



# SUMMERHILL BIOMASS SYSTEMS

210 Fayette Street | Manlius | NY 13104 | 202.540.8032 | Fax: 610.980.5433



## Summary of Summerhill Flue Gas Emissions Test Results and Comparisons with Oil and Pellet Burner Emissions

*Prepared by James T. McKnight and James Kimball McKnight*

### Procedures used for Summerhill combustion tests.

*Continued burner flue gas test results as of 8-27-11*

Adjustments of the air supply for the burner were made with the objective of minimum carbon monoxide emissions and these gave the following results:

With the 4ft straight sample tube (no jacket) placed approximately 2 inches inside the end of burner tube with approximately 2.5 inches directly exposed to the flue gas the readings stabilized at 25 ppm carbon monoxide at 10.5% oxygen. Further adjustments were made with stable readings of 7 ppm at 9.5% oxygen. The flue gas temperature at the end of the combustion tube with these conditions was 1500 F.

There was no visible evidence of the flame under these conditions.

Even under these sampling procedures there was clearly a time variation in the paired carbon monoxide/oxygen results.

Each test begins with the meter reading 20.8 % oxygen and 0 ppm carbon monoxide. The tube is then placed in the flue gas stream and over a period of 30 seconds, as described previously the reported oxygen levels drop and the carbon monoxide levels rise and then over the next approximately 20 seconds will drop significantly to an approximately stable level, plus or minus 10% of the reading.

A set of tests with these same air adjustments was performed with the water jacketed sample tube at the same sample point with approximate 2 inches exposed to the flue gas:

These results were in the range of 9 ppm carbon monoxide at 7% oxygen.

The air supply was then adjusted so that the flame extended approximately 4 inches beyond the end of the combustion tube:

At the end of the combustion tube the temperature was 1890 F and carbon monoxide reading was 3000 ppm with 1% oxygen (i.e., insufficient secondary air addition).

These results suggest that with further refinement carbon monoxide levels in the range of 20ppm or less at 7% oxygen could be standard performance.



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## Conclusions—comparison with oil, wood pellet, or natural gas burners

At the higher capacity burner settings, representative results were 50 ppm carbon monoxide at 8% oxygen with a flame temperature of 1500F.

The 50 ppm measured in the flue gas is equivalent to 80 ppm/lb of air used for complete combustion  
The lbs of carbon monoxide produced per lb of wood burned =  $7 \times 80 / 1000000 = 0.00056$  lbs of carbon monoxide released per 7500 btu.

With the above as baseline the lbs of carbon monoxide released per million btu =  $0.00056 \times 1000000 / 7500 = 0.075$  lbs carbon monoxide per million btu used or 0.03 lbs carbon monoxide if the carbon monoxide concentration is 20ppm instead of 50ppm. At 7ppm carbon monoxide, a level which has been demonstrated with Summerhill Burners, the results are even better than the best oil burner results (see derivation below).

The following tightened emission standards have been proposed in the US<sup>1</sup>:

Oil combustion emission factors = 5 lb carbon monoxide / 1000 gal.  
=  $5 \text{ lb CO} / 1000 \text{ gal} / 140,000 \text{ btu} / \text{gal} \times 1000000 \text{ btu} = 0.036$  lbs carbon monoxide per million btu used (It should be noted that oil combustion emissions also include condensable organics which are the oil burner odor.)

Biomass combustion proposed limits = 500 to 40 ppm carbon monoxide at 3% oxygen depending on burner system used.

Natural gas limits = 1 ppm carbon monoxide

<sup>1</sup> The proposed rules concerning carbon monoxide limits are discussed in the Federal Register Vol. 75 No. 107 issued Friday June 4 2010 Proposed rules, see pages 32012 to 32029; EPA proposed Rules 6-10 retrieved from <http://www.gpo.gov/fdsys/pkg/FR-2010-06-04/html/2010-10827.htm>

Note: EPA rules have superseded the above as of March 21, 2011. Retrieved from [http://www.cleaverbrooks.com/uploadedFiles/PDF%20Packet%20For%20Website\(2\).pdf](http://www.cleaverbrooks.com/uploadedFiles/PDF%20Packet%20For%20Website(2).pdf)