



Project Summary

Analysis of Residential Coal Stove Emissions

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The report provides combustion conditions and compound-specific organic analyses on residential coal stoves burning both bituminous and anthracite fuels. A Modified Method 5 collection system, evacuated glass bulbs, and gravimetric fuel depletion measurements were used to sample effluents and gauge burn rates. One stove tested was a residential appliance primarily designed for wood combustion then modified by the manufacturer for coal use. The report describes combustion parameters, concentrations of volatile organic constituents, and measured concentrations of several polynuclear aromatic hydrocarbons.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This study was a cooperative program with the Vermont Agency of Environmental Conservation. Some interest has been shown in the Northeastern United States about the effects of coal combustion in residential appliances, especially stoves designed to use wood then retrofitted for coal. These stoves may not contain the proper engineering criteria for clean operation when burning coal fuel, especially Eastern bituminous coal. The State of Vermont has instituted a detailed residential research program to evaluate impacts of residential coal com-

bustion. Table 1 summarizes the tests conducted.

Table 1. Stove Tests

| <i>Unit</i> | <i>Fuel</i> | |
|---|-------------------|-------------------|
| <i>Converted Coal/ Wood Stove (low burn rate)</i> | <i>Bituminous</i> | <i>Anthracite</i> |
| <i>Residential Coal Stove (high burn rate)</i> | <i>Bituminous</i> | <i>Anthracite</i> |
| <i>Residential Coal Stove (low burn rate)</i> | <i>Bituminous</i> | <i>Anthracite</i> |

A primary goal of this study was to investigate the levels of air pollutants and organic constituents found in small residential coal-fired stoves when operated in a manner characteristic of home heating. The two stoves investigated in this program operated from 22,000 to 57,000 Btu/hr (23 to 60 MJ/hr) and are characteristic of small hand-stoked stoves used in the United States for residential space heating. One stove, designed by the manufacturer for coal combustion, was operated at a high burn rate and in an air-starved mode which generated a low burn rate. The second stove, primarily designed for wood combustion, had been modified by the manufacturer to accommodate coal. Each stove was tested with anthracite and bituminous coal to evaluate the effect of the two fuels on emissions.

Analyses included fixed combustion gases, condensable organics, Method 5 particulates, principal volatile compound screening by gas mass spectrometry



(GMS), and polynuclear aromatic hydrocarbon (PAH) analysis by high resolution gas chromatography/mass spectrometry (GC/MS).

The stove operating data in Table 2 shows that burn rates varied between 0.6

and 1.6 kg/hr, and that typical gas discharge volumes varied between 44 and 80 m³. Volatile organics analysis revealed the presence of methane, ethane, sulfur dioxide, carbonyl sulfide, and nitrogen oxides in anthracite and

bituminous tests. PAH compounds were measured by analysis of 18 indicator compounds. Table 3 shows the results for benzo(a)pyrene expressed in several combustion related units.

Table 2. Stove and Sampling Parameters

| Stove Parameter | High Burn Rate | | Low Burn Rate | | | |
|-------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------------------|--------------------------------|
| | Bituminous Coal Stove | Anthracite Coal Stove | Bituminous Coal Stove | Anthracite Coal Stove | Bituminous Modified Wood Stove | Anthracite Modified Wood Stove |
| Fuel per Test, kg (lb) | 2.5 (5.6) | 2.8 (6.2) | 1.7 (3.8) | 1.3 (2.9) | 2.4 (5.4) | 1.7 (3.7) |
| Burn Rate, kg/hr (lb/hr)* | 1.2 (2.6) | 1.9 (3.1) | 0.8 (1.7) | 0.7 (1.5) | 1.2 (2.6) | 0.9 (1.8) |
| Mean Stack Temperature, °C (°F)** | 270 (520) | 250 (480) | 220 (420) | 140 (278) | 160 (315) | 140 (280) |
| Sampling Time, min | 120 | 120 | 150 | 155 | 155 | 155 |
| Stack Water, percent | 1.8 | 3.5 | 1.8 | 1.6 | 1.9 | 2.3 |
| Stack Oxygen, percent† | 13 | 10 | 17 | 17 | 14 | 13 |
| Stack Carbon Dioxide, percent† | 6 | 10 | 4 | 3 | 6 | 7 |
| Stack Carbon Monoxide, percent† | 0.6 | 0.6 | 0.2 | 0.0 | 0.4 | 0.4 |
| Method 5 Volume (dry), SCM (SCF) | 1.8 (64) | 1.9 (68) | 2.0 (70) | 2.4 (85) | 2.3 (81) | 2.5 (87) |
| Total Stack Discharge, Q, SCM (SCF) | 64 (2,300) | 58 (2,050) | 72 (2,500) | 80 (2,800) | 67 (2,400) | 44 (1,600) |

* Averaged over total test.

**At Method 5 probe.

† Approximate, values determined by ORSAT technique.

Table 3. Benzo(a)pyrene Concentrations in Vermont Coal Stove Study

| Emission | High Burn Rate | | Low Burn Rate | | | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------------|--------------------------------|
| | Bituminous Coal Stove | Anthracite Coal Stove | Bituminous Coal Stove | Anthracite Coal Stove | Bituminous Modified Wood Stove | Anthracite Modified Wood Stove |
| Gaseous Emission, µg/SCM | 110 | 0.1 | 52 | 0.08 | 120 | 0.17 |
| Fuel Based Emission, ppb-dry-ash free | 2800 | 3 | 1700 | 5 | 3400 | 4 |
| Thermal Based Emission, ng/J | 8.1x10 ⁻² | 7.3x10 ⁻⁵ | 5.0x10 ⁻² | 1.5x10 ⁻⁴ | 9.8x10 ⁻² | 1.2x10 ⁻⁴ |
| Thermal Input to Furnace, Btu/hr (MJ/hr) | 4.2x10 ⁴ (44) | 4.7x10 ⁴ (50) | 2.2x10 ⁴ (23) | 1.7x10 ⁴ (18) | 3.0x10 ⁴ (32) | 2.1x10 ⁴ (22) |

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Michael C. Osborne is the EPA Project Officer (see below).

The complete report, entitled "Analysis of Residential Coal Stove Emissions," (Order No. PB 84-130 442; Cost: \$8.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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