{mod} mol SO_2 (32 lb/lb-mol) prives (4500/(1-0.5)). See page A 100% Conversion CF_{SSO2} (lb SO_2/lb S) 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 $	$00022470.1980.1046510$ austed as SO2.         oduct. 32 / 16 = 2.         -5 of Appendix A to AP-42 $HV_{fuel}$ (Bfu/lb)         8667         9000         D. Blosser (1980) Informat         DOI:10.1080/00022470.11         cduct. 32 / 16 = 2. But em         cduct. 32 / 16 = 2. Soutem         cduct. 32 / 16 = 2. Soutem         cduct. 32 / 16 = 2. Soutem         could amount of data from         could amount of data from         could amount of a a Appendix A to AP-42         HV <sub>fuel</sub> cgtu/ta         cold Appendix A to AP-42         HV <sub>fuel</sub> cgtu/ta         cgtu/ta         cgtu/ta         cgtu/ta         cgtu/ta         cgtu/ta         cgtu/ta         cgtu/ta         <	7 2, September 1985. CF <sub>BtuMMBtu</sub> (Btu/MMBtu) 1.0E+06 1.0E		

r	Option 1: 0.017 lb/MADtu						
8	Option 1: 0.017 lb/MMBtu	4.0.0					
	Basis: AP-42, September 2003. Table	1.6-3.					
	<u>Option 1</u> : 195 lb CO <sub>2</sub> e/IMBtu Basis: (a) AP-42, September 2003. Table 1.6-3. (b) 40 CFR 98, Subpart A. Table A-1.						
	EF (lb CO <sub>2</sub> e/MMBtu) = EF (lb CO <sub>2</sub> /MM						
	AP-42 Calculated CO <sub>2</sub> e EF	AP-42 EF	40 CFR 98 GWP <sub>CO2</sub>				
	(Ib CO <sub>2</sub> e/MMBtu)	(lb CO <sub>2</sub> /MMBtu)	(lb CO <sub>2</sub> e/lb CO <sub>2</sub> )				
	195.0	195	1				
9	Option 2: 206.8 lb CO <sub>2</sub> e/MMBtu						
	Basis: (a) 40 CFR 98, Subpart C. Table	( )					
	EF (lb CO <sub>2</sub> e/MMBtu) = EF (kg CO <sub>2</sub> /MM	1Btu) X CF <sub>kg→lb</sub> (lb/kg)	X GWP <sub>CO2</sub> (lb CO <sub>2</sub> e/lb CO <sub>2</sub> )	-			
	40 CFR 98			40 CFR 98			
	Calculated CO <sub>2</sub> e EF	40 CFR 98 EF	CF <sub>kg→lb</sub>	GWP <sub>CO2</sub>			
	(Ib CO <sub>2</sub> e/MMBtu)	(kg CO <sub>2</sub> /MMBtu)	(lb/kg)	(lb CO <sub>2</sub> e/lb CO <sub>2</sub> )			
	206.8	93.8	2.20462262	1			
	Option 1: 0.525 lb CO2e/MMBtu						
	Basis: (a) AP-42, September 2003. Ta	. ,	•				
	EF (lb CO <sub>2</sub> e/MMBtu) = EF (lb CH <sub>4</sub> /MM	Btu) X GWP <sub>CH4</sub> (lb CO	D <sub>2</sub> e/lb CH <sub>4</sub> )				
	AP-42 Calculated CO <sub>2</sub> e EF	AP-42 EF	40 CFR 98 GWP <sub>CH4</sub>				
	(lb CO <sub>2</sub> e/MMBtu)	(Ib CH <sub>4</sub> /MMBtu)	(lb CO <sub>2</sub> e/lb CH <sub>4</sub> )				
	0.525	0.021	25				
10	Option 2: 1.764 lb CO <sub>2</sub> e/MMBtu						
	Basis: (a) 40 CFR 98, Subpart C. Table	e C-2. (b) 40 CFR 98,					
	EF (Ib CO <sub>2</sub> e/MMBtu) = EF (kg CH <sub>4</sub> /MM	lBtu) X CF <sub>kg→lb</sub> (lb/kg)	X GWP <sub>CH4</sub> (lb CO <sub>2</sub> e/lb CH <sub>4</sub> )				
	40 CFR 98			40 CFR 98 GWP <sub>CH4</sub>			
	Calculated CO <sub>2</sub> e EF	40 CFR 98 EF	CF <sub>kg→lb</sub>	GWP <sub>CH4</sub>			
	(lb CO <sub>2</sub> e/MMBtu)	(kg CH <sub>4</sub> /MMBtu)	(lb/kg)	(lb CO <sub>2</sub> e/lb CH <sub>4</sub> )			
	1.764	0.032	2.20462262	25			
	Option 1: 3.874 lb CO2e/MMBtu						
	Basis: (a) AP-42, September 2003. Ta	ble 1.6-3. (b) 40 CFR	98, Subpart A. Table A-1.				
	EF (lb CO <sub>2</sub> e/MMBtu) = EF (lb N <sub>2</sub> O/MM	Btu) X GWP <sub>N2O</sub> (lb Co	D <sub>2</sub> e/lb N <sub>2</sub> O)				
	AP-42 Calculated CO <sub>2</sub> e EF	AP-42 EF	40 CFR 98 GWP <sub>N20</sub>				
	(lb CO <sub>2</sub> e/MMBtu)	(lb N <sub>2</sub> O/MMBtu)	(Ib CO <sub>2</sub> e/Ib N <sub>2</sub> O)				
	3.874	0.013	298				
11	Option 2: 2.759 lb CO <sub>2</sub> e/MMBtu			-			
	Basis: (a) 40 CFR 98, Subpart C. Tabl	e C-2. (b) 40 CFR 98,	Subpart A. Table A-1.				
	EF (lb CO <sub>2</sub> e/MMBtu) = EF (kg N <sub>2</sub> O/MM	lBtu) X CF <sub>kg→lb</sub> (lb/kg)	X GWP <sub>N2O</sub> (lb CO <sub>2</sub> e/lb N <sub>2</sub> O)				
	40 CFR 98			40 CFR 98			
	Calculated CO <sub>2</sub> e EF	40 CFR 98 EF	CF <sub>kg→lb</sub>	GWP <sub>N20</sub>			
	(lb CO <sub>2</sub> e/MMBtu)	(kg N <sub>2</sub> O/MMBtu)	(lb/kg)	(lb CO <sub>2</sub> e/lb N <sub>2</sub> O)			
	2.759	0.0042	2.20462262	298			

Acronyms

ACF: Annual Capacity Factor for Wood

C: Construction

CF: Conversion Factor

EF: Emission Factor

FARR: Federal Air Rules for Reservations

GWP: Global Warming Potential

HV: Heating Value

M: Modification

MW: Molecular Weight

NESHAP: National Emission Standards for Hazardous Air Pollutants

PTE: Potential to Emit

R: Reconstruction