

## **Recommended Procedure for Compiling Emission Inventory Data for Manufactured Wax/Sawdust Fireplace Logs**

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### **Introduction**

A recommended procedure for compiling emission inventory activity data for residential wood combustion has been submitted to the U.S. Environmental Protection Agency<sup>1,2</sup>. Activity levels (the amount of wood used) for fireplaces were included in the procedure. Fireplace activity levels were calculated by multiplying the number of fireplaces in use by the average wood burn rate per unit. The average wood burn rate per unit was estimated from the review of numerous surveys. Burn rates for two categories of fireplace usage were estimated. These were: (1) heating, and, (2) aesthetic. Fireplaces without inserts only were included in the "fireplace" category since fireplaces with inserts are more like woodstoves in their usage patterns and emission factors.

It has been estimated from surveys that manufactured wax/sawdust fireplace logs (firelogs) are burned exclusively in 12% to 15% of wood burning fireplaces (without inserts) that are in use and burned some of the time in 28% to 30% of them<sup>3,4,5</sup>. Further, it has been estimated that 100 million manufactured fireplace logs are sold each year<sup>5</sup>. The cordwood equivalents of manufactured fireplace logs need to be subtracted from the calculated cordwood activity value to provide an accurate fireplace cordwood activity value. In addition, emission factors for manufactured fireplace logs need to be multiplied by their activity value to take into consideration the contribution of manufactured wax/sawdust fireplace logs to particulate emissions.

Manufactured wax/sawdust fireplace logs are made for one-at-a time use in fireplaces (not for use in woodstoves or fireplace inserts) and require no kindling due to their wax content. They have almost twice the heat content and one tenth the moisture content of seasoned cordwood. (15,700 BTU/dry lb. and 2% moisture wet basis for fireplace logs versus approximately 8800 BTU/ dry lb. and 20% moisture for well-seasoned cordwood). Because of these differences and because their burning and usage characteristics are different, a one-to-one comparison between manufactured fireplace logs and cordwood cannot be made but rather an equivalent value based on their

respective typical usage in fireplaces has been developed.

Example calculations have been completed for 1997 and 1999 base years. The 1997 base year has been included to be consistent with the recommended residential wood combustion activity procedure document<sup>1,2</sup> submitted to the U.S. EPA which uses the 1997 base year for example calculations. The 1999 base year activity data has been included for use in the 1999 national emission inventory. As with the residential wood combustion activity procedure, the manufactured fireplace log activity procedure was designed to use public sector American Housing Survey (AHS) and Energy Information Administration (EIA) reports for regular updates.

**Manufactured Wax/Sawdust Fireplace Log Activity**

The national and regional (U.S.Census Bureau regions) activity data for the wax/sawdust fireplace logs for the Sept. 98 to Sept. 99 time period are shown in Table 1. The data were calculated from a national survey of firelog use<sup>6,7</sup>. The total weight of logs was calculated from the number of logs multiplied by the average wet weight per log. The average wet weight per log was calculated as 4.95 lbs. This average is based on 40% 6 lb. logs, 35% 5 lb. logs, 25% 3.2 lb. logs, and an insignificant number of 3lb and 2.5 lb. logs<sup>7</sup>. The Sept 98 to Sept 99 weight was adjusted to the 1997 and 1999 base years by interpolating the number of fireplaces between 1997 and 1999 to the Sept. 98 to Sept 99 time period then using the ratios of the number of fireplaces to calculate the weight of fireplace logs used in the 1997 and 1999 base years. The data are shown in Tables 2 and 3. The number of fireplaces in use in 1997 and 1999 were obtained from AHS documents<sup>8,9</sup>. The wet weight of manufactured fireplace logs was multiplied by 0.98 to get the dry weight since proximate/ultimate analyses of the logs show that the typical moisture content on a wet basis is 2%. For interest, the number of homes built in 1997 that contain one or more fireplaces<sup>10</sup> is also shown in Table 2. It should be emphasized that the values in Table 1 are for wax/sawdust manufactured fireplace logs only and do not include manufactured densified logs. It is estimated that there are less than 10 million densified logs manufactured annually, they are mostly manufactured in the Northwest and are designed primarily for use in woodstoves<sup>11</sup>. It is also estimated that 85% to 90% of them are used in woodstoves rather than fireplaces as they are more difficult to start in a fireplace for an occasional fire. Consequently, the contribution of densified logs to fireplace fuel is small, although it should be noted that they do produce lower emissions than cordwood<sup>12, 13</sup>.

Table 1  
Manufactured Wax/Sawdust Fireplace Log Activity Levels – Sept. 98 to Sept. 99

Region	Percent of logs by region	Sept. 98 – Sept. 99 total logs	Sept. 98 – Sept. 99 weight of logs (tons)
National	100	103,738,112	256,752
Northeast	11	11,411,192	28,243
Midwest	9	9,336,430	23,108
South	37	38,383,101	94,998
West	43	44,607,388	110,403

Table 2  
Adjustment of Activity Levels to the 1997 and 1999 Base Years (Part 1)

Region	Homes with usable fireplaces 1997	Homes with usable fireplaces 1999	Homes with usable fireplaces as of Sept 1999	Percent of homes built in 1997 with fireplaces
National	31,825,000	33,269,000	33,088,500	61.2
Northeast	5,015,000	5,035,000	5,032,500	59.1
Midwest	6,604,000	6,909,000	6,905,188	60.2
South	10,983,000	11,672,000	11,585,875	59.9
West	9,223,000	9,672,000	9,615,875	66.0

Table 3  
Adjustment of Activity to the 1997 and 1999 Base Years (Part 2)

Region	Ratio of homes with fireplaces, 1997/Sept. 1999	Ratio of homes with fireplaces, 1999/Sept. 1999	Dry weight wax/sawdust fireplace logs 1997 base year (tons)	Dry weight wax/sawdust fireplace logs 1999 base year (tons)
National	0.962	1.005	242,055	252,875
Northeast	0.996	1.000	27,567	27,015
Midwest	0.956	1.001	21,649	22,668
South	0.948	1.007	88,257	93,749
West	0.959	1.006	103,758	108,844

### **Reduction to Fireplace Cordwood Activity Levels and Environmental Significance**

While the calculation of wax/sawdust fireplace log activity (dry tons used per year) is straight forward, the calculation of the reduction in the cordwood usage and concomitant change in overall particulate emissions due to the use of fireplace logs is more complex. The distribution of fireplace cordwood burn rates is shown in Table 4. These data are derived from a review of fireplace literature and are based on 377 tests on 177 models of fireplaces<sup>14</sup>. The size distribution of the 177 fireplace models used in the 377 tests are not representative of the distribution of the size in home use in the United States, as the data based contained a disproportionate number of

larger fireplaces. The most common fireplace type currently in use in homes in the United States is a 36-inch, zero-clearance manufactured unit. The 36-inch, other than some rare exceptions, is also the smallest common size fireplace in use. Experimentation with a representative 36-inch zero clearance fireplace revealed that burn rates between 3 kg/hr to 3.5 dry kg/hr were normal-appearing, reasonable burn rates for a 36-inch fireplace<sup>15,16</sup>. The overall national average burn rate for fireplaces will be higher than that typical for 36 inch fireplaces due to larger fireplaces in use. Review of individual tests and the distribution of burn rates from the 377 tests revealed that 4 dry kg/hr is a reasonable conservative estimate for an average fireplace burn rate. It should be noted that 4.0 dry kg/hr is also the mode for the distribution of burn rates for the 377 tests.

Table 4  
Cordwood Burn Rates in Fireplaces

Parameter	Burn rate (dry kg/hr)
mean <sup>1</sup>	5.6
mean minus standard deviation <sup>1</sup>	2.4
median <sup>1</sup>	4.8
mode <sup>1</sup>	4.0
36 inch typical fireplace <sup>2</sup>	2.9-3.4

1. 377 tests on 177 models
2. references 15 and 16

The average burn duration for a fireplace in homes is three hours<sup>17</sup>. Three hours multiplied by 4 dry kg/hr yields 12 dry kg of cordwood. The burn duration of a typical six pound manufactured fireplace log is 4.15 hours from start to the last “flicker” of flames<sup>18</sup>. As previously mentioned, due to their higher BTU content and label instructions, manufactured fireplace logs are burnt one-at-a-time. Based on observations, most home users would consider a 6 lb. log to produce about three hours of “quality” flames. Consequently, 12 dry kg of cordwood corresponds to approximately 2.67 dry kg of manufactured fireplace log mass (6 lbs. X 0.98 dry lbs./wet lb. X 0.454 kg/lb.). Table 5 illustrates the adjustment in the 1997 annual cordwood values calculated for fireplaces<sup>1</sup> when manufactured fireplace log use is taken into consideration.

Table 5  
Estimate of Cordwood Activity Reduction by the Use of Wax/Sawdust Fireplace Logs

Region	Cordwood consumed in fireplaces without inserts, 1997, calculated without considering wax/sawdust fireplace logs (dry tons)	Approximate cordwood equivalent value for wax/sawdust fireplace logs used in 1997 (dry tons)	Cordwood value adjusted for wax/sawdust fireplace log use 1997 (dry tons)
National	3,980,949	1,086,827	2,829,092
Northeast	429,147	123,776	305,371
Midwest	660,584	97,204	563,380
South	1,537,486	396,274	1,141,212
West	1,352,569	465,873	886,696

Using the PM<sub>10</sub> emission factor for fireplaces burning cordwood published in AP-42 of 34.6 lbs./ton<sup>19</sup> and the PM<sub>10</sub> emission factor for typical manufactured fireplace logs of 51.8 lbs./ton<sup>20</sup>, the change in PM<sub>10</sub> emission through the use of manufactured fireplace logs can be calculated (Tables 6 and 7). It should be noted that even though the emission factor is higher for manufactured fireplace logs than cordwood burned in fireplaces, the net outcome is fewer particles are emitted into the atmosphere when manufactured fireplace logs replace cordwood due to the smaller mass of manufactured fireplace logs used. It also should be noted that the total particulate (PM) emissions, and PM<sub>2.5</sub> emissions are approximately the same as PM<sub>10</sub> emissions for both cordwood and manufactured fireplace logs since the particulate emissions from both fuels are predominately submicron, albeit there appears to be slightly less fine particles in the emissions from manufactured fireplace logs than cordwood<sup>15,16,21,22</sup>.

Table 6  
PM<sub>10</sub> Fireplace Emissions – 1997 (Part1)

Region	PM <sub>10</sub> emissions from cordwood without firelog adjustment (tons)	PM <sub>10</sub> emissions from firelogs (tons)	PM <sub>10</sub> emissions from cordwood with firelog adjustment (tons)
National	68,870	6269	49,085
Northeast	7424	714	5298
Midwest	11,428	561	9775
South	26,598	2286	19,800
West	23,399	2687	15,384

Table 7  
PM<sub>10</sub> Fireplace Emissions – 1997 (Part2)

Region	Sum of PM <sub>10</sub> emissions from cordwood adjusted for firelog use plus PM <sub>10</sub> emissions from firelog use (tons) (sum of columns 2 and 3, Table 6)	“Environmental Gain” Difference in PM <sub>10</sub> emissions when firelog use is taken into consideration (tons) (column 1, Table 6 minus column 1 this table)
National	55,354	13,516
Northeast	6012	1412
Midwest	10,336.	1092
South	22,086.	4512
West	18,071	5328

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