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Jaasma, D. R., C. H. Stern, and M. Champion, EPA 600/R-94-061

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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October 30, 1991

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Dear Mike:

Enclosed is the EPA version of the Crested Butte Phase 2 final report.

Please call me if you have any questions or if you need additional information.

Sincerely yours,

Bob

Robert C. McCrillis
Organics Control Branch (MD-61)

Enclosure

United States
Environmental Protection
Agency

EPA-600/7-91-005

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EPA

Research and Development

FIELD PERFORMANCE OF
WOODBURNING AND COALBURNING
APPLIANCES IN CRESTED BUTTE
DURING THE 1989-90 HEATING SEASON

Prepared for

EPA Region 8

Prepared by

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October 1991

FIELD PERFORMANCE OF WOODBURNING AND COALBURNING APPLIANCES IN CRESTED BUTTE DURING THE 1989-90 HEATING SEASON

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ABSTRACT

The field performance of woodburning and coalburning appliances in and around Crested Butte, CO, has been evaluated. Measurements included particulate matter (PM), carbon monoxide (CO), and weekly average burn rates. Woodburning appliances included conventional airtight stoves, EPA-certified catalytic stoves, and EPA-certified noncatalytic stoves. Compared to the emissions measured from conventional stoves, the certified stoves reduced PM emission factors (g/kg) by 53% and CO emission factors by 49%. Coalburning appliances included a commercial scale boiler, a residential stoker, and a hand-fired coalstove. The coalburning appliances were compared to conventional woodstoves on a grams of pollutant per joule of heat output basis. The automatically stoked coal appliances reduced PM and CO emissions by roughly 84% and 85%, respectively. The hand-fired stove was cleaner than expected, reducing PM by 55% and CO by 27%.

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INTRODUCTION

The Town of Crested Butte contracted with Virginia Polytechnic Institute (VPI) for the field measurement of woodstove emissions in Crested Butte, Colorado during the winters of 1988-89 and 1989-90. These measurements were intended to determine the effect of a town-wide changeover from conventional to EPA-certified woodstoves. Both particulate matter (PM) and carbon monoxide (CO) emissions were to be measured.

The hardware used for the measurements is shown schematically in Figure 1 and is known as the "VPI sampler." This sampler has been compared to the EPA reference method for PM and to the dilution tunnel method for CO measurement and has been found to be accurate.

This report deals primarily with the results of the second year of work, wherein the emphasis was on measurement of emissions from the certified stoves which currently make up over 90% of the stove population in Crested Butte. However, in order to gain some additional data on old technology stoves, 17 weeks of conventional stove monitoring was performed in houses outside the town limits. To get preliminary information on how coalburning sources affect the Crested Butte airshed, 13 runs were performed on three coalburning sources.

The project was overseen by an advisory committee composed of representatives of the Town of Crested Butte, Colorado Department of Health, EPA, and the Wood Heating Alliance (WHA). Major project decisions such as the number and types of appliances to be sampled were handled by the advisory committee. Additional technical guidance was provided by the EPA Office of Research and Development. Project organization is shown in Figure 2.

Prior to the winter of 1989-90, many of the certified stoves in Crested Butte were examined by representatives of WHA. Fresh catalysts were installed in all the older catalytic stoves except the one at site CAT 26. All chimney systems were checked to see that they were adequate. During the project, the results of the sampling were reviewed weekly by WHA. If a stove was performing at emission levels greater than expected, the operator was contacted in an attempt to determine if the stove was being used properly. Remedial steps (e.g., catalyst replacement, further operator training, stove repair, or stove replacement) were taken in some instances. A WHA-supplied listing of these activities is given in Appendix A.

A field laboratory was set up in space provided by the Town of Crested Butte, and sampling commenced on October 30, 1989. Sampling continued until April 9, 1990. A total of 27 appliances were monitored: seven conventional stoves, twelve catalytic stoves, five noncatalytic stoves, and three coalburning appliances. Household profiles for each site are in Appendix C. Four woodstove models (A, B, C, F) are EPA Phase I certified and four (D, E, G, H) are Phase II certified. This report describes the results of the 1989-1990 sampling and compares the results with data from the previous year.[2]

INITIAL QUALITY ASSURANCE PLAN

A quality assurance plan was developed for the project. Because the paperwork for funding the project was not in place until 9/21/89, it was not possible to complete the plan and have it reviewed before sampling commenced.

The initial plan was submitted Nov. 10, 1989. The plan was reviewed under EPA contract by Research Triangle Institute (RTI). In response to the RTI review, additional documentation was added to the QA plan and several revisions were made to the procedures used in the study. The technical issues raised by the review and the VPI responses are discussed in the following subsections.

Moisture Content Measurements

The original QA plan called for wood moisture content to be measured by desiccation of wood samples obtained by drilling holes in five pieces of wood at each site. The major issues were whether desiccation can give accurate measurements, whether sampling five pieces of wood is adequate to characterize the moisture content of the fuel burned during an entire week, and how the desiccation method compares to use of an electrical resistance meter.

Laboratory data generated at VPI in early 1989 had shown that desiccation gave moisture contents about 1 to 2 percentage points lower than oven drying. Since oven drying drives off organic material in addition to water, it is not surprising that oven-dry moisture contents are higher than desiccated values. Exactly how much of this difference is due to organic material is unknown, but it is commonly believed that the oven-dry value is more accurate, i.e., most of the 1 to 2 percentage point difference is probably due to moisture rather than organic material. About halfway through the study a drying oven became available and was used for the rest of the moisture determinations.

To quantify the relation between the desiccated and oven-dry values during this field study, nineteen field samples taken during January and February were first desiccated to constant weight at room temperature and then dried in an oven at 102 C. For each run the moisture content was determined for both methods, and the average difference was 1.558 percentage points with a standard deviation of 0.436 percentage point. Based on these data all moisture contents determined by desiccation were corrected by 1.558 percentage points for final data analysis.

Multiple moisture content samples were taken at three homes to see if the sampling of five logs gave a reasonably accurate measure of the average moisture content of the entire pile. The dry basis percent moisture contents were as follows:

	SITE 1	SITE 2	SITE 3
SAMPLE 1	24.3	15.5	8.6
SAMPLE 2	25.2	17.0	8.6
SAMPLE 3	30.2	14.5	8.5
MEAN OF 3 SAMPLES	26.6	15.7	8.6
STANDARD DEVIATION	2.6	1.0	0.1

Site 1 wood was exceptionally moist, site 2 wood was uncovered and wet on the surface, and site 3 wood was from a covered woodpile. These results indicate that random sampling errors will be on the order of a few percentage points at most. Such random errors are an inherent part of all field studies.

Resistance meter readings were not used because most of the wood is stored outdoors at temperatures reaching 40 degrees below zero. Under these conditions it can be difficult to drive electrodes into the fuel, and the meter manufacturer has indicated that at higher moisture contents (above the fiber saturation point) these resistance meters are not intended for use on frozen wood samples. Part way through the study, during the performance evaluation audit, two wood samples were measured by resistance meter and the same two samples were measured using the drying technique. Satisfactory agreement (within 1.1 and 1.5 percentage points respectively) was obtained.

Weighing

Questions were raised concerning the accuracy of the weighings of the glass probes (ca. 10 g) and the glass petri dishes (ca. 35 g). The analytical balance used in these weighings has an absolute accuracy (determined by calibration weights) close to 0.2 mg and a repeatability of 0.1 mg.

The absolute accuracy of the balance is a consistent error which is less troublesome than one might expect. Consider the pretest weighing of a clean filter with a true weight of 0.1200 g before accumulating 5.0 mg of catch. A consistent error of +0.2 mg at a nominal weight of 0.1200 g means that the initial and final weighings would be 0.1202 and 0.1252 g, and the difference would be exactly correct within the repeatability of the balance. Errors in reported PM values due to systematic weighing errors are therefore small compared to random errors due to the 0.1 mg precision of the balance.

Any single measured weight could be in error by 0.1 mg due to the precision of the balance. Such errors are random and tend to partially cancel each other because at least five components (probe, line, two filters, wash petri) are weighed twice to determine the total catch. In runs where the O-rings were weighed to determine the O-ring residue, two more components are each weighed twice. With this many weighings the anticipated error due to the precision of the balance is on the order of 0.31 to 0.37 mg. The noncatalytic certified stoves in this study had the lowest average PM catch of any woodburning appliance category, and the error in PM rates and factors would average only about 3% due to the precision of the balance. Other factors can contribute to weighing errors and the error analysis discussed in the RESULTS section takes all known sources of error into account. Weighing errors were most serious with the coalburning appliances because the catches were the smallest.

After being cleaned with acetone there is a carbonaceous residue in the probe, and RTI was concerned that the probes are not perfectly clean when installed at a sampling site. However, this residue becomes a part of the tare weight of the probe and has no significant effect on the accuracy of the measurements.

Oxygen Content Calculation

The method for calculating the oxygen content of the flue gas from CO_2 and CO data was unclear to the reviewers. A detailed derivation of the equations was supplied to RTI, and the method is believed to be accurate to within 1 mole percent. Since the calculated O_2 concentration is only used to determine the molecular weight of the stack gas, the accuracy of the calculated O_2 concentration in this study is not critical. Emissions calculations strongly depend on CO_2 concentration, and the CO_2 concentrations are directly measured via a laboratory quality infrared analyzer which is calibrated before each measurement.

Recommendation for Blanks and Duplicate Samples

The advisory committee did not originally plan for blanks or duplicate sampling runs. At RTI's suggestion, the project director petitioned the advisory committee for permission to substitute blanks and dual sampling in lieu of datapoints which would otherwise be obtained. A total of 11 blank runs and two dual-sampler runs were performed during the course of the study.

QUALITY ASSURANCE AUDIT

The quality assurance audit of this project consisted of two parts. A technical systems audit (TSA) is a qualitative on-site evaluation of a measurement system, and this audit was conducted during the 1/16-1/18/90 visit of RTI personnel to Crested Butte. A performance evaluation audit (PEA) is a quantitative evaluation of a measurement system which usually involves the measurement or analysis of a reference material of known value or composition. The performance evaluation audit was begun during the 1/16-1/19/90 visit but had to be completed at a later date because several gas cylinders were lost in a plane crash. Replacement cylinders were shipped to Crested Butte and the PEA was then completed.

The technical systems audit resulted in a rating of "acceptable with qualifications" for both the work at individual sampling sites and the work in the laboratory at Crested Butte. The performance evaluation audit covered measurement systems for CO, CO_2, wood weight, and weight of particulate catch. Ratings for these systems were "acceptable with qualifications," "acceptable," "acceptable," and "conditionally acceptable," respectively. The significant issues raised by the audit and the VPI responses are discussed in the following subsections.

O-Ring Residues

The weighing procedures used during the project required that any filter material remaining on an O-ring be scraped off the O-ring and deposited on the filter. Despite careful scraping, this procedure leaves a slight amount of material on the O-ring. This material is mostly filter paper (rather than particulate matter emitted from the stove), and if not taken into account the mass of this residue results in a decrease in measured catch. Starting at the time of the audit, the O-ring residue became a measured quantity and the residues were used to adjust the values for total catch. The O-ring residues were weighed by weighing the O-ring before and after wiping with a lint-free cloth. The residues were on the order of 0.0002 g per O-ring and were fairly consistent. Neglecting the residue would lead to PM measurements which were low by 1 to 5%, depending on how clean the appliance was.

CO Analyzer

During the audit the CO analyzer gave the following values compared to the RTI reference gases:

REFERENCE VALUE (mol%)	MEASURED VALUE (mol%)	ERROR (% of value)
0.22	0.20	-9.1
0.52	0.47	-9.6
1.02	0.94	-7.8

These errors are larger than expected, and appear quite consistent.

During the course of the project, normal procedure was to zero and span the analyzer before each use. The analyzer was then checked on one or two midrange calibration gases. One gas (0.19% CO) was used as a check gas for workups until 1/19/90 and two gases (0.19 and 0.79% CO) were used after that date. The analyzer was recalibrated if either reading was not within 0.02 mole percent (absolute). Such recalibration was required only once during the course of the project, indicating that the CO analyzer was generally stable. Since the least count of the analyzer is 0.01 mol% and both the RTI audit gases and the VPI calibration gases are supposed to be accurate to within 2% of stated value, even if the gases are wrong in opposite directions a 9% error is unexplained when measuring concentrations of 0.5 mol% or greater. At very low (< 0.10 mol%) concentrations, the CO error is dominated by the resolution of the instrument. Thus the error analysis assumes a bias error of 9%. There is a chance that the CO measurements are much better than this, but as of now the discrepancy has not been resolved. Fortunately there is only about a 1% error in PM emissions for a 9% error in CO measurement. This is because the carbon balance depends mostly on CO_2.

Wood Consumption Measurements

The auditors expressed concern that wood consumption would not be accurately measured if participants ran out of preweighed wood during the week a sampler was in place or if participants used wood which was not a part of the preweighed pile.

The preweighed wood was separated from the unweighed wood by a bright orange ribbon, and in all cases the participants were instructed to use only the preweighed wood. In 89% of the cases enough preweighed wood was available that there was leftover wood when the sampler was retrieved. In 12 cases there was no preweighed wood left but the participants had, per instructions from the VPI field staff, unplugged the sampler when their preweighed wood was gone. In three cases the operators used more than the preweighed wood and did not unplug the sampler (Runs 15, 22, 42). In these cases the field staff had to estimate the additional wood consumption. Two participants counted the number of extra pieces used: 5 in one case, 6 in the other. These quantities of wood are minor compared to the total wood consumption at these sites for the weeks in question. For Run 22, wood consumption was estimated from the remaining wood at the site, and the field staff estimate of uncertainty is 12 kg (8% of wood use) for that week at that site.

Power Failures

The auditors pointed out that if there was a power failure during the time a sampler was in place there was no way to know this. No corrective actions (i.e., installation of sensors which would indicate that an outage occurred or would measure the duration of an outage) were taken in time for the current study. However, the reliability of electric service in Crested Butte was excellent during the study.

The Gunnison Electric Service Association reports that during this study there were no power outages within the Town of Crested Butte. However, one sampling site located outside of town is served by a circuit which had a 32 minute outage during the time one sampler was in place. This outage could have affected the data by about 2%, but since it is not known if the stove was operating during the outage no adjustments have been made to the data.

Blanks

The "conditionally acceptable" rating was contingent upon the running of field blanks to define the bias and precision of the total particulate catch. These runs were performed and the data are in the RESULTS section of this report.

TEST EQUIPMENT AND PROCEDURES

The equipment and procedures used for the VPI sampler were essentially the same as those used in the 1988-89 study[2], except that quality control procedures were improved by the addition of numerous one-time and periodic checks on equipment performance: the synchronous hourmeters which record elapsed sampling time were checked (once) for accuracy; the stack thermocouples and their temperature controllers were checked prior to each deployment; the wood weighing scale was checked prior to each use; multiple reference weights were used to check the analytical balance before each use; and whenever possible the Bennert manometer was used to measure the pressure of sample tanks. An overview of field procedures follows, and the flowbench schematic for the laboratory is shown in Figure 3.

At the field laboratory, the sample tank is evacuated to an absolute pressure less than 0.4 kPa (3 torr) using an oil-type vacuum pump. The pressure is checked using a Bennert style mercury manometer, i.e., one which is closed off and evacuated at one end.

A cleaned probe, connector fitting, and Teflon sample line are selected and separately weighed after static electricity is removed by a nuclear (polonium) source. (Static electricity can affect the indicated weight of the probe and the sample line.) Filters which have been desiccated for 24 hr or more are weighed and placed in the filter housings. The sample train is assembled and connected to the evacuated tank.

A leak check is performed from the probe tip to the solenoidvalve under a minimum of 4" water vacuum. This is about four times the highest expected vacuum during sampling. Leak rates in excess of 1% of the sample rate are unacceptable.

The sample flow rate is set by adjusting the metering valve. To maintain choked flow and therefore keep the flow rate approximately constant, flow rates are set to allow the vacuum tank to fill to about one-half the ambient atmospheric pressure during the time the sampler is operating.

The desiccant in the sample train removes virtually all moisture from the sample gas. Otherwise some moisture would condense within the metering valve and cause erratic flow rates.

The metering valve is adjusted while sample flow is measured in ambient milliliters per minute using a 10 ml bubble flowmeter. Depending on the expected use of the stove, the flow rate is set so that at the end of the sampling period the tank will be approximately half full. If the stove is expected to be used continuously for seven days, the flow rate would be about 3.7 ml/min, and a sampler for a stove operated 50% of the time would be set to a flow rate near 7.4 ml/min. For laboratory comparability tests lasting 15 hours a flow rate of ca. 40 ml/min was used. The sampler is transported to the field test site after checking that the controller operates at the correct setpoint and recording the initial hourmeter reading, absolute pressure of the tank, and train component weights.

Prior to beginning the field sampling the issue of setpoint temperature was discussed with EPA and Colorado personnel. Field studies in the Northeast and Northwest had used 38 C (100 F) as a sampler cutoff temperature. It was felt that such a temperature would result in the samplers operating when there was a negligible amount of combustion going on in the stove, and thus it was decided to use 80 C as the setpoint. This temperature was used in the latter part of the 1988-89 Crested Butte study. In the current study the setpoint temperature was changed to 60 C (140 F) beginning with Run 63 because one stove was observed to be producing non-negligible emissions at a stack temperature a few degrees below the 80 C setpoint which was being used at that time. The effect of setpoint temperature is unknown; to measure the effect on reported emissions it would be necessary to simultaneously operate two samplers with different setpoints, but it appears that this has not been done in any field study to date.

At the site the sampler is placed about one meter from the stove and plugged in. Two holes are drilled in the woodstove connector pipe at a location 0.3 m downstream of the flue collar. The holes are sized so that when the probe and thermocouple are inserted there will be negligible air leakage into the flue. A bracket is used to provide strain relief for the quartz probe and thermocouple. In two cases where the probe penetrated a double-wall (air-insulated) connector pipe, stainless steel probes were used to avoid possible breakage.

To keep the responsibility of the stove operator to a minimum, the fuel consumption of the stove is monitored by the field staff. A part of the participant's woodpile, believed to be sufficient for over seven days of burning, is weighed. A brightly colored ribbon is laid on the unweighed wood and the weighed wood is restacked onto the pile. The wood on top of the ribbon is referred to as the "designated woodpile." The stove operator is instructed to use only the wood from the designated woodpile. Thus, the operator uses his or her normal wood supply. In the case of coalburning sources, a scale was not available to leave at each site and the operators at two of the sites were instructed to count the number of buckets of coal they used. In these two cases the coal supply consisted of 1 inch diameter pieces and the mass of sample buckets was consistent to better than 10%. The third coalburning site used large chunks of coal. In this case a one-week supply was weighed out by the field staff and placed on a plastic tarp, separate from the maincoal pile.

The moisture content of the fuel is needed for data reduction purposes. Drillings were taken to provide a sample of wood from five representative logs at each household. A 3/8" diameter, sharp drill bit was used at low speed to minimize drying of the sample as it was extracted. Care was taken not to oversample the wettest (central) part of each piece, as would happen if the chips were collected from a hole drilled straight through a round piece of wood. Drillings were immediately placed in a zip-lock bag or plastic 35 mm film container. These drillings were taken to the lab, weighed, and then dried (by desiccation for early runs, by oven for later runs) to constant weight in a tared petri-dish. The moisture content is determined by the change in weight. This method is believed to be equivalent to field readings obtained with a resistance type moisture meter, and if fuel species is in doubt (as it sometimes is in field studies) it is probably superior because the resistance meter readings must be corrected for species. Fuel moisture contents at coalburning sites were determined by commercial analysis of field samples.

At completion of the 6 to 8 day sampling period, the sampler is retrieved. At the laboratory, the final hourmeter reading is noted and the absolute pressure of the sampler tank is measured, using the Bennert manometer or a Datametrics absolute pressure sensor which is calibrated before each use against a mercury barometer. The CO and CO_2 concentrations are measured before the post-test sample train leak check and flow check. The post-test sample flow rate is measured and a post-test leak check is done in the same manner described previously.

A gravimetric analysis of the filters, sample line, probe and connector fitting determines the total particulate catch. The two 47 mm filters are removed from their housings. Any filter residue on the silicone O-rings is carefully scraped off and deposited on its respective filter. Generally this still leaves a small amount of residue on the O-ring, and in the latter part of the project this residue was quantified by weighing the O-ring before and after it was wiped clean with lens paper. The residue weight averaged about 0.25 mg for front filters and about 0.21 mg for rear filters and was applied as a correction to the data. The filters are weighed, desiccated for 24-36 hrs, and then weighed to constant weight. Constant weight is defined as two weighings at least one hour apart which give a weight loss rate of less than 0.1 mg per hour.

The probe, sample line, and connecting fitting are flushed with 20 ml of low residue acetone. The acetone wash is collected in the condensate trap which now contains a mixture of water, particulates, acetone, and dissolved hydrocarbons. Dry nitrogen at 0.5 l/min is run through the probe, line, and trap to remove moisture from the sample line and probe. After approximately 5 minutes, the sample line is disconnected from the trap and its exterior is wiped clean using a lint free cloth and acetone. The probe and connector fitting are also wiped clean on the outside. These pieces are then alternately weighed and flushed with dry nitrogen until constant weight is achieved. The anti-static device is employed before each weighing.

The condensate and acetone wash in the trap is poured into a tared petri dish and allowed to evaporate into room air for 24 hours. The petri dish is then desiccated to constant weight and the final value is recorded. The total catch is the sum of the catches from the filters, probe, sample line, and petri dish. After consultation with RTI during the performance evaluation audit, it was agreed that for later runs aluminum dishes would be used in lieu of glass petri dishes, the advantages being a lower tare weight and decreased potential for errors due to static electricity.

The emission rates and emission factors depend on the following parameters:

PARAMETER	SYMBOL	UNITS
Elapsed time	t	hours
Mass of wet fuel	m	kg
Moisture content of fuel	MC	dry fraction
Initial and final tank pressures	P1, P2	kPa
Final tank temperature	T	degrees Kelvin
Total PM catch	C	g
Stack CO concentration	CO	volume fraction
Stack CO_2 concentration	CO_2	volume fraction
Tank volume	V	cubic meters
Carbon content of fuel	XC	mass fraction
Contribution to dry stack gas per unit of dry fuel consumed	w	kg gas/kg fuel
Carbon as hydrocarbons per mole of carbon as CO	y	molar ratio
Moles of O_2 (all forms) per mole dry stack gas	z	molar ratio

The first eight parameters listed are measured for each datapoint of the study. The carbon fraction of the wood is assumed to be 0.51, and the carbon content of the coal is measured. Three coal samples (one from each of the three coalburning sites) were sent out for analysis by Commercial Testing and Engineering, Denver, CO. Copies of the results are in the appendix. The dry stack gas contribution for the wood and coal are calculated based on stoichiometric considerations.

Thus the instrumentation for the project consists primarily of the analytical balance, pressure transducers for the tank pressures, scale for weighing the fuel, and the gas analyzers. Step-by-step laboratory and on-site procedures and sample copies of the data sheets are in the appendix. Calculations are described in the next section and sample calculations are in the appendix.

Datasheets were faxed to VPI on a rolling basis during the project and the data were entered into a spreadsheet. All data entries were checked for accurate transcription and reasonable values.

CALCULATIONS

For all calculations the carbon fraction of dry wood is assumed to be 0.51, a value which is correct to within 2% for most species. The difficulty of determining the exact wood species (or mix of species) burned during any given week at a site makes this a reasonable procedure. The carbon fractions assumed for the coals are the ones shown by the coal analyses in the appendix.

For wood, the "oxygen fraction" of the dry sample gas is assumed to be such that z = 0.21, i.e., 1.0 mole of dry stack gas contains 0.21 moles of oxygen as CO, CO_2, and O_2:

$$O_2 = 0.21-CO_2-CO/2 \quad (1)$$

The value 0.21 can be calculated from data in the literature[3] and has been consistently observed during many tests in the VPI Solid Fuel Combustion Laboratory wherein CO, CO_2, and O_2 analyzers were used simultaneously for flue gas analysis. This value can also be predicted by performing a chemical balance which assumes complete combustion of the fuel and a typical elemental analysis of the wood. For the coals burned, which have significantly different elemental analyses than wood, the expected concentration of oxygen (all forms) in dry stack gas is 19%. As is the case with the calculations for wood, this value has little effect on measured emissions.

Nitrogen content is calculated by ignoring minor species and assuming that N_2 is the balance gas:

$$N_2 = 1-CO_2-CO-O_2 \quad (2)$$

The dry stack gas molecular weight is calculated using the nominal molecular weight of each species:

$$M = 44*CO_2+28*CO+32*O_2+28*N_2 \quad (3)$$

The air-fuel ratio (kg of dry air per kg of dry fuel burned) is calculated by a carbon balance which assumes y = 0.5, i.e., there is 0.5 mole of carbon emitted as smoke or vapor-phase hydrocarbons for each mole of CO emitted. Thus the carbon balance contains the sum of the CO_2 concentration and 1.5 times the CO concentration:

$$AF = N_2*4.76/3.76*29/[12*(CO_2+1.5*CO)]*XC \quad (4)$$

The value 0.5 is approximate; the true ratio is different from appliance type to appliance type and from burn to burn, but, because CO and hydrocarbon levels are an order of magnitude less than CO_2 level the calculated air fuel ratio is not very sensitive to this constant. Doubling the constant or reducing it to 0 would affect calculated emission rates by at most 4%. In the above equation the ratio 4.76/3.76 is the number of moles of dry air per mole of nitrogen, 29 is the molecular weight of air, and 12 is the molecular weight of carbon. In this study the CO_2 analyzer was zeroed on ambient air, and the measured CO_2 values were corrected for this prior to final data reduction. Details of all such data modifications are given in the appendix.

The mass of dry sampled gas is calculated from the ideal gas law and the pressure and temperature of the tank before and after the sampling. The result is insensitive to initial tank temperature (since initial pressure is very low) and thus the calculation assumes initial and final temperatures are equal:

$$GAS = (P2-P1)/8.314*M/T*V \tag{5}$$

The dry gas sample flow rate is given by:

$$SAMPFLO = GAS/t \tag{6}$$

The dry gas stack flow rate is given by:

$$STKFLO = (AF+w)/t*m*(1/(1+MC)) \tag{7}$$

The parameter w is the net contribution of the dry fuel to the dry stack gas. For wood this fraction is approximately 0.51, and for the coals burned in this study the value is near 0.42. These numbers are calculated from stoichiometric considerations, and emission results are not very sensitive to them.

The total PM emitted during the sampling period is calculated by multiplying the catch by the ratio of the stack flow to the sample flow:

$$PM = C*STKFLO/SAMPFLO \tag{8}$$

The PM emission rate is the total PM emitted divided by the time the sampler was operating:

$$PMRATE = PM/t \tag{9}$$

The dry fuel burn rate is given by:

$$BRATE = m*[1/(1+MC)]/t \tag{10}$$

The PM emission factor is obtained by dividing the PM emission rate by the dry fuel burn rate:

$$PMEF = PMRATE/BRATE \tag{11}$$

The CO emission rate is obtained by:

$$CORATE = STKFLO/M*CO*28*1000 \tag{12}$$

where 28 is the molecular weight of CO and 1000 converts from kilograms to grams.

Finally, the CO emission factor is given by:

$$COEF = CORATE/BRATE \tag{13}$$

Of the 156 sampler workups, four were the result of duplicate sampling, i.e., sampling the same flue with two samplers at the same time. Data from these tests allow the field precision of the VPI train to be calculated. In this report the percent precision of a sample train is defined by the following equation where A and B are the simultaneously measured rates and A is the greater of the two:

$$\text{PRECISION} = 100 * \frac{(A - B)}{(A + B)/2} \qquad (14)$$

The sample calculations in Appendix G use input data from Run 133 for emission calculations and dual sampler data from Runs 139 and 140 for the sampler precision calculation.

RESULTS

A spreadsheet printout showing the raw and calculated data of this study is in Appendix I. Tables 1 and 2 summarize the results for each appliance. Unless otherwise noted, all PM emission rates and factors in this report are as measured using the VPI sampler. This means that data have not been corrected to "dilution tunnel equivalent" or "Method 5H equivalent" numbers. Conversions between methods can be performed, but there are always questions about the conversion equation(s). Strong correlation[4] ($r^2 = 0.975$) has been observed between the VPI sampler and dilution tunnel data for PM, and if Method 5G tunnel equivalents are desired they can be calculated by the equation

$$5G = 0.669*VPI^{1.0043} \qquad (15)$$

Equivalent 5H values could be calculated by using the EPA equation[5] which relates 5G and 5H emissions:

$$5H = 1.82*5G^{0.83} \qquad (16)$$

Although this equation fits the data fairly well at low emission levels, it is unsatisfactory at values of 5G > 6 g/hr. A new least squares fit to the available data has been run[4] to give the equation

$$5H = 1.619 *5G^{0.905} \qquad (17)$$

which does a very adequate job of fitting the entire range of data. Equations 15 and 17 can be combined to give an equation which relates VPI sampler PM values to their 5H equivalents, and this equation is

$$5H = 1.125 \ VPI^{0.909} \qquad (18)$$

Using this equation on the 1990 EPA 4.1 and 7.5 g/hr limits (for catalytic and noncatalytic appliances respectively) gives 4.15 and 8.1 g/hr for the EPA limits when expressed as VPI sampler equivalents. As a practical matter the VPI sampler data are equivalent to 5H values, and throughout this report the PM emissions are as measured by the VPI sampler unless otherwise noted. If 5H equivalents are listed, equation 18 is the basis for the conversion.

There is no need for a conversion equation for CO emissions. This is because CO measurement is not sensitive to dilution ratio, as in the case of semivolatile hydrocarbons which are captured to a greater or lesser extent depending on how dilute the sample is when it is filtered.

The discussion which follows concentrates on emission factors rather than emission rates. Emission rates depend on burn rates, and if two appliances with the same emission factors are compared on the basis of emission rates one appliance might look bad because its average burn rate is twice that of the other appliance. Comparing emission factors is not a perfect procedure either, since emission factors themselves are a function of burn rate for some appliances. However, the emission factor gives a somewhat fundamental indication of the cleanliness of combustion and is primarily discussed in the following paragraphs.

Data Completeness

A total of 156 sampler deployments occurred during the 1989-90 monitoring in Crested Butte. Of these deployments, 2 failed to produce useful data due to probe breakage, one sampler did not sample due to a kinked line, one trap broke during a workup but the catch was salvaged, and four runs (10, 11, 30, 48) failed to pass the post-test leak check.

The post-test leak check is very stringent in that it subjects the filter and sample line to much greater vacuum than exists during sampling. Thus it is possible to fail the leak test and still have a negligibly small leak during sampling. If substantial leakage occurs during sampling of an appliance, the measured CO_2 level should be lower than the levels for the other runs at the same site. This was only true for Runs 10 and 48, indicating that significant leakage did not occur during Runs 11 and 30. In Run 10 the CO_2 level was only about 2/3 of the average level for the other four runs in the test series. In Run 48 there was a major leak due to a cut in the sample line and the CO_2 concentration of the tank gas was only 0.2 mol%. This near-ambient concentration indicates that the cut in the line occurred before any appreciable amount of sampling occurred. Fortunately, with the VPI sampler leakage has little effect on measured emission rates and factors. Incorrect air/fuel ratios will be measured, but emission rates and factors will be virtually unaffected because leakage causes the calculated air/fuel ratio to be too high and the measured catch (and CO concentration) to be too low. These effects compensate for each other, giving good emission data even if some leakage occurs. If leakage is severe there will be problems (catch and CO levels too low to measure accurately), so there is a limit to how much leakage can be tolerated. Since three of the four tests which failed their leak tests produced useful data, the completeness is 152/156 or 97% for the entire project.

Blanks

Eleven blank runs were performed. The samplers were prepared as usual in the lab and were then transported to an apartment which did not have a solid-fuel appliance. The samplers were allowed to sample room air for 46 to 115 hours and were then transported back to the laboratory for workup. The residue remaining on the O-rings was weighed for 9 of the blank runs, but the first two runs occurred before this procedure was instituted. Thus the first two runs used the average residue values computed from the rest of the project as estimates of the residues which would have been measured.

The average gravimetric catch for the blanks was 0.61 mg with a standard deviation of 0.50 mg. The highest blank had a catch of 1.2 mg and the lowest had a catch of -0.44 mg. These values indicate that the equipment and personnel in the study were performing very well. A correction of 0.61 mg was applied to all the datapoints representing the sampling of an operating appliance. The magnitude of this correction is 5% for the average noncatalytic stove, 4% for the average catalytic stove, and 2% for the average conventional stove. The different effects are due to the average catch being different for each category of stove. For coalburning appliances the correction averages 12% because the average catches for the coalburning appliances were lower than those for woodburning appliances.

The CO_2 and CO concentrations of the blanks were very low (0.0 or 0.1% CO_2, 0.00 or 0.01% CO) except for the first blank sampler which was worked up. This sampler was located close to the kitchen of the apartment, and one possibility is that CO_2 from cooking contributed to the 0.3% CO_2 reading obtained. In any event the blank CO_2 and CO levels are low enough that corrections are not required.

Precision

Eleven dual-train laboratory tests[1] have previously shown average precisions of 7.6% (PM) and 2.2% (CO) for the VPI sampler. During these earlier precision tests the samplers were turned on and off at the same time, and thus no precision for burn rate was measured. During the current field study, dual VPI samplers were deployed for two weeks of sampling on the stove designated CAT 17. The sampler workups are Runs 139, 140, 147, and 148 in Appendix I. The samplers operated completely independently of each other, i.e., each sampler had its own thermocouple and controller which determined when sampling would occur. The results are as follows, where A and B refer to the results of the two samplers:

DEPLOYMENT DATE	PM (g/kg) A	PM (g/kg) B	CO (g/kg) A	CO (g/kg) B	BURN RATE (kg/hr) A	BURN RATE (kg/hr) B
3/19/90	21.08	21.97	78.46	79.32	0.592	0.590
3/26/90	13.92	14.00	49.07	49.07	0.593	0.596

The worst-case precision for these data is 4.1% for the PM measurements of the samplers deployed 3/19/90. The rest of the precisions are 1% or better. These results are extraordinarily good, and it is likely that for a larger sample of dual-train operation the precisions would be closer to the values observed during laboratory work. However, the agreement of the two dual train runs helps to create confidence in the results of the current study.

Conventional Stoves

During the 1989-90 season seven conventional stoves were monitored to give 27 useful datapoints. Each datapoint represents the average performance of a stove during a one-week period. In the 1988-89 Crested Butte work[2] eleven conventional stoves were monitored to give 37 datapoints for CO emissions and 32 datapoints for PM emissions. Equal numbers of datapoints for PM and CO were not obtained during the 1988-89 study because the PM data for the first 8 runs of the season were questionable due to use of a faulty weighing procedure. The results of the two studies are summarized below, where PM values are as measured by the VPI sampler. Each number represents the arithmetic averages of the datapoints of all conventional stoves.

RESULTS OF CRESTED BUTTE CONVENTIONAL WOODSTOVE MONITORING
(PM is as measured using the VPI sampler)

	1988-89	1989-90 (current study)
PM (g/kg)	22.1	22.2
CO (g/kg)	115	111
PM (g/hr)	29.4	35.2
CO (g/hr)	154	178
BURN RATE (dry kg/hr)	1.35	1.64

The EPA-recommended 5H value for conventional stove PM emissions is 15 g/kg[6], which when converted to the corresponding VPI sampler value is 17.3 g/kg. Thus the conventional stove Crested Butte PM factors are about 28% higher than the EPA values. The CO emission factors are about 19% lower than the 140 g/kg value used by EPA at this time.

The emission factor agreement between the 88-89 and 89-90 studies is very encouraging. The PM factors are virtually identical and the CO factors are different by only about 6%. This indicates that the sample sizes give good estimates of average emission factors for the conventional stove population. It is interesting that the higher PM and CO g/hr values (21 and 18% higher respectively) for the 1989-90 season are for the most part explainable by the 21% increase in burn rate. Weather, choice of stoves monitored, or operator use patterns could also contribute to the difference.

Catalytic Stoves

Twelve (eleven if you do not count the replacement stove at site CAT 16) catalytic stoves were monitored, resulting in 72 useful datapoints. In the previous Crested Butte work two catalytic stoves were monitored to give nine datapoints for CO emissions and six datapoints for PM emissions. The results of the two studies, expressed as arithmetic averages of the datapoints, are summarized as follows:

RESULTS OF CRESTED BUTTE CATALYTIC WOODSTOVE MONITORING

	1988-89	1989-90 (current study)
PM (g/kg)	5.5	11.1
CO (g/kg)	39.6	52.3
PM (g/hr)	5.2	10.4
CO (g/hr)	34.9	49.4
BURN RATE (kg/hr)	0.86	0.93

Compared to the 1988-89 data, the 1989-90 emission factors are about 32% higher for CO and 100% higher for PM. The reason for the differences is probably that the two catalytic stoves from the first season (both are the same model) are better performers than the mix of stoves during the second season, but other factors, e.g., operator habits, could also be important. One of the stoves (CAT 12) was monitored during both years and had approximately the same PM and CO emissions both years. The other 1988-89 catalytic stove (CAT 27), monitored only during 1988-89, had PM and CO emission factors of 4.0 and 35.5 g/kg. With respect to PM emissions it was the cleanest woodburning stove of the two year study.

Appendix J contains graphs showing the week-to-week performance of each stove. The graphs are arranged in alphabetical order, i.e., the sequence is catalytic, coal, conventional, and noncatalytic stoves.

Most of the individual stoves performed consistently from week to week, but there were exceptions. At site CAT 16 (see graph in Appendix J) the stove emitted like a conventional stove for three weeks, after which the catalyst was changed. Emissions were immediately reduced by about a factor of two. After one week with the new catalyst the stove was replaced. After two weeks with the new stove the catalyst of the new stove was replaced and a further decrease in emissions was observed. Higher than average emissions for CAT 17 are unexplained during week 7. The relatively low PM emissions of CAT 19 during week four appear to be due to an unusual weight loss for the sample line. Since CO emissions for this run are consistent with other runs, the week four PM reading is suspect. Catalyst replacement after week three at site CAT 21 was followed by a drop in CO level.

Noncatalytic Stoves

Twenty eight valid datapoints describing the operation of five noncatalytic (but certified) stoves were obtained. No noncatalytic stoves were monitored during the 1988-89 heating season, and therefore no data are available for year-to-year comparison. Results are given below as arithmetic averages of the datapoints.

RESULTS OF 1989-90 CRESTED BUTTE NONCATALYTIC WOODSTOVE MONITORING

PM (g/kg)	9.9
CO (g/kg)	76.2
PM (g/hr)	9.4
CO (g/hr)	77.2
BURN RATE (dry kg/hr)	1.10

The data for noncatalytic stoves represent two different stove models. The NCAT 13 and NCAT 20 sites both had stove model G and both stoves performed fairly consistently at the 5 to 9 g/kg PM level.

The model H noncatalytic stoves were monitored at sites 15, 23, and 25. At site NCAT 23 model H performed consistently at the 6 g/kg PM level except for one week with 13 g/kg PM. This week had the lowest burn rates of the tests at that site. At sites NCAT 15 and NCAT 25 this model performed erratically at averages of 14 and 16 g/kg respectively. Figure 4 shows the PM factors of model H stoves as a function of burn rate, and one can see that for this model the differences in performance correlate with burn rate. The data from all three stoves seem to follow the same trend. This increase in emissions with decreasing burn rate is what one would expect from a noncatalytic stove which is unable to sustain adequate combustion temperatures at low burn rate. Site NCAT 15 had substantially higher emissions during the final three weeks of monitoring, presumably because the average burn rates for those weeks were inadequate to maintain secondary combustion.

Considering all the noncatalytic stoves as a group, Figure 5 shows that the PM emission factor was about 10 g/kg or less whenever the average burn rate was greater than about 0.9 kg/hr. The two model G stoves were not operated at an average burn rate less than 0.95 kg/hr, and thus their performance at low burn rates is unknown.

Differences Between Woodstove Models

Differences between stove models are apparent in Table 1 and Figures 6 and 7, which give averages and the standard deviations of the emission factors for each model tested. The nine conventional stove models (for 1988-89 and 1989-90) have been grouped together for the purpose of these graphs. Each datapoint represents the average of all datapoints for the model indicated at the bottom of the graph. The average PM reduction relative to the average of all (1988-89 and 1989-90) conventional stove PM emission factors was about 71% for models A, C, and G; and in the 34 to 51% range for models B, D, E, F, and H. The average CO reduction ranged from 43 to 63% for all models except noncatalytic model H, which was operated at relatively low burn rates and reduced CO only 21% compared to conventional stoves. On average, each certified stove model performed better than the average conventional stove.

Differences between PM emission factors of stoves which are the same model are apparent in Table 1 and Figures 8 and 9. (In these figures 5 bars are plotted for model D stoves. The first bar is the first stove at site CAT 16, the second bar is the same stove with a new catalyst, the third bar is a replacement stove, and the fourth bar is the replacement stove with a new catalyst. The fifth bar represents the average of all data for the model D stove at site CAT 21.) For example, stove F1 (CAT 19) performed consistently at about 6 g/kg (except for Run 96, which had a relatively large sample line weight loss which suggests a weighing error), and stove F2 (CAT 26) appeared to give increasing PM emissions, averaging about 17 g/kg. Emissions and operating conditions differed as shown:

	CAT 19 (F1)	CAT 26 (F2)
PM EMISSIONS (g/kg)	6	17
CO EMISSIONS (g/kg)	34	90
FUEL MOISTURE (dry basis%)	15	24
BURN RATE RANGE (dry kg/hr)	0.75 - 0.93	0.97 - 1.28
STACK CO_2 (dry mol%)	6.0 - 8.3	4.3 - 5.3

After testing was complete the model F stove at site CAT 26 was inspected by WHA personnel who reported that the bypass plate was cracked. Enough data are not available to tell if the difference in emissions is due to the bypass plate, fuel moisture content, operating pattern, or other physical differences in the stoves. The difference in CO_2 levels could be due to the difference in fuel moisture contents, the difference in burn rates, or the difference in the airtightness of the appliances, but would not be explained by the cracked bypass. This stove was not new at the beginning of the study and its catalyst was not replaced prior to sampling. It is possible that the relatively poor performance is due to a catalyst problem.

Correlation of PM and CO

This woodstove field study is the first to generate a database for both CO and PM emissions. The average CO and PM emission factors for both years of the study are plotted in Figure 10. It is clear that CO and PM emissions correlate, but the correlation is somewhat noisy. It is also noteworthy that the noncatalytic stove models (G and H) tend to have either average or high CO emissions compared to the other models. This is not surprising, since laboratory certification testing shows that noncatalytic stoves tend to have higher CO emissions.

Coalburning Sources

The three coalburning appliances were a hand-fired stove (COAL 02), an automatically stoked, thermostatically controlled residential central heater (COAL 06), and a commercial boiler (COAL 07). With only one of each appliance type, the data of this study are insufficient to predict what average emission rates for large numbers of such appliances would be. However, the measured rates are believed to be an accurate assessment of the emissions for these particular appliances.

The hand-fired stove was about 60 years old and operated with high excess air relative to most woodburning stoves. The PM emission factors averaged 15.1 g/kg, about 32% less than the 22.2 g/kg PM emission factor for the conventional woodburning stoves in this study. The CO emission factor averaged 121 g/kg, which is close to the 113 g/kg value for conventional stoves in this study. Since the heating value of the coal is about 1.5 times that of wood, it is better to compare the wood and coal stoves on a grams/Joule (grams of pollutant per unit of energy delivered) basis. If the coalstoves and woodstoves are assumed to have roughly the same energy efficiency (a reasonable assumption), the CO and PM emissions on a g/kJ basis are respectively reduced by 19 and 55% compared to conventional stove emissions. The 19% figure may not be statistically significant, but the 55% reduction in PM for this stove can not be discounted.

The automatically stoked residential heater at site COAL 06 had a barometric damper built into it, and as a result the excess air levels in the stack were very high. Average CO_2 concentration was 2.1% and average catch was 1.9 mg. The CO emission factors were fairly tightly grouped for the five runs (high of 45 and low of 31 g/kg) but the PM emission factors (high of 6.9 and low of 1.7 g/kg) showed wide variation. The consistency of the CO factors leads one to believe that the appliance operation was relatively consistent and that the PM variation is due to noise in measuring such an exceptionally low catch. The average PM emission factor is 4.9 g/kg, and this value is believed to be a valid indication of actual PM emissions. Thus the CO and PM emissions from this appliance are respectively reduced by about 67 and 78% compared to the conventional woodstove emission factors of this study.

The commercial boiler consumed roughly 500 kg of wet fuel each week. The CO emission factor averaged an extremely low 14.5 g/kg and the PM emission factor was 6.0 g/kg. Both the automatically stoked coalburning units were very clean when compared to conventional woodburning stoves. Since the emissions were measured using stack sampling, the issue of secondary sulfate formation was not addressed in this study.

Error Analysis

A preliminary error analysis was performed at the beginning of the study in order to see which measured or assumed parameters might create the greatest errors in reported emissions. This preliminary analysis is shown in Table 3. The analysis was run for baseline cases of catalytic stoves and conventional stoves, using average data (by appliance type) from the 1988-89 study to define the baseline conditions. Individual parameters were perturbed one at a time to see the effect of each perturbation.

The perturbation values used for each parameter in the initial analysis were at that time the best available estimates of maximum error for each quantity. Later experience, including the results of the performance evaluation audit, provides for a better estimate of the possible errors in each measured quantity. A complete error analysis has subsequently been performed. The derivation of the error analysis equations is in the appendix. The precision and bias estimates used in the analysis are shown in Table 4, and the estimates are discussed in the following paragraphs.

The time measurement was handled by a synchronous hourmeter which ran whenever the stack temperature was above the setpoint. When the hourmeters were individually checked against an electronic wristwatch they were found to be accurate to within the least count (0.1 hr) of their readouts. Thus there is no bias and the precision is taken as 0.1 hr.

The least count on the Accuweigh scale used to determine wet fuel weight is 0.2 kg. The precision of the wet fuel weight measurement is taken as 0.1 kg because repeated weighings of the same mass have been observed to be reproducible within 0.1 kg. The performance evaluation audit indicated that for the range of weights measured in the field the Accuweigh scale was reading from 0.4 to 1.5% high. In the data reduction process the fuel consumption data were adjusted downward by 0.95%, and thus the error analysis includes no bias for the scale readings.

Fuel moisture measurement precision was taken as 15% of the moisture content value. Two thirds of this estimate corresponds to the worst standard deviation observed out of three sets of samples from three different woodpiles, and the other third is the estimated precision for conversion of desiccated to oven-dry moisture contents. The bias is taken as 0 because the gravimetric method used for all moisture content determinations in this project is the reference method for wood moisture measurements.

Precision for the initial tank pressure was taken as 1 torr, the least count of the Bennert manometer. Bias is 0 because the mercury manometer is the reference method for pressure measurement.

Precision for the final tank pressure is 1 torr, which is the repeatability of measurements taken with the Datametrics transducer or with the Bennert manometer. Bias is possibly as high as 2 torr, since a new calibration curve would not be drawn for the Datametrics sensor unless its error was greater than 2 torr.

Sampler temperature precision was estimated as the resolution of the digital thermometer used for the measurements. Comparison of the digital thermometer readings with a mercury thermometer gave agreement to within 1 degree C for laboratory temperature, and this value is used as the bias estimate.

The precision of the PM catch measurement is limited by the ability to repeatably weigh the sample line, filters, probe, petri dish, and O-ring residue. The repeatability of line weighings is typically within 0.3 mg, and the repeatability of the other weighings is 0.1 mg each. Thus the precision is estimated as 0.8 mg for the PM catch. The bias is taken as 0.2 mg, the worst case error (for the range of weights encountered) found during the performance audit.

The audit gave errors of 9% for each of three CO concentrations measured. This is about twice the maximum error which was expected. It is unclear why the error was so large, and the authors believe that field measurements of CO may have in fact been more accurate than the audit results suggest. However, in the error analysis the bias is estimated at 9 percent of reading for CO measurements. Precision is estimated as 0.01 mol% (100 ppm), the resolution of the analyzer display. Fortunately, the measured PM emissions are not sensitive to CO measurements and the PM emissions are affected only by about 1% due to a 9% error in CO.

Audit results gave CO_2 errors of one to three percent of measured value for the concentration ranges encountered during the study. Since the audit cylinder contents are known only to within

2% of value, the bias for CO_2 measurements was estimated as 2% of value for all readings. The precision is taken as 0.1 mol%, the resolution of the digital display.

Most of the tank volumes were measured using a gravimetric procedure. Each tank was evacuated with a vacuum pump, weighed, filled with argon to approximately 170 psia, and weighed again. The final tank pressure was measured using a bourdon tube gage which had been calibrated using a dead weight gage tester, and the tank volume was calculated using the ideal gas law. The scale used for weighing the sampler was checked for accuracy in the incremental weight range where the sampler weighings occurred. The volumes of four tanks on loan from EPA for the study were not measured and were assumed to be the same as the average of the other sampler volumes. For the eight samplers whose volumes were measured, the difference between greatest and smallest sampler volumes was approximately 5% of the average volume. Bias is estimated at 2.5%, and precision is estimated at 0% because assumed values are used.

The carbon fraction of dry wood is 0.51 +/- 0.01 for most wood species. The bias is estimated at 2% and the precision for this parameter is estimated at 0% because an assumed value was used.

One sample of coal from each coalburning site was analyzed for elemental composition and moisture content. All three coalpiles were from the same mine. The 0% precision estimate is used because the carbon content was not measured for each week of sampling. The bias estimate is taken as 2% to account for the fact that the coal samples from each site may not have been perfectly representative of the composition of the whole pile. This estimate is reasonable, since the analyses for the three coal samples gave carbon contents of 74.51, 72.42, and 72.91 respectively.

The contribution to dry stack gas per unit of fuel consumed is the parameter w, which is calculated from the elemental analysis of the fuel. If the fuel was pure carbon, w would be 1.0 because one kg of dry fuel would add 1.0 kg of carbon (as CO_2 or CO) to the incoming air and no oxygen would be removed from the air to form water. For an imaginary fuel of composition $C_2H_4O_2$ the carbon content is 50% on a mass basis and w is 0.5 because the H and O in the fuel will form water which will not appear in the dry stack gas. When a fuel contains H and O in other than a 2:1 molar ratio the value of w will not be the same as the fuel carbon fraction. The three coal analyses give w values of 0.41, 0.42, and 0.43. Data from each coalburning site were reduced using the appropriate value. A precision of 0% and a bias of 0.06 are assumed in the error analysis. This value is large enough to take into account the variations of fuel elemental composition which are likely to occur. The actual value of w is not critical, since emissions are very insensitive to this parameter.

Two types of error calculations were performed in the final error analysis. The spreadsheet printout in Appendix I shows, for each test, the estimated errors in each emission rate (and factor) due to the assumed "maximum possible" error in each individual measured or assumed input parameter. These estimates of maximum possible errors for individual parameters are the sums of the precision and bias estimates shown in Table 4. Also shown in the spreadsheet for each test are the "maximum probable errors" due to simultaneous occurrence of the maximum errors for all individual input parameters. These "probable error" estimates are calculated by taking the square root of the sum of the squares of the possible errors due to individual parameters. This procedure gives error estimates which take into account the fact that some errors are likely to be in opposite directions and therefore will at least partially cancel. Since the worst case errors for each parameter are used in the calculation, it is likely that the maximum probable errors listed are upper bounds on the actual errors. The averages of the maximum probable errors are as follows, listed by appliance type.

AVERAGES OF MAXIMUM PROBABLE ERRORS
IN EMISSION FACTOR MEASUREMENTS
(as percent of reported values)

	COAL APPLIANCES	CONVENTIONAL WOODSTOVES	CATALYTIC WOODSTOVES	NONCATALYTIC WOODSTOVES
PM	32.3	10.3	11.0	13.5
CO	25.7	13.0	14.7	12.7

The worst errors for CO emission factors occur for conditions where the sample gas is dilute. The lowest CO value measured during the study was 0.04%, a value which occurred for a coalburning automatically-stoked appliance with a concomitant CO_2 concentration of 2.2%. Since the CO analyzer used in the study had a digital display with a resolution of 0.01 mole percent, the probable CO errors could be significantly reduced in future studies by use of a more appropriately ranged instrument. In the case of automatically stoked coalburning appliances, where maximum probable CO errors are 29 to 35%, it is noteworthy that the errors are large as a percentage because the appliances are very clean. These percentages correspond to CO errors of only 4 to 14 g/kg. For woodstoves, maximum CO errors are probably as much as 20% in only three runs, wherein the CO concentrations were near 0.09%, the lowest measured value for woodburning stoves in this study.

The probable errors in PM emissions are dominated by the ability to measure the particulate catch. The residential coal stoker (COAL 06) was clean burning and had a barometric damper, giving the worst possible conditions for accurate PM measurement.

Maximum probable PM errors are in the 15 to 52% range for seven runs, with a maximum probable error of 119% for the eighth run. These 15 to 119% errors give PM emission factor errors of 0.9 to 2.9 g/kg. For woodstoves, only two runs had maximum probable PM errors greater than 30%. For maximum probable PM errors of 34.5 and 33.3%, the corresponding maximum probable errors in PM factors are 1.4 and 2.7 g/kg. The average maximum probable error for PM was 1.1 g/kg for catalytic stoves and 1.2 g/kg for noncatalytic stoves.

SUMMARY AND CONCLUSIONS

During the 1988-89 and 1989-90 heating seasons PM and CO emissions of eighteen certified woodburning stoves representing eight models (six catalytic, two noncatalytic) were measured. Emissions were also measured from 18 conventional woodburning stoves. A summary of results by appliance type is shown in Table 5. Compared to the emissions measured from conventional stoves, the 18 certified stoves reduced PM and CO by about a factor of 2, as shown in Figures 11 and 12.

There was a difference in the performance of the two low emission technologies, catalytic and noncatalytic. Figures 11 and 12 show that PM reduction was about the same for both technologies but CO reduction was greater for the catalytic stoves. Figures 6 and 7 show that there were significant differences between the performance of different stove models. In most cases additional measurements and/or stove inspection are required to determine the causes.

Both noncatalytic stove models had reduced emissions compared to conventional stoves. For model G, average PM and CO reductions were 71 and 48% respectively, and for model H the reductions were 44 and 19%. Comparison of the two models is not straightforward, since two of the three model H stoves were operated at low burn rates compared to the burn rates for model G stoves. The noncatalytic models performed best at higher burn rates, and the data suggest that operators be encouraged to operate at burn rates averaging 0.9 kg or more.

All the catalytic stove models had reduced emissions compared to the conventional stoves. The average PM emission factor reduction for the catalytic models ranged from 34 to 71%, while CO reduction ranged from 41 to 64%. There is currently not enough data to determine the reasons for differences in performance, but additional work could determine this.

The hand-fired coalstove was cleaner than expected. On a gram/Joule basis the PM emission factors were reduced by 55% compared to conventional woodstoves. The CO emissions were reduced by about 27%. Since only one hand-fired stove was monitored it is not possible to say whether its behavior is average when compared to other hand-fired coalburning stoves. The two automatically stoked coal appliances were very clean compared to the conventional stoves monitored. Average PM reductions were 84% and average CO reductions were 85%.

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2. Jaasma, D. R., and M. R. Champion, "Field Performance of Woodburning Stoves in Crested Butte during the 1988-89 Heating Season," final report to the Town of Crested Butte, Crested Butte, CO, June 30, 1989.

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4. McCrillis, R. C., and D. R. Jaasma, "Comparability Between Various Field and Laboratory Woodstove Emission Measurement Methods," presented at the 84th Annual Meeting of the Air and Waste Management Association, Vancouver, B. C., June 16-21, 1991.

5. 40CFR Part 60, Standards for Performance for New Stationary Sources, Standards of Performance for New Sources, Residential Wood Heaters; Federal Register, February 26, 1988, pp. 5860-5926.

6. "Compilation of Air Pollution Emission Factors, Volume I: Stationary Point and Area Sources, AP-42, Supplement C," (GPO 055-000-00369-6), U.S. Environmental Protection Agency, September 1990.

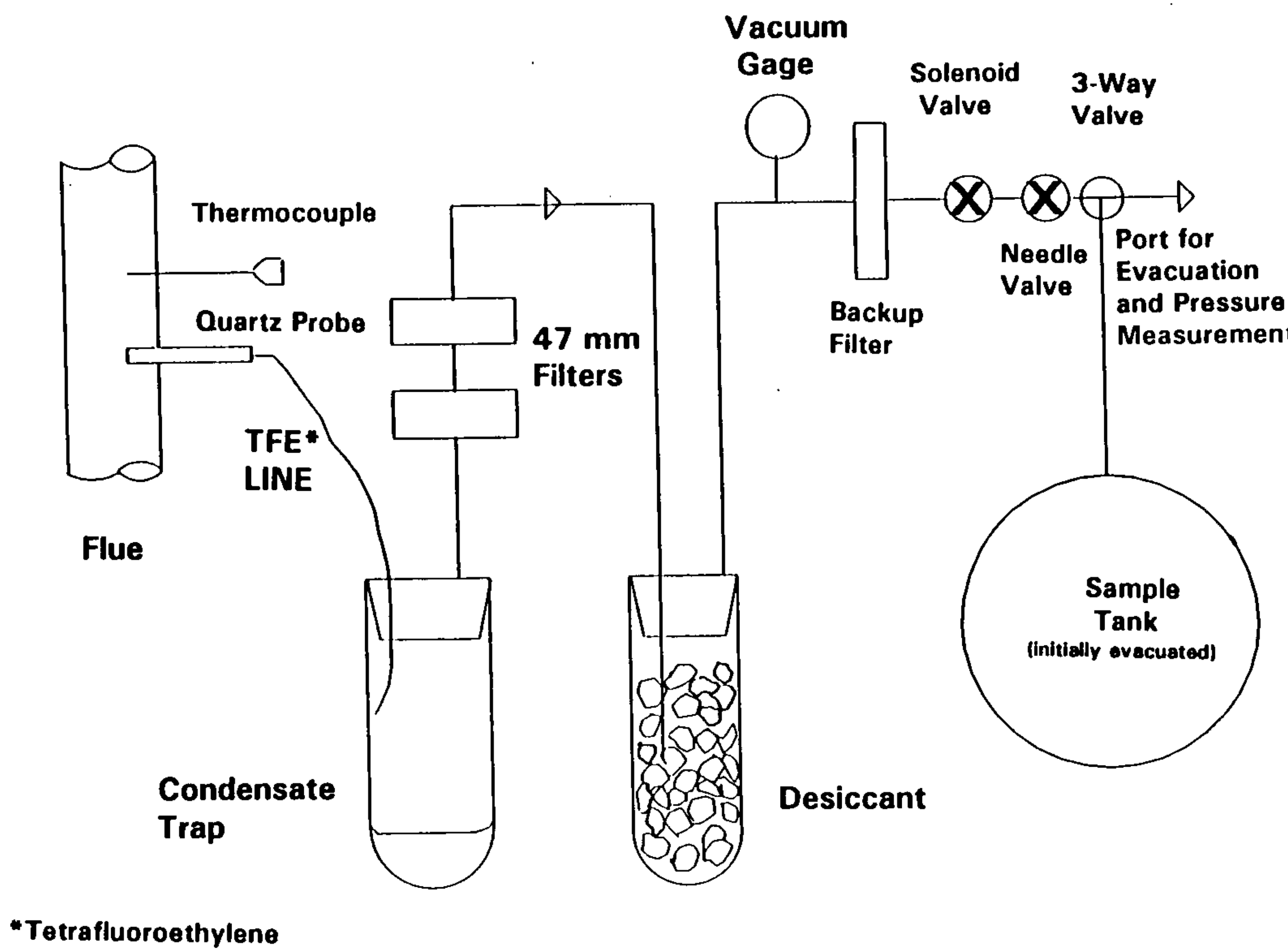

Figure 1. Schematic of the VPI Sampler.

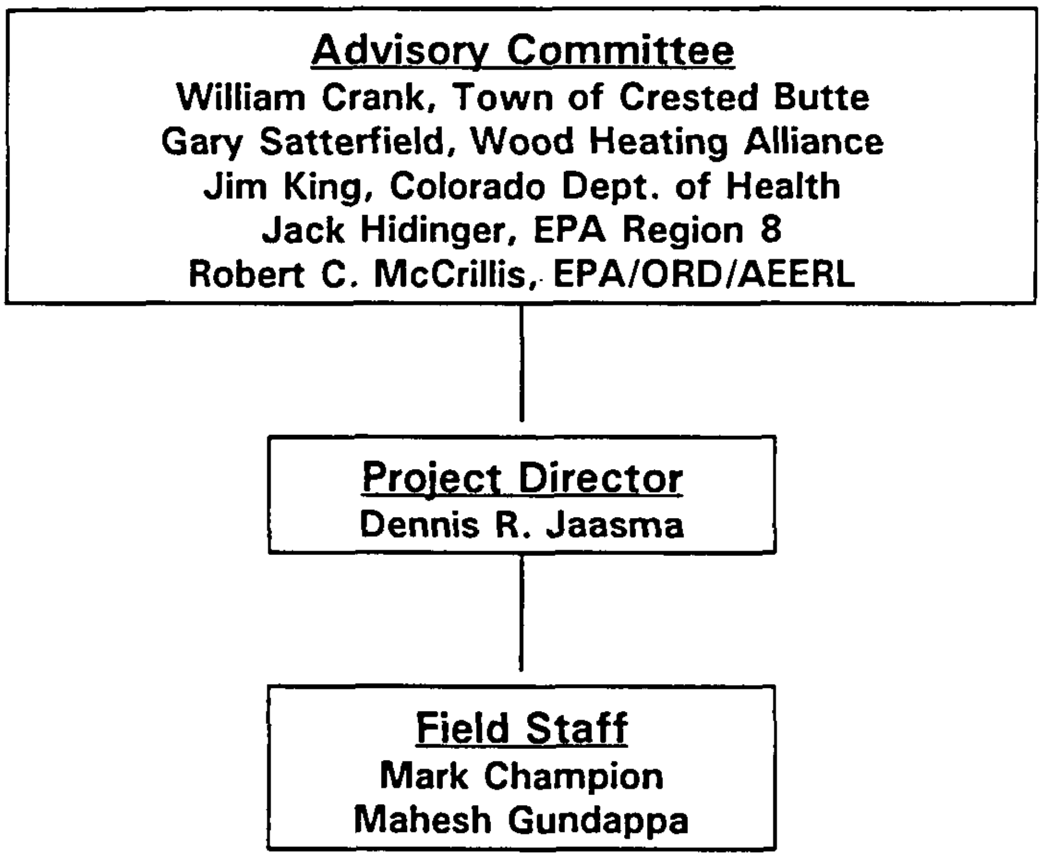

Figure 2. Crested Butte 1989-90 Project Organization.

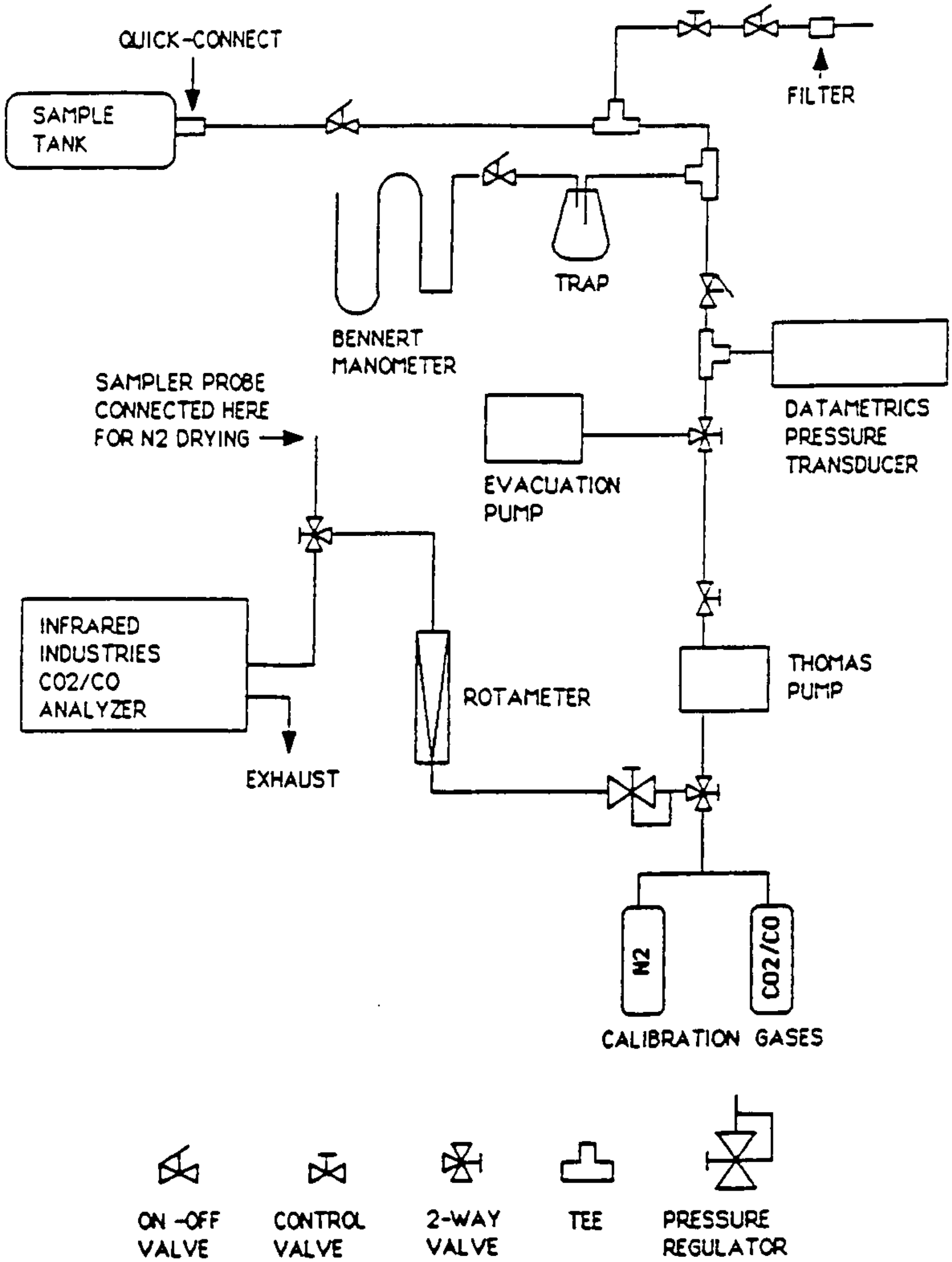

Figure 3. Flowbench for Sampler Workup and Preparation.

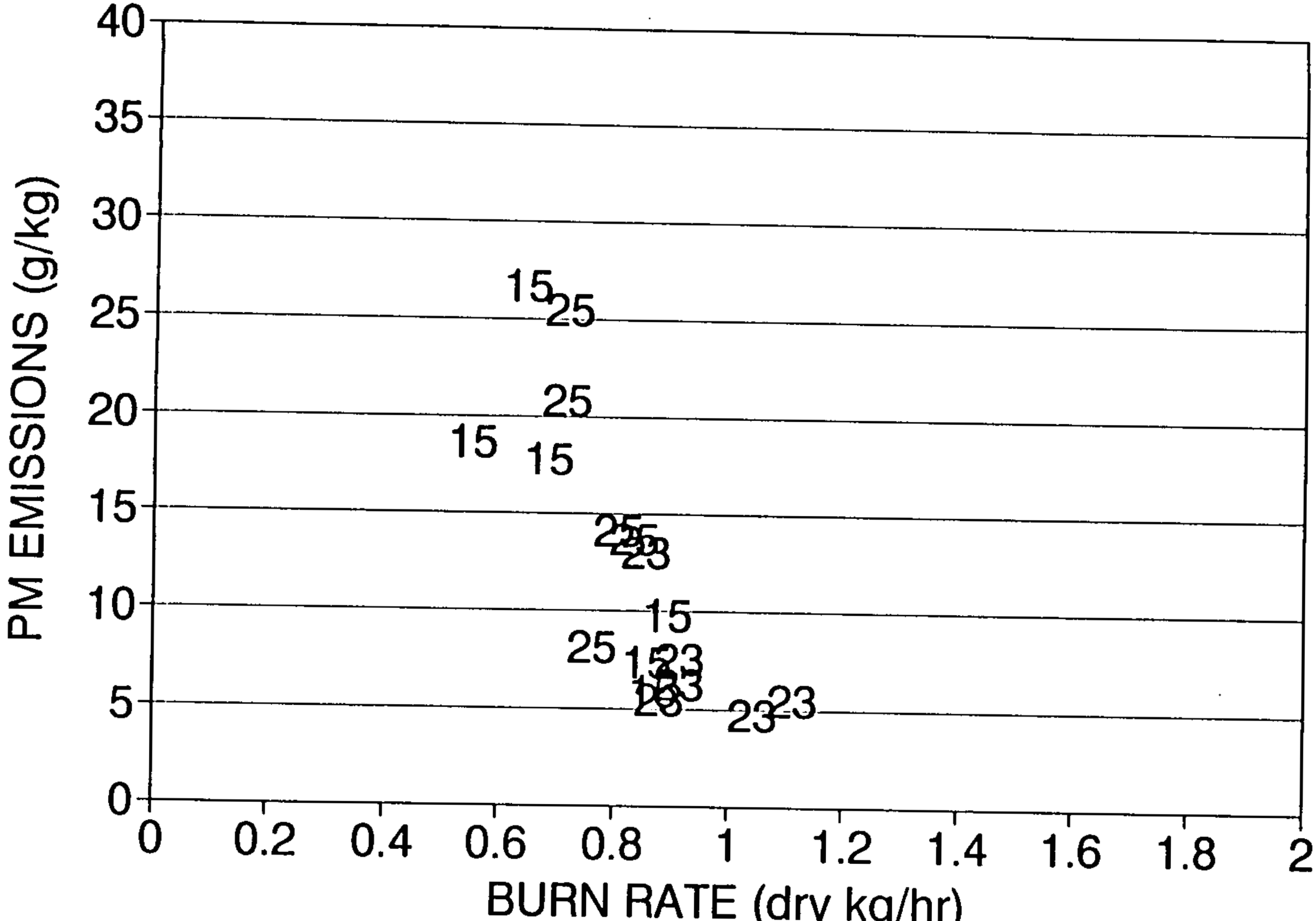

Figure 4. Noncatalytic Model H Emissions.
(sites 15, 23, and 25)

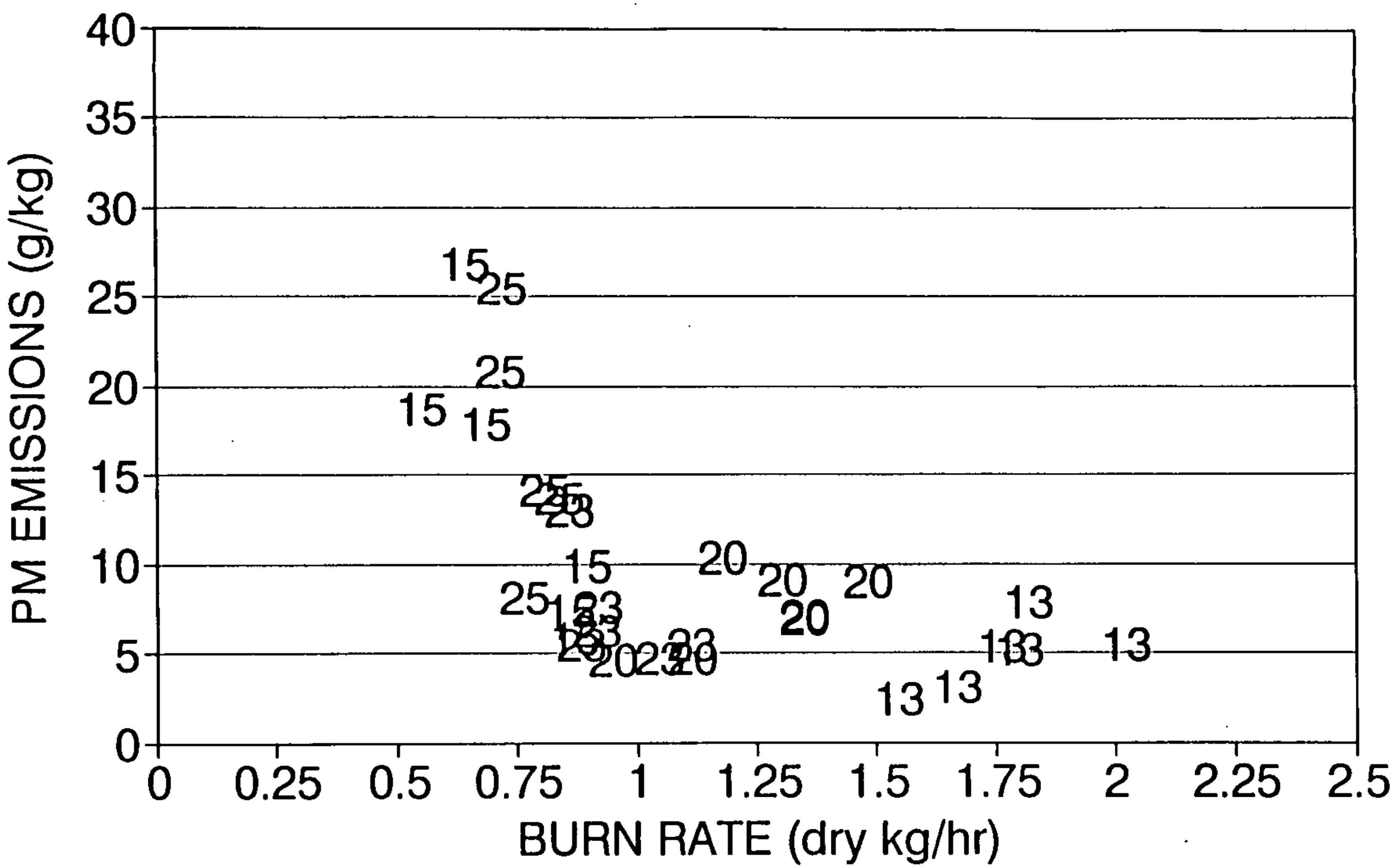

Figure 5. Noncatalytic Stove PM Emissions.
(15, 23, 25 = model H; 13, 20 = model G)

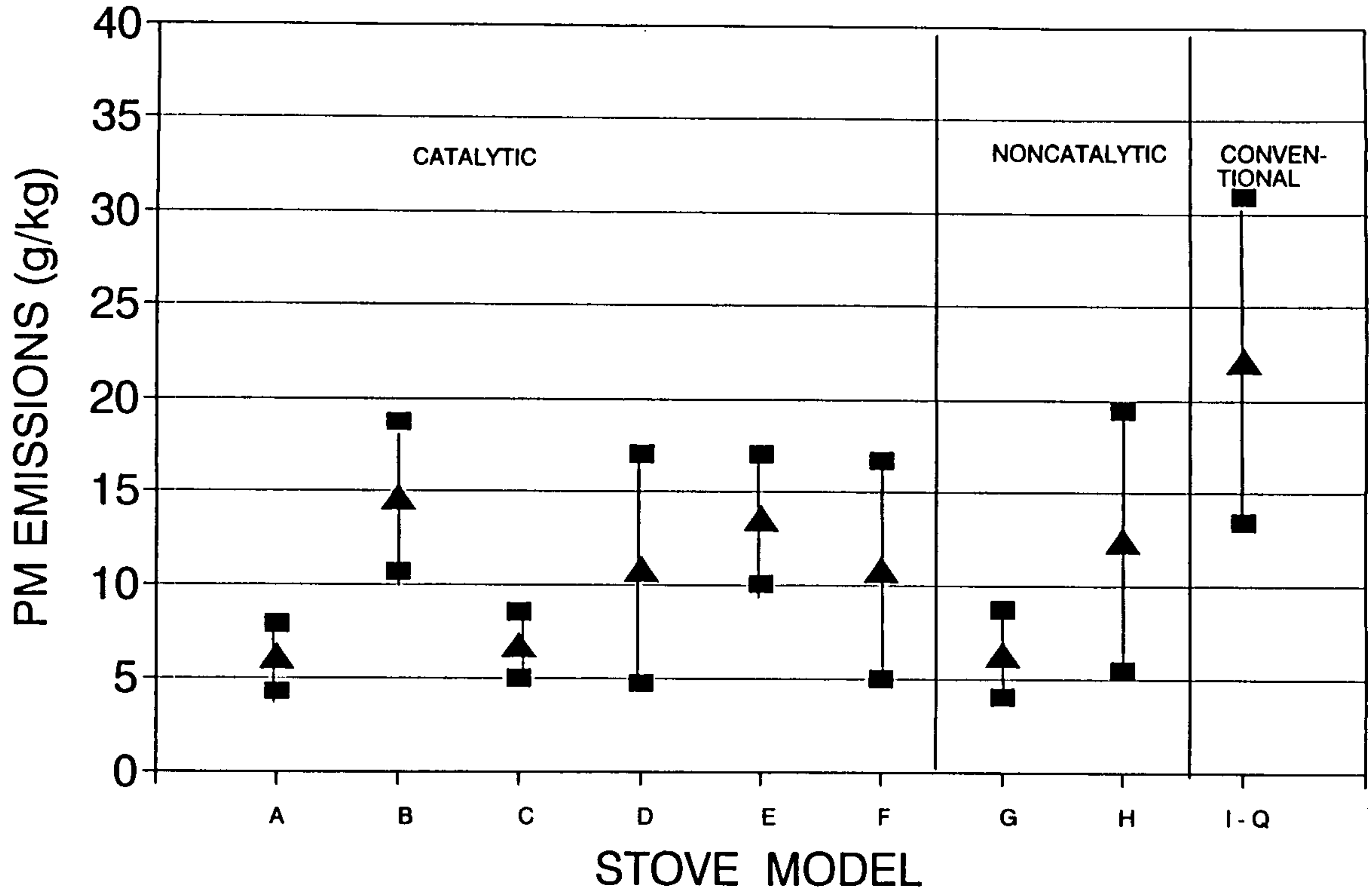

Figure 6. PM Emissions by Stove Model.
(squares show +/- one std. dev.)

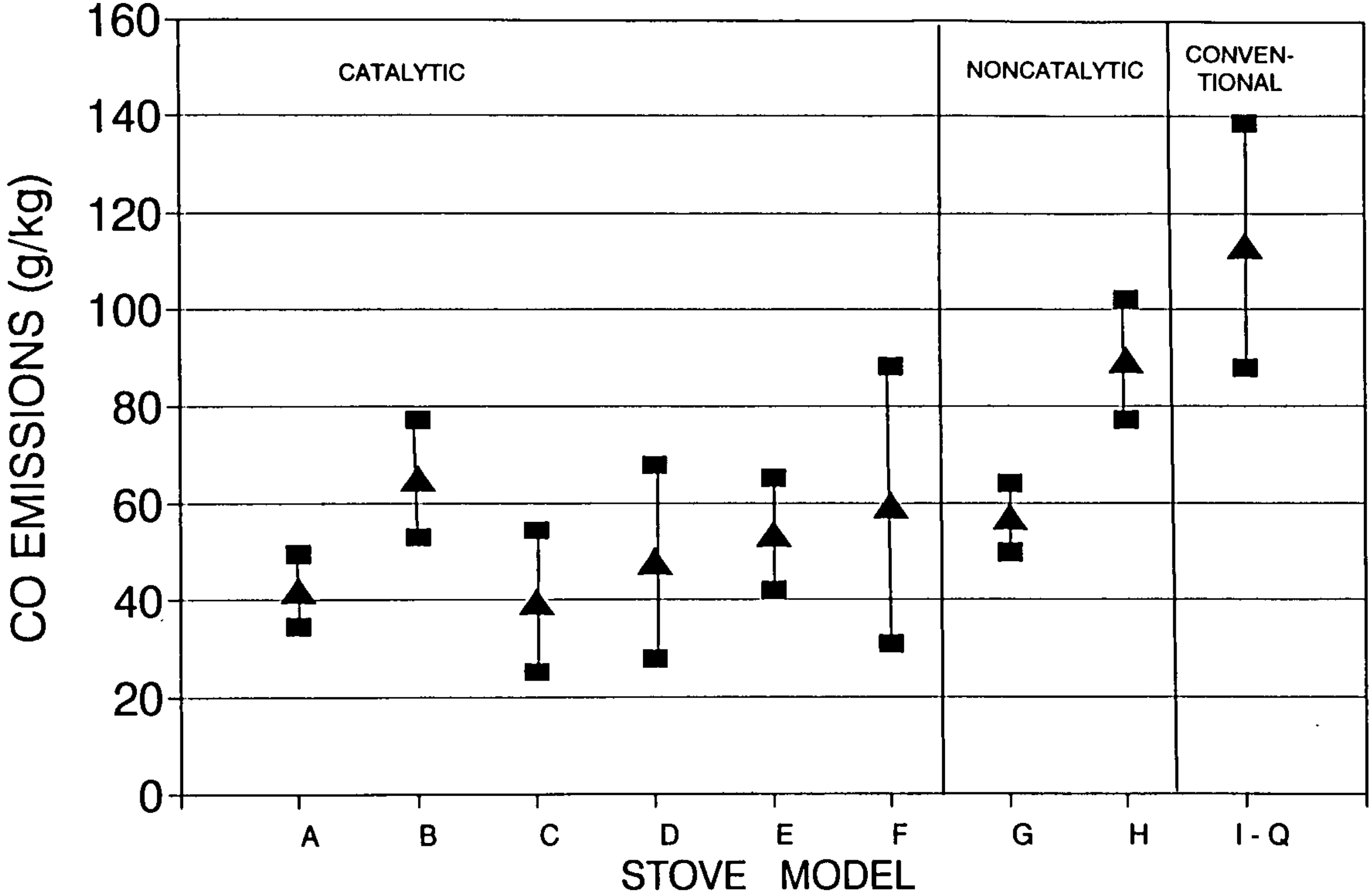

Figure 7. CO Emissions by Stove Model.
(squares show +/- one std. dev.)

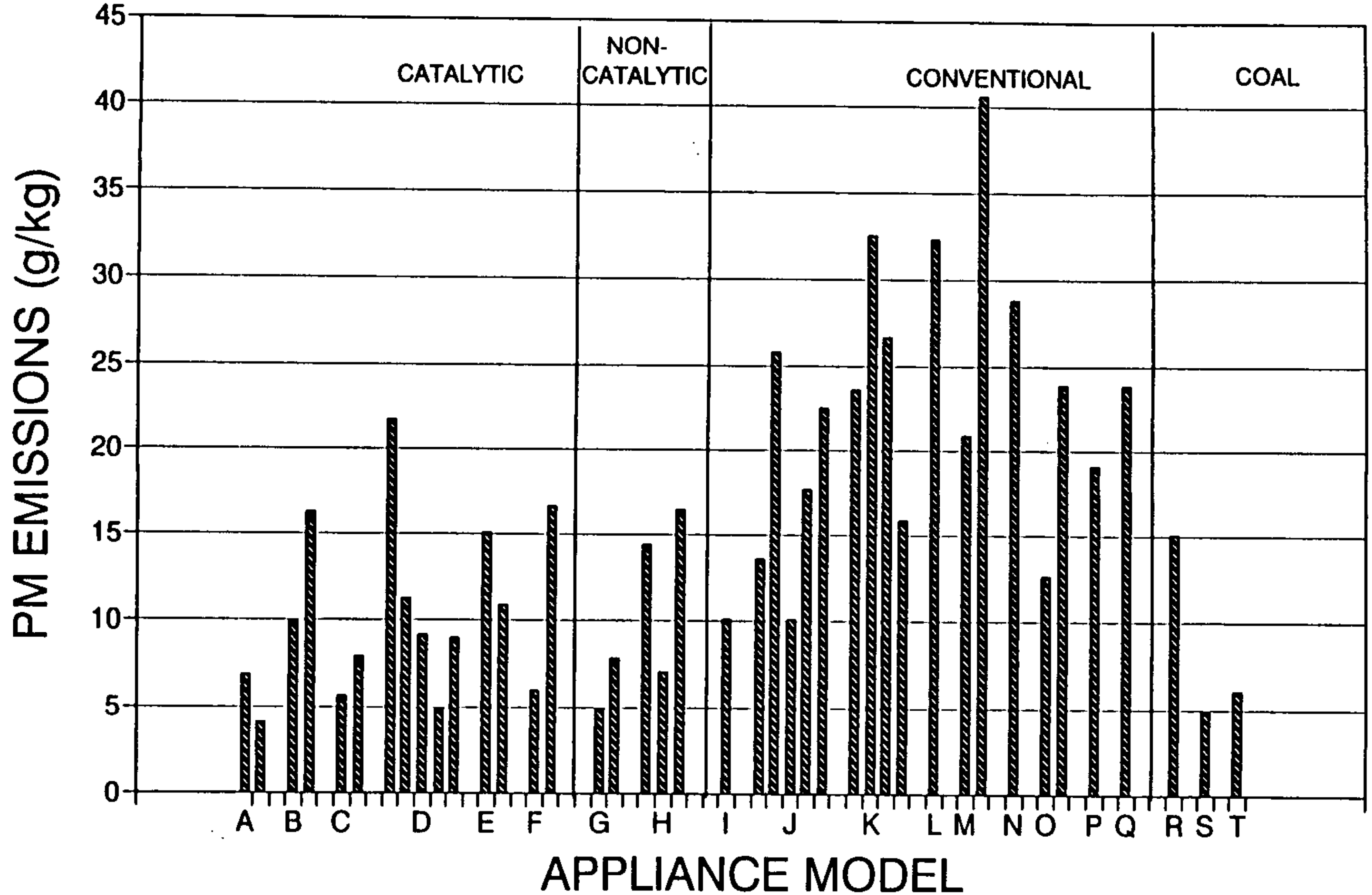

Figure 8. PM Emissions by Appliance.
(appliances of each model appear in same order as in Appendix I)

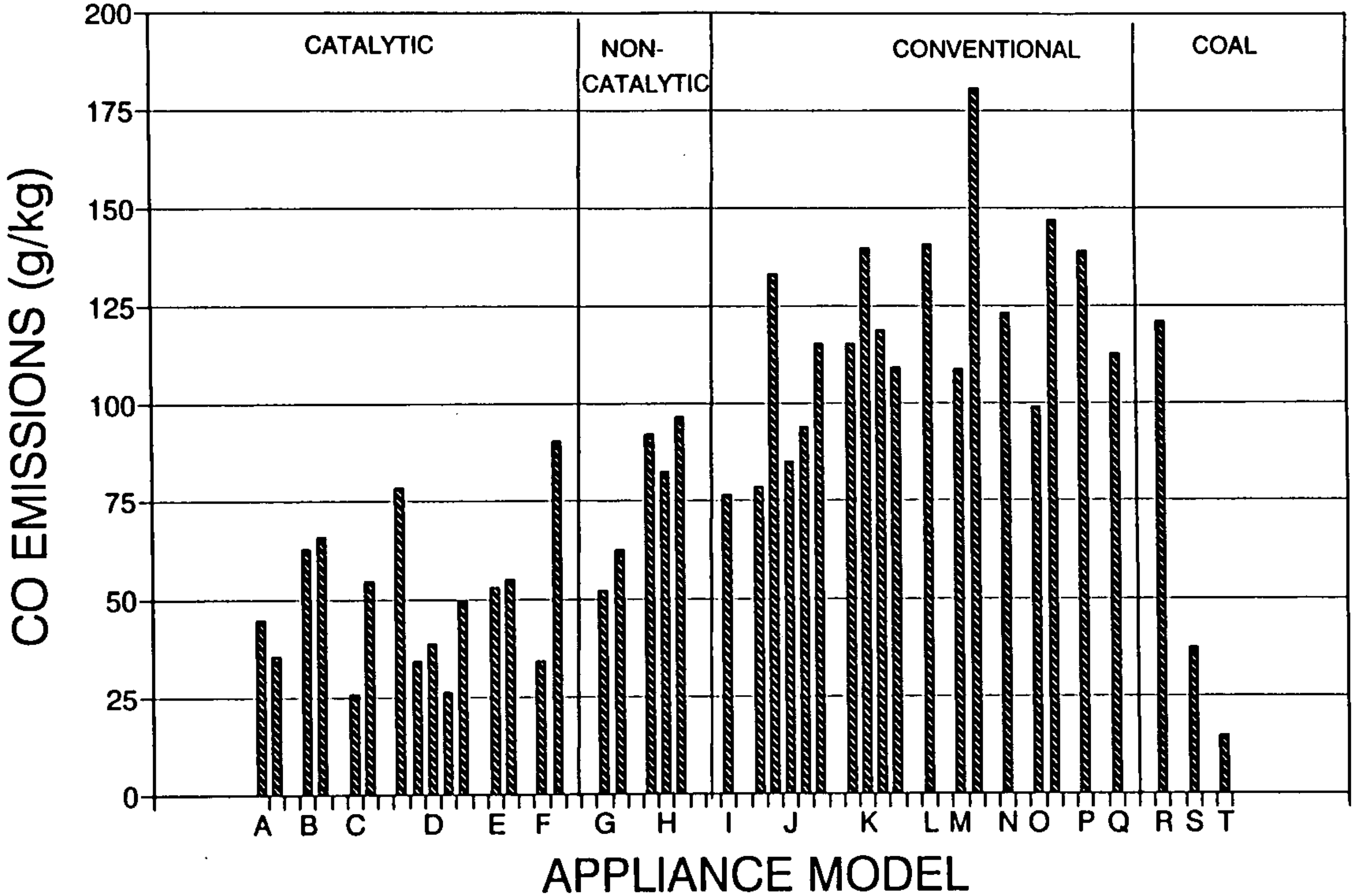

Figure 9. CO Emissions by Appliance .
(appliances of each model appear in same order as in Appendix I)

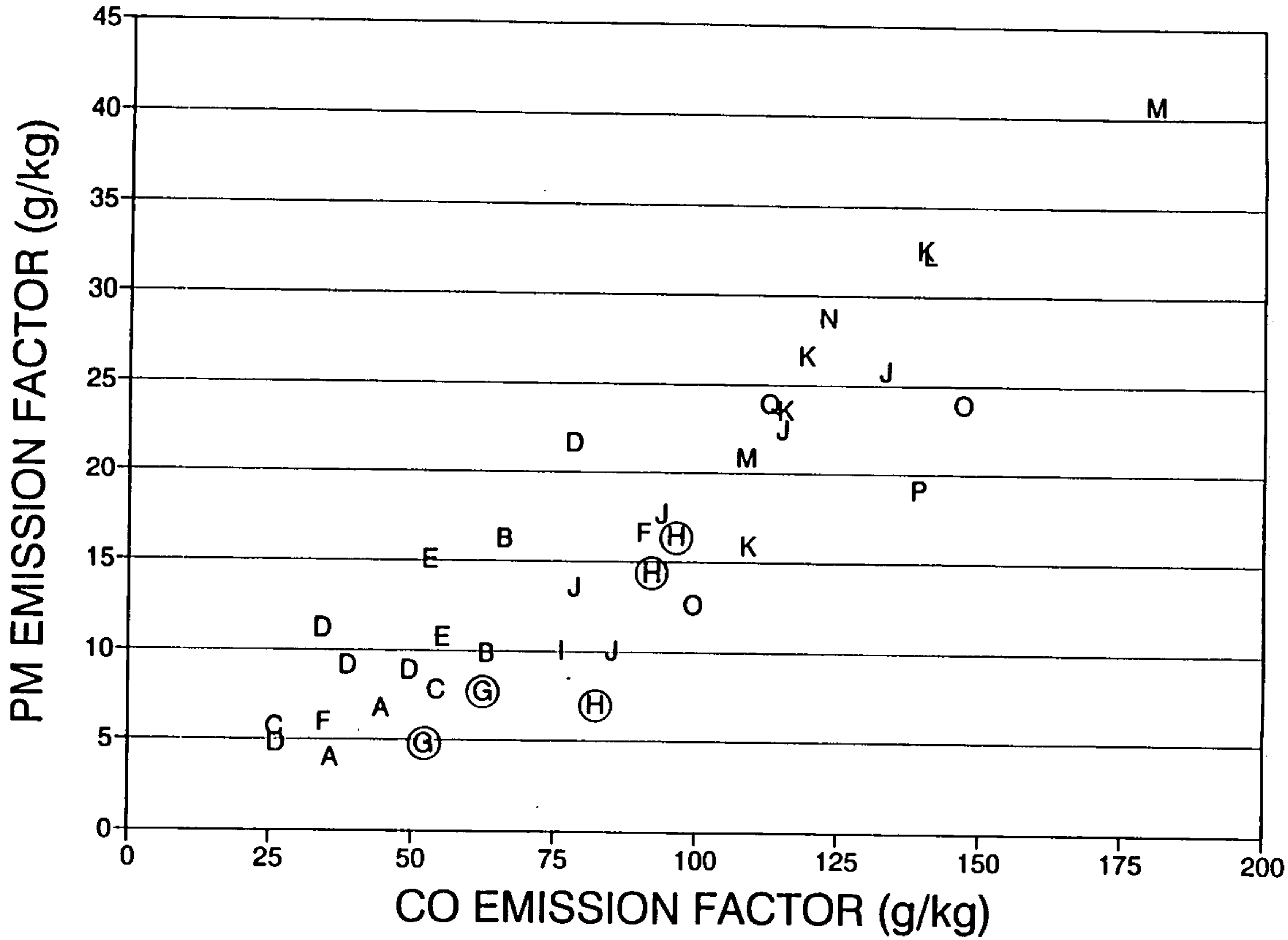

Figure 10. Correlation of CO and PM.
(circled models are noncatalytic)

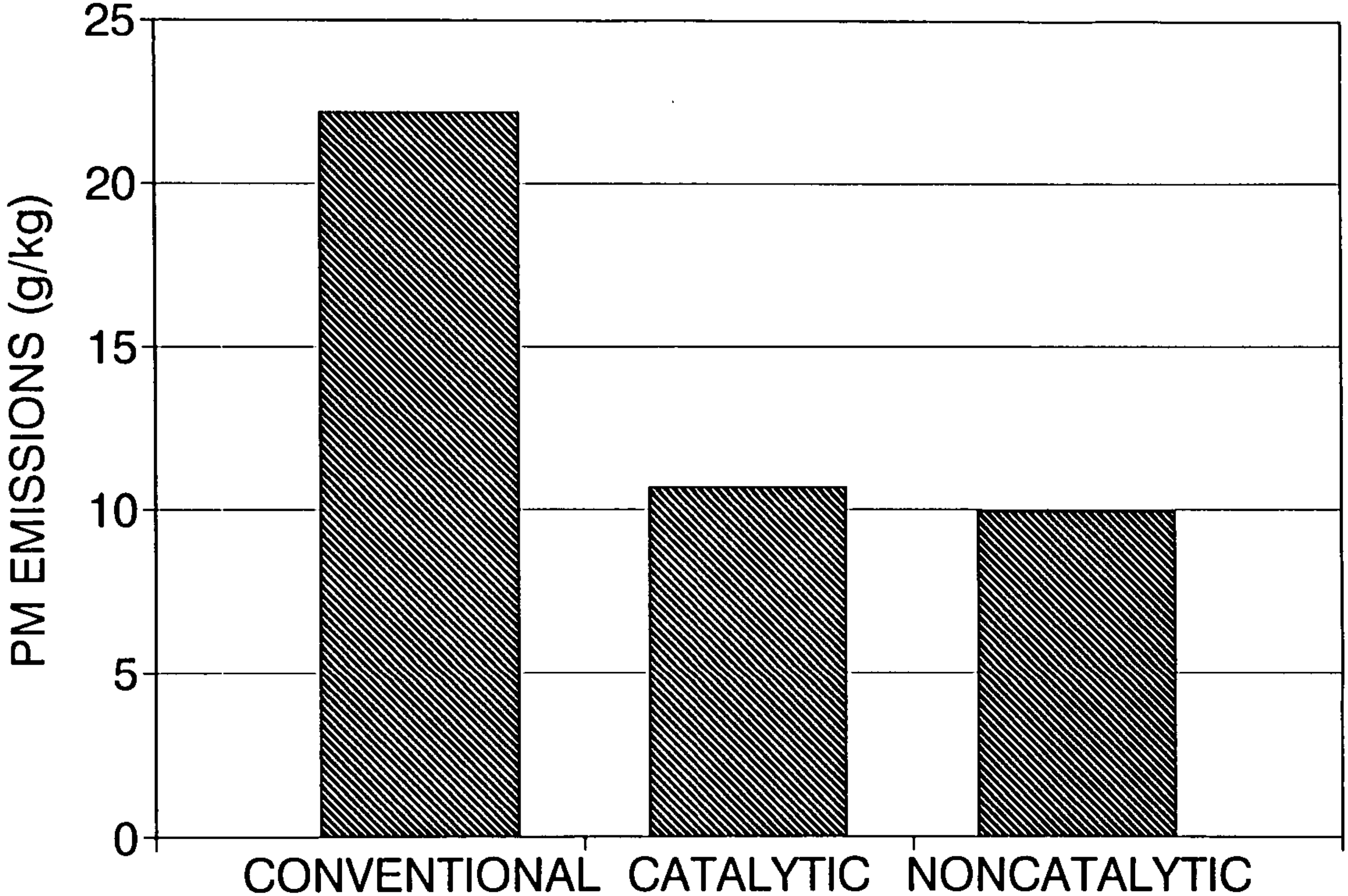

Figure 11. PM Emissions in Crested Butte.
(averages for each woodstove category)

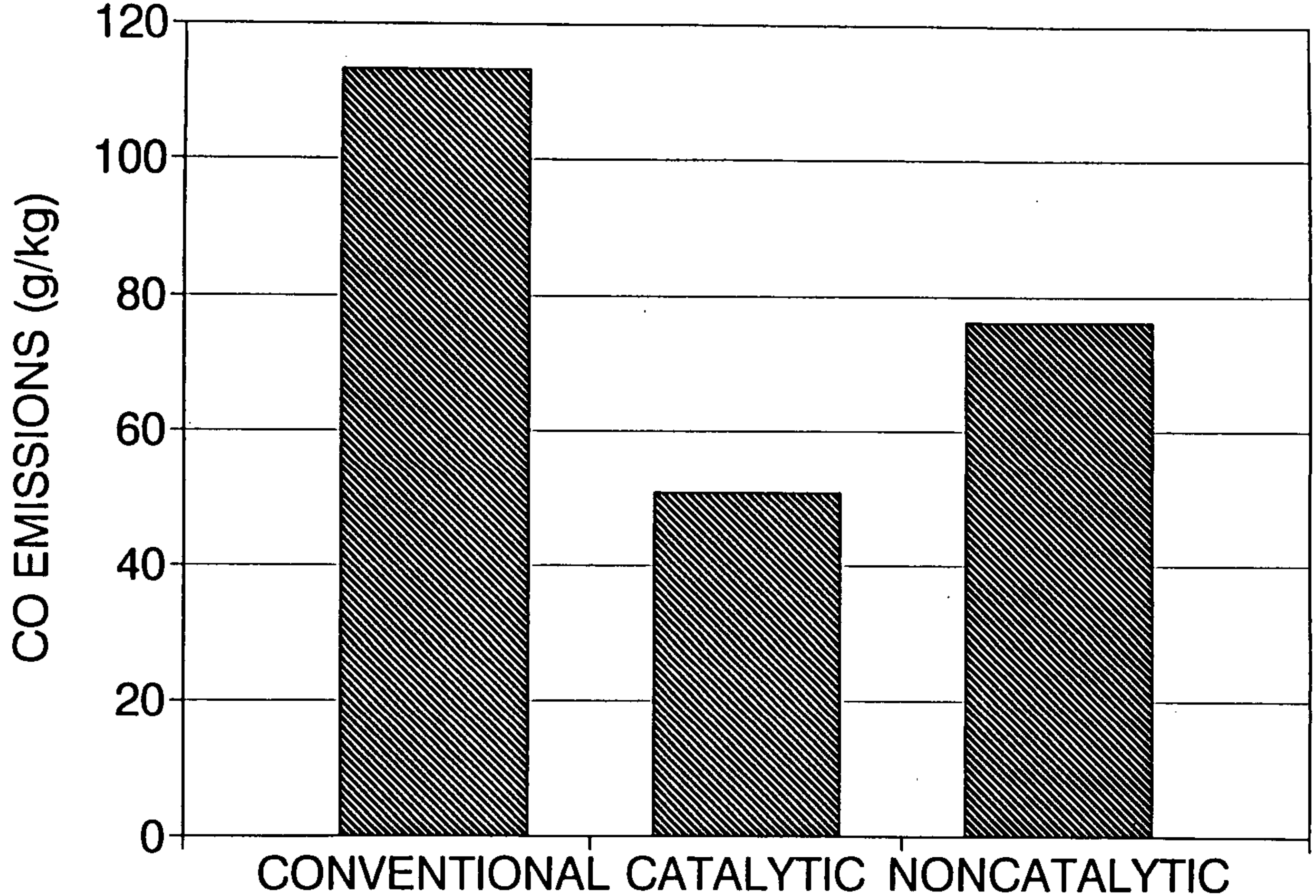

Figure 12. CO Emissions in Crested Butte.
(averages for each woodstove category)

TABLE 1. AVERAGE EMISSION FACTORS AND STANDARD DEVIATIONS.

Data are for 1989-90 unless noted, PM data are as measured by the VPI sampler.

SITE CODE	STOVE MODEL	CO EMISSIONS AVG. g/kg	CO EMISSIONS STD.DEV. g/kg	PM EMISSIONS AVG. g/kg	PM EMISSIONS STD.DEV. g/kg
CAT 12 (88-89)	A	43	5.3	7.0	1.4
CAT 12 (89-90)	A	46	6.3	6.7	1.5
CAT 12 (both yrs)	B	44	6.0	6.8	1.5
CAT 27 (88-89)	B	36	7.2	4.0	0.9
CAT 08	C	63	13.5	9.9	2.8
CAT 18	C	66	11.7	16.3	3.0
CAT 14	D	26	3.4	5.7	0.8
CAT 24	D	54	3.8	7.9	1.8
CAT 16 (first stove)	D	78	3.4	21.7	1.5
CAT 16 (new catalyst)	D	34	-	11.2	-
CAT 16 (second stove)	D	38	1.3	9.2	0.7
CAT 16 (new catalyst)	E	26	2.4	4.9	1.2
CAT 21	E	49	14.7	9.0	3.5
CAT 17	F	53	14.0	15.1	3.5
CAT 22	F	55	4.2	10.9	1.4
CAT 19		34	2.3	6.0	1.7
CAT 26	G	90	9.0	16.6	3.2
	G				
NCAT 13	H	52	4.9	4.9	1.8
NCAT 20	H	62	5.0	7.8	1.9
NCAT 15	H	92	14.8	14.4	7.4
NCAT 23		82	5.1	7.1	2.8
NCAT 25	I	96	11.3	16.5	6.0
	J				
CONV 01	J	76	6.3	10.1	3.0
CONV 03	J	78	2.5	13.6	1.9
CONV 09	J	133	9.6	25.8	4.3
CONV 28 (88-89)	J	85	5.9	10.1	2.6
CONV 29 (88-89)	K	94	5.5	17.6	1.3
CONV 30 (88-89)	K	115	6.3	22.5	4.0
CONV 04	K	115	4.8	23.6	4.9
CONV 31 (88-89)	K	140	4.8	32.6	4.5
CONV 32 (88-89)	L	119	1.8	26.6	1.5
CONV 33 (88-89)	M	109	12.2	15.9	5.2
CONV 05	M	141	20.0	32.3	6.0
CONV 10	N	109	8.7	20.9	6.7
CONV 34 (88-89)	O	181	3.7	40.7	3.8
CONV 11	O	123	1.5	28.8	3.4
CONV 35 (88-89)	P	99	10.4	12.6	4.4
CONV 36 (88-89)	Q	147	-	23.9	-
CONV 37 (88-89)		139	2.8	19.1	1.1
CONV 38 (88-89)	R	113	3.5	23.9	2.8
	S				
COAL 02	T	121	12	15.1	1.2
COAL 06		37	5	4.9	1.9
COAL 07		14	2	6.0	0.5

TABLE 2. AVERAGE EMISSION FACTORS AND STANDARD DEVIATIONS.

Data are for 1989-90 unless noted, PM data are expressed as 5H equivalents.

SITE CODE	STOVE MODEL	CO EMISSIONS AVG. g/kg	CO EMISSIONS STD.DEV. g/kg	PM EMISSIONS AVG. g/kg	PM EMISSIONS STD.DEV. g/kg
CAT 12 (88-89)	A	43	5.3	6.6	1.5
CAT 12 (89-90)	A	46	6.3	6.3	1.6
CAT 12 (both yrs)	A	44	6.0	66.4	1.6
CAT 27 (88-89)	A	36	7.2	4.0	1.0
CAT 08	B	63	13.5	9.0	2.9
CAT 18	B	66	11.7	14.2	3.0
CAT 14	C	26	3.4	5.5	0.8
CAT 24	C	54	3.8	7.4	1.9
CAT 16 (first stove)	D	78	3.4	18.4	1.6
CAT 16 (new catalyst)	D	34	-	10.1	0.0
CAT 16 (second stove)	D	38	1.3	8.5	0.8
CAT 16 (new catalyst)	D	26	2.4	4.8	1.4
CAT 21	D	49	14.7	8.3	3.5
CAT 17	E	53	14.0	13.3	3.5
CAT 22	E	55	4.2	9.8	1.5
CAT 19	F	34	2.3	5.7	1.8
CAT 26	F	90	9.0	14.5	3.3
NCAT 13	G	52	4.9	4.8	1.9
NCAT 20	G	62	5.0	7.3	2.0
NCAT 15	H	92	14.8	12.7	6.9
NCAT 23	H	82	5.1	6.7	2.9
NCAT 25	H	96	11.3	14.4	5.8
CONV 01	I	76	6.3	9.2	3.0
CONV 03	J	78	2.5	12.1	2.0
CONV 09	J	133	9.6	21.6	4.3
CONV 28 (88-89)	J	85	5.9	9.2	2.7
CONV 29 (88-89)	J	94	5.5	15.3	1.4
CONV 30 (88-89)	J	115	6.3	19.0	4.0
CONV 04	K	115	4.8	19.9	4.8
CONV 31 (88-89)	K	140	4.8	26.7	4.4
CONV 32 (88-89)	K	119	1.8	22.2	1.6
CONV 33 (88-89)	K	109	12.2	13.9	5.0
CONV 05	L	141	20.0	26.5	5.8
CONV 10	M	109	8.7	17.8	6.4
CONV 34 (88-89)	M	181	3.7	32.6	3.8
CONV 11	N	123	1.5	23.8	3.4
CONV 35 (88-89)	O	99	10.4	11.3	4.3
CONV 36 (88-89)	O	147	-	20.1	0.0
CONV 37 (88-89)	P	139	2.8	16.5	1.2
CONV 38 (88-89)	Q	113	3.5	20.2	2.8
COAL 02	R	121	12	13.3	1.4
COAL 06	S	37	5	4.8	2.0
COAL 07	T	14	2	5.8	0.6

TABLE 3. SENSITIVITY OF EMISSION RATES AND FACTORS TO ERRORS IN MEASURED AND ASSUMED INPUTS.
Error analysis uses equations from 12/31/89 spreadsheet at Crested Butte.
Stove operating conditions are from 1988-89 Crested Butte data.

	FUEL wet kg	FUEL MC dry %	SAMPLING TIME hr	CO2 %	CO %	FUEL CARBON %	TANK VOLUME m^3	TOTAL CATCH g	TANK PRESSURE torr	TANK TEMP C	TOTAL O2 dry %	HC FACTOR	ERRORS PM g/hr %	ERRORS CO g/hr %	ERRORS PM g/kg %	ERRORS CO g/kg %
CONVENTIONAL STOVES:																
BASELINE	100	20	67	3.7	0.43	51	0.0736	0.0178	270	18	21	1.5	0.0	0.0	0.0	0.0
	102.0	20	67	3.7	0.43	51	0.0736	0.0178	270	18	21	1.5	2.0	2.0	0.0	-0.0
	100	23.0	67	3.7	0.43	51	0.0736	0.0178	270	18	21	1.5	-2.4	-2.4	0.0	-0.0
	100	20	67.1	3.7	0.43	51	0.0736	0.0178	270	18	21	1.5	-0.1	-0.1	0.0	-0.0
	100	20	67	3.90	0.43	51	0.0736	0.0178	270	18	21	1.5	-4.4	-4.4	-4.4	-4.4
	100	20	67	3.7	0.460	51	0.0736	0.0178	270	18	21	1.5	-1.0	5.9	-1.0	5.9
	100	20	67	3.7	0.43	53.0	0.0736	0.0178	270	18	21	1.5	3.9	3.9	3.9	3.9
	100	20	67	3.7	0.43	51	0.07507	0.0178	270	18	21	1.5	-2.0	0.0	-2.0	0.0
	100	20	67	3.7	0.43	51	0.0736	0.01830	270	18	21	1.5	2.8	0.0	2.8	0.0
	100	20	67	3.7	0.43	51	0.0736	0.0178	272.0	18	21	1.5	-0.7	0.0	-0.7	0.0
	100	20	67	3.7	0.43	51	0.0736	0.0178	270	20.0	21	1.5	0.7	0.0	0.7	0.0
	100	20	67	3.7	0.43	51	0.0736	0.0178	270	18	22.0	1.5	-1.1	-1.1	-1.1	-1.1
	100	20	67	3.7	0.43	51	0.0736	0.0178	270	18	21	2.00	-4.6	-4.6	-4.6	-4.6
CATALYTIC STOVES:																
BASELINE	100	20	114	6.65	0.23	51	0.0736	0.0090	270	18	21	1.5	0.0	0.0	0.0	0.0
	102.0	20	114	6.65	0.23	51	0.0736	0.0090	270	18	21	1.5	2.0	2.0	0.0	0.0
	100	23.0	114	6.65	0.23	51	0.0736	0.0090	270	18	21	1.5	-2.4	-2.4	0.0	0.0
	100	20	114.1	6.65	0.23	51	0.0736	0.0090	270	18	21	1.5	-0.1	-0.1	0.0	0.0
	100	20	114	6.850	0.23	51	0.0736	0.0090	270	18	21	1.5	-2.8	-2.8	-2.8	-2.8
	100	20	114	6.65	0.260	51	0.0736	0.0090	270	18	21	1.5	-0.7	12.3	-0.7	12.3
	100	20	114	6.65	0.23	53.0	0.0736	0.0090	270	18	21	1.5	3.8	3.8	3.8	3.8
	100	20	114	6.65	0.23	51	0.07507	0.0090	270	18	21	1.5	-2.0	0.0	-2.0	0.0
	100	20	114	6.65	0.23	51	0.0736	0.00950	270	18	21	1.5	5.6	0.0	5.6	0.0
	100	20	114	6.65	0.23	51	0.0736	0.0090	272.0	18	21	1.5	-0.7	0.0	-0.7	0.0
	100	20	114	6.65	0.23	51	0.0736	0.0090	270	20.0	21	1.5	0.7	0.0	0.7	0.0
	100	20	114	6.65	0.23	51	0.0736	0.0090	270	18	22.0	1.5	-1.1	-1.1	-1.1	-1.1
	100	20	114	6.65	0.23	51	0.0736	0.0090	270	18	21	2.00	-1.6	-1.6	-1.6	-1.6

TABLE 4. PRECISION AND BIAS ESTIMATES FOR MEASURED AND ASSUMED PARAMETERS. Percent symbols alone indicate measured value.

PARAMETER	HOW DETERMINED	PRECISION	BIAS
Elapsed time	Synchronous hourmeter	0.1 hr	0%
Mass of wet fuel	Spring scale	0.1 kg	0%
Fuel moisture	Desiccation or oven	15%	0%
Initial tank pressure	Bennert manometer	1 torr	0%
Final tank pressure	Datametrics 600-A pressure sensor	1 torr	2 torr
Final tank temperature	Digital thermometer	1 deg	1 deg C
Total PM catch	Mettler AE-100 balance	0.8 mg	0.1 mg
Stack CO	Infrared Industries IR702-D	0.01 mol%	9%
Stack CO_2	Infrared Industries IR702-D	0.1 mol%	2%
Tank volume	Argon fill/gravimetric	0%	2.5%
Fuel carbon (wood)	Literature values	1%	1%
Fuel carbon (coal)	Commercial analysis	0%	2%
Contributed mass of dry stack gas per mass of dry fuel	Stoichiometric calculation	0%	6%
Moles of carbon as hydrocarbons per mole of CO	Laboratory experience	0%	20%
Moles of O_2 (all forms) per mole of dry stack gas	Stoichiometric calculation	0%	1%

Table 5. SUMMARY OF 1988-1990 CRESTED BUTTE WOODSTOVE EMISSION MEASUREMENTS.

STOVE TYPE	NO. OF MODELS	NO. OF STOVES	FUEL MOISTURE	BURN RATE	PARTICULATE MATTER			CARBON MONOXIDE		
			(dry %)	(dry kg/hr)	n*	g/kg	g/hr	n*	g/kg	g/hr
1988-89:										
CONV.	6	11	18.1	1.35	32	22.1	29.4	37	115	154
CAT.	1	2	26.8	0.86	6	5.5	5.2	9	40	35
1989-90:										
CONV.	6	7	16.1	1.64	27	22.2	35.2	27	111	178
CAT.	6	12	17.8	0.93	72	11.1	10.4	72	52	49
NONCAT.	2	5	14.7	1.10	29	9.9	9.4	29	76	77
SUMMARY:										
CONV.	9	18	17.2	1.46	59	22.2	32.1	64	113	164
CAT.	6	13	18.8	0.92	78	10.6	10.0	81	51	48
NCAT.	2	5	14.7	1.10	29	9.9	9.4	29	76	77
ALL	17	36			166			174		

*Number of valid datapoints.

Appendix A

WHA INTERACTIONS WITH HOUSEHOLDS OF IN-SITU WOODSTOVE TESTING

Stove #	WHEN	TYPE OF INTERACTION
CAT 08		Apparatus pulled out. Householder did not cooperate
NCAT 13	Week 2	Received phone call after week #2, asking if anything had happened. Homeowner explained that someone else had operated the stove.
CAT 14		Stove had 3" (1990) catalyst
CAT 16	Start of week 3 Start of week 4 Start of week 5	Homeowner instructed re operation. Catalyst replaced. New stove installed; original stove was inspected after removal and it was determined that the stove had a possible air leak which caused the catalyst not to maintain ignition at low burnrates.
	Start of week 7	Catalyst replaced
CAT 17		Visited by factory rep, no change in burning habits
CAT 18	Start of week 7	New wood source from WHA
NCAT 20	Start of week 5	Stove bypass was adjusted and homeowner reminded of instructions (in the manual) of how to adjust bypass.
CAT 21	Start of week 4	New catalyst, secondary air adjusted
CAT 22		Visited by factory rep, no change in burning habits
CAT 24	One week before first test	New catalyst (3" deep) installed -- no coaching
CAT 26		After testing, crack in bypass discovered --no coaching

Appendix B

NOTES ON INDIVIDUAL TESTS

Run No.	
7	Kinked sample line - no recovery
10	Post-test leak due to cracked trap - limited recovery
11	Leak at cartridge filter (post test) - holds 0.4" H_2O
16	Broken probe - pieces recovered and washed into rinse (assume zero probe catch)
22	Estimated 10 boards extra used 10 x 3 kg/ea = 30 kg
24	Static electric problem (weighing line) - assume zero catch in line
29	Sampler - unplugged when weighed wood ran out
33	Sampler - unplugged when weighed wood ran out
37	Flow rate increased at deployment so sample could be removed before a Christmas party
46	Owner removed 8 pieces of wood from woodpile est. @ 20 kg. (added to final woodpile weight)
48	Post-test leak check failed
54	Trap broke at workup - contents transferred to new trap; only a few drops lost
59	Operator informed by manuf. rep. that cat. should be engaged 2 hours after fire was started
61	User coached on cat. operation
66	2" cat. changed to 3" cat. after deployment; CAT 14
68	Sample removed prematurely - broken probe
74	Wood appears wet even though kept covered
79	Probe found broken on retrieval
81	Cat. replaced at deployment
83	Cat. 4 months old

NOTES ON INDIVIDUAL TESTS

90	New stove
93	Bypass damper control fixed 2/13/90 by John Crouch
94	Owner changed from aspen to pine
96	Sample line lost 0.0084 g (probably static at pretest weighing) chimney cleaned by homeowner - probe ok
97	New cat. (3") one week before testing began
111	Cat. replaced with different brand, primary and secondary air intakes adjusted
112	Cat. replaced prior to deployment
113	Wood appears wet
114	Repaired damper - crack in side wall of stove
122	Metal probe
127	Sampler found unplugged - wood estimated
130	One month old cat. - blower installed
136	Longer fires in this period due to company in house
145	Wetter wood than previously

Appendix C

HOUSEHOLD PROFILES

Site Code: CAT 08

Stove Type: Catalytic A1

Flue: 8" dia, triple-wall air-insulated pipe

Comments: Continuous operation

Wood Type & Condition: small to medium size aspen and soft pine, kept outdoors uncovered

During the study the average dry basis moisture content of the wood was 19.7% with a s.d. = ± 3.6 percentage points.

Site Code: CAT 12

Stove Type: Catalytic B

Flue: 8" dia, double-wall (insulated) Metalbestos pipe

Comments: Both husband and wife work during the day. Stove loaded each evening and again each morning before leaving for work.

Wood Type & Condition: Small to moderately sized pieces of pine. Wood is stored inside the house in the basement.

During the study the average dry basis moisture content of the wood was 11.3% with a s.d. = ± 1.0 percentage points.

HOUSEHOLD PROFILES

Site Code: CAT 14

Stove Type: Catalytic C1

Flue: 6" dia, Duraliner pipe inside exterior masonry chimney

Comments: Wood stove is primary source of heat. Owners prefer to maintain house hot > 70°F at all times. Stove is loaded each morning, stoked afternoon and reloaded each night.

Wood Type & Condition: Small to moderately sized pieces of pine. Wood is stored outside the house in a semi-covered pile.

During the study the average dry basis moisture content of the wood was 15.0% with a s.d. = ± 1.0 percentage points.

Site Code: CAT 16

Stove Type: Catalytic D1 (weeks 1-3)
Catalytic D2 (weeks 4-9)

Flue: 8" dia, Duravent triple wall pipe

Comments: Owner uses stove as a primary source of heat. Stays at home all night and most of the day.

Wood Type & Condition: Small to moderately sized pieces of a mixture of 60% oak and 40% pine. Towards the end of the study owner mixed in some apple (about 20%).

During the study the average dry basis moisture content of the wood was 19.2% with a s.d. = ± 3.1 percentage points.

HOUSEHOLD PROFILES

Site Code: CAT 17

Stove Type: Catalytic E1

Flue: 6" dia, triple wall pipe

Comments: Owners like to maintain home around 70°F. House has some passive solar heating through large windows. Stove loaded during day and stoked (reloaded if necessary) at noon.

Wood Type & Condition: Mostly aspen mixed with a little pine. Wood stored outside the house in a semi-covered pile.

During the study the average dry basis moisture content of the wood was 15.2% with a s.d. = ± 1.6 percentage points.

Site Code: CAT 18

Stove Type: Catalytic A2

Flue: 6" dia, Metalbestos insulated pipe

Comments: Single parent household. Owner maintains home above 70°F at all times. Stove is in continuous use. Stove has a blower installed as necessary.

Wood Type & Condition: Moderately sized pieces of pine (60%) and oak (40%). Wood was wet for runs 3-6. Average moisture content (36.2%). Wood is stacked outside house, usually uncovered.

During the study the average dry basis moisture content of the wood was 26.4% with a s.d. = ± 9.9 percentage points.

HOUSEHOLD PROFILES

Site Code: CAT 19

Stove Type: Catalytic F1

Flue: 6" dia, Heat-Fab liner inside brick chimney

Comments: Both husband and wife work during the day. Typically load the stove each morning, stoke it at noon and reload in the evening.

Wood Type & Condition: Owners use small pieces of lodgepole pine. Wood is kept covered in the yard. Owners are cautious about maintaining wood dry.

During the study the average dry basis moisture content of the wood was 14.8% with a s.d. = ± 1.2 percentage points.

Site Code: CAT 21

Stove Type: Catalytic D3

Flue: 8" dia, Metalbestos insulated pipe

Comments: Both husband and wife work in the mornings. House has passive solar heating. Fire started each evening and again in the morning (if necessary).

Wood Type & Condition: Moderately sized pieces of pine. (Aspen used for Run #1). Wood is stored in a semi-covered pile outside the house.

During the study the average dry basis moisture content of the wood was 15.4% with a s.d. = ± 4.2 percentage points.

HOUSEHOLD PROFILES

Site Code: CAT 22

Stove Type: Catalytic E2

Flue: 8" dia outside chimney

Comments: Owner works during the day. Loads the stove each evening and again the following morning. Stove is left unattended between loadings.

Wood Type & Condition: Usually a 60-40 mix of pine and oak. Most of the wood is stocked inside the house. Wood outside the house is semi-covered.

During the study the average dry basis moisture content of the wood was 20.1% with a s.d. = ± 1.5 percentage points.

Site Code: CAT 24

Stove Type: Catalytic C2

Flue: 6" dia Metalbestos insulated pipe

Comments: Owner does not use the stove often. Starts a fire each evening and lets it burn out before reloading. House has some passive solar heating.

Wood Type & Condition: Owner uses mostly apple (80%) and some pine (20%). Wood is kept outside the house in a semi-covered woodpile.

During the study the average dry basis moisture content of the wood was 13.5% with a s.d. = ± 0.6 percentage points.

HOUSEHOLD PROFILES

Site Code: CAT 26

Stove Type: Catalytic F2

Flue: 8" dia. single wall inside masonry

Comments: Owners always have a medium to large fire in stove. House is usually about 75oF. Owners do not stoke the fire often.

Wood Type & Condition: Wood is usually wet. Owners use oak exclusively. Wood is kept outside the house. Usually left uncovered.

During the study the average dry basis moisture content of the wood was 24.0% with a s.d. = ± 3.4 percentage points.

Site Code: COAL 02

Stove Type: Coal R (manual loading, barrel shaped)

Flue: Brick chimney 9" square

Comments: Stove is primary heat source for the house. Runs continuously.

Fuel Type & Condition: Bituminous coal, piece size ranged between 2" dia to 8" dia chunks.

During the study the dry basis moisture content of the coal was 10.6%.

HOUSEHOLD PROFILES

Site Code: COAL 06

Stove Type: COAL S (Automatic, thermostatically controlled stoker)

Flue: 6", single wall 20' stack

Comments: Primary heat source, continuously run during cold weather.

Fuel Type & Condition: bituminous, 1" dia piece size.

During the study the moisture content of the coal was 6.4%.

Site Code: COAL 07

Stove Type: COAL T (Automatic, auger fed stoker)

Flue: 12" connector vented to brick chimney

Comments: Continuous operation. Used for hot water production for a hotel.

Fuel Type & Condition: bituminous coal, 1" piece size

During the study the dry basis moisture content of the coal was 4.7%.

HOUSEHOLD PROFILES

Site Code: CONV 01

Stove Type: Conventional I

Flue: 6" dia, double wall Metalbestos insulated pipe

Comments: Stove is fired each evening and is used to complement electric baseboard heaters. Occasionally the operator would use more wood then initially weighed by the technician but would keep count of the number of extra pieces used. Fuel pieces were very uniform, (precut lumber) so total fuel consumption was based on the count of extra pieces in these cases.

Wood Type & Condition: Kiln dried pine untreated 2" x 10" lumber 2 ft in length.

During the study the average dry basis moisture content of the wood was 10.3% with a s.d. = ± 1.3 percentage points.

Site Code: CONV 03

Stove Type: Conventional J1

Flue: 6" double wall Metalbestos insulated pipe

Comments: Both husband and wife work, stove used evening hrs only. Fired daily for 6-7 hours.

Wood Type & Condition: 25% oak, 75% pinion pine. Fuel kept outside and under cover.

During the study the average dry basis moisture content of the wood was 11.6% with a s.d. = ± 0.4 percentage points.

HOUSEHOLD PROFILES

Site Code #: CONV 04

Stove Type: Conventional K

Flue: 8" dia, triple wall air insulated pipe

Comments: Stove is continuously run. Primary heat source for a very large house.

Wood Type & Condition: 50% oak, 50% pine. All fuel kept outdoors, semi-covered.

During the study the average dry basis moisture content of the wood was 28.0% with a s.d. = ± 2.3 percentage points.

Site Code: CONV 05

Stove Type: Conventional L

Flue: 8" dia, Metalbestos insulated pipe

Comments: Operated daily, no particular pattern due to two operators and changing work schedules.

Wood Type & Condition: 100% pine, large piece size kept outside, uncovered.

During the study the average dry basis moisture content of the wood was 13.4% with a s.d. = ± 1.1 percentage points.

HOUSEHOLD PROFILES

Site Code: CONV 09

Stove Type: Conventional J2

Flue: 6" dia Metalbestos insulated pipe

Comments: This stove was located inside a business and was operated daily during business hours 10 a.m. - 9 p.m.

Wood Type & Condition: Large pieces of soft pine kept indoors.

During the study the average dry basis moisture content of the wood was 11.5% with a s.d. = ± 2.4 percentage points.

Site Code: CONV 10

Stove Type: Conventional M

Flue: 8" dia, insulated pipe

Comments: Used in the evening only. Secondary heat source.

Wood Type & Condition: 50% oak, 50% pine kept outdoors, partially covered. Medium piece size.

During the study the average dry basis moisture content of the wood was 25.7% with a s.d. = ± 2.5 percentage points.

HOUSEHOLD PROFILES

Site Code: CONV 11

Stove Type: Conventional N

Flue: 8" dia, single wall 12' stack

Comments: Continuously operated, primary heat source.

Wood Type & Condition: medium to large piece size, kept indoors, 100% pine.

During the study the average dry basis moisture content of the wood was 15.1% with a s.d. = ± 0.5 percentage points.

Site Code: NCAT 13

Stove Type: Noncatalytic G1

Flue: 8" dia, triple wall air insulated

Comments: Large house with passive solar heating. Owner likes to maintain house temperature at 70oF all the time.

Wood Type & Condition: Small to moderately sized pieces of pine. Wood is stored outside the house incovered woodpile.

During the period of study the average dry basis moisture content (dry basis) the wood was 14.6% with a s.d. = ± 1.5 percentage points.

HOUSEHOLD PROFILES

Site Code: NCAT 15

Stove Type: Noncatalytic H1

Flue: 8" dia Duravent triple wall air insulated

Comments: Owner works at night and does not use the stove often. Loads the stove with a few pieces each morning and does not bother with the stove until it needs reloading. Uses electric heat in addition to the woodstove.

Wood Type & Condition: Small pieces of pine wood are stored in a semi-covered wood pile outside the house and sometimes inside the house right next to the stove.

During the study the average dry basis moisture content of the wood was 13.7% with a s.d. = ± 0.9 percentage points.

Site Code: NCAT 20

Stove Type: Noncatalytic G2

Flue: 6" dia, Duraliner inside brick chimney

Comments: Wife usually at home all day. Owners usually start a fire each evening. Reload each morning if necessary. Wife usually stokes the fire when required.

Wood Type & Condition: Small to moderately sized pieces of pine. Wood is stored outside the house in an enclosed space.

During the study the average dry basis moisture content of the wood was 14.9% with a s.d. = ± 0.9 percentage points.

HOUSEHOLD PROFILES

Site Code: NCAT 23

Stove Type: Noncatalytic H2

Flue: 6" dia triple wall pipe

Chimney: 8" dia triple wall pipe

Comments: Owner works during the day and evenings. Keeps home warm (about 70°F). Stokes the fire each afternoon. Roommate attends to the fire in owner's absence.

Wood Type & Condition: Small pieces of pine. Wood is stacked outside the house. Semi-covered wood pile.

During the study the average dry basis moisture content of the wood was 14.4% with a s.d = ± 0.6%.

Site Code: NCAT 25

Stove Type: Noncatalytic H3

Flue: 6" dia, single wall stack

Chimney: 8: dia, Preway triple wall pipe

Comments: Both husband and wife work in shifts. Owners usually start a fire each morning and evening. Follow manufacturer's instructions in stove operation. Fire attended most of the time.

Wood Type & Condition: Use a variety of wood types including pine, aspen and fir.

During the study the average dry basis moisture content of the wood was 16.5% with a s.d. = ± 2.8 percentage points.

Appendix D

COAL ANALYSES

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300

Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
10775 E. 51ST AVE., DENVER, CO 80239
TELEPHONE: (303) 373-4772
FAX: (303) 373-4791

December 21, 1989

VIRGINIA TECH
Room 13, Randolph Hall
VPI Blacksburg, VA 25061

Sample identification by
VIRGINIA TECH
Sample #: 02
Auth/PO#: 713513

Kind of sample reported to us: COAL

Sample taken at: XXXXX

Sample taken by: VIRGINIA TECH

Date sampled: XXXXXXXX

Date received: 12/12/89

Analysis report no. 72-196471

SHORT PROXIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	9.56	xxxxx
% Ash	5.43	6.00
Btu/lb.	11701	12938
% Sulfur	0.52	0.57

ULTIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	9.56	xxxxx
% Carbon	65.94	72.91
% Hydrogen	4.87	5.38
% Nitrogen	1.64	1.81
% Sulfur	0.52	0.57
% Ash	5.43	6.00
% Oxygen	12.04	13.33
	100.00	100.00

MAF Btu/lb.	13764
Lbs. Sul. Dioxide / Mill. Btu	0.88
% Air Dry Loss	5.20

Moist Mm free Btu/lb.	12440 •
Lbs. Sul. / Mill. Btu	0.44
As Rec'd Net Sample Wt.	1326.40 grams

• Based on As Received moisture

/vs

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Denver Laboratory

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OVER 40 BRANCH LABORATORIES STRATEGICALLY LOCATED IN PRINCIPAL COAL MINING AREAS, TIDEWATER AND GREAT LAKES PORTS, AND RIVER LOADING FACILITIES

F-404

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10775 E. 51ST AVE., DENVER, CO 80239
TELEPHONE: (303) 373-4772
FAX: (303) 373-4791

VIRGINIA TECH
Room 13, Randolph Hall
VPI Blacksburg, VA 25061

December 21, 1989

Sample identification by

VIRGINIA TECH
Sample #: 06
Auth/PO#: 713513

Kind of sample reported to us: COAL

Sample taken at: XXXXX

Sample taken by: VIRGINIA TECH

Date sampled: XXXXXXXX

Date received: 12/12/89

Analysis report no. 72-196472

SHORT PROXIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	6.01	xxxxx
% Ash	8.46	9.00
Btu/lb.	12337	13126
% Sulfur	0.52	0.55

ULTIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	6.01	xxxxx
% Carbon	68.07	72.42
% Hydrogen	4.97	5.29
% Nitrogen	1.60	1.70
% Sulfur	0.52	0.55
% Ash	8.46	9.00
% Oxygen	10.37	11.04
	100.00	100.00

MAF Btu/lb.	14424
Lbs. Sul. Dioxide / Mill. Btu	0.84
% Air Dry Loss	3.98
Moist Mm free Btu/lb.	13592 *
Lbs. Sul. / Mill. Btu	0.42
As Rec'd Net Sample Wt.	1454.10 grams

* Based on As Received moisture

/vs

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Denver Laboratory

F-464

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PLEASE ADDRESS ALL CORRESPONDENCE TO:
10775 E. 51ST AVE., DENVER, CO 80239
TELEPHONE: (303) 373-4772
FAX: (303) 373-4791

VIRGINIA TECH
Room 13, Randolph Hall
VPI Blacksburg, VA 25061

December 21, 1989

Sample identification by
VIRGINIA TECH
Sample #: 07
Auth/PO#: 713513

Kind of sample reported to us: COAL

Sample taken at: XXXXX

Sample taken by: VIRGINIA TECH

Date sampled: XXXXXXXX

Date received: 12/12/89

Analysis report no. 72-196473

SHORT PROXIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	4.51	xxxxx
% Ash	6.59	6.90
Btu/lb.	12764	13367
% Sulfur	0.53	0.56

ULTIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	4.51	xxxxx
% Carbon	71.15	74.51
% Hydrogen	5.13	5.37
% Nitrogen	1.63	1.71
% Sulfur	0.53	0.56
% Ash	6.59	6.90
% Oxygen	10.46	10.95
	100.00	100.00

MAF Btu/lb.	14358
Lbs. Sul. Dioxide / Mill. Btu	0.84
% Air Dry Loss	2.67
Moist Mm free Btu/lb.	13757 *
Lbs. Sul. / Mill. Btu	0.42
As Rec'd Net Sample Wt.	1441.90 grams

* Based on As Received moisture

/vs

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Denver Laboratory

Appendix E

LABORATORY AND ON-SITE PROCEDURES

SAMPLER PREPARATION

1. Calibrate balance.
   a. Perform internal calibration of the balance as per manufacturer's instructions.
   b. Check balance calibration by using 0.2 g, 20 g, and 30 g weights.
   c. Note balance readings on 'daily calibration log' sheet.
2. Weigh probe and sample line.
   a. Take a clean probe and inspect it to ensure that there are no cracks or chipped ends.
   b. Select a sample line of proper length and inspect it for kinks and cuts.
   c. Inspect fitting (used to connect probe with sample line) for proper ferrule orientation and ensure that both probe and sample line fit properly in fitting.
   d. Connect probe with fitting and clean the outside with filter paper soaked with acetone. Use the anti-static device on the probe. Weigh this assembly and note reading on data sheet.
   e. Clean exterior of sample line with acetone and coil it to a diameter of approximately 3".
   f. Place the metal plate on the balance and tare its weight.
   g. Use the anti-static device on the sample line and place it on the tared plate. Record the weight of the sample line on the data sheet.

h. Remove the sample line and plate from the balance and rezero the balance.

i. Connect sample line to the probe via the probe fitting.

3. Clean the trap (test tube) with acetone. Select an appropriate rubber stopper for the trap.

4. Weigh a connector that has been desiccated for at least 24 hours and then cleaned with acetone. Record the weight on the data sheet.

5. Inspect the filter assembly for cracks and the o-rings for nicks or cuts.

6. Connect the weighed connector to the Swagelok fitting on the filter assembly.

7. Remove a filter from the desiccator carefully and weight it. Record the filter weight on the data sheet under filter #1.

8. Place the filter in the filter housing that is closer to the connector. Ensure o-ring is properly seated in the housing and that it remains in place while the filter cap is being screwed down.

9. Repeat steps 7 & 8 with filter #2, although it is placed in its own housing downstream of filter #1.

10. Insert the connector at the end of the filter assembly into the hole of the rubber stopper of the trap. Do this by holding the rubber stopper below the connector of the filter assembly while inserting the connector. This procedure ensures that any shreds of rubber that might be dislodged from

the stopper do not settle down on the filter within the filter housing.

11. Insert the sample line through the curved metal tube in the rubber stopper of the trap until the line extends about a couple of inches in the trap and the end of the sample line touches the wall of the trap. Tighten the Swagelok fitting at the end of the curved metal tube.
12. Place the trap with the filter assembly in the sampler.
13. Empty the desiccant flask in the sampler and fill it with fresh desiccant.
14. Connect the filter assembly to the desiccant flask by inserting the Tygon tubing (above the filter assembly) over the inlet metal tubing in the desiccant. The latter can be identified as the longer of the two tubes in the desiccant flask. (The one that reaches all the way into the desiccant.)
15. Connect the shorter tube of the desiccant flask to the inlet filter of the sampler. The sampler is now ready for pretest leak check.
16. Connect the probe to one end of a U-tube water manometer.
17. Plug the sampler into a grounded AC outlet and turn the 3-way valve on the sampler unit to the solenoid valve position.
18. Monitor the level of H_2O on the U-tube manometer. When the difference in water levels between the two legs of the manometer is about 4 inches, close off the sampler valve by switching the valve to its middle position.

19. Start the stop watch and note the vacuum manometer reading on the data sheet.

20. After about 2 minutes note down the manometer reading and the elapsed time.

21. The difference between the initial and final readings gives a measure of the leakage over that time period. This difference divided by the elapsed time (as monitored by the stop watch) gives the leak rate. Ensure that the leak rate is within 0.1 ml/min. If the leak rate is above this value, check connections for possible sources of leakage, implement remedial measures, and repeat the leak check procedure (steps #17-21).

22. After the sampler has passed the leak check a desired sample flow rate must be set.

23. Remove the probe from the manometer and connect it to the bubble flow meter.

24. Turn on the sampler valve as in step #17.

25. Measure the time taken for the soap bubble to traverse 5 divisions (i.e. 5 ml). Adjust the metering valve on the sampler to increase or decrease the flow rate as desired.

26. Record the pretest sample flow rate on the data sheet.

27. Close the three way sampler valve by switching it to the center position.

28. Disconnect the probe from the bubble meter and cap the end of the probe.

29. Coil the sample line and place the probe sample line assembly in the box above the sampler tank.

30. Check the set point on the controller and ensure it is set at 60°. Record this reading as the nominal set point on data sheet.

31. Connect the thermocouple to the temperature controller.

32. Insert the thermocouple tip into the first (hottest) aluminum block.

33. Read the temperature of the block as indicated by the mercury thermometer inserted in the center of the block. Record this reading as the actual block temperature on the data sheet.

34. Record the hourmeter and controller status and ensure that they are as expected (expected status is indicated on data sheet).

35. Insert the thermocouple in the second (cooler by 5°C) heated aluminum block and repeat steps #33-34.

36. Disconnect the sampler power and thermocouple.

37. Place the thermocouple in the box and record initial hourmeter reading.

38. Measure initial tank pressure as follows:

    a. Connect quick-connect to evacuation port on sampler.

    b. Ensure that valve (1) on the control panel is open.

    c. Close valve (2) and valve (4).

    d. Turn on the vacuum pump.

e. Now turn valve (4) to evacuate position. Wait for about 4 seconds until the line is evacuated (as indicated by Datametrics pressure sensor reading).

f. Close valve (4).

g. Open sampler valve toward evacuation port.

h. Read tank pressure on Bennert manometer.
Check to see if pressure < 3 torr.

39. If pressure > 3 torr,

a. Turn on the vacuum pump.

b. Set valve (4) to evacuate position.

c. Evacuate tank until desired pressure is achieved.

40. Close the sampler valve by switching it to the center position.

41. Close valve (1) on unit.

42. Disconnect quick connect.

The sampler is now ready for deployment.

SAMPLER INSTALLATION AND RETRIEVAL

A. Laboratory check-list

Before leaving the laboratory for sampler deployment ensure that the following items have been taken.

a) A sampler tank that has been prepared according to the instructions outlined under "Sampler Preparation Procedures".
b) The "Accu Weigh" scale to weigh the wood used for the test. The scale must be zeroed in the laboratory and calibrated using the calibration weights (22.68 kg and 45.36 kg). The actual scale readings are recorded in the "Daily Calibration Log". The scale is recalibrated if an error > 0.5 kg is noticed.
c) A cordless drill.
d) A 35 mm film container to collect wood samples on-site.
e) A roll of duct tape, a roll of bright orange flagging tape, a cap for the probe (this is for the sampler that will be retrieved from the site), 1/4", 1/32", and 3/8" drill bits.
f) Data sheet for the previous week's run at the test site*.
g) Data sheet for the present installation at the test site.

B. On-site activity

‡ a) Drill 2 holes approximately 1/2" apart through the flue pipe about a foot downstream from the stove collar. The holes are (1/4" dia and 1/32" dia) respectively.
‡ b) Mount a bracket by means of a c-clamp that fits around the flue pipe. The bracket is positioned so that the glass probe can be inserted through the 1/4" dia hole in the pipe and the probe fitting rests in a recess cut in the bracket. In this position the tip of the probe will be at about the center line of the flue.
c) After mounting the bracket insert the probe through the flue pipe.
d) Insert the thermocouple through the smaller (1/32") hole in the flue pipe and ensure that the tip is also at or about the center line of the flue pipe.
e) Ensure that the probe of sample line assembly is not strained. (Provide strain relief on sample line, probe of thermocouple by appropriately fastening sample line, or thermocouple wire, to sampler tank and/or side walls with duct tape.)
f) Plug in the sampler tank to the nearest grounded 115V AC outlet. Turn on sampler valve (toward solenoid).
g) The sampler is now installed and ready for sampling.
• h) Weigh any wood left over from the wood pile of the previous run. Include this weighing under "final wood pile weighings" recorded on the appropriate data sheet.

i) Weigh a fresh batch of wood for the test run. The wood weighings are taped to distinguish the weighed wood from the rest of the wood pile.

j) Select about 5 pieces of wood to reflect the species mix of the wood pile and drill holes (3/8" drill bit) in each of the pieces. Carefully transfer the wood drillings into the 35 mm film containers. The drillings will be analyzed to provide the moisture content of the wood.

• not applicable for first deployment at test site.
‡ not applicable for subsequent deployments at test site.

SAMPLER WORKUP

Gas Analyzer (CO and CO_2) calibration check:

1. Ensure male quick connect is disconnected from sampler and is able to sample room air.
2. Ensure valve (2) on unit (i.e. the bleed valve) is closed.
3. Set valve (4) to SAMPLE and valve (5) to ANAL position.
4. Close valve (6) and set valve (7) to PUMP position.
5. Turn on the sample pump.
6. Adjust valve (6) to obtain a flow rate of 0.5 liter per minute (i.e. a reading of 45 on the rotameter mounted on the control unit).
7. Wait for about 2 minutes for the analyzer readings to stabilize.
8. Adjust the zero knobs (if required) to zero the CO and CO_2 readings on room air.
9. Turn off the sample pump. Set valve (7) to CAL position.
10. Turn on the span gas. Adjust pressure regulator on the gas bottle to achieve a flow rate of 0.5 lpm.
11. Adjust span controls on analyzer to set the span at the CO & CO_2 concentrations indicated on the bottle.
12. Turn off span gas.
13. Set valve (7) to PUMP position and repeat steps #5-9 to recheck the zero on the analyzer.
14. Turn on first mid-point gas. Adjust flow rate as in step #10.
15. Record analyzer readings under "Gas Analyzer Calibration Check" on back of Sampler Data Sheet.
16. Correct the CO & CO_2 analyzer readings from their respective and most recent calibration curves. Check if the corrected values are within the acceptable bias as indicated on the data sheet.
17. Repeat steps #14-16 with the other midpoint gas.

18. If the corrected analyzer readings are outside the specified bias, a new calibration curve must be generated. Include a date on this curve. This curve now serves as the calibration curve for future analyzer use until a new calibration is deemed necessary.

The calibration check on the analyzer is now complete.

19. Record the final hourmeter reading of the sampler.

20. Record sampler temperature with a surface temperature probe.

21. Measure tank pressure as follows:

    a. Hook up quick connect to the evacuation port on the sampler.
    b. Ensure sampler valve is closed.
    c. Close valve (4) on unit.
    d. Turn on vacuum pump.
    e. Set valve (4) to EVAC position.
    f. Wait for about 5 secs (for line to evacuate).
    g. Close valve (4) and turn off vacuum pump.
    h. Close glass ball valve on Bennert manometer.
    i. Open sampler valve slowly toward evacuation port.
    j. Read final tank pressure off voltmeter hooked to Datametrics pressure transducer.
    k. If pressure is less than 240 torr, open glass ball valve on Bennert manometer and read pressure directly from the Bennert manometer. Note this reading as the final tank pressure on the data sheet.
    l. If pressure > 240 torr, note the pressure reading from the Datametrics pressure sensor and read the corrected reading from the most recent calibration curve. Record this corrected pressure on the data sheet.

22. Close sampler valve and glass ball valve on Bennert manometer.

23. Set valve (4) to SAMPLE position, open valve (6); set valve (7) to PUMP position.

24. Turn on sample pump.

25. Ensure ball on rotameter goes to zero. This ensures that there is no leak in the sampling circuit.

26. Open sampler valve toward evacuation port. Adjust flow rate to 0.5 lpm (i.e. a reading of 45 on rotameter).

27. Read CO and CO_2 gas concentrations from the analyzer display. Record these numbers on the data sheet and calculate corrected values from their respective calibration curves.

28. Turn off sampler valve (i.e. center position).

29. Turn off sample pump.

The gas analysis is now complete. The post-test leak check and flow rate check must now be performed.

30. Remove the probe from the box atop the sampler tank. Hold the probe in a vertical position with the capped open end facing up. Carefully remove the cap from the end of the probe and clean the outside of the probe with filter paper dipped in acetone. During the cleaning process ensure that the particulate matter (soot, creosote, etc.) on the outside of the probe does not get into the probe.

31. Connect the probe to one leg of the U-tube water manometer.

32. Open the sampler valve toward the solenoid.

33. Connect the sampler power cord to a 115 VAC outlet.

34. Ensure the sampler thermocouple is disconnected. This in turn ensures that the solenoid valve will remain open.

35. Obtain at least a 4" H_2O vacuum.

36. Turn off sampler valve.

37. Measure leak rate by noting initial and final manometer readings and the elapsed time with a stop watch. Record data on data sheet under post-test leak check.

38. Disconnect probe from the manometer and connect it to the bubble meter.

39. Turn the sampler valve toward the solenoid again.

40. Determine time taken for the soap bubble to traverse 5 divisions (i.e. 5 ml) on the bubble meter. Record your observations on the data sheet.

41. Turn on the vacuum pump. Set valve (4) to EVAC position and sampler valve toward evacuation port.

42. The sampler tank is now being evacuated and readied for a future preparation and subsequent deployment.

Particulate matter work-up:

43. Disconnect desiccant flask from the assembly consisting of the trap, filter, sample line, and probe.

44. Remove the rubber stopper from the trap and place the trap on the stand. Gently remove the filter assembly from the rubber stopper. Ensure that the rubber stopper is below the filter assembly during this procedure so that pieces of rubber do not settle down on filter #1.

45. Place the filter assembly aside and close the trap with the rubber stopper again.

46. Remove the probe from the bubble flow meter.

47. Remove the barrel from the syringe, connect the probe to the syringe outlet, and pour about 10 ml of acetone into the syringe.

48. Insert the syringe barrel into the syringe and gently force the acetone through the probe and sample line into the trap.

49. Repeat steps 47 & 48 with an additional 10 ml of acetone.

50. Connect the probe to the desiccate port of valve (5).

51. Set valve (5) to desiccate position.

52. Ensure valve (7) is at CAL position.

53. Turn on the nitrogen and adjust the pressure regulator on the unit to achieve a flow rate of 0.5 lpm.

54. Start the stop watch.

While the probe and sample line are being desiccated the filters and connector can be weighed.

55. Perform internal calibration of the Mettler balance as per manufacturer's instructions.

56. Disconnect the connector from the filter assembly and wipe it (outside only) with filter paper dipped in acetone.

57. Weigh the connector and record its weight on the data sheet.

58. Place the connector in the desiccator.

59. Gently unscrew the filter assembly #1 and carefully remove the filter with a pair of tweezers. Place the filter on a labelled piece of paper that uniquely identifies the filter number (1 or 2) and the test run. With a sharp blade gently

scrape off any filter residue from the O-ring onto the filter.

60. Place the O-ring on the balance and tare its weight.

61. Wipe off any residue from the O-ring surface with filter paper and weigh the O-ring again.

62. This balance reading (usually negative) is the O-ring residue and is recorded on the data sheet.

63. Rezero the balance and weigh the filter with the O-ring residue that was scraped off. Record this weight. Also record the date and time of this weighing.

64. Repeat steps #59-63 for filter #2.

65. Place the labelled sheet containing both filters with their respective O-ring residues in the desiccator.

66. Note the time elapsed (stop watch) since N_2 desiccation began on the probe and sample line.

67. If the elapsed time is at least 10 minutes stop the stop watch, disconnect the probe from the desiccate port of valve (5).

68. Disconnect the sample line from the probe fitting.

69. Clean the outside of the probe with acetone and filter paper. Gently scrape off any remaining creosote buildup with a blade.

70. Remove any static buildup on the probe by slowly rubbing it against a polonium nuclear source.

71. Weight the probe and fitting and record its weight.

72. Clean the outer surface of the sample line with acetone and lens paper and coil it to about a 3" diameter.

73. Place the metal plate on the balance and tare its weight.

74. Remove any static buildup on the sample line by rubbing it against a polonium nuclear source.

75. Place the sample line on the plate in the balance and record the sample line weight.

76. Reconnect the sample line to the probe and connect this assembly to the desiccate port of the valve (5).

77. Start the stop watch again and if necessary, adjust the pressure regulator on the unit to achieve a flow rate of 0.5 lpm.

78. Repeat steps #66-75 until the probe and sample line achieve constant weights.

79. Turn off the nitrogen tank and rezero the balance (if necessary). Weigh an aluminum pan that has been desiccated for at least 24 hours and numbered to uniquely identify the test run. Record both the identification number and weight of this empty pan on the data sheet.

80. Carefully pour the contents of the trap into the pan. Use an additional amount of acetone to rinse the trap completely. Include this rinse in the pan also.

81. Place the pan in room air for 24 hours before transferring it to a desiccator for final desiccation.

82. Check the calibration of the balance using the internal 100 g weight. Note this reading on the data sheet.

The post-test workup is now complete.

83. By this time the sampler tank is almost completely evacuated. Check tank pressure. After closing valve (4) on unit if pressure is < 3 torr the sampler tank is ready for the pretest procedure and subsequent deployment.

84. If pressure > 3 torr continue evacuation until pressure < 3 torr.

Appendix F

SAMPLER DATA SHEET

SAMPLER DATASHEET
(front side, 2/5/90 version)

TEST NO. ________ SAMPLER SN ______
DATE DEPLOYED ________________ APPLIANCE ____________________
DATE RETRIEVED ________________ APPLIANCE CODE ____________________
TEST LOCATION ________________ DATALOGGER SN ____________________

PRETEST SAMPLFLO _____ wet ml per _____ s NOMINAL SETPOINT _____ C

PRETEST LEAK CHK: VAC= ___ " H2O, 0.25" MANOM FELL _____ " IN _____ MINUTES
PRETEST LEAK RATE: ___ "/min
LEAK RATE < 0.1 "/min? ___

PRE-TEST	ALLOWABLE TEMP. RANGE (C)	60-65	55-60	STATUS
SETPOINT	ACTUAL BLOCK TEMPERATURE (C)	______	______	
CHECK	CONTROLLER LIGHT (ON or OFF)	______	______	off on
	HOURMETER STATUS (ON or OFF)	______	______	on off

INITIAL HOURMETER ______________ FINAL HOURMETER ______________
PRE-TEST TANK PRESSURE ______ torr PRE-TEST PRESSURE < 3 torr? ___

BALANCE CHECKS:	100 g weight weighs 100.0000 ____	before pretest weighings
(using the	100 g weight weighs __________	after pretest weighings
internal	100 g weight weighs 100.0000 ____	before postest weighings
cal. weight)	100 g weight weighs __________	after postest weighings

GRAMS MASS AFTER FLOWING 0.5 lpm NITROGEN FOR INDICATED TIME

	PRETEST	+__ MIN.	+__ MIN.	+__ MIN.	+__ MIN.	+__ MIN.
PROBE+FITTING	______	______	______	______	______	______
SAMPLE LINE	______	______	______	______	______	______

		INITIAL	24-36 HR.			O-RING RES.
DATE		______	______	______	______	
TIME		______	______	______	______	
FILTER #1	______	______	______	______	______	______
FILTER #2	______	______	______	______	______	______
CONNECTOR	______	______	______	______	______	
WASH PETRI (# ______)	______	______	______	______	______	

CALIBRATION OF TELOG DATALOGGER:

CHANNEL NO.	NOMINAL VALUE	TRUE VALUE	DISPLAYED VALUE	ERROR
1	1.5 V	______	______	______
1	0 V	______	______	______
2	100 C	______	______	______
2	20 C	______	______	______
3	100 C	______	______	______
3	20 C	______	______	______
4	1.5 V	______	______	______
4	0 V	______	______	______

NOTE: REJECT DATA IF ERROR > 10 F or > 0.02V

LABORATORY MANAGER ______________

SAMPLER DATASHEET
(back side)

TEST NO. ________

POST-TEST SAMPLFLO _____ wet ml per ______ s   FUEL (wood/coal) _____
species _____

GAS ANALYZER CALIBRATION CHECK:

CAL GAS LABEL VALUE	ANALYZER READING	CORRECTED CONC. FROM CAL. CURVE	CORRECT TO WITHIN VALUE SHOWN?
_____ % CO_2	_____ % CO_2	_____ % CO_2	_____ (0.2%)
_____ % CO	_____ % CO	_____ % CO	_____ (0.03%)
_____ % CO_2	_____ % CO_2	_____ % CO_2	_____ (0.2%)
_____ % CO	_____ % CO	_____ % CO	_____ (0.03%)

POST-TEST LEAK CHK: VAC= ___ " H_2O, 0.25" MANOM FELL ____ " IN ____ MINUTES
POST-TEST LEAK RATE: ___ "/min
LEAK RATE < 0.1"/min? ___

POST-TEST TANK STATUS: PRESSURE _______ torr TEMPERATURE ______ C
CORRECTED PRESSURE _______ torr (if Datametrics used)

POST-TEST GAS ANALYSIS:

LEAK TEST ROTAMETER @ 0?	ANALYZER READING	CONCENTRATION FROM CALIBRATION CURVE
________	______ % CO_2	______ % CO_2
	______ % CO	______ % CO

FUEL PILE WEIGHINGS (kg)

INITIAL	FINAL
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________ initial total	________ final total

WOOD/COAL MOISTURE CONTENT DATA

Empty petri dish _______ g

DATE	TIME	PETRI+SAMPLE (g)
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______

Dry basis mc (%) _______

Method: Oven dried _____
Desiccator _____

COMMENTS:

Appendix G

SAMPLE CALCULATION (run 133)

The measured CO_2 concentration was 5.1 mol%. Since this is greater than the lowest CO_2 calibration gas used (0.79 mol%), the ambient correction is -0.04 mol% and the spreadsheet value has been adjusted to show 5.06%. The CO reading was 0.265 mol% after correction using the analyzer calibration curve and equation (1) gives the molar O_2 fraction as

$$O_2=0.21-0.0506-0.00265/2 = 0.1581$$

Nitrogen fraction is calculated by equation (2):

$$N_2=1-0.0506-0.00265-0.1581 = 0.7887$$

The molecular weight is given by equation (3):

$$M=44*0.0506+28*0.00265+32*0.1581+28*0.7887 = 29.44$$

The air/fuel ratio is given by equation (4):

$$AF=0.7887*4.76/3.76*29/[12*(0.0506+1.5*0.00265)]*0.51 = 22.548$$

The measured tank pressures are 2 and 215 torr (0.267 and 28.66 kPa) and tank temperature during the workup is 17 C (290 K). The sample gas mass is given by equation (5):

$$GAS=(28.66-0.267)/8.314*29.44/290*0.0737 = 0.02555 \text{ kg}$$

where the tank volume is 0.0737 m^3. The dry gas sample flow rate during the 57.2 hr sampling period is given by equation (6):

$$SAMPFLO=0.02555/57.2 = 0.0004467 \text{ kg/hr}$$

The moisture content of the fuel was measured as 14.5 dry percent using the oven drying method. If the desiccation method was used the measured value would be increased by 1.558 percentage points to 16.058%. The wet fuel mass in the spreadsheet is 49.5 kg, which is 99% of the weight recorded by the scale. The 99% figure compensates for the bias determined by the scale audit. The dry gas stack flow is given by equation (7):

$$STKFLO=(22.55+0.51)/57.2*49.5*[1/(1+0.145)] = 17.43 \text{ kg/hr}$$

The total measured PM catch is 0.0084 g, which includes the measured O-ring residue correction. Since the average blank run had a catch of 0.6 mg, the corrected catch for Run 133 is 0.0078 g. The total PM emissions are given by equation (8):

$$PM=0.0078*17.43/0.0004467 = 304.4\ g$$

and the PM rate is given by equation (9):

$$PMRATE=304.4/57.2 = 5.32\ g/hr$$

The dry fuel burn rate is given by equation (10):

$$BRATE=49.5*[1/(1+0.145)]/57.2 = 0.756\ kg/hr$$

The PM emission factor is calculated by equation (11):

$$PMEF=5.32/0.756 = 7.04\ g/kg$$

The CO emission rate is given by equation (12):

$$CORATE=17.43/29.44*0.00265*28*1000 = 43.9\ g/hr$$

The CO emission factor is given by equation (13):

$$COEF=43.9/0.756 = 58.1\ g/kg$$

Precision can be calculated if two samplers sampled the same stove during the same time period, as was the case for Runs 139 and 140. The PM precision for these runs is given by equation (14):

$$PRECISION = \frac{22.3 - 21.5}{(22.3 + 21.5)/2} * 100 = 3.7\%$$

Appendix H

DATA MODIFICATIONS

Moisture Content: During the first part of the study the moisture content (dry basis) of the wood was determined by the desiccation method (Run #'s 1-69). The procedure involved desiccating the wood sample to a constant weight at room temperature over a period of several days. Halfway through the study a temperature controlled oven became available and was used for the rest of the moisture determinations.

Previous laboratory experience has shown that the moisture content values obtained by oven drying are usually one to two percentage points higher than corresponding values obtained by the desiccation method. In this field study a total of 19 wood samples (Run #'s 70-74, 77-79, 81-87, 89-92) were first desiccated to a constant weight at room temperature and then oven dried. For each run the moisture content was determined by both methods. As expected, in each case, the moisture content values obtained after oven drying were consistently higher than the values obtained after desiccation. The average difference between the two methods was 1.558 dry basis percentage points with a standard deviation of 0.436 percentage point. Based on this all moisture content values for wood stove tests up to and including Run #69 were increased by 1.558%. Beyond Run #93 the moisture content was determined by the oven drying method.

Total Particulate Catch Adjustments

A total of 11 blanks were run during the field study. For these tests each sampler was subjected to the same pre-test preparation and post-test analysis procedure that was used for the actual test. The sampler was transported to a site, allowed to sample unfiltered room air, and then was transported to the laboratory for workup.

An analysis of the 11 blanks reveals that the total particulate catch has an average value of 0.6 mg with a standard deviation of 0.5 mg. The probable error at the 95% confidence level is 1.0 mg and this value was used for the uncertainty analysis. The average value of 0.6 mg was subtracted from the total particulate catch values for each of the test runs.

O-ring Residues

The o-ring residues were measured beginning with Run 60. The average residue measured for Runs 60 to 156 is 0.0025 g for the front filter and 0.00021 g for the back filter. Data for Runs 1 to 59 were adjusted by assuming these average values for filter residues.

Appendix I

RAW AND CALCULATED EMISSIONS DATA

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LOADED FUEL wet kg	SAMPLING TIME hr	DRY BURN RATE kg/hr	CO2 %	CO %	O2 %	AIR/ FUEL RATIO	COMMENTS	TANK TEMP C	PROBE g pre	PROBE g post
COAL 02	2	R	91.7	122.7	0.68	2.46	0.21	16.4	65.1		16	34.3948	34.3964
COAL 02	5	R	110.1	118.4	0.84	2.76	0.22	16.1	58.5		19	33.7238	33.7250
COAL 02	10	R	82.4	94.6	0.79	1.77	0.15	17.2	90.8	POST TEST LEAK	18	34.1083	34.1086
COAL 02	12	R	90.2	106.7	0.77	2.76	0.19	16.1	59.3		22	33.8375	33.8388
COAL 02	18	R	107.1	119.8	0.81	3.06	0.20	15.8	53.8		18	33.8398	33.8410
COAL 06	11	S	98.9	80.2	1.16	2.16	0.04	16.8	80.4	POST TEST LEAK	18	34.4427	34.4418
COAL 06	16	S	128.8	97.0	1.25	1.86	0.05	17.1	92.0		19	34.3949	34.3949
COAL 06	19	S	227.8	146.2	1.46	2.16	0.04	16.8	80.4		25	34.4784	34.4785
COAL 06	24	S	247.6	144.9	1.61	2.16	0.05	16.8	79.8		14	33.3373	33.3367
COAL 06	28	S	168.4	137.9	1.15	2.16	0.05	16.8	79.8		18	34.3600	34.3600
COAL 07	23	T	433.3	120.5	3.44	5.26	0.05	13.7	34.8		19	34.5777	34.5781
COAL 07	27	T	502.7	122.7	3.91	5.86	0.05	13.1	31.3		18	34.1018	34.1024
COAL 07	31	T	589.3	139.0	4.05	6.16	0.04	12.8	29.9		14	33.7146	33.7151
BLANK	55		0.0	115.3		0.32	0.01	20.7		BLANK	18	33.4233	33.4234
BLANK	56		0.0	83.1		0.11	0.00	20.9		BLANK	16	33.9063	33.9064
BLANK	75		0.0	115.4		0.11	0.01	20.9		BLANK	18	33.9072	33.9069
BLANK	76		0.0	109.9		0.11	0.00	20.9		BLANK	19	33.1019	33.1018
BLANK	88		0.0	66.0		0.11	0.00	20.9		BLANK	17	33.1353	33.1353
BLANK	107		0.0	46.7		0.11	0.00	20.9		BLANK	17	34.8635	34.8638
BLANK	144		0.0	98.0		0.11	0.01	20.9		BLANK	21	33.3538	33.3538
BLANK	146		0.0	67.7		0.00	0.00	21.0		BLANK	21	33.8988	33.8987
BLANK	152		0.0	95.1		0.11	0.00	20.9		BLANK	19	33.7576	33.7578
BLANK	153		0.0	95.0		0.00	0.00	21.0		BLANK	18	33.6948	33.6952
BLANK	154		0.0	95.0		0.11	0.01	20.9		BLANK	16	33.7555	33.7556
CAT 08	30	A1	182.6	117.2	1.38	7.46	0.30	13.4	15.6	POST TEST LEAK	11	34.1758	34.1792
CAT 08	35	A1	111.5	97.3	0.95	6.66	0.39	14.1	17.0		20	34.0458	34.0518
CAT 08	40	A1	82.2	48.3	1.40	8.56	0.62	12.1	12.9		15	33.8422	33.8444
CAT 12	38	B	103.6	87.2	1.07	6.26	0.21	14.6	18.7		14	33.7833	33.7852
CAT 12	44	B	112.3	139.7	0.73	6.79	0.32	14.1	16.9		19	34.0475	34.0518
CAT 12	49	B	130.5	137.1	0.88	7.57	0.37	13.2	15.1		15	33.7533	33.7578
CAT 12	54	B	183.0	102.7	1.64	6.31	0.23	14.6	18.5		15	33.9648	33.9667
CAT 12	61	B	161.6	136.4	1.07	7.08	0.25	13.8	16.5		18	33.7116	33.7160
CAT 12	67	B	182.3	141.8	1.17	7.16	0.31	13.7	16.1		17	33.9732	33.9752
CAT 14	46	C1	104.6	161.8	0.57	9.36	0.24	11.5	12.7		16	33.6834	33.6871
CAT 14	51	C1	113.1	147.4	0.68	7.76	0.20	13.1	15.3		19	33.0651	33.0682
CAT 14	57	C1	115.5	119.9	0.86	7.28	0.13	13.7	16.5		16	33.9949	33.9981
CAT 14	60	C1	198.3	162.3	1.07	8.16	0.20	12.7	14.6		17	33.7582	33.7607
CAT 14	66	C1	208.2	165.2	1.10	7.08	0.14	13.9	16.9		18	33.8772	33.8787
CAT 14	73	C1	185.4	165.9	0.96	7.37	0.15	13.6	16.2		17	33.8673	33.8676
CAT 16	59	D1	205.6	164.9	1.05	3.90	0.30	17.0	28.3		17	33.8879	33.8957
CAT 16	65	D1	210.4	164.8	1.11	4.10	0.28	16.8	27.2		16	34.1008	34.1122
CAT 16	72	D1	190.8	163.9	0.94	4.48	0.32	16.4	24.8		16	33.7474	33.7536
CAT 16	81	D1	191.4	160.1	0.96	4.38	0.13	16.6	26.9	NEW CAT 2/5	16	33.6869	33.6909
CAT 16	90	D2	167.0	154.2	0.91	5.54	0.18	15.4	21.2	NEW STOVE 2/12	18	33.6134	33.6159
CAT 16	100	D2	142.6	155.5	0.80	4.58	0.16	16.3	25.5		21	34.2905	34.2972
CAT 16	111	D2	106.4	136.5	0.67	4.28	0.10	16.7	27.8	NEW CAT 2/26	16	33.7884	33.7894
CAT 16	120	D2	94.1	143.7	0.55	3.70	0.09	17.3	32.1		16	34.1628	34.1636
CAT 16	129	D2	86.1	112.2	0.64	5.15	0.10	15.8	23.2		17	33.7140	33.7146

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LOADED FUEL wet kg	SAMPLING TIME hr	DRY BURN RATE kg/hr	CO2 %	CO %	O2 %	AIR/ FUEL RATIO	COMMENTS	TANK TEMP C	PROBE g pre	PROBE g post
CAT 17	64	E1	165.8	154.4	0.96	6.89	0.28	14.0	16.8		18	33.8351	33.8469
CAT 17	71	E1	140.1	155.2	0.79	6.12	0.20	14.8	19.2		18	33.6833	33.6892
CAT 17	80	E1	129.4	139.7	0.81	5.77	0.27	15.1	20.0		17	33.7093	33.7167
CAT 17	89	E1	140.7	160.7	0.75	6.50	0.23	14.4	18.0		22	33.7908	33.7990
CAT 17	99	E1	121.9	139.3	0.78	5.83	0.22	15.1	20.0		18	33.8375	33.8465
CAT 17	110	E1	102.2	125.9	0.70	5.83	0.29	15.0	19.6		17	33.8490	33.8535
CAT 17	139	E1	75.1	107.8	0.59	5.35	0.39	15.5	20.7	DUAL SAMPLERS	21	32.9275	32.9315
CAT 17	140	E1	75.1	108.1	0.59	5.15	0.38	15.7	21.5	DUAL SAMPLERS	21	34.4684	34.4713
CAT 17	147	E1	68.3	100.1	0.59	6.50	0.28	14.4	17.8	DUAL SAMPLERS	18	35.0464	35.0504
CAT 17	148	E1	68.3	99.6	0.60	6.50	0.28	14.4	17.8	DUAL SAMPLERS	18	33.8498	33.8536
CAT 18	68	A2								BROKEN PROBE	25		
CAT 18	74	A2	247.0	143.4	1.35	6.02	0.21	14.9	19.4		16	34.9278	34.9353
CAT 18	82	A2	197.3	121.6	1.42	4.86	0.23	16.0	23.7		17	33.9062	33.9105
CAT 18	92	A2	223.5	135.2	1.28	3.90	0.26	17.0	28.7		24	34.7735	34.7803
CAT 18	101	A2	217.7	152.1	1.02	3.90	0.27	17.0	28.5		19	34.3121	34.3186
CAT 18	113	A2	164.6	122.8	0.96	3.32	0.24	17.6	33.5	WOOD APPEARS WET	18	34.2910	34.2969
CAT 18	119	A2	156.1	105.9	1.09	3.32	0.22	17.6	33.8		15	34.6496	34.6540
CAT 18	128	A2	147.6	101.0	1.22	5.25	0.30	15.6	21.6	NEW WOOD SOURCE	19	34.9146	34.9186
CAT 18	141	A2	103.4	83.3	1.06	3.61	0.24	17.3	31.0		18	34.7730	34.7751
CAT 18	150	A2	98.7	75.1	1.15	3.32	0.21	17.6	33.9		18	34.3657	34.3664
CAT 19	69	F1	195.7	181.3	0.94	8.26	0.27	12.6	14.2		18	33.7118	33.7145
CAT 19	78	F1	168.0	165.1	0.88	7.96	0.21	12.9	14.9		18	33.9110	33.9120
CAT 19	86	F1	128.8	136.5	0.82	7.17	0.20	13.7	16.5		17	33.9731	33.9748
CAT 19	96	F1	173.5	168.7	0.91	6.60	0.20	14.3	17.8		16	33.9053	33.9081
CAT 19	105	F1	122.6	142.7	0.75	6.02	0.19	14.9	19.5		18	34.9274	34.9290
CAT 19	116	F1	143.2	163.8	0.77	6.98	0.22	13.9	16.8		18	33.7323	33.7348
CAT 21	83	D3	112.3	79.8	1.13	3.03	0.17	17.9	37.5		17	34.0939	34.0972
CAT 21	94	D3	77.3	86.6	0.79	3.51	0.21	17.4	32.2	WOOD TYPE CHANGED	15	33.8334	33.8342
CAT 21	103	D3	92.5	71.5	1.14	3.23	0.19	17.7	35.0		17	34.1294	34.1292
CAT 21	112	D3	111.5	74.8	1.32	3.42	0.09	17.5	34.7	NEW CAT 2/27	17	33.8376	33.8378
CAT 21	121	D3	70.1	76.0	0.82	3.03	0.10	17.9	38.7		14	34.3900	34.3905
CAT 21	131	D3	99.4	81.1	1.07	3.42	0.11	17.5	34.4		18	33.9520	33.9519
CAT 22	84	E2	167.6	161.6	0.88	4.29	0.24	16.6	26.5		17	34.8552	34.8575
CAT 22	95	E2	149.6	132.6	0.95	4.86	0.21	16.0	23.8		21	32.9412	32.9441
CAT 22	104	E2	159.7	143.3	0.91	3.90	0.20	17.0	29.3		19	33.9052	33.9078
CAT 22	117	E2	148.2	144.5	0.85	4.29	0.22	16.6	26.7		18	33.1070	33.1116
CAT 22	125	E2	150.6	137.9	0.90	3.42	0.17	17.5	33.5		17	33.7888	33.7918
CAT 22	134	E2	100.6	108.3	0.78	3.32	0.15	17.6	34.7		17	33.6135	33.6149
CAT 24	97	C2	75.7	87.7	0.76	5.54	0.27	15.3	20.7	NEW CAT 2/9	20	33.8496	33.8523
CAT 24	109	C2	49.1	65.7	0.66	4.72	0.24	16.2	24.2		18	33.8928	33.8948
CAT 24	115	C2	46.9	66.7	0.62	4.72	0.22	16.2	24.4		18	34.6127	34.6156
CAT 24	123	C2	43.2	54.3	0.70	5.25	0.22	15.6	22.1		20	34.6042	34.6058
CAT 24	133	C2	49.5	57.2	0.76	5.06	0.27	15.8	22.5		17	34.1124	34.1146
CAT 24	142	C2	44.2	63.9	0.61	4.48	0.23	16.4	25.5		20	34.3133	34.3162
CAT 26	130	F2	183.6	118.9	1.28	5.25	0.42	15.5	20.9	NEW CAT 2/90	17	34.0481	34.0561
CAT 26	138	F2	83.8	70.8	0.97	4.58	0.36	16.2	24.0		18	34.4941	34.4994
CAT 26	145	F2	109.0	82.2	1.02	4.29	0.36	16.5	25.5	WOOD WETTER	18	34.6021	34.6099
CAT 26	151	F2	104.4	85.2	0.97	4.58	0.36	16.2	24.0		17	33.9147	33.9214

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LOADED FUEL wet kg	SAMPLING TIME hr	DRY BURN RATE kg/hr	CO2 %	CO %	O2 %	AIR/FUEL RATIO	COMMENTS	TANK TEMP C	PROBE g pre	PROBE g post
CAT 26	156	F2	113.1	85.4	1.09	5.25	0.55	15.5	20.2		23	33.0256	33.0341
CONV 01	1	I	94.4	59.8	1.47	3.26	0.25	17.6	33.9		16	34.6801	34.6830
CONV 01	6	I	72.8	38.0	1.78	3.16	0.19	17.7	35.7		18	34.2489	34.2487
CONV 01	15	I	118.9	64.9	1.67	2.86	0.20	18.0	39.0		15	34.0831	34.0861
CONV 01	22	I	145.8	76.2	1.74	4.56	0.34	16.3	24.3		17	35.0015	35.0022
CONV 03	3	J1	94.7	50.6	1.69	3.16	0.23	17.7	35.1		20	34.1975	34.1989
CONV 03	9	J1	87.0	45.8	1.73	3.26	0.23	17.6	34.1		18	34.2256	34.2267
CONV 03	17	J1	119.6	60.8	1.79	3.26	0.25	17.6	33.9		17	33.3484	33.3503
CONV 03	21	J1	143.4	74.1	1.76	3.56	0.25	17.3	31.3		19	34.2996	34.3025
CONV 04	4	K	280.1	137.0	1.65	4.36	0.47	16.4	24.3		21	34.8594	34.8673
CONV 04	8	K	202.2	80.8	2.00	4.16	0.47	16.6	25.3		18	33.9037	33.9091
CONV 04	14	K	237.2	115.8	1.57	4.36	0.47	16.4	24.3		22	34.2471	34.2523
CONV 04	26	K	224.2	118.5	1.50	3.46	0.42	17.3	30.1		17	35.0605	35.0671
CONV 05	7	L	84.8	37.1	2.09					NO RECOVERY	25		
CONV 05	13	L	109.4	54.1	1.83	1.18	0.12	19.8	90.8		19	35.0611	35.0621
CONV 05	20	L	137.0	75.6	1.63	1.67	0.26	19.2	59.8		18	34.6833	34.6834
CONV 05	25	L	129.2	93.0	1.23	3.36	0.53	17.4	29.6		18	33.8407	33.8457
CONV 05	29	L	176.7	109.1	1.43	2.16	0.34	18.7	46.1		16	33.9704	33.9730
CONV 09	32	J2	161.6	80.9	1.85	7.66	0.94	12.9	13.5		12	33.9151	33.9234
CONV 09	36	J2	186.3	87.9	1.92	8.16	1.07	12.3	12.5		11	34.0515	34.0614
CONV 09	42	J2	208.0	123.6	1.48	6.60	0.84	14.0	15.6		20	33.8895	33.9010
CONV 09	53	J2	174.9	99.1	1.64	7.45	1.14	13.0	13.4		19	33.6840	33.6937
CONV 09	48	J2	189.6	127.4	1.34	0.20	0.01	20.8		POST TEST LEAK	17	33.9630	33.9649
CONV 10	33	M	163.1	71.8	1.89	4.56	0.54	16.2	22.9		12	33.7681	33.7729
CONV 10	37	M	97.1	40.8	1.90	5.46	0.56	15.3	19.5		23	33.9264	33.9299
CONV 10	43	M	153.5	61.3	1.98	4.87	0.46	15.9	22.1		15	33.9886	33.9913
CONV 11	34	N	189.6	122.3	1.36	6.36	0.78	14.3	16.3		23	33.7470	33.7590
CONV 11	39	N	180.7	127.8	1.24	6.06	0.73	14.6	17.1		20	33.7121	33.7197
CONV 11	45	N	221.5	139.2	1.40	6.31	0.75	14.3	16.5		18	33.2707	33.2813
CONV 11	50	N	245.2	157.5	1.38	6.50	0.80	14.1	15.9		18	33.9621	33.9802
NCAT 13	41	G1	116.5	65.6	1.57	6.16	0.31	14.7	18.6		16	33.7774	33.7768
NCAT 13	47	G1	138.5	67.1	1.84	6.60	0.35	14.2	17.3		17	33.6930	33.7002
NCAT 13	52	G1	106.6	46.4	2.05	7.08	0.33	13.8	16.2		18	32.9091	32.9127
NCAT 13	58	G1	134.5	66.6	1.82	6.72	0.31	14.1	17.1		17	33.9047	33.9056
NCAT 13	63	G1	140.7	72.7	1.69	5.46	0.24	15.4	21.1		18	33.7605	33.7600
NCAT 13	70	G1	175.3	85.4	1.76	6.79	0.26	14.1	17.1		15	33.7567	33.7582
NCAT 15	62	H1	81.0	84.1	0.87	5.35	0.44	15.4	20.5		17	33.3391	33.3413
NCAT 15	77	H1	74.9	75.6	0.87	4.48	0.27	16.4	25.2		17	33.8334	33.8348
NCAT 15	91	H1	44.8	43.9	0.89	4.86	0.42	15.9	22.4		14	33.5984	33.5987
NCAT 15	108	H1	36.3	47.1	0.68	3.90	0.37	16.9	27.6		18	34.5046	34.5062
NCAT 15	124	H1	32.3	43.8	0.64	3.61	0.40	17.2	29.2		17	33.7962	33.7967
NCAT 15	136	H1	42.8	68.6	0.55	3.61	0.32	17.2	30.1		18	34.5857	34.5875
NCAT 20	79	G2	234.6	137.6	1.48	0.20	0.02	20.8		BROKEN PROBE	18		
NCAT 20	85	G2	205.6	134.0	1.35	4.86	0.26	16.0	23.5		17	33.7799	33.7855
NCAT 20	93	G2	193.1	128.0	1.30	7.56	0.42	13.2	15.0		13	35.0847	35.0885
NCAT 20	102	G2	214.9	140.0	1.35	6.21	0.37	14.6	18.2		20	33.9532	33.9555
NCAT 20	114	G2	199.1	146.1	1.18	5.44	0.29	15.4	20.9	STOVE REPAIRS 2/27	18	34.1288	34.1309
NCAT 20	122	G2	134.1	123.7	0.95	4.86	0.32	16.0	23.0		17	49.2240	49.2292

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LOADED FUEL wet kg	SAMPLING TIME hr	DRY BURN RATE kg/hr	CO2 %	CO %	O2 %	AIR/ FUEL RATIO	COMMENTS	TANK TEMP C	PROBE g pre	PROBE g post
NCAT 20	132	G2	141.4	109.0	1.12	5.83	0.30	15.0	19.6	USED METAL PROBE	18	48.4002	48.4028
NCAT 23	87	H2	145.4	122.3	1.05	6.22	0.43	14.6	17.9		16	33.9334	33.9351
NCAT 23	98	H2	117.5	92.3	1.11	6.89	0.49	13.9	16.1		20	32.9158	32.9180
NCAT 23	106	H2	88.6	87.2	0.88	4.96	0.38	15.9	22.2		17	33.8207	33.8218
NCAT 23	118	H2	118.4	113.3	0.92	4.96	0.38	15.9	22.2		16	32.8833	32.8857
NCAT 23	126	H2	91.9	93.6	0.86	4.67	0.40	16.1	23.4		16	34.3697	34.3697
NCAT 23	137	H2	80.4	77.0	0.91	5.54	0.45	15.2	19.8		17	32.9441	32.9460
NCAT 25	127	H3	29.8	32.5	0.76	4.29	0.34	16.5	25.6	ESTIMATED FUEL	17	34.5053	34.5053
NCAT 25	135	H3	109.7	115.7	0.83	4.96	0.42	15.8	22.0		18	33.6986	33.7026
NCAT 25	143	H3	70.3	82.7	0.71	4.67	0.44	16.1	23.0		18	34.4404	34.4450
NCAT 25	149	H3	84.0	103.1	0.72	3.71	0.42	17.1	28.3		19	34.4959	34.4995
NCAT 25	155	H3	67.4	72.6	0.80	4.48	0.38	16.3	24.4		17	33.7649	33.7673
HIGHEST COAL VALUE			589.3	146.2	4.05	6.16	0.22	17.2	92.0		25	34.5777	34.5781
LOWEST COAL VALUE			82.4	80.2	0.68	1.77	0.04	12.8	29.9		14	33.3373	33.3367
HIGHEST WOOD VALUE			280.1	181.3	2.09	9.36	1.14	20.8	90.8		25	49.2240	49.2292
LOWEST WOOD VALUE			29.8	32.5	0.55	0.20	0.01	11.5	12.5		11	32.8833	32.8857
CATALYTIC AVERAGE			131.7	121.0	0.93	5.41	0.24	15.5	23.1		18	34.0073	34.0111
NONCATALYTIC AVERAGE			110.9	87.6	1.10	5.34	0.36	15.5	21.6		17	34.8897	34.8920
CONVENTIONAL AVERAGE			159.6	87.3	1.65	4.36	0.49	16.4	29.0		18	34.1282	34.1335
BLANK AVERAGE				89.7		0.11	0.00	20.9			18	33.7089	33.7090
COAL AVERAGE			221.4	119.3	1.68	3.12	0.10	15.8	64.3		18	34.1009	34.1013

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LINE g pre	LINE g post	FILTER 1 g pre	FILTER 1 g post	FILTER 2 g pre	FILTER 2 g post	TRAP g pre	TRAP g post	TANK tor pre	TANK tor post
COAL 02	2	R	23.9943	23.9934	0.1188	0.1205	0.1216	0.1223	35.7252	35.7312	3	323
COAL 02	5	R	29.8553	29.8555	0.1209	0.1229	0.1198	0.1203	35.7253	35.7303	2	258
COAL 02	10	R	27.1108	27.1112	0.1211	0.1220	0.1202	0.1205	41.6218	41.6253	2	269
COAL 02	12	R	31.9529	31.9530	0.1202	0.1213	0.1192	0.1197	40.0970	40.1013	2	276
COAL 02	18	R	29.8690	29.8693	0.1215	0.1230	0.1207	0.1212	41.6198	41.6252	2	282
COAL 06	11	S	27.8519	27.8511	0.1203	0.1208	0.1194	0.1198	41.6200	41.6227	3	335
COAL 06	16	S	25.3148	25.3148	0.1210	0.1214	0.1205	0.1208	40.0952	40.0970	2	272
COAL 06	19	S	30.1803	30.1806	0.1197	0.1201	0.1206	0.1210	41.6214	41.6223	2	230
COAL 06	24	S	24.0915	24.0900	0.1200	0.1205	0.1201	0.1205	38.0345	38.0366	2	302
COAL 06	28	S	21.6871	21.6869	0.1198	0.1204	0.1216	0.1221	41.5921	41.5942	2	320
COAL 07	23	T	23.3563	23.3563	0.1202	0.1209	0.1197	0.1203	37.0595	37.0641	3	273
COAL 07	27	T	33.8570	33.8566	0.1203	0.1212	0.1206	0.1214	37.0598	37.0634	2	260
COAL 07	31	T	29.4649	29.4653	0.1207	0.1215	0.1206	0.1213	42.2012	42.2056	3	289
BLANK	55		19.9665	19.9664	0.1198	0.1195	0.1208	0.1203	40.0950	40.0952	1	210
BLANK	56		26.8982	26.8983	0.1201	0.1199	0.1208	0.1205	43.3942	43.3936	3	139
BLANK	75		29.1145	29.1151	0.1201	0.1201	0.1218	0.1218	1.5290	1.5292	2	211
BLANK	76		25.7503	25.7501	0.1219	0.1215	0.1213	0.1212	1.5293	1.5297	2	308
BLANK	88		26.3335	26.3332	0.1234	0.1234	0.1244	0.1241	1.5433	1.5442	2	197
BLANK	107		26.3311	26.3313	0.1225	0.1221	0.1232	0.1228	1.5565	1.5570	2	216
BLANK	144		37.0804	37.0806	0.1194	0.1194	0.1195	0.1192	1.5533	1.5538	2	270
BLANK	146		34.5097	34.5100	0.1191	0.1190	0.1184	0.1182	1.5421	1.5424	2	249
BLANK	152		36.5747	36.5744	0.1180	0.1180	0.1169	0.1168	1.5451	1.5458	2	261
BLANK	153		36.5254	36.5255	0.1175	0.1173	0.1188	0.1186	1.5631	1.5639	2	248
BLANK	154		37.0802	37.0803	0.1190	0.1190	0.1197	0.1196	1.5662	1.5666	2	312
CAT 08	30	A1	29.2065	29.2068	0.1212	0.1216	0.1220	0.1220	38.0344	38.0478	3	310
CAT 08	35	A1	27.3761	27.3775	0.1200	0.1203	0.1204	0.1202	39.9468	39.9651	3	273
CAT 08	40	A1	31.5641	31.5647	0.1207	0.1208	0.1199	0.1201	41.5916	41.5979	2	121
CAT 12	38	B	29.3208	29.3208	0.1205	0.1211	0.1208	0.1209	41.5924	41.5980	1	228
CAT 12	44	B	28.1495	28.1503	0.1205	0.1211	0.1215	0.1214	35.9535	35.9574	1	293
CAT 12	49	B	25.7509	25.7508	0.1195	0.1197	0.1198	0.1197	39.5752	39.5869	3	230
CAT 12	54	B	36.3584	36.3583	0.1207	0.1213	0.1199	0.1200	38.3719	38.3800	2	207
CAT 12	61	B	35.9851	35.9850	0.1226	0.1232	0.1231	0.1232	45.4959	45.5080	2	351
CAT 12	67	B	35.5352	35.5357	0.1235	0.1242	0.1244	0.1247	1.5303	1.5378	2	249
CAT 14	46	C1	31.3959	31.3960	0.1213	0.1211	0.1210	0.1204	41.5951	41.6071	2	315
CAT 14	51	C1	36.5504	36.5515	0.1209	0.1212	0.1195	0.1195	42.2035	42.2135	2	292
CAT 14	57	C1	36.2882	36.2884	0.1185	0.1187	0.1197	0.1199	35.7261	35.7328	3	236
CAT 14	60	C1	31.0651	31.0652	0.1231	0.1234	0.1233	0.1232	41.5583	41.5715	2	308
CAT 14	66	C1	29.2652	29.2659	0.1201	0.1208	0.1198	0.1197	1.5237	1.5329	2	411
CAT 14	73	C1	34.6544	34.6543	0.1218	0.1222	0.1230	0.1231	1.5251	1.5343	2	240
CAT 16	59	D1	26.5317	26.5319	0.1214	0.1219	0.1211	0.1215	38.6270	38.6403	2	268
CAT 16	65	D1	34.6533	34.6546	0.1234	0.1243	0.1236	0.1236	1.5567	1.5733	2	295
CAT 16	72	D1	27.4286	27.4301	0.1238	0.1243	0.1237	0.1239	1.5352	1.5517	2	246
CAT 16	81	D1	35.6121	35.6117	0.1238	0.1246	0.1239	0.1243	1.5298	1.5395	2	301
CAT 16	90	D2	37.4097	37.4100	0.1213	0.1219	0.1221	0.1221	1.5294	1.5385	1	267
CAT 16	100	D2	35.6069	35.6070	0.1246	0.1252	0.1235	0.1235	1.5800	1.5892	2	359
CAT 16	111	D2	33.8854	33.8851	0.1239	0.1243	0.1247	0.1247	1.5549	1.5607	2	347
CAT 16	120	D2	35.3557	35.3559	0.1171	0.1177	0.1176	0.1178	1.5184	1.5246	2	335
CAT 16	129	D2	34.4512	34.4514	0.1181	0.1186	0.1187	0.1188	1.5236	1.5278	2	290

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LINE g pre	LINE g post	FILTER 1 g pre	FILTER 1 g post	FILTER 2 g pre	FILTER 2 g post	TRAP g pre	TRAP g post	TANK tor pre	TANK tor post
CAT 17	64	E1	27.6009	27.6012	0.1245	0.1259	0.1237	0.1239	1.5758	1.5925	2	363
CAT 17	71	E1	35.9722	35.9736	0.1240	0.1250	0.1224	0.1224	1.5407	1.5587	2	311
CAT 17	80	E1	37.6697	37.6709	0.1230	0.1238	0.1235	0.1236	1.5352	1.5481	2	265
CAT 17	89	E1	35.1009	35.1013	0.1237	0.1241	0.1240	0.1241	1.5337	1.5440	2	234
CAT 17	99	E1	34.2321	34.2320	0.1233	0.1244	0.1238	0.1240	1.5406	1.5559	2	395
CAT 17	110	E1	28.7333	28.7332	0.1240	0.1249	0.1221	0.1224	1.5056	1.5227	2	236
CAT 17	139	E1	36.7806	36.7803	0.1195	0.1211	0.1169	0.1170	1.5601	1.5883	2	286
CAT 17	140	E1	33.5270	33.5271	0.1179	0.1199	0.1176	0.1180	1.5346	1.5650	2	305
CAT 17	147	E1	33.4832	33.4832	0.1195	0.1202	0.1188	0.1190	1.5220	1.5355	2	204
CAT 17	148	E1	35.1386	35.1390	0.1188	0.1201	0.1190	0.1194	1.5495	1.5686	2	269
CAT 18	68	A2									2	
CAT 18	74	A2	37.6184	37.6187	0.1236	0.1239	0.1210	0.1212	1.5256	1.5362	2	227
CAT 18	82	A2	35.9651	35.9725	0.1225	0.1229	0.1240	0.1240	1.5595	1.5680	2	204
CAT 18	92	A2	35.4097	35.4096	0.1239	0.1245	0.1236	0.1236	1.5540	1.5655	2	288
CAT 18	101	A2	34.7691	34.7692	0.1243	0.1260	0.1227	0.1230	1.5374	1.5568	2	415
CAT 18	113	A2	35.6072	35.6073	0.1192	0.1202	0.1189	0.1190	1.5260	1.5391	1	304
CAT 18	119	A2	37.6878	37.6879	0.1193	0.1204	0.1187	0.1188	1.5439	1.5578	1	268
CAT 18	128	A2	35.1572	35.1569	0.1184	0.1190	0.1182	0.1184	1.5419	1.5560	1	250
CAT 18	141	A2	36.7363	36.7360	0.1186	0.1196	0.1177	0.1180	1.5324	1.5415	2	239
CAT 18	150	A2	36.7603	36.7609	0.1178	0.1186	0.1178	0.1179	1.5414	1.5480	2	208
CAT 19	69	F1	35.8270	35.8279	0.1227	0.1235	0.1227	0.1231	1.5218	1.5378	2	357
CAT 19	78	F1	37.5821	37.5821	0.1225	0.1223	0.1253	0.1249	1.5421	1.5528	2	234
CAT 19	86	F1	34.2326	34.2328	0.1228	0.1232	0.1237	0.1236	1.5544	1.5624	2	208
CAT 19	96	F1	35.6948	35.6864	0.1224	0.1227	0.1247	0.1245	1.5285	1.5395	2	367
CAT 19	105	F1	34.9401	34.9399	0.1173	0.1177	0.1182	0.1182	1.5808	1.5901	2	289
CAT 19	116	F1	34.6067	34.6068	0.1188	0.1197	0.1182	0.1186	1.5593	1.5724	2	340
CAT 21	83	D3	29.1149	29.1146	0.1227	0.1231	0.1214	0.1215	1.5206	1.5255	2	171
CAT 21	94	D3	35.1090	35.1094	0.1228	0.1232	0.1238	0.1239	1.5546	1.5625	1	231
CAT 21	103	D3	37.2939	37.2938	0.1193	0.1197	0.1190	0.1190	1.5789	1.5844	1	211
CAT 21	112	D3	33.8749	33.8747	0.1190	0.1196	0.1194	0.1197	1.5483	1.5505	2	201
CAT 21	121	D3	37.3867	37.3872	0.1182	0.1187	0.1182	0.1184	1.5203	1.5239	2	201
CAT 21	131	D3	34.6700	34.6703	0.1181	0.1186	0.1179	0.1180	1.5455	1.5506	2	224
CAT 22	84	E2	34.3671	34.3670	0.1228	0.1232	0.1217	0.1218	1.5841	1.5916	2	238
CAT 22	95	E2	25.5964	25.5969	0.1227	0.1235	0.1244	0.1248	1.5842	1.5935	2	264
CAT 22	104	E2	37.2709	37.2711	0.1197	0.1201	0.1176	0.1177	1.5328	1.5408	2	293
CAT 22	117	E2	37.0427	37.0430	0.1183	0.1186	0.1175	0.1176	1.5250	1.5347	1	287
CAT 22	125	E2	33.6791	33.6795	0.1194	0.1203	0.1193	0.1194	1.5434	1.5542	2	326
CAT 22	134	E2	33.4828	33.4831	0.1184	0.1188	0.1181	0.1182	1.5394	1.5441	2	206
CAT 24	97	C2	34.1154	34.1152	0.1232	0.1233	0.1237	0.1235	1.5697	1.5744	2	237
CAT 24	109	C2	35.5649	35.5646	0.1184	0.1187	0.1240	0.1240	1.5716	1.5765	2	187
CAT 24	115	C2	34.9390	34.9395	0.1186	0.1192	0.1195	0.1198	1.5814	1.5858	2	220
CAT 24	123	C2	35.4220	35.4220	0.1185	0.1190	0.1194	0.1195	1.5599	1.5638	2	150
CAT 24	133	C2	37.2127	37.2126	0.1184	0.1191	0.1176	0.1177	1.5765	1.5816	2	215
CAT 24	142	C2	35.0526	35.0531	0.1183	0.1185	0.1173	0.1172	1.5415	1.5475	2	173
CAT 26	130	F2	36.8876	36.8874	0.1183	0.1199	0.1189	0.1193	1.5428	1.5547	2	314
CAT 26	138	F2	36.8287	36.8290	0.1187	0.1198	0.1190	0.1192	1.5537	1.5622	2	235
CAT 26	145	F2	35.0118	35.0121	0.1190	0.1214	0.1192	0.1195	1.5204	1.5332	2	295
CAT 26	151	F2	33.3647	33.3652	0.1192	0.1203	0.1172	0.1176	1.5586	1.5718	2	217

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LINE g pre	LINE g post	FILTER 1 g pre	FILTER 1 g post	FILTER 2 g pre	FILTER 2 g post	TRAP g pre	TRAP g post	TANK tor pre	TANK tor post
CAT 26	156	F2	34.5074	34.5092	0.1175	0.1200	0.1201	0.1203	1.5523	1.5715	2	297
CONV 01	1	I	29.5159	29.5162	0.1200	0.1210	0.1210	0.1208	33.9298	33.9371	2	272
CONV 01	6	I	23.3117	23.3116	0.1208	0.1213	0.1203	0.1203	33.9301	33.9356	3	199
CONV 01	15	I	25.1109	25.1108	0.1202	0.1207	0.1203	0.1202	35.7269	35.7346	2	260
CONV 01	22	I	27.6111	27.6120	0.1194	0.1196	0.1198	0.1196	35.7265	35.7335	3	290
CONV 03	3	J1	27.2525	27.2523	0.1201	0.1214	0.1196	0.1198	40.0956	40.1012	3	186
CONV 03	9	J1	30.0000	29.9993	0.1199	0.1210	0.1207	0.1207	35.7275	35.7339	2	195
CONV 03	17	J1	27.7380	27.7382	0.1196	0.1210	0.1202	0.1202	33.9305	33.9389	2	272
CONV 03	21	J1	29.6347	29.6345	0.1203	0.1211	0.1188	0.1188	33.9317	33.9393	2	178
CONV 04	4	K	31.7595	31.7589	0.1205	0.1220	0.1197	0.1199	41.6187	41.6481	2	325
CONV 04	8	K	23.7427	23.7426	0.1199	0.1208	0.1201	0.1201	40.0956	40.1088	2	217
CONV 04	14	K	34.0710	34.0717	0.1211	0.1216	0.1202	0.1203	40.0963	40.1131	3	259
CONV 04	26	K	29.6105	29.6114	0.1209	0.1219	0.1196	0.1201	35.7261	35.7476	3	253
CONV 05	7	L										
CONV 05	13	L	29.7917	29.7920	0.1199	0.1203	0.1208	0.1206	33.9312	33.9361	2	223
CONV 05	20	L	29.6102	29.6105	0.1213	0.1234	0.1213	0.1214	35.7273	35.7460	3	292
CONV 05	25	L	28.5801	28.5803	0.1198	0.1208	0.1210	0.1212	33.9307	33.9604	2	258
CONV 05	29	L	23.9610	23.9614	0.1207	0.1225	0.1211	0.1211	41.6210	41.6420	3	297
CONV 09	32	J2	28.4293	28.4300	0.1215	0.1231	0.1219	0.1223	41.5932	41.6178	1	179
CONV 09	36	J2	28.9888	28.9888	0.1203	0.1282	0.1197	0.1200	38.0352	38.0853	1	308
CONV 09	42	J2	25.8796	25.8790	0.1199	0.1236	0.1207	0.1207	40.8093	40.8555	2	343
CONV 09	53	J2	27.9875	27.9889	0.1214	0.1228	0.1207	0.1207	36.8010	36.8531	3	226
CONV 09	48	J2	21.2543	21.2545	0.1210	0.1208	0.1201	0.1196	37.0607	37.0609	2	305
CONV 10	33	M	31.7216	31.7228	0.1205	0.1210	0.1219	0.1219	40.8081	40.8251	3	152
CONV 10	37	M	28.2738	28.2734	0.1203	0.1221	0.1206	0.1207	40.8080	40.8223	2	178
CONV 10	43	M	27.2373	27.2375	0.1195	0.1196	0.1197	0.1196	39.5738	39.5835	1	166
CONV 11	34	N	21.5441	21.5450	0.1213	0.1249	0.1220	0.1229	39.5740	39.6255	1	304
CONV 11	39	N	21.9202	21.9208	0.1198	0.1218	0.1204	0.1209	42.2009	42.2358	2	265
CONV 11	45	N	16.6844	16.6846	0.1206	0.1218	0.1207	0.1206	38.0357	38.0703	3	264
CONV 11	50	N	27.0863	27.0875	0.1205	0.1238	0.1213	0.1218	38.0361	38.0928	2	342
NCAT 13	41	G1	21.3893	21.3891	0.1205	0.1213	0.1205	0.1209	38.0357	38.0389	3	228
NCAT 13	47	G1	20.1200	20.1201	0.1220	0.1223	0.1201	0.1201	33.9298	33.9348	3	237
NCAT 13	52	G1	31.2203	31.2205	0.1193	0.1195	0.1207	0.1208	47.5536	47.5552	3	144
NCAT 13	58	G1	27.7440	27.7441	0.1206	0.1207	0.1199	0.1200	38.4824	38.4891	3	220
NCAT 13	63	G1	36.1692	36.1689	0.1229	0.1233	0.1219	0.1220	44.3671	44.3720	2	268
NCAT 13	70	G1	30.8881	30.8892	0.1234	0.1237	0.1234	0.1236	1.5255	1.5288	2	183
NCAT 15	62	H1	23.8303	23.8302	0.1201	0.1205	0.1197	0.1198	1.5376	1.5418	2	155
NCAT 15	77	H1	35.3763	35.3762	0.1208	0.1212	0.1229	0.1231	1.5426	1.5455	2	170
NCAT 15	91	H1	37.4522	37.4523	0.1220	0.1224	0.1238	0.1239	1.5966	1.6039	1	161
NCAT 15	108	H1	35.2824	35.2827	0.1223	0.1231	0.1231	0.1233	1.5575	1.5685	2	185
NCAT 15	124	H1	36.9821	36.9819	0.1194	0.1201	0.1194	0.1194	1.5365	1.5510	2	147
NCAT 15	136	H1	37.5508	37.5505	0.1191	0.1201	0.1178	0.1181	1.5575	1.5701	2	207
NCAT 20	79	G2	35.3142	35.3148	0.1239	0.1235	0.1234	0.1231	1.5832	1.5839	2	202
NCAT 20	85	G2	27.2669	27.2666	0.1247	0.1252	0.1234	0.1237	1.5517	1.5614	2	346
NCAT 20	93	G2	37.6202	37.6198	0.1235	0.1239	0.1218	0.1217	1.5462	1.5577	2	267
NCAT 20	102	G2	37.2388	37.2388	0.1237	0.1242	0.1210	0.1210	1.5530	1.5683	1	312
NCAT 20	114	G2	37.1111	37.1109	0.1193	0.1199	0.1189	0.1185	1.5415	1.5517	2	322
NCAT 20	122	G2	33.6623	33.6620	0.1182	0.1188	0.1190	0.1192	1.5627	1.5706	2	256

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	LINE g pre	LINE g post	FILTER 1 g pre	FILTER 1 g post	FILTER 2 g pre	FILTER 2 g post	TRAP g pre	TRAP g post	TANK tor pre	TANK tor post
NCAT 20	132	G2	35.3556	35.3556	0.1190	0.1194	0.1183	0.1183	1.5683	1.5735	2	302
NCAT 23	87	H2	35.7661	35.7664	0.1237	0.1241	0.1233	0.1233	1.5481	1.5525	2	211
NCAT 23	98	H2	28.9098	28.9100	0.1235	0.1241	0.1237	0.1236	1.5254	1.5308	1	205
NCAT 23	106	H2	27.2652	27.2663	0.1180	0.1185	0.1179	0.1180	1.5492	1.5545	2	283
NCAT 23	118	H2	37.1097	37.1094	0.1176	0.1187	0.1186	0.1193	1.5392	1.5474	2	302
NCAT 23	126	H2	28.5417	28.5417	0.1185	0.1189	0.1186	0.1185	1.5248	1.5322	2	115
NCAT 23	137	H2	36.9550	36.9553	0.1191	0.1198	0.1178	0.1180	1.5433	1.5481	2	213
NCAT 25	127	H3	36.9396	36.9392	0.1191	0.1194	0.1191	0.1192	1.5513	1.5544	2	77
NCAT 25	135	H3	35.3034	35.3030	0.1174	0.1185	0.1173	0.1176	1.5360	1.5532	2	300
NCAT 25	143	H3	34.3170	34.3176	0.1183	0.1202	0.1186	0.1191	1.5463	1.5693	2	290
NCAT 25	149	H3	36.6185	36.6188	0.1177	0.1193	0.1180	0.1185	1.5437	1.5652	2	264
NCAT 25	155	H3	34.1192	34.1215	0.1195	0.1207	0.1195	0.1200	1.5477	1.5556	2	206
HIGHEST COAL VALUE			33.8570	33.8566	0.1215	0.1230	0.1216	0.1223	42.2012	42.2056	2.8	335
LOWEST COAL VALUE			21.6871	21.6869	0.1188	0.1201	0.1192	0.1197	35.7252	35.7303	1.7	230
HIGHEST WOOD VALUE			37.6878	37.6879	0.1247	0.1282	0.1253	0.1249	47.5536	47.5552	2.9	415
LOWEST WOOD VALUE			16.6844	16.6846	0.1171	0.1177	0.1169	0.1170	1.5056	1.5227	0.8	77
CATALYTIC AVERAGE			34.0837	34.0840	0.1208	0.1214	0.1208	0.1209	8.4921	8.5028	1.9	267
NONCATALYTIC AVERAGE			32.9002	32.9003	0.1205	0.1211	0.1203	0.1204	8.2586	8.2671	2.0	227
CONVENTIONAL AVERAGE			27.0825	27.0827	0.1204	0.1219	0.1205	0.1206	37.8243	37.8459	2.2	250
BLANK AVERAGE			30.5604	30.5605	0.1201	0.1199	0.1205	0.1203	8.8561	8.8565	2.0	238
COAL AVERAGE			27.5835	27.5834	0.1203	0.1213	0.1204	0.1209	39.5441	39.5476	2.1	284

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	MEASURED CATCHES PROBE g	LINE g	FILTER1 g	FILTER2 g	TRAP g	FILTER 1 RESIDUE g	FILTER 2 RESIDUE g	TOTAL g	DRY MOL WT g/mol	DRY SAMPLE FLOW g/s
COAL 02	2	R	0.0016	-0.0009	0.0017	0.0007	0.0060	0.00025	0.00021	0.00956	29.1	0.00009
COAL 02	5	R	0.0012	0.0002	0.0020	0.0005	0.0050	0.00025	0.00021	0.00936	29.1	0.00007
COAL 02	10	R	0.0003	0.0004	0.0009	0.0003	0.0035	0.00025	0.00021	0.00586	29.0	0.00009
COAL 02	12	R	0.0013	0.0001	0.0011	0.0005	0.0043	0.00025	0.00021	0.00776	29.1	0.00008
COAL 02	18	R	0.0012	0.0003	0.0015	0.0005	0.0054	0.00025	0.00021	0.00936	29.1	0.00008
COAL 06	11	S	-0.0009	-0.0008	0.0005	0.0004	0.0027	0.00025	0.00021	0.00236	29.0	0.00014
COAL 06	16	S	0.0000	0.0000	0.0004	0.0003	0.0018	0.00025	0.00021	0.00296	29.0	0.00009
COAL 06	19	S	0.0001	0.0003	0.0004	0.0004	0.0009	0.00025	0.00021	0.00256	29.0	0.00005
COAL 06	24	S	-0.0006	-0.0015	0.0005	0.0004	0.0021	0.00025	0.00021	0.00136	29.0	0.00007
COAL 06	28	S	0.0000	-0.0002	0.0006	0.0005	0.0021	0.00025	0.00021	0.00346	29.0	0.00008
COAL 07	23	T	0.0004	0.0000	0.0007	0.0006	0.0046	0.00025	0.00021	0.00676	29.4	0.00007
COAL 07	27	T	0.0006	-0.0004	0.0009	0.0008	0.0036	0.00025	0.00021	0.00596	29.5	0.00007
COAL 07	31	T	0.0005	0.0004	0.0008	0.0007	0.0044	0.00025	0.00021	0.00726	29.5	0.00007
BLANK	55		0.0001	-0.0001	-0.0003	-0.0005	0.0002	0.00025	0.00021	-0.00014	28.9	0.00006
BLANK	56		0.0001	0.0001	-0.0002	-0.0003	-0.0006	0.00025	0.00021	-0.00044	28.9	0.00005
BLANK	75		-0.0003	0.0006	0.0000	0.0000	0.0002	0.00030	0.00040	0.00120	28.9	0.00006
BLANK	76		-0.0001	-0.0002	-0.0004	-0.0001	0.0004	0.00040	0.00020	0.00017	28.9	0.00009
BLANK	88		0.0000	-0.0003	0.0000	-0.0003	0.0009	0.00040	0.00020	0.00090	28.9	0.00010
BLANK	107		0.0003	0.0002	-0.0004	-0.0004	0.0005	0.00020	0.00020	0.00060	28.9	0.00015
BLANK	144		0.0000	0.0002	0.0000	-0.0003	0.0005	0.00010	0.00030	0.00080	28.9	0.00009
BLANK	146		-0.0001	0.0003	-0.0001	-0.0002	0.0003	0.00020	0.00020	0.00060	28.8	0.00012
BLANK	152		0.0002	-0.0003	0.0000	-0.0001	0.0007	0.00020	0.00010	0.00080	28.9	0.00009
BLANK	153		0.0004	0.0001	-0.0002	-0.0002	0.0008	0.00020	0.00010	0.00120	28.8	0.00008
BLANK	154		0.0001	0.0001	0.0000	-0.0001	0.0004	0.00030	0.00020	0.00100	28.9	0.00011
CAT 08	30	A1	0.0034	0.0003	0.0004	0.0000	0.0134	0.00025	0.00021	0.01796	29.7	0.00009
CAT 08	35	A1	0.0060	0.0014	0.0003	-0.0002	0.0183	0.00025	0.00021	0.02626	29.6	0.00009
CAT 08	40	A1	0.0022	0.0006	0.0001	0.0002	0.0063	0.00025	0.00021	0.00986	29.9	0.00008
CAT 12	38	B	0.0019	0.0000	0.0006	0.0001	0.0056	0.00025	0.00021	0.00866	29.6	0.00009
CAT 12	44	B	0.0043	0.0008	0.0006	-0.0001	0.0039	0.00025	0.00021	0.00996	29.6	0.00007
CAT 12	49	B	0.0045	-0.0001	0.0002	-0.0001	0.0117	0.00025	0.00021	0.01666	29.7	0.00006
CAT 12	54	B	0.0019	-0.0001	0.0006	0.0001	0.0081	0.00025	0.00021	0.01106	29.6	0.00007
CAT 12	61	B	0.0044	-0.0001	0.0006	0.0001	0.0121	0.00020	0.00050	0.01780	29.7	0.00009
CAT 12	67	B	0.0020	0.0005	0.0007	0.0003	0.0075	0.00010	0.00020	0.01130	29.7	0.00006
CAT 14	46	C1	0.0037	0.0001	-0.0002	-0.0006	0.0120	0.00025	0.00021	0.01546	30.0	0.00007
CAT 14	51	C1	0.0031	0.0011	0.0003	0.0000	0.0100	0.00025	0.00021	0.01496	29.8	0.00007
CAT 14	57	C1	0.0032	0.0002	0.0002	0.0002	0.0067	0.00025	0.00021	0.01096	29.7	0.00007
CAT 14	60	C1	0.0025	0.0001	0.0003	-0.0001	0.0132	0.00040	0.00020	0.01660	29.8	0.00006
CAT 14	66	C1	0.0015	0.0007	0.0007	-0.0001	0.0092	0.00030	0.00030	0.01260	29.7	0.00008
CAT 14	73	C1	0.0003	-0.0001	0.0004	0.0001	0.0092	0.00030	0.00030	0.01050	29.7	0.00005
CAT 16	59	D1	0.0078	0.0002	0.0005	0.0004	0.0133	0.00025	0.00021	0.02266	29.3	0.00005
CAT 16	65	D1	0.0114	0.0013	0.0009	0.0000	0.0166	0.00020	0.00020	0.03060	29.3	0.00006
CAT 16	72	D1	0.0062	0.0015	0.0005	0.0002	0.0165	0.00020	0.00020	0.02530	29.4	0.00005
CAT 16	81	D1	0.0040	-0.0004	0.0008	0.0004	0.0097	0.00040	0.00040	0.01530	29.4	0.00006
CAT 16	90	D2	0.0025	0.0003	0.0006	0.0000	0.0091	0.00030	0.00030	0.01310	29.5	0.00006
CAT 16	100	D2	0.0067	0.0001	0.0006	0.0000	0.0092	0.00010	0.00000	0.01670	29.4	0.00008
CAT 16	111	D2	0.0010	-0.0003	0.0004	0.0000	0.0058	0.00020	0.00020	0.00730	29.4	0.00008
CAT 16	120	D2	0.0008	0.0002	0.0006	0.0002	0.0062	0.00030	0.00030	0.00860	29.3	0.00008
CAT 16	129	D2	0.0006	0.0002	0.0005	0.0001	0.0042	0.00010	0.00010	0.00580	29.5	0.00009

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	MEASURED CATCHES PROBE g	LINE g	FILTER1 g	FILTER2 g	TRAP g	FILTER 1 RESIDUE g	FILTER 2 RESIDUE g	TOTAL g	DRY MOL WT g/mol	DRY SAMPLE FLOW g/s
CAT 17	64	E1	0.0118	0.0003	0.0014	0.0002	0.0167	0.00020	0.00030	0.03090	29.7	0.00008
CAT 17	71	E1	0.0059	0.0014	0.0010	0.0000	0.0180	0.00020	0.00040	0.02690	29.6	0.00007
CAT 17	80	E1	0.0074	0.0012	0.0008	0.0001	0.0129	0.00040	0.00030	0.02310	29.5	0.00006
CAT 17	89	E1	0.0082	0.0004	0.0004	0.0001	0.0103	0.00020	0.00010	0.01970	29.6	0.00005
CAT 17	99	E1	0.0090	-0.0001	0.0011	0.0002	0.0153	0.00020	0.00020	0.02590	29.5	0.00009
CAT 17	110	E1	0.0045	-0.0001	0.0009	0.0003	0.0171	0.00020	0.00020	0.02310	29.5	0.00006
CAT 17	139	E1	0.0040	-0.0003	0.0016	0.0001	0.0282	0.00010	0.00030	0.03400	29.5	0.00009
CAT 17	140	E1	0.0029	0.0001	0.0020	0.0004	0.0304	0.00040	0.00020	0.03640	29.5	0.00009
CAT 17	147	E1	0.0040	0.0000	0.0007	0.0002	0.0135	0.00040	0.00030	0.01910	29.6	0.00007
CAT 17	148	E1	0.0038	0.0004	0.0013	0.0004	0.0191	0.00020	0.00000	0.02520	29.6	0.00009
CAT 18	68	A2										
CAT 18	74	A2	0.0075	0.0003	0.0003	0.0002	0.0106	0.00040	0.00020	0.01950	29.6	0.00005
CAT 18	82	A2	0.0043	0.0074	0.0004	0.0000	0.0085	0.00010	0.00030	0.02100	29.4	0.00006
CAT 18	92	A2	0.0068	-0.0001	0.0006	0.0000	0.0115	0.00030	0.00020	0.01930	29.3	0.00007
CAT 18	101	A2	0.0065	0.0001	0.0017	0.0003	0.0194	0.00030	0.00020	0.02850	29.3	0.00009
CAT 18	113	A2	0.0059	0.0001	0.0010	0.0001	0.0131	0.00020	0.00010	0.02050	29.2	0.00008
CAT 18	119	A2	0.0044	0.0001	0.0011	0.0001	0.0139	0.00020	0.00030	0.02010	29.2	0.00008
CAT 18	128	A2	0.0040	-0.0003	0.0006	0.0002	0.0141	0.00030	0.00030	0.01920	29.5	0.00008
CAT 18	141	A2	0.0021	-0.0003	0.0010	0.0003	0.0091	0.00020	0.00020	0.01260	29.3	0.00009
CAT 18	150	A2	0.0007	0.0006	0.0008	0.0001	0.0066	0.00030	0.00020	0.00930	29.2	0.00009
CAT 19	69	F1	0.0027	0.0009	0.0008	0.0004	0.0160	0.00050	0.00020	0.02150	29.8	0.00007
CAT 19	78	F1	0.0010	0.0000	-0.0002	-0.0004	0.0107	0.00040	0.00030	0.01180	29.8	0.00005
CAT 19	86	F1	0.0017	0.0002	0.0004	-0.0001	0.0080	0.00010	0.00020	0.01050	29.7	0.00005
CAT 19	96	F1	0.0028	-0.0084	0.0003	-0.0002	0.0110	0.00030	0.00030	0.00610	29.6	0.00007
CAT 19	105	F1	0.0016	-0.0002	0.0004	0.0000	0.0093	0.00040	0.00030	0.01180	29.6	0.00007
CAT 19	116	F1	0.0025	0.0001	0.0009	0.0004	0.0131	0.00020	0.00010	0.01730	29.7	0.00007
CAT 21	83	D3	0.0033	-0.0003	0.0004	0.0001	0.0049	0.00010	0.00020	0.00870	29.2	0.00007
CAT 21	94	D3	0.0008	0.0004	0.0004	0.0001	0.0079	0.00030	0.00020	0.01010	29.3	0.00009
CAT 21	103	D3	-0.0002	-0.0001	0.0004	0.0000	0.0055	0.00010	0.00010	0.00580	29.2	0.00010
CAT 21	112	D3	0.0002	-0.0002	0.0006	0.0003	0.0022	0.00010	0.00010	0.00330	29.2	0.00009
CAT 21	121	D3	0.0005	0.0005	0.0005	0.0002	0.0036	0.00020	0.00030	0.00580	29.2	0.00009
CAT 21	131	D3	-0.0001	0.0003	0.0005	0.0001	0.0051	0.00010	0.00020	0.00620	29.2	0.00009
CAT 22	84	E2	0.0023	-0.0001	0.0004	0.0001	0.0075	0.00060	0.00030	0.01110	29.4	0.00005
CAT 22	95	E2	0.0029	0.0005	0.0008	0.0004	0.0093	0.00030	0.00020	0.01440	29.4	0.00006
CAT 22	104	E2	0.0026	0.0002	0.0004	0.0001	0.0080	0.00040	0.00010	0.01180	29.3	0.00007
CAT 22	117	E2	0.0046	0.0003	0.0003	0.0001	0.0097	0.00040	0.00030	0.01570	29.4	0.00007
CAT 22	125	E2	0.0030	0.0004	0.0009	0.0001	0.0108	0.00040	0.00010	0.01570	29.2	0.00008
CAT 22	134	E2	0.0014	0.0003	0.0004	0.0001	0.0047	0.00010	0.00000	0.00700	29.2	0.00006
CAT 24	97	C2	0.0027	-0.0002	0.0001	-0.0002	0.0047	0.00030	0.00030	0.00770	29.5	0.00009
CAT 24	109	C2	0.0020	-0.0003	0.0003	0.0000	0.0049	0.00030	0.00020	0.00740	29.4	0.00009
CAT 24	115	C2	0.0029	0.0005	0.0006	0.0003	0.0044	0.00020	0.00020	0.00910	29.4	0.00011
CAT 24	123	C2	0.0016	0.0000	0.0005	0.0001	0.0039	0.00030	0.00020	0.00660	29.5	0.00009
CAT 24	133	C2	0.0022	-0.0001	0.0007	0.0001	0.0051	0.00020	0.00020	0.00840	29.4	0.00012
CAT 24	142	C2	0.0029	0.0005	0.0002	-0.0001	0.0060	0.00000	0.00000	0.00950	29.4	0.00009
CAT 26	130	F2	0.0080	-0.0002	0.0016	0.0004	0.0119	0.00030	0.00020	0.02220	29.5	0.00009
CAT 26	138	F2	0.0053	0.0003	0.0011	0.0002	0.0085	0.00030	0.00030	0.01600	29.4	0.00011
CAT 26	145	F2	0.0078	0.0003	0.0024	0.0003	0.0128	0.00020	0.00020	0.02400	29.3	0.00012
CAT 26	151	F2	0.0067	0.0005	0.0011	0.0004	0.0132	0.00040	0.00020	0.02250	29.4	0.00008

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	[......MEASURED CATCHES							......]	DRY MOL WT g/mol	DRY SAMPLE FLOW g/s
			PROBE g	LINE g	FILTER1 g	FILTER2 g	TRAP g	FILTER 1 RESIDUE g	FILTER 2 RESIDUE g	TOTAL g		
CAT 26	156	F2	0.0085	0.0018	0.0025	0.0002	0.0192	0.00000	0.00020	0.03240	29.5	0.00011
CONV 01	1	I	0.0029	0.0003	0.0010	-0.0002	0.0073	0.00025	0.00021	0.01176	29.2	0.00015
CONV 01	6	I	-0.0002	-0.0001	0.0005	0.0000	0.0055	0.00025	0.00021	0.00616	29.2	0.00017
CONV 01	15	I	0.0030	-0.0001	0.0005	-0.0001	0.0077	0.00025	0.00021	0.01146	29.2	0.00013
CONV 01	22	I	0.0007	0.0009	0.0002	-0.0002	0.0070	0.00025	0.00021	0.00906	29.4	0.00013
CONV 03	3	J1	0.0014	-0.0002	0.0013	0.0002	0.0056	0.00025	0.00021	0.00876	29.2	0.00012
CONV 03	9	J1	0.0011	-0.0007	0.0011	0.0000	0.0064	0.00025	0.00021	0.00836	29.2	0.00014
CONV 03	17	J1	0.0019	0.0002	0.0014	0.0000	0.0084	0.00025	0.00021	0.01236	29.2	0.00015
CONV 03	21	J1	0.0029	-0.0002	0.0008	0.0000	0.0076	0.00025	0.00021	0.01156	29.3	0.00008
CONV 04	4	K	0.0079	-0.0006	0.0015	0.0002	0.0294	0.00025	0.00021	0.03886	29.4	0.00008
CONV 04	8	K	0.0054	-0.0001	0.0009	0.0000	0.0132	0.00025	0.00021	0.01986	29.3	0.00009
CONV 04	14	K	0.0052	0.0007	0.0005	0.0001	0.0168	0.00025	0.00021	0.02376	29.4	0.00007
CONV 04	26	K	0.0066	0.0009	0.0010	0.0005	0.0215	0.00025	0.00021	0.03096	29.2	0.00007
CONV 05	7	L										
CONV 05	13	L	0.0010	0.0003	0.0004	-0.0002	0.0049	0.00025	0.00021	0.00686	29.0	0.00013
CONV 05	20	L	0.0001	0.0003	0.0021	0.0001	0.0187	0.00025	0.00021	0.02176	29.0	0.00013
CONV 05	25	L	0.0050	0.0002	0.0010	0.0002	0.0297	0.00025	0.00021	0.03656	29.2	0.00009
CONV 05	29	L	0.0026	0.0004	0.0018	0.0000	0.0210	0.00025	0.00021	0.02626	29.1	0.00009
CONV 09	32	J2	0.0083	0.0007	0.0016	0.0004	0.0246	0.00025	0.00021	0.03606	29.7	0.00008
CONV 09	36	J2	0.0099	0.0000	0.0079	0.0003	0.0501	0.00025	0.00021	0.06866	29.8	0.00012
CONV 09	42	J2	0.0115	-0.0006	0.0037	0.0000	0.0462	0.00025	0.00021	0.06126	29.6	0.00009
CONV 09	53	J2	0.0097	0.0014	0.0014	0.0000	0.0521	0.00025	0.00021	0.06506	29.7	0.00008
CONV 09	48	J2	0.0019	0.0002	-0.0002	-0.0005	0.0002	0.00025	0.00021	0.00206	28.9	0.00008
CONV 10	33	M	0.0048	0.0012	0.0005	0.0000	0.0170	0.00025	0.00021	0.02396	29.4	0.00007
CONV 10	37	M	0.0035	-0.0004	0.0018	0.0001	0.0143	0.00025	0.00021	0.01976	29.5	0.00014
CONV 10	43	M	0.0027	0.0002	0.0001	-0.0001	0.0097	0.00025	0.00021	0.01306	29.4	0.00009
CONV 11	34	N	0.0120	0.0009	0.0036	0.0009	0.0515	0.00025	0.00021	0.06936	29.6	0.00008
CONV 11	39	N	0.0076	0.0006	0.0020	0.0005	0.0349	0.00025	0.00021	0.04606	29.6	0.00007
CONV 11	45	N	0.0106	0.0002	0.0012	-0.0001	0.0346	0.00025	0.00021	0.04696	29.6	0.00006
CONV 11	50	N	0.0181	0.0012	0.0033	0.0005	0.0567	0.00025	0.00021	0.08026	29.6	0.00007
NCAT 13	41	G1	-0.0006	-0.0002	0.0008	0.0004	0.0032	0.00025	0.00021	0.00406	29.6	0.00012
NCAT 13	47	G1	0.0072	0.0001	0.0003	0.0000	0.0050	0.00025	0.00021	0.01306	29.6	0.00012
NCAT 13	52	G1	0.0036	0.0002	0.0002	0.0001	0.0016	0.00025	0.00021	0.00618	29.7	0.00010
NCAT 13	58	G1	0.0009	0.0001	0.0001	0.0001	0.0067	0.00025	0.00021	0.00836	29.6	0.00011
NCAT 13	63	G1	-0.0005	-0.0003	0.0004	0.0001	0.0049	0.00020	0.00030	0.00510	29.5	0.00012
NCAT 13	70	G1	0.0015	0.0011	0.0003	0.0002	0.0033	0.00050	0.00040	0.00730	29.6	0.00007
NCAT 15	62	H1	0.0022	-0.0001	0.0004	0.0001	0.0042	0.00020	0.00010	0.00710	29.5	0.00006
NCAT 15	77	H1	0.0014	-0.0001	0.0004	0.0002	0.0029	0.00030	0.00010	0.00520	29.4	0.00007
NCAT 15	91	H1	0.0003	0.0001	0.0004	0.0001	0.0073	0.00040	0.00030	0.00890	29.4	0.00012
NCAT 15	108	H1	0.0016	0.0003	0.0008	0.0002	0.0110	0.00030	0.00020	0.01440	29.3	0.00013
NCAT 15	124	H1	0.0005	-0.0002	0.0007	0.0000	0.0145	0.00040	0.00030	0.01620	29.3	0.00011
NCAT 15	136	H1	0.0018	-0.0003	0.0010	0.0003	0.0126	0.00010	0.00000	0.01550	29.3	0.00010
NCAT 20	79	G2		0.0006	-0.0004	-0.0003	0.0007	0.00030	0.00020	0.00110	28.9	0.00005
NCAT 20	85	G2	0.0056	-0.0003	0.0005	0.0003	0.0097	0.00020	0.00010	0.01610	29.4	0.00009
NCAT 20	93	G2	0.0038	-0.0004	0.0004	-0.0001	0.0115	0.00020	0.00000	0.01540	29.7	0.00007
NCAT 20	102	G2	0.0023	0.0000	0.0005	0.0000	0.0153	0.00030	0.00020	0.01860	29.6	0.00007
NCAT 20	114	G2	0.0021	-0.0002	0.0006	-0.0004	0.0102	0.00040	0.00030	0.01300	29.5	0.00007
NCAT 20	122	G2	0.0052	-0.0003	0.0006	0.0002	0.0079	0.00030	0.00010	0.01400	29.4	0.00007

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	MEASURED CATCHES PROBE g	LINE g	FILTER1 g	FILTER2 g	TRAP g	FILTER 1 RESIDUE g	FILTER 2 RESIDUE g	TOTAL g	DRY MOL WT g/mol	DRY SAMPLE FLOW g/s
NCAT 20	132	G2	0.0026	0.0000	0.0004	0.0000	0.0052	0.00030	0.00030	0.00880	29.5	0.00009
NCAT 23	87	H2	0.0017	0.0003	0.0004	0.0000	0.0044	0.00010	0.00020	0.00710	29.6	0.00006
NCAT 23	98	H2	0.0022	0.0002	0.0006	-0.0001	0.0054	0.00020	0.00020	0.00870	29.7	0.00007
NCAT 23	106	H2	0.0011	0.0011	0.0005	0.0001	0.0053	0.00030	0.00030	0.00870	29.4	0.00011
NCAT 23	118	H2	0.0024	-0.0003	0.0011	0.0007	0.0082	0.00020	0.00030	0.01260	29.4	0.00009
NCAT 23	126	H2	0.0000	0.0000	0.0004	-0.0001	0.0074	0.00010	0.00020	0.00800	29.4	0.00004
NCAT 23	137	H2	0.0019	0.0003	0.0007	0.0002	0.0048	0.00030	0.00020	0.00840	29.5	0.00009
NCAT 25	127	H3	0.0000	-0.0004	0.0003	0.0001	0.0031	0.00020	0.00010	0.00340	29.3	0.00008
NCAT 25	135	H3	0.0040	-0.0004	0.0011	0.0003	0.0172	0.00000	0.00010	0.02230	29.4	0.00009
NCAT 25	143	H3	0.0046	0.0006	0.0019	0.0005	0.0230	0.00030	0.00010	0.03100	29.4	0.00012
NCAT 25	149	H3	0.0036	0.0003	0.0016	0.0005	0.0215	0.00030	0.00030	0.02810	29.3	0.00008
NCAT 25	155	H3	0.0024	0.0023	0.0012	0.0005	0.0079	0.00010	0.00010	0.01450	29.4	0.00009
HIGHEST COAL VALUE			0.0016	0.0004	0.0020	0.0008	0.006	0.00025	0.00021	0.00956	29.5	0.00014
LOWEST COAL VALUE			-0.0009	-0.0015	0.0004	0.0003	0.0009	0.00025	0.00021	0.00136	29.0	0.00005
HIGHEST WOOD VALUE			0.0181	0.0074	0.0079	0.0009	0.0567	0.00060	0.00050	0.08026	30.0	0.00017
LOWEST WOOD VALUE			-0.0006	-0.0084	-0.0004	-0.0006	0.0002	0.00000	0.00000	0.00110	28.9	0.00004
CATALYTIC AVERAGE			0.0038	0.0002	0.0007	0.0001	0.0107	0.00025	0.00022	0.01598	29.5	0.00008
NONCATALYTIC AVERAGE			0.0023	0.0001	0.0006	0.0002	0.0085	0.00025	0.00019	0.01207	29.5	0.00009
CONVENTIONAL AVERAGE			0.0053	0.0003	0.0015	0.0001	0.0215	0.00025	0.00021	0.02917	29.4	0.00010
BLANK AVERAGE			0.0001	0.0001	-0.0001	-0.0002	0.0004	0.00025	0.00021	0.00061		0.00009
COAL AVERAGE			0.0004	-0.0002	0.0009	0.0005	0.0036	0.00025	0.00021	0.00574	29.1	0.00008

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	N2 dry %	RHOA kg/m^3	CONSTANT KS	CORRECTED VALUES							
						MC %	CATCH g	BURN RATE kg/hr	STACK FLOW g/s	PM g/hr	CO g/hr	CO g/kg	PM g/kg
COAL 02	2	R	80.9	0.52	0.028	10.57	0.0090	0.68	12.3	10.4	90	133	15.4
COAL 02	5	R	80.9	0.41	0.031	10.57	0.0088	0.84	13.8	14.4	105	125	17.1
COAL 02	10	R	80.9	0.43	0.020	10.57	0.0053	0.79	20.0	12.0	104	132	15.3
COAL 02	12	R	80.9	0.43	0.030	10.57	0.0072	0.77	12.7	10.3	84	109	13.4
COAL 02	18	R	80.9	0.45	0.034	10.57	0.0088	0.81	12.2	11.6	84	104	14.3
COAL 06	11	S	81.0	0.53	0.022	6.39	0.0018	1.16	26.0	4.2	36	31	3.6
COAL 06	16	S	81.0	0.43	0.019	6.39	0.0024	1.25	32.1	8.6	56	45	6.9
COAL 06	19	S	81.0	0.36	0.022	6.39	0.0020	1.46	32.9	8.8	46	31	6.0
COAL 06	24	S	81.0	0.49	0.022	6.39	0.0008	1.61	35.8	2.7	62	39	1.7
COAL 06	28	S	81.0	0.51	0.022	6.39	0.0029	1.15	25.6	7.0	44	39	6.1
COAL 07	23	T	81.0	0.44	0.053	4.72	0.0062	3.44	33.7	23.3	58	17	6.8
COAL 07	27	T	81.0	0.42	0.059	4.72	0.0054	3.91	34.6	21.6	59	15	5.5
COAL 07	31	T	81.0	0.47	0.062	4.72	0.0067	4.05	34.2	23.5	47	12	5.8
BLANK	55		79.0	0.33	0.003		-0.0007						
BLANK	56		79.0	0.22	0.001		-0.0010						
BLANK	75		79.0	0.33	0.001		0.0006						
BLANK	76		79.0	0.48	0.001		-0.0004						
BLANK	88		79.0	0.31	0.001		0.0003						
BLANK	107		79.0	0.34	0.001		-0.0000						
BLANK	144		79.0	0.42	0.001		0.0002						
BLANK	146		79.0	0.39	0.000		-0.0000						
BLANK	152		79.0	0.41	0.001		0.0002						
BLANK	153		79.0	0.39	0.000		0.0006						
BLANK	154		79.0	0.50	0.001		0.0004						
CAT 08	30	A1	78.9	0.52	0.079	14.66	0.01736	1.36	6.06	9.98	62	45	7.3
CAT 08	35	A1	78.8	0.44	0.072	21.66	0.0257	0.94	4.6	13.1	61	64	13.9
CAT 08	40	A1	78.7	0.20	0.095	22.86	0.0093	1.39	5.2	11.8	108	78	8.5
CAT 12	38	B	78.9	0.37	0.066	12.56	0.0081	1.06	5.6	5.9	40	38	5.6
CAT 12	44	B	78.8	0.47	0.073	11.36	0.0094	0.72	3.5	3.4	38	53	4.7
CAT 12	49	B	78.8	0.38	0.081	10.03	0.0161	0.87	3.8	7.8	47	54	9.1
CAT 12	54	B	78.9	0.34	0.067	10.16	0.0105	1.62	8.5	13.0	66	41	8.0
CAT 12	61	B	78.9	0.57	0.075	12.56	0.0172	1.05	5.0	7.3	42	40	7.0
CAT 12	67	B	78.8	0.41	0.076	11.36	0.0107	1.15	5.3	6.9	56	49	6.0
CAT 14	46	C1	78.9	0.52	0.097	15.16	0.0149	0.56	2.1	2.9	16	29	5.1
CAT 14	51	C1	78.9	0.47	0.081	14.36	0.0144	0.67	2.9	4.4	20	30	6.5
CAT 14	57	C1	78.9	0.38	0.075	13.16	0.0104	0.85	4.0	5.3	18	21	6.2
CAT 14	60	C1	78.9	0.50	0.085	15.66	0.0160	1.06	4.4	6.8	30	28	6.5
CAT 14	66	C1	78.9	0.67	0.073	15.76	0.0120	1.09	5.3	4.6	25	23	4.2
CAT 14	73	C1	78.9	0.39	0.076	15.90	0.0099	0.96	4.5	5.5	23	24	5.7
CAT 16	59	D1	78.9	0.43	0.044	20.76	0.0221	1.03	8.3	20.6	85	83	20.0
CAT 16	65	D1	78.9	0.48	0.045	16.26	0.0300	1.10	8.5	26.0	81	74	23.7
CAT 16	72	D1	78.8	0.40	0.050	24.30	0.0247	0.94	6.6	20.0	73	78	21.3
CAT 16	81	D1	78.9	0.49	0.046	23.90	0.0147	0.96	7.4	10.8	33	34	11.2
CAT 16	90	D2	78.9	0.43	0.058	19.00	0.0125	0.91	5.5	7.7	34	37	8.5
CAT 16	100	D2	78.9	0.57	0.048	15.20	0.0161	0.80	5.8	7.9	32	40	9.9
CAT 16	111	D2	79.0	0.56	0.044	15.80	0.0067	0.67	5.3	3.1	18	27	4.6
CAT 16	120	D2	79.0	0.54	0.038	18.60	0.0080	0.55	5.0	3.6	16	28	6.5
CAT 16	129	D2	79.0	0.47	0.053	19.20	0.0052	0.64	4.2	2.3	15	23	3.6

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	N2 dry %	RHOA kg/m^3	CONSTANT KS	CORRECTED VALUES MC %	CATCH g	BURN RATE kg/hr	STACK FLOW g/s	PM g/hr	CO g/hr	CO g/kg	PM g/kg
CAT 17	64	E1	78.9	0.59	0.073	13.01	0.0303	0.95	4.6	11.5	44	46	12.1
CAT 17	71	E1	78.9	0.50	0.064	14.70	0.0263	0.79	4.3	11.0	29	37	14.0
CAT 17	80	E1	78.9	0.43	0.062	13.90	0.0225	0.81	4.6	11.8	42	51	14.6
CAT 17	89	E1	78.9	0.37	0.068	16.40	0.0191	0.75	3.9	9.7	30	40	12.8
CAT 17	99	E1	78.9	0.64	0.062	12.90	0.0253	0.78	4.4	8.5	33	42	11.0
CAT 17	110	E1	78.9	0.38	0.063	15.40	0.0225	0.70	3.9	11.3	39	56	16.1
CAT 17	139	E1	78.8	0.46	0.059	17.70	0.0334	0.59	3.5	12.5	46	78	21.1
CAT 17	140	E1	78.8	0.49	0.057	17.70	0.0358	0.59	3.6	13.0	47	79	22.0
CAT 17	147	E1	78.9	0.33	0.069	15.20	0.0185	0.59	3.0	8.2	29	49	13.9
CAT 17	148	E1	78.9	0.44	0.069	15.20	0.0246	0.60	3.0	8.3	29	49	14.0
CAT 18	68	A2				34.06							
CAT 18	74	A2	78.9	0.37	0.063	27.50	0.0189	1.35	7.5	18.7	53	39	13.9
CAT 18	82	A2	78.9	0.33	0.052	14.10	0.0204	1.42	9.6	29.0	74	52	20.4
CAT 18	92	A2	78.9	0.45	0.043	29.30	0.0187	1.28	10.4	21.0	91	72	16.4
CAT 18	101	A2	78.9	0.66	0.043	39.70	0.0279	1.02	8.3	17.0	78	76	16.5
CAT 18	113	A2	78.9	0.49	0.037	40.20	0.0199	0.96	9.0	18.0	74	77	18.8
CAT 18	119	A2	78.9	0.43	0.036	35.70	0.0195	1.09	10.3	22.7	78	72	20.9
CAT 18	128	A2	78.8	0.40	0.057	20.10	0.0186	1.22	7.5	16.8	77	63	13.8
CAT 18	141	A2	78.9	0.38	0.040	17.10	0.0120	1.06	9.3	14.2	76	72	13.4
CAT 18	150	A2	78.9	0.33	0.036	14.30	0.0087	1.15	11.0	14.1	79	69	12.2
CAT 19	69	F1	78.9	0.58	0.087	16.56	0.0209	0.93	3.8	6.6	34	37	7.2
CAT 19	78	F1	78.9	0.38	0.083	15.30	0.0112	0.88	3.8	5.4	27	30	6.1
CAT 19	86	F1	78.9	0.34	0.075	15.50	0.0099	0.82	3.9	5.5	26	32	6.7
CAT 19	96	F1	78.9	0.60	0.069	13.30	0.0055	0.91	4.6	2.1	31	35	2.3
CAT 19	105	F1	78.9	0.47	0.063	14.60	0.0112	0.75	4.2	4.9	27	36	6.5
CAT 19	116	F1	78.9	0.55	0.073	13.40	0.0167	0.77	3.7	5.5	28	36	7.1
CAT 21	83	D3	78.9	0.27	0.033	24.70	0.0081	1.13	11.9	17.3	70	62	15.3
CAT 21	94	D3	78.9	0.37	0.038	12.80	0.0095	0.79	7.2	8.9	52	65	11.3
CAT 21	103	D3	78.9	0.34	0.035	13.10	0.0052	1.14	11.3	8.5	74	65	7.4
CAT 21	112	D3	79.0	0.32	0.036	13.20	0.0027	1.32	12.9	5.3	40	30	4.0
CAT 21	121	D3	79.0	0.32	0.032	13.20	0.0052	0.82	8.9	7.0	31	38	8.5
CAT 21	131	D3	78.9	0.36	0.036	15.10	0.0056	1.07	10.3	7.9	39	37	7.4
CAT 22	84	E2	78.9	0.38	0.046	18.20	0.0105	0.88	6.6	8.8	54	61	10.0
CAT 22	95	E2	78.9	0.42	0.052	19.00	0.0138	0.95	6.4	10.3	46	48	10.8
CAT 22	104	E2	78.9	0.47	0.042	22.00	0.0112	0.91	7.6	8.8	52	57	9.7
CAT 22	117	E2	78.9	0.46	0.046	20.90	0.0151	0.85	6.4	10.2	48	57	12.0
CAT 22	125	E2	78.9	0.52	0.037	21.50	0.0151	0.90	8.5	12.0	50	55	13.3
CAT 22	134	E2	78.9	0.33	0.035	18.70	0.0064	0.78	7.7	7.3	40	51	9.3
CAT 24	97	C2	78.9	0.38	0.060	12.90	0.0071	0.76	4.5	4.1	42	55	5.4
CAT 24	109	C2	78.9	0.30	0.051	12.90	0.0068	0.66	4.6	5.0	37	56	7.6
CAT 24	115	C2	78.9	0.35	0.050	13.30	0.0085	0.62	4.3	5.1	32	52	8.1
CAT 24	123	C2	78.9	0.24	0.056	14.20	0.0060	0.70	4.4	5.4	33	47	7.7
CAT 24	133	C2	78.9	0.35	0.055	14.50	0.0078	0.76	4.8	5.3	44	58	7.0
CAT 24	142	C2	78.9	0.27	0.048	13.00	0.0089	0.61	4.4	7.0	34	56	11.4
CAT 26	130	F2	78.8	0.51	0.059	20.80	0.0216	1.28	7.6	15.8	110	86	12.3
CAT 26	138	F2	78.8	0.38	0.051	22.20	0.0154	0.97	6.6	13.2	81	84	13.6
CAT 26	145	F2	78.8	0.47	0.048	29.90	0.0234	1.02	7.4	17.8	91	89	17.4
CAT 26	151	F2	78.8	0.35	0.051	25.70	0.0219	0.97	6.6	20.3	82	84	20.9

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	N2 dry %	RHOA kg/m^3	CONSTANT K5	CORRECTED VALUES: MC %	CATCH g	BURN RATE kg/hr	STACK FLOW g/s	PM g/hr	CO g/hr	CO g/kg	PM g/kg
CAT 26	156	F2	78.7	0.47	0.061	21.30	0.0318	1.09	6.3	20.8	118	108	19.0
CONV 01	1	I	78.9	0.44	0.036	8.86	0.0112	1.45	13.8	17.3	119	82	11.9
CONV 01	6	I	78.9	0.32	0.034	9.06	0.0056	1.76	17.7	15.2	116	66	8.7
CONV 01	15	I	78.9	0.42	0.032	11.46	0.0109	1.64	18.0	22.8	124	76	13.8
CONV 01	22	I	78.8	0.47	0.051	11.76	0.0085	1.71	11.8	10.4	138	80	6.1
CONV 03	3	J1	78.9	0.29	0.035	12.26	0.0082	1.67	16.5	22.4	131	79	13.4
CONV 03	9	J1	78.9	0.31	0.036	11.56	0.0078	1.70	16.4	20.0	130	76	11.7
CONV 03	17	J1	78.9	0.44	0.036	11.46	0.0118	1.76	16.8	22.2	145	82	12.6
CONV 03	21	J1	78.9	0.28	0.039	11.16	0.0110	1.74	15.4	29.1	132	76	16.7
CONV 04	4	K	78.8	0.52	0.051	25.86	0.0383	1.63	11.2	40.4	180	111	24.8
CONV 04	8	K	78.8	0.35	0.049	26.76	0.0193	1.97	14.1	38.3	228	116	19.4
CONV 04	14	K	78.8	0.41	0.051	31.76	0.0232	1.55	10.7	29.6	173	111	19.1
CONV 04	26	K	78.8	0.40	0.041	27.56	0.0304	1.48	12.6	46.1	182	123	31.1
CONV 05	7	L				11.16		2.29					
CONV 05	13	L	78.9	0.35	0.014	12.16	0.0063	1.80	45.7	39.8	191	106	22.1
CONV 05	20	L	78.9	0.46	0.021	12.56	0.0212	1.61	26.9	60.2	243	151	37.4
CONV 05	25	L	78.7	0.41	0.042	14.46	0.0360	1.21	10.1	43.2	185	153	35.6
CONV 05	29	L	78.8	0.47	0.027	14.46	0.0257	1.42	18.3	48.3	216	152	34.2
CONV 09	32	J2	78.5	0.30	0.091	9.46	0.0355	1.82	7.1	41.3	226	124	22.6
CONV 09	36	J2	78.5	0.52	0.098	11.96	0.0681	1.89	6.9	44.2	248	131	23.3
CONV 09	42	J2	78.6	0.55	0.079	15.16	0.0607	1.46	6.5	35.1	187	128	24.0
CONV 09	53	J2	78.4	0.36	0.092	9.36	0.0645	1.61	6.2	53.7	241	149	33.3
CONV 09	48	J2	79.0	0.48	0.002	12.86	0.0015	1.32					
CONV 10	33	M	78.7	0.25	0.054	22.16	0.0234	1.86	12.1	56.0	224	120	30.1
CONV 10	37	M	78.7	0.28	0.063	26.76	0.0192	1.88	10.4	34.7	200	106	18.5
CONV 10	43	M	78.8	0.27	0.056	28.06	0.0125	1.96	12.3	27.7	194	99	14.1
CONV 11	34	N	78.6	0.49	0.075	15.36	0.0688	1.34	6.3	43.4	167	124	32.3
CONV 11	39	N	78.6	0.42	0.072	15.46	0.0455	1.22	6.0	31.4	150	122	25.6
CONV 11	45	N	78.6	0.43	0.074	15.46	0.0464	1.38	6.5	34.7	166	121	25.1
CONV 11	50	N	78.6	0.55	0.077	14.26	0.0797	1.36	6.2	43.7	169	124	32.0
NCAT 13	41	G1	78.8	0.37	0.066	14.96	0.0035	1.54	8.2	3.7	86	56	2.4
NCAT 13	47	G1	78.8	0.38	0.071	13.46	0.0125	1.82	9.0	14.2	107	59	7.8
NCAT 13	52	G1	78.8	0.23	0.076	13.81	0.0056	2.02	9.4	11.1	105	52	5.5
NCAT 13	58	G1	78.8	0.36	0.072	12.46	0.0078	1.80	8.8	9.4	93	52	5.2
NCAT 13	63	G1	78.9	0.43	0.058	16.16	0.0045	1.67	10.0	5.1	82	49	3.1
NCAT 13	70	G1	78.9	0.30	0.072	16.50	0.0067	1.76	8.6	9.5	76	43	5.4
NCAT 15	62	H1	78.8	0.25	0.060	12.46	0.0065	0.86	5.0	6.4	75	88	7.4
NCAT 15	77	H1	78.9	0.27	0.049	14.09	0.0046	0.87	6.2	5.1	56	65	5.9
NCAT 15	91	H1	78.8	0.26	0.055	14.40	0.0083	0.89	5.7	8.8	81	91	9.8
NCAT 15	108	H1	78.8	0.30	0.045	12.80	0.0138	0.68	5.3	12.2	68	100	17.8
NCAT 15	124	H1	78.8	0.23	0.042	15.00	0.0156	0.64	5.3	17.2	73	114	26.8
NCAT 15	136	H1	78.8	0.33	0.041	13.40	0.0149	0.55	4.7	10.3	52	94	18.7
NCAT 20	79	G2	79.0	0.32		15.10	0.0005	1.48					
NCAT 20	85	G2	78.9	0.56	0.052	13.70	0.0155	1.35	9.0	12.2	79	58	9.0
NCAT 20	93	G2	78.8	0.44	0.082	15.80	0.0148	1.30	5.6	9.2	79	61	7.1
NCAT 20	102	G2	78.8	0.50	0.068	13.70	0.0180	1.35	7.0	12.2	88	65	9.1
NCAT 20	114	G2	78.9	0.52	0.059	15.60	0.0124	1.18	7.0	8.2	70	60	6.9
NCAT 20	122	G2	78.8	0.41	0.053	14.30	0.0134	0.95	6.2	9.8	68	72	10.4

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	N2 dry %	RHOA kg/m^3	CONSTANT KS	MC %	CATCH g	BURN RATE kg/hr	STACK FLOW g/s	PM g/hr	CO g/hr	CO g/kg	PM g/kg
						CORRECTED VALUES							
NCAT 20	132	G2	78.8	0.49	0.063	16.20	0.0082	1.12	6.2	5.1	64	58	4.6
NCAT 23	87	H2	78.8	0.34	0.069	13.70	0.0065	1.05	5.3	5.0	79	76	4.7
NCAT 23	98	H2	78.8	0.33	0.076	14.30	0.0081	1.11	5.1	6.1	86	77	5.5
NCAT 23	106	H2	78.8	0.46	0.055	15.50	0.0081	0.88	5.6	4.8	72	82	5.5
NCAT 23	118	H2	78.8	0.49	0.055	14.10	0.0120	0.92	5.8	6.9	75	82	7.6
NCAT 23	126	H2	78.8	0.18	0.053	14.70	0.0074	0.86	5.7	11.1	77	90	13.0
NCAT 23	137	H2	78.8	0.34	0.062	14.30	0.0078	0.91	5.1	5.7	80	87	6.2
NCAT 25	127	H3	78.8	0.12	0.048	20.30	0.0028	0.76	5.5	6.2	65	85	8.2
NCAT 25	135	H3	78.8	0.48	0.056	13.60	0.0217	0.83	5.2	11.4	76	91	13.7
NCAT 25	143	H3	78.8	0.47	0.053	19.30	0.0304	0.71	4.7	14.8	71	99	20.8
NCAT 25	149	H3	78.8	0.42	0.043	13.80	0.0275	0.72	5.7	18.3	84	117	25.5
NCAT 25	155	H3	78.8	0.33	0.050	15.30	0.0139	0.80	5.6	11.4	72	89	14.2
HIGHEST COAL VALUE			81.0	0.53	0.062	10.57	0.0090	4.05	35.8	23.5	105	133	17.14
LOWEST COAL VALUE			80.9	0.36	0.019	4.72	0.0008	0.68	12.2	2.7	36	12	1.70
HIGHEST WOOD VALUE			79.0	0.67	0.098	40.20	0.0797	2.29	45.7	60.2	248	153	37.43
LOWEST WOOD VALUE			78.4	0.12	0.002	8.86	0.0005	0.55	2.1	2.1	15	21	2.28
CATALYTIC AVERAGE			78.9	0.43	0.058	17.8	0.0154	0.93	6.1	10.4	49.4	52.3	11.1
NONCATALYTIC AVERAGE			78.8	0.37	0.059	14.7	0.0115	1.10	6.4	9.4	77.2	76.2	9.9
CONVENTIONAL AVERAGE			78.8	0.40	0.051	16.05	0.0286	1.64	13.4	35.2	178	111	22.21
BLANK AVERAGE				0.38	0.001								
COAL AVERAGE			80.9	0.45	0.033	7.61	0.0051	1.68	25.1	12.2	67	64	9.09

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	W/XC ratio	XC frac	TOTAL OXYGEN frac	W frac	TANK DELTA P Pa	C	E	K2	K3	K4	CATCH PM g/hr& g/kg	CO PM g/hr& g/kg
COAL 02	2	R	0.59	0.73	0.19	0.43	42730	2.48	0.65	2.49	0.90	29.05	10.0	1.6
COAL 02	5	R	0.59	0.73	0.19	0.43	34144	2.48	0.65	2.49	0.90	29.09	10.3	1.5
COAL 02	10	R	0.59	0.73	0.19	0.43	35637	2.48	0.65	2.49	0.90	28.97	17.1	1.8
COAL 02	12	R	0.59	0.73	0.19	0.43	36544	2.48	0.65	2.49	0.90	29.09	12.6	1.3
COAL 02	18	R	0.59	0.73	0.19	0.43	37370	2.48	0.65	2.49	0.90	29.12	10.3	1.3
COAL 06	11	S	0.57	0.72	0.19	0.41	44290	2.48	0.68	2.49	0.94	29.02	51.1	0.9
COAL 06	16	S	0.57	0.72	0.19	0.41	35957	2.48	0.68	2.49	0.94	28.98	38.1	1.1
COAL 06	19	S	0.57	0.72	0.19	0.41	30424	2.48	0.68	2.49	0.94	29.02	45.9	0.9
COAL 06	24	S	0.57	0.72	0.19	0.41	40023	2.48	0.68	2.49	0.94	29.02	118.4	1.0
COAL 06	28	S	0.57	0.72	0.19	0.41	42423	2.48	0.68	2.49	0.94	29.02	31.5	1.0
COAL 07	23	T	0.56	0.75	0.19	0.42	36037	2.48	0.69	2.51	0.95	29.39	14.6	0.4
COAL 07	27	T	0.56	0.75	0.19	0.42	34397	2.48	0.69	2.51	0.95	29.46	16.8	0.4
COAL 07	31	T	0.56	0.75	0.19	0.42	38170	2.48	0.69	2.51	0.95	29.50	13.5	0.3
BLANK	55						27864	3.06	1.53	3.06	1.00	28.04		
BLANK	56						18159	3.06	1.53	3.06	1.00	28.01		
BLANK	75						27864	3.06	1.53	3.06	1.00	28.01		
BLANK	76						40797	3.06	1.53	3.06	1.00	28.01		
BLANK	88						25998	3.06	1.53	3.06	1.00	28.01		
BLANK	107						28531	3.06	1.53	3.06	1.00	28.01		
BLANK	144						35730	3.06	1.53	3.06	1.00	28.01		
BLANK	146						32931	3.06	1.53	3.06	1.00	28.00		
BLANK	152						34530	3.06	1.53	3.06	1.00	28.01		
BLANK	153						32797	3.06	1.53	3.06	1.00	28.00		
BLANK	154						41330	3.06	1.53	3.06	1.00	28.01		
CAT 08	30	A1	1.00	0.51	0.21	0.51	40943	2.42	0.03	2.49	0.87	29.73	5.2	0.7
CAT 08	35	A1	1.00	0.51	0.21	0.51	36050	2.42	0.03	2.48	0.82	29.63	3.5	0.9
CAT 08	40	A1	1.00	0.51	0.21	0.51	15932	2.42	0.03	2.50	0.81	29.85	9.7	1.0
CAT 12	38	B	1.00	0.51	0.21	0.51	30238	2.42	0.03	2.48	0.89	29.59	11.2	0.7
CAT 12	44	B	1.00	0.51	0.21	0.51	38877	2.42	0.03	2.48	0.90	29.65	9.6	0.8
CAT 12	49	B	1.00	0.51	0.21	0.51	30278	2.42	0.03	2.49	0.91	29.74	5.6	0.8
CAT 12	54	B	1.00	0.51	0.21	0.51	27278	2.42	0.03	2.48	0.91	29.59	8.6	0.7
CAT 12	61	B	1.00	0.51	0.21	0.51	46530	2.42	0.03	2.49	0.89	29.68	5.2	0.7
CAT 12	67	B	1.00	0.51	0.21	0.51	32931	2.42	0.03	2.49	0.90	29.69	8.4	0.7
CAT 14	46	C1	1.00	0.51	0.21	0.51	41717	2.42	0.03	2.51	0.87	29.96	6.1	0.5
CAT 14	51	C1	1.00	0.51	0.21	0.51	38663	2.42	0.03	2.49	0.87	29.77	6.3	0.5
CAT 14	57	C1	1.00	0.51	0.21	0.51	31131	2.42	0.03	2.49	0.88	29.71	8.7	0.4
CAT 14	60	C1	1.00	0.51	0.21	0.51	40797	2.42	0.03	2.50	0.86	29.82	5.6	0.5
CAT 14	66	C1	1.00	0.51	0.21	0.51	54529	2.42	0.03	2.49	0.86	29.69	7.5	0.5
CAT 14	73	C1	1.00	0.51	0.21	0.51	31731	2.42	0.03	2.49	0.86	29.72	9.1	0.5
CAT 16	59	D1	1.00	0.51	0.21	0.51	35464	2.42	0.03	2.46	0.83	29.30	4.1	1.3
CAT 16	65	D1	1.00	0.51	0.21	0.51	39063	2.42	0.03	2.46	0.86	29.33	3.0	1.2
CAT 16	72	D1	1.00	0.51	0.21	0.51	32531	2.42	0.03	2.46	0.80	29.37	3.6	1.2
CAT 16	81	D1	1.00	0.51	0.21	0.51	39863	2.42	0.03	2.46	0.81	29.36	6.1	0.7
CAT 16	90	D2	1.00	0.51	0.21	0.51	35464	2.42	0.03	2.47	0.84	29.50	7.2	0.7
CAT 16	100	D2	1.00	0.51	0.21	0.51	47596	2.42	0.03	2.46	0.87	29.39	5.6	0.8
CAT 16	111	D2	1.00	0.51	0.21	0.51	45996	2.42	0.03	2.46	0.86	29.35	13.4	0.6
CAT 16	120	D2	1.00	0.51	0.21	0.51	44396	2.42	0.03	2.45	0.84	29.28	11.2	0.7
CAT 16	129	D2	1.00	0.51	0.21	0.51	38397	2.42	0.03	2.47	0.84	29.46	17.3	0.5

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	W/XC ratio	XC frac	TOTAL OXYGEN frac	W frac	TANK DELTA P Pa	C	E	K2	K3	K4	CATCH PM g/hr& g/kg	CO PM g/hr& g/kg
CAT 17	64	E1	1.00	0.51	0.21	0.51	48129	2.42	0.03	2.49	0.88	29.66	3.0	0.7
CAT 17	71	E1	1.00	0.51	0.21	0.51	41197	2.42	0.03	2.48	0.87	29.57	3.4	0.7
CAT 17	80	E1	1.00	0.51	0.21	0.51	35064	2.42	0.03	2.47	0.88	29.53	4.0	0.8
CAT 17	89	E1	1.00	0.51	0.21	0.51	30931	2.42	0.03	2.48	0.86	29.62	4.7	0.7
CAT 17	99	E1	1.00	0.51	0.21	0.51	52396	2.42	0.03	2.48	0.89	29.54	3.6	0.7
CAT 17	110	E1	1.00	0.51	0.21	0.51	31197	2.42	0.03	2.48	0.87	29.53	4.0	0.9
CAT 17	139	E1	1.00	0.51	0.21	0.51	37864	2.42	0.03	2.47	0.85	29.47	2.7	1.1
CAT 17	140	E1	1.00	0.51	0.21	0.51	40397	2.42	0.03	2.47	0.85	29.45	2.5	1.2
CAT 17	147	E1	1.00	0.51	0.21	0.51	26931	2.42	0.03	2.48	0.87	29.61	4.9	0.8
CAT 17	148	E1	1.00	0.51	0.21	0.51	35597	2.42	0.03	2.48	0.87	29.61	3.7	0.8
CAT 18	68	A2	1.00	0.51	0.21	0.51								
CAT 18	74	A2	1.00	0.51	0.21	0.51	29998	2.42	0.03	2.48	0.78	29.56	4.8	0.7
CAT 18	82	A2	1.00	0.51	0.21	0.51	26931	2.42	0.03	2.47	0.88	29.42	4.4	0.9
CAT 18	92	A2	1.00	0.51	0.21	0.51	38130	2.42	0.03	2.46	0.77	29.30	4.8	1.2
CAT 18	101	A2	1.00	0.51	0.21	0.51	55062	2.42	0.03	2.46	0.72	29.30	3.2	1.2
CAT 18	113	A2	1.00	0.51	0.21	0.51	40397	2.42	0.03	2.45	0.71	29.23	4.5	1.3
CAT 18	119	A2	1.00	0.51	0.21	0.51	35597	2.42	0.03	2.45	0.74	29.23	4.6	1.2
CAT 18	128	A2	1.00	0.51	0.21	0.51	33197	2.42	0.03	2.47	0.83	29.46	4.8	1.0
CAT 18	141	A2	1.00	0.51	0.21	0.51	31597	2.42	0.03	2.45	0.85	29.27	7.5	1.2
CAT 18	150	A2	1.00	0.51	0.21	0.51	27464	2.42	0.03	2.45	0.87	29.23	10.3	1.2
CAT 19	69	F1	1.00	0.51	0.21	0.51	47329	2.42	0.03	2.50	0.86	29.83	4.3	0.6
CAT 19	78	F1	1.00	0.51	0.21	0.51	30931	2.42	0.03	2.50	0.87	29.79	8.0	0.5
CAT 19	86	F1	1.00	0.51	0.21	0.51	27464	2.42	0.03	2.49	0.87	29.70	9.1	0.6
CAT 19	96	F1	1.00	0.51	0.21	0.51	48663	2.42	0.03	2.48	0.88	29.63	16.4	0.6
CAT 19	105	F1	1.00	0.51	0.21	0.51	38264	2.42	0.03	2.48	0.87	29.56	8.0	0.6
CAT 19	116	F1	1.00	0.51	0.21	0.51	45063	2.42	0.03	2.49	0.88	29.67	5.4	0.6
CAT 21	83	D3	1.00	0.51	0.21	0.51	22531	2.42	0.03	2.45	0.80	29.20	11.1	1.2
CAT 21	94	D3	1.00	0.51	0.21	0.51	30664	2.42	0.03	2.45	0.89	29.26	9.5	1.1
CAT 21	103	D3	1.00	0.51	0.21	0.51	27998	2.42	0.03	2.45	0.88	29.22	17.3	1.2
CAT 21	112	D3	1.00	0.51	0.21	0.51	26531	2.42	0.03	2.45	0.88	29.25	33.3	0.8
CAT 21	121	D3	1.00	0.51	0.21	0.51	26531	2.42	0.03	2.45	0.88	29.20	17.3	0.9
CAT 21	131	D3	1.00	0.51	0.21	0.51	29598	2.42	0.03	2.45	0.87	29.25	16.1	0.8
CAT 22	84	E2	1.00	0.51	0.21	0.51	31464	2.42	0.03	2.46	0.85	29.35	8.6	1.0
CAT 22	95	E2	1.00	0.51	0.21	0.51	34930	2.42	0.03	2.47	0.84	29.42	6.5	0.8
CAT 22	104	E2	1.00	0.51	0.21	0.51	38797	2.42	0.03	2.46	0.82	29.30	8.0	1.0
CAT 22	117	E2	1.00	0.51	0.21	0.51	38130	2.42	0.03	2.46	0.83	29.35	6.0	1.0
CAT 22	125	E2	1.00	0.51	0.21	0.51	43196	2.42	0.03	2.45	0.82	29.25	6.0	1.0
CAT 22	134	E2	1.00	0.51	0.21	0.51	27198	2.42	0.03	2.45	0.84	29.24	14.1	1.0
CAT 24	97	C2	1.00	0.51	0.21	0.51	31331	2.42	0.03	2.47	0.89	29.50	12.7	0.9
CAT 24	109	C2	1.00	0.51	0.21	0.51	24665	2.42	0.03	2.46	0.89	29.40	13.2	0.9
CAT 24	115	C2	1.00	0.51	0.21	0.51	29064	2.42	0.03	2.46	0.88	29.40	10.6	0.9
CAT 24	123	C2	1.00	0.51	0.21	0.51	19732	2.42	0.03	2.47	0.88	29.47	15.0	0.8
CAT 24	133	C2	1.00	0.51	0.21	0.51	28398	2.42	0.03	2.47	0.87	29.44	11.5	0.9
CAT 24	142	C2	1.00	0.51	0.21	0.51	22798	2.42	0.03	2.46	0.88	29.37	10.1	0.9
CAT 26	130	F2	1.00	0.51	0.21	0.51	41597	2.42	0.03	2.47	0.83	29.46	4.2	1.2
CAT 26	138	F2	1.00	0.51	0.21	0.51	31064	2.42	0.03	2.46	0.82	29.38	5.8	1.2
CAT 26	145	F2	1.00	0.51	0.21	0.51	39063	2.42	0.03	2.46	0.77	29.35	3.8	1.3
CAT 26	151	F2	1.00	0.51	0.21	0.51	28664	2.42	0.03	2.46	0.80	29.38	4.1	1.2

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	W/XC ratio	XC frac	TOTAL OXYGEN frac	W frac	TANK DELTA P Pa	C	E	K2	K3	K4	CATCH PM g/hr& g/kg	CO PM g/hr& g/kg
CAT 26	156	F2	1.00	0.51	0.21	0.51	39330	2.42	0.03	2.47	0.82	29.46	2.8	1.5
CONV 01	1	I	1.00	0.51	0.21	0.51	35944	2.42	0.03	2.45	0.92	29.23	8.1	1.3
CONV 01	6	I	1.00	0.51	0.21	0.51	26145	2.42	0.03	2.45	0.92	29.22	16.2	1.2
CONV 01	15	I	1.00	0.51	0.21	0.51	34464	2.42	0.03	2.45	0.90	29.18	8.3	1.3
CONV 01	22	I	1.00	0.51	0.21	0.51	38330	2.42	0.03	2.46	0.89	29.38	10.6	1.2
CONV 03	3	J1	1.00	0.51	0.21	0.51	24465	2.42	0.03	2.45	0.89	29.21	11.0	1.3
CONV 03	9	J1	1.00	0.51	0.21	0.51	25731	2.42	0.03	2.45	0.90	29.23	11.6	1.3
CONV 03	17	J1	1.00	0.51	0.21	0.51	35984	2.42	0.03	2.45	0.90	29.23	7.7	1.3
CONV 03	21	J1	1.00	0.51	0.21	0.51	23425	2.42	0.03	2.45	0.90	29.26	8.2	1.2
CONV 04	4	K	1.00	0.51	0.21	0.51	43116	2.42	0.03	2.46	0.79	29.35	2.4	1.5
CONV 04	8	K	1.00	0.51	0.21	0.51	28624	2.42	0.03	2.46	0.79	29.33	4.7	1.6
CONV 04	14	K	1.00	0.51	0.21	0.51	34144	2.42	0.03	2.46	0.76	29.35	3.9	1.5
CONV 04	26	K	1.00	0.51	0.21	0.51	33371	2.42	0.03	2.45	0.78	29.25	3.0	1.8
CONV 05	7	L	1.00	0.51	0.21	0.51								
CONV 05	13	L	1.00	0.51	0.21	0.51	29438	2.42	0.03	2.43	0.89	28.98	14.4	2.3
CONV 05	20	L	1.00	0.51	0.21	0.51	38543	2.42	0.03	2.43	0.89	29.03	4.3	2.4
CONV 05	25	L	1.00	0.51	0.21	0.51	34091	2.42	0.03	2.45	0.87	29.23	2.5	2.1
CONV 05	29	L	1.00	0.51	0.21	0.51	39210	2.42	0.03	2.44	0.87	29.09	3.5	2.3
CONV 09	32	J2	1.00	0.51	0.21	0.51	23758	2.42	0.03	2.49	0.91	29.74	2.5	1.6
CONV 09	36	J2	1.00	0.51	0.21	0.51	40930	2.42	0.03	2.50	0.89	29.80	1.3	1.6
CONV 09	42	J2	1.00	0.51	0.21	0.51	45450	2.42	0.03	2.48	0.87	29.62	1.5	1.6
CONV 09	53	J2	1.00	0.51	0.21	0.51	29758	2.42	0.03	2.49	0.91	29.71	1.4	1.8
CONV 09	48	J2												
CONV 10	33	M	1.00	0.51	0.21	0.51	19878	2.42	0.03	2.46	0.82	29.38	3.9	1.6
CONV 10	37	M	1.00	0.51	0.21	0.51	23465	2.42	0.03	2.47	0.79	29.48	4.7	1.4
CONV 10	43	M	1.00	0.51	0.21	0.51	21985	2.42	0.03	2.47	0.78	29.42	7.2	1.4
CONV 11	34	N	1.00	0.51	0.21	0.51	40357	2.42	0.03	2.48	0.87	29.59	1.3	1.6
CONV 11	39	N	1.00	0.51	0.21	0.51	35024	2.42	0.03	2.48	0.87	29.55	2.0	1.6
CONV 11	45	N	1.00	0.51	0.21	0.51	34810	2.42	0.03	2.48	0.87	29.58	1.9	1.6
CONV 11	50	N	1.00	0.51	0.21	0.51	45330	2.42	0.03	2.48	0.88	29.60	1.1	1.6
NCAT 13	41	G1	1.00	0.51	0.21	0.51	30051	2.42	0.03	2.48	0.87	29.57	26.0	0.9
NCAT 13	47	G1	1.00	0.51	0.21	0.51	31264	2.42	0.03	2.48	0.88	29.63	7.2	0.9
NCAT 13	52	G1	1.00	0.51	0.21	0.51	18825	2.42	0.03	2.49	0.88	29.68	16.1	0.8
NCAT 13	58	G1	1.00	0.51	0.21	0.51	28958	2.42	0.03	2.48	0.89	29.64	11.6	0.8
NCAT 13	63	G1	1.00	0.51	0.21	0.51	35464	2.42	0.03	2.47	0.86	29.49	20.0	0.8
NCAT 13	70	G1	1.00	0.51	0.21	0.51	24131	2.42	0.03	2.48	0.86	29.65	13.4	0.7
NCAT 15	62	H1	1.00	0.51	0.21	0.51	20398	2.42	0.03	2.47	0.89	29.47	13.8	1.2
NCAT 15	77	H1	1.00	0.51	0.21	0.51	22398	2.42	0.03	2.46	0.88	29.37	19.6	1.0
NCAT 15	91	H1	1.00	0.51	0.21	0.51	21332	2.42	0.03	2.47	0.87	29.41	10.8	1.3
NCAT 15	108	H1	1.00	0.51	0.21	0.51	24398	2.42	0.03	2.46	0.89	29.30	6.5	1.5
NCAT 15	124	H1	1.00	0.51	0.21	0.51	19332	2.42	0.03	2.45	0.87	29.27	5.8	1.6
NCAT 15	136	H1	1.00	0.51	0.21	0.51	27331	2.42	0.03	2.45	0.88	29.27	6.0	1.4
NCAT 20	79	G2	1.00	0.51	0.21	0.51	26664							
NCAT 20	85	G2	1.00	0.51	0.21	0.51	45863	2.42	0.03	2.47	0.88	29.42	5.8	0.9
NCAT 20	93	G2	1.00	0.51	0.21	0.51	35330	2.42	0.03	2.49	0.86	29.74	6.1	0.9
NCAT 20	102	G2	1.00	0.51	0.21	0.51	41463	2.42	0.03	2.48	0.88	29.58	5.0	1.0
NCAT 20	114	G2	1.00	0.51	0.21	0.51	42663	2.42	0.03	2.47	0.87	29.49	7.3	0.9
NCAT 20	122	G2	1.00	0.51	0.21	0.51	33864	2.42	0.03	2.47	0.87	29.42	6.7	1.1

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	W/XC ratio	XC frac	TOTAL OXYGEN frac	W frac	TANK DELTA P Pa	C	E	K2	K3	K4	CATCH PM g/hr& g/kg	CO PM g/hr& g/kg
NCAT 20	132	G2	1.00	0.51	0.21	0.51	39997	2.42	0.03	2.48	0.86	29.53	11.0	0.9
NCAT 23	87	H2	1.00	0.51	0.21	0.51	27864	2.42	0.03	2.48	0.88	29.58	13.8	1.1
NCAT 23	98	H2	1.00	0.51	0.21	0.51	27198	2.42	0.03	2.49	0.87	29.66	11.1	1.1
NCAT 23	106	H2	1.00	0.51	0.21	0.51	37464	2.42	0.03	2.47	0.87	29.43	11.1	1.2
NCAT 23	118	H2	1.00	0.51	0.21	0.51	39997	2.42	0.03	2.47	0.88	29.43	7.5	1.2
NCAT 23	126	H2	1.00	0.51	0.21	0.51	15065	2.42	0.03	2.46	0.87	29.39	12.2	1.3
NCAT 23	137	H2	1.00	0.51	0.21	0.51	28131	2.42	0.03	2.47	0.87	29.50	11.5	1.2
NCAT 25	127	H3	1.00	0.51	0.21	0.51	9999	2.42	0.03	2.46	0.83	29.35	32.1	1.3
NCAT 25	135	H3	1.00	0.51	0.21	0.51	39730	2.42	0.03	2.47	0.88	29.43	4.1	1.3
NCAT 25	143	H3	1.00	0.51	0.21	0.51	38397	2.42	0.03	2.46	0.84	29.39	3.0	1.4
NCAT 25	149	H3	1.00	0.51	0.21	0.51	34930	2.42	0.03	2.45	0.88	29.28	3.3	1.7
NCAT 25	155	H3	1.00	0.51	0.21	0.51	27198	2.42	0.03	2.46	0.87	29.37	6.5	1.3
HIGHEST COAL VALUE			0.59	0.75	0.19	0.43	44290	2.48	0.69	2.51	0.95	29.50	118.4	1.8
LOWEST COAL VALUE			0.56	0.72	0.19	0.41	30424	2.48	0.65	2.49	0.90	28.97	10.0	0.3
HIGHEST WOOD VALUE			1.00	0.51	0.21	0.51	55062	2.42	0.03	2.51	0.92	29.96	33.3	2.4
LOWEST WOOD VALUE			1.00	0.51	0.21	0.51	9999	2.42	0.03	2.43	0.71	28.98	1.1	0.4
CATALYTIC AVERAGE			1.0	0.5	0.2	0.5	35354	2.4	0.03	2.47	0.85	29.48	7.9	0.9
NONCATALYTIC AVERAGE			1.0	0.5	0.2	0.5	29967	2.4	0.03	2.47	0.87	29.47	10.9	1.1
CONVENTIONAL AVERAGE			1.00	0.51	0.21	0.51	32806	2.42	0.03	2.46	0.86	29.37	5.5	1.6
BLANK AVERAGE							31503	3.06	1.53	3.06	1.00	28.01		
COAL AVERAGE			0.57	0.73	0.19	0.42	37550	2.48	0.67	2.50	0.93	29.13	30.0	1.0

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	............MAXIMUM PROBABLE % ERROR DUE TO INDIVIDUAL PARAMETERS...............												PM RATE %
			CO2	m	MC	T	P1	P2	t	XC	HC	OX	W	CO	
			PM&CO g/hr& g/kg	PM&CO g/hr	PM&CO g/hr	PM g/hr& g/kg	PM g/hr& g/kg	PM g/hr& g/kg	PM&CO g/hr	PM&CO g/hr& g/kg	PM&CO g/hr& g/kg	PM&CO g/hr& g/kg	PM&CO g/hr& g/kg	CO g/hr& g/kg	
COAL 02	2	R	9.0	0.1	1.4	0.7	0.3	0.9	0.1	2.7	1.5	1.4	0.09	12.2	14.1
COAL 02	5	R	8.3	0.1	1.4	0.7	0.4	1.2	0.1	2.7	1.4	1.4	0.10	12.1	13.9
COAL 02	10	R	11.9	0.1	1.4	0.7	0.4	1.1	0.1	2.7	1.5	1.4	0.07	13.9	21.3
COAL 02	12	R	8.4	0.1	1.4	0.7	0.4	1.1	0.1	2.7	1.2	1.4	0.10	12.9	15.7
COAL 02	18	R	7.8	0.1	1.4	0.7	0.4	1.1	0.1	2.7	1.2	1.4	0.11	12.7	13.5
COAL 06	11	S	11.0	0.1	0.9	0.7	0.3	0.9	0.1	2.8	0.4	1.4	0.07	33.1	52.4
COAL 06	16	S	12.3	0.1	0.9	0.7	0.4	1.1	0.1	2.8	0.5	1.4	0.06	27.9	40.2
COAL 06	19	S	11.0	0.0	0.9	0.7	0.4	1.3	0.1	2.8	0.4	1.4	0.07	33.1	47.4
COAL 06	24	S	10.9	0.0	0.9	0.7	0.3	1.0	0.1	2.8	0.4	1.4	0.07	28.0	119.0
COAL 06	28	S	10.9	0.1	0.9	0.7	0.3	0.9	0.1	2.8	0.4	1.4	0.07	28.0	33.5
COAL 07	23	T	5.8	0.0	0.7	0.7	0.4	1.1	0.1	2.6	0.2	1.4	0.17	28.6	16.1
COAL 07	27	T	5.4	0.0	0.7	0.7	0.4	1.2	0.1	2.6	0.2	1.4	0.19	28.6	18.0
COAL 07	31	T	5.3	0.0	0.7	0.7	0.3	1.0	0.1	2.6	0.1	1.4	0.20	33.7	14.9
BLANK	55														
BLANK	56														
BLANK	75														
BLANK	76														
BLANK	88														
BLANK	107														
BLANK	144														
BLANK	146														
BLANK	152														
BLANK	153														
BLANK	154														
CAT 08	30	A1	4.4	0.1	1.9	0.7	0.3	1.0	0.1	3.8	0.7	1.4	0.37	11.6	8.3
CAT 08	35	A1	4.6	0.1	2.7	0.7	0.4	1.1	0.1	3.8	1.0	1.4	0.34	10.6	7.8
CAT 08	40	A1	3.9	0.1	2.8	0.7	0.8	2.5	0.2	3.8	1.3	1.4	0.45	9.6	12.0
CAT 12	38	B	4.9	0.1	1.7	0.7	0.4	1.3	0.1	3.8	0.6	1.4	0.31	13.1	13.1
CAT 12	44	B	4.6	0.1	1.5	0.7	0.3	1.0	0.1	3.8	0.9	1.4	0.34	11.3	11.6
CAT 12	49	B	4.3	0.1	1.4	0.7	0.4	1.3	0.1	3.8	0.9	1.4	0.38	10.9	8.5
CAT 12	54	B	4.9	0.1	1.4	0.7	0.5	1.5	0.1	3.8	0.7	1.4	0.32	12.7	11.0
CAT 12	61	B	4.6	0.1	1.7	0.7	0.3	0.9	0.1	3.8	0.7	1.4	0.35	12.3	8.4
CAT 12	67	B	4.5	0.1	1.5	0.7	0.4	1.2	0.1	3.8	0.8	1.4	0.36	11.5	10.6
CAT 14	46	C1	4.0	0.1	2.0	0.7	0.3	1.0	0.1	3.8	0.5	1.4	0.46	12.7	8.6
CAT 14	51	C1	4.4	0.1	1.9	0.7	0.3	1.0	0.1	3.8	0.5	1.4	0.38	13.5	9.0
CAT 14	57	C1	4.6	0.1	1.7	0.7	0.4	1.3	0.1	3.8	0.3	1.4	0.35	16.3	10.9
CAT 14	60	C1	4.3	0.1	2.0	0.7	0.3	1.0	0.1	3.8	0.5	1.4	0.40	13.5	8.5
CAT 14	66	C1	4.7	0.0	2.0	0.7	0.2	0.7	0.1	3.8	0.4	1.4	0.34	15.7	10.0
CAT 14	73	C1	4.6	0.1	2.1	0.7	0.4	1.3	0.1	3.8	0.4	1.4	0.36	15.2	11.3
CAT 16	59	D1	6.4	0.0	2.6	0.7	0.4	1.1	0.1	3.9	1.4	1.4	0.21	11.1	9.3
CAT 16	65	D1	6.2	0.0	2.1	0.7	0.3	1.0	0.1	3.8	1.2	1.4	0.22	11.4	8.6
CAT 16	72	D1	5.8	0.1	2.9	0.7	0.4	1.2	0.1	3.8	1.3	1.4	0.24	10.9	8.8
CAT 16	81	D1	6.3	0.1	2.9	0.7	0.3	1.0	0.1	3.8	0.6	1.4	0.22	16.0	10.2
CAT 16	90	D2	5.4	0.1	2.4	0.7	0.4	1.1	0.1	3.8	0.6	1.4	0.28	13.9	10.3
CAT 16	100	D2	6.1	0.1	2.0	0.7	0.3	0.8	0.1	3.8	0.7	1.4	0.23	14.5	9.5
CAT 16	111	D2	6.4	0.1	2.0	0.7	0.3	0.9	0.1	3.9	0.4	1.4	0.21	18.4	15.7
CAT 16	120	D2	7.1	0.1	2.4	0.7	0.3	0.9	0.1	3.9	0.5	1.4	0.18	19.4	14.2
CAT 16	129	D2	5.7	0.1	2.4	0.7	0.3	1.0	0.1	3.8	0.4	1.4	0.25	18.5	18.9

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	............MAXIMUM PROBABLE % ERROR DUE TO INDIVIDUAL PARAMETERS...............												|.....
			CO2	m	MC	T	P1	P2	t	XC	HC	OX	W	CO	
			PM&CO g/hr& g/kg	PM&CO g/hr	PM&CO g/hr	PM g/hr& g/kg	PM g/hr& g/kg	PM g/hr& g/kg	PM&CO g/hr	PM&CO g/hr& g/kg	PM&CO g/hr& g/kg	PM&CO g/hr& g/kg	PM&CO g/hr& g/kg	CO g/hr& g/kg	PM RATE %
CAT 17	64	E1	4.6	0.1	1.7	0.7	0.3	0.8	0.1	3.8	0.7	1.4	0.35	11.9	7.2
CAT 17	71	E1	5.0	0.1	1.9	0.7	0.3	1.0	0.1	3.8	0.6	1.4	0.30	13.3	7.7
CAT 17	80	E1	5.1	0.1	1.8	0.7	0.4	1.1	0.1	3.8	0.8	1.4	0.29	12.0	8.1
CAT 17	89	E1	4.8	0.1	2.1	0.7	0.4	1.3	0.1	3.8	0.6	1.4	0.32	12.7	8.3
CAT 17	99	E1	5.1	0.1	1.7	0.7	0.3	0.8	0.1	3.8	0.7	1.4	0.29	12.9	7.8
CAT 17	110	E1	5.1	0.1	2.0	0.7	0.4	1.3	0.1	3.8	0.9	1.4	0.30	11.5	8.1
CAT 17	139	E1	5.2	0.1	2.3	0.7	0.4	1.1	0.1	3.8	1.3	1.4	0.28	10.4	7.8
CAT 17	140	E1	5.3	0.1	2.3	0.7	0.3	1.0	0.1	3.8	1.3	1.4	0.27	10.5	7.8
CAT 17	147	E1	4.8	0.1	2.0	0.7	0.5	1.5	0.1	3.8	0.8	1.4	0.33	11.8	8.4
CAT 17	148	E1	4.8	0.1	2.0	0.7	0.4	1.1	0.1	3.8	0.8	1.4	0.33	11.8	7.7
CAT 18	68	A2													
CAT 18	74	A2	5.1	0.0	3.2	0.7	0.4	1.3	0.1	3.8	0.6	1.4	0.30	13.1	8.9
CAT 18	82	A2	5.7	0.1	1.9	0.7	0.5	1.5	0.1	3.8	0.9	1.4	0.25	12.5	8.8
CAT 18	92	A2	6.5	0.0	3.4	0.7	0.3	1.0	0.1	3.9	1.2	1.4	0.21	11.8	9.9
CAT 18	101	A2	6.4	0.0	4.3	0.7	0.2	0.7	0.1	3.9	1.2	1.4	0.21	11.4	9.5
CAT 18	113	A2	7.2	0.1	4.3	0.7	0.3	1.0	0.1	3.9	1.3	1.4	0.18	11.9	10.6
CAT 18	119	A2	7.3	0.1	3.9	0.7	0.4	1.1	0.1	3.9	1.2	1.4	0.18	12.4	10.6
CAT 18	128	A2	5.3	0.1	2.5	0.7	0.4	1.2	0.1	3.8	1.0	1.4	0.27	11.3	8.9
CAT 18	141	A2	6.9	0.1	2.2	0.7	0.4	1.3	0.1	3.9	1.2	1.4	0.19	12.0	11.4
CAT 18	150	A2	7.3	0.1	1.9	0.7	0.5	1.5	0.1	3.9	1.1	1.4	0.17	12.6	13.7
CAT 19	69	F1	4.2	0.1	2.1	0.7	0.3	0.8	0.1	3.8	0.6	1.4	0.41	12.2	7.7
CAT 19	78	F1	4.3	0.1	2.0	0.7	0.4	1.3	0.1	3.8	0.5	1.4	0.39	13.3	10.3
CAT 19	86	F1	4.6	0.1	2.0	0.7	0.5	1.5	0.1	3.8	0.5	1.4	0.35	13.5	11.3
CAT 19	96	F1	4.8	0.1	1.8	0.7	0.3	0.8	0.1	3.8	0.6	1.4	0.33	13.4	17.7
CAT 19	105	F1	5.1	0.1	1.9	0.7	0.3	1.0	0.1	3.8	0.6	1.4	0.30	13.6	10.6
CAT 19	116	F1	4.6	0.1	1.8	0.7	0.3	0.9	0.1	3.8	0.6	1.4	0.35	13.0	8.5
CAT 21	83	D3	7.9	0.1	3.0	0.7	0.6	1.8	0.1	3.9	1.0	1.4	0.16	13.7	14.8
CAT 21	94	D3	7.1	0.1	1.7	0.7	0.4	1.3	0.1	3.9	1.1	1.4	0.18	12.7	12.8
CAT 21	103	D3	7.5	0.1	1.7	0.7	0.5	1.4	0.1	3.9	1.1	1.4	0.17	13.1	19.5
CAT 21	112	D3	7.6	0.1	1.7	0.7	0.5	1.5	0.1	3.9	0.5	1.4	0.17	19.3	34.5
CAT 21	121	D3	8.2	0.1	1.7	0.7	0.5	1.5	0.1	3.9	0.6	1.4	0.15	18.1	19.8
CAT 21	131	D3	7.5	0.1	2.0	0.7	0.4	1.4	0.1	3.9	0.6	1.4	0.17	17.3	18.4
CAT 22	84	E2	6.2	0.1	2.3	0.7	0.4	1.3	0.1	3.8	1.0	1.4	0.22	12.2	11.7
CAT 22	95	E2	5.7	0.1	2.4	0.7	0.4	1.1	0.1	3.8	0.8	1.4	0.25	13.0	10.1
CAT 22	104	E2	6.6	0.1	2.7	0.7	0.3	1.0	0.1	3.9	0.9	1.4	0.20	13.0	11.7
CAT 22	117	E2	6.2	0.1	2.6	0.7	0.3	1.0	0.1	3.8	0.9	1.4	0.22	12.6	10.0
CAT 22	125	E2	7.3	0.1	2.7	0.7	0.3	0.9	0.1	3.9	0.9	1.4	0.18	13.9	10.8
CAT 22	134	E2	7.5	0.1	2.4	0.7	0.5	1.5	0.1	3.9	0.8	1.4	0.17	14.7	16.8
CAT 24	97	C2	5.2	0.1	1.7	0.7	0.4	1.3	0.1	3.8	0.9	1.4	0.28	11.8	14.5
CAT 24	109	C2	5.8	0.2	1.7	0.7	0.5	1.6	0.2	3.8	0.9	1.4	0.24	12.3	15.3
CAT 24	115	C2	5.8	0.2	1.8	0.7	0.5	1.4	0.1	3.8	0.8	1.4	0.24	12.7	13.0
CAT 24	123	C2	5.5	0.2	1.9	0.7	0.7	2.0	0.2	3.8	0.8	1.4	0.27	12.8	16.8
CAT 24	133	C2	5.5	0.2	1.9	0.7	0.5	1.4	0.2	3.8	0.9	1.4	0.26	11.8	13.7
CAT 24	142	C2	6.0	0.2	1.7	0.7	0.6	1.8	0.2	3.8	0.9	1.4	0.23	12.5	12.8
CAT 26	130	F2	5.2	0.1	2.6	0.7	0.3	1.0	0.1	3.8	1.4	1.4	0.28	10.1	8.5
CAT 26	138	F2	5.7	0.1	2.7	0.7	0.4	1.3	0.1	3.8	1.4	1.4	0.24	10.5	9.8
CAT 26	145	F2	5.9	0.1	3.5	0.7	0.3	1.0	0.1	3.8	1.5	1.4	0.23	10.5	9.2
CAT 26	151	F2	5.7	0.1	3.1	0.7	0.5	1.4	0.1	3.8	1.4	1.4	0.24	10.5	9.0

............MAXIMUM PROBABLE % ERROR DUE TO INDIVIDUAL PARAMETERS..............|.....

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	CO2 PM&CO g/hr& g/kg	m PM&CO g/hr	MC PM&CO g/hr	T PM g/hr& g/kg	P1 PM g/hr& g/kg	P2 PM g/hr& g/kg	t PM&CO g/hr	XC PM&CO g/hr& g/kg	HC PM&CO g/hr& g/kg	OX PM&CO g/hr& g/kg	w PM&CO g/hr& g/kg	CO CO g/hr& g/kg	PM RATE %
CAT 26	156	F2	5.0	0.1	2.6	0.7	0.3	1.0	0.1	3.8	1.8	1.4	0.29	9.4	8.0
CONV 01	1	I	7.3	0.1	1.2	0.7	0.4	1.1	0.2	3.9	1.4	1.4	0.17	11.7	11.9
CONV 01	6	I	7.6	0.1	1.2	0.7	0.5	1.5	0.3	3.9	1.1	1.4	0.17	13.1	18.6
CONV 01	15	I	8.1	0.1	1.5	0.7	0.4	1.2	0.2	3.9	1.2	1.4	0.15	12.7	12.6
CONV 01	22	I	5.7	0.1	1.6	0.7	0.3	1.0	0.1	3.8	1.3	1.4	0.24	10.7	13.0
CONV 03	3	J1	7.5	0.1	1.6	0.7	0.5	1.6	0.2	3.9	1.3	1.4	0.17	12.0	14.3
CONV 03	9	J1	7.4	0.1	1.6	0.7	0.5	1.6	0.2	3.9	1.3	1.4	0.17	12.1	14.6
CONV 03	17	J1	7.3	0.1	1.5	0.7	0.4	1.1	0.2	3.9	1.4	1.4	0.17	11.7	11.7
CONV 03	21	J1	6.9	0.1	1.5	0.7	0.6	1.7	0.1	3.9	1.3	1.4	0.19	11.8	11.9
CONV 04	4	K	5.7	0.0	3.1	0.7	0.3	0.9	0.1	3.8	1.8	1.4	0.24	9.6	8.4
CONV 04	8	K	5.8	0.0	3.2	0.7	0.5	1.4	0.1	3.8	1.9	1.4	0.23	9.5	9.6
CONV 04	14	K	5.7	0.0	3.6	0.7	0.4	1.2	0.1	3.8	1.8	1.4	0.24	9.6	9.2
CONV 04	26	K	6.6	0.0	3.2	0.7	0.4	1.2	0.1	3.9	2.0	1.4	0.20	9.6	9.4
CONV 05	7	L													
CONV 05	13	L	16.5	0.1	1.6	0.7	0.5	1.4	0.2	3.9	1.8	1.4	0.07	15.0	22.6
CONV 05	20	L	11.3	0.1	1.7	0.7	0.3	1.0	0.1	3.9	2.5	1.4	0.10	10.4	13.4
CONV 05	25	L	6.4	0.1	1.9	0.7	0.4	1.2	0.1	3.9	2.5	1.4	0.20	8.8	9.0
CONV 05	29	L	9.1	0.1	1.9	0.7	0.3	1.0	0.1	3.9	2.5	1.4	0.13	9.7	11.4
CONV 09	32	J2	3.9	0.1	1.3	0.7	0.6	1.7	0.1	3.8	2.0	1.4	0.43	8.5	7.0
CONV 09	36	J2	3.7	0.1	1.6	0.7	0.3	1.0	0.1	3.8	2.1	1.4	0.46	8.3	6.6
CONV 09	42	J2	4.2	0.0	2.0	0.7	0.3	0.9	0.1	3.8	2.1	1.4	0.37	8.6	7.0
CONV 09	53	J2	3.8	0.1	1.3	0.7	0.4	1.3	0.1	3.8	2.4	1.4	0.43	8.0	6.8
CONV 09	48	J2													
CONV 10	33	M	5.4	0.1	2.7	0.7	0.7	2.0	0.1	3.8	2.0	1.4	0.26	9.2	8.9
CONV 10	37	M	4.9	0.1	3.2	0.7	0.6	1.7	0.2	3.8	1.7	1.4	0.30	9.4	9.0
CONV 10	43	M	5.3	0.1	3.3	0.7	0.6	1.8	0.2	3.8	1.6	1.4	0.27	9.8	10.8
CONV 11	34	N	4.3	0.1	2.0	0.7	0.3	1.0	0.1	3.8	2.0	1.4	0.36	8.7	7.0
CONV 11	39	N	4.5	0.1	2.0	0.7	0.4	1.1	0.1	3.8	2.0	1.4	0.34	8.8	7.3
CONV 11	45	N	4.4	0.0	2.0	0.7	0.4	1.1	0.1	3.8	2.0	1.4	0.35	8.8	7.2
CONV 11	50	N	4.3	0.0	1.9	0.7	0.3	0.9	0.1	3.8	2.0	1.4	0.37	8.7	6.9
NCAT 13	41	G1	4.9	0.1	2.0	0.7	0.4	1.3	0.2	3.8	0.9	1.4	0.31	11.4	26.9
NCAT 13	47	G1	4.7	0.1	1.8	0.7	0.4	1.3	0.1	3.8	1.0	1.4	0.34	11.0	9.9
NCAT 13	52	G1	4.5	0.1	1.8	0.7	0.7	2.1	0.2	3.8	0.8	1.4	0.36	11.2	17.5
NCAT 13	58	G1	4.7	0.1	1.7	0.7	0.5	1.4	0.2	3.8	0.8	1.4	0.34	11.4	13.4
NCAT 13	63	G1	5.3	0.1	2.1	0.7	0.4	1.1	0.1	3.8	0.8	1.4	0.28	12.4	21.3
NCAT 13	70	G1	4.7	0.1	2.1	0.7	0.6	1.7	0.1	3.8	0.7	1.4	0.34	12.2	15.1
NCAT 15	62	H1	5.1	0.1	1.7	0.7	0.7	2.0	0.1	3.8	1.4	1.4	0.29	10.0	15.7
NCAT 15	77	H1	5.9	0.1	1.9	0.7	0.6	1.8	0.1	3.8	1.1	1.4	0.23	11.7	21.1
NCAT 15	91	H1	5.4	0.2	1.9	0.7	0.6	1.9	0.2	3.8	1.5	1.4	0.26	10.1	13.2
NCAT 15	108	H1	6.2	0.3	1.7	0.7	0.5	1.6	0.2	3.9	1.6	1.4	0.21	10.2	10.5
NCAT 15	124	H1	6.5	0.3	2.0	0.7	0.7	2.1	0.2	3.9	1.9	1.4	0.20	9.8	10.4
NCAT 15	136	H1	6.7	0.2	1.8	0.7	0.5	1.5	0.1	3.9	1.5	1.4	0.20	10.7	10.4
NCAT 20	79	G2													
NCAT 20	85	G2	5.7	0.0	1.8	0.7	0.3	0.9	0.1	3.8	1.0	1.4	0.25	12.0	9.4
NCAT 20	93	G2	4.3	0.1	2.0	0.7	0.4	1.1	0.1	3.8	1.0	1.4	0.39	10.5	8.9
NCAT 20	102	G2	4.8	0.0	1.8	0.7	0.3	1.0	0.1	3.8	1.1	1.4	0.32	10.8	8.4
NCAT 20	114	G2	5.3	0.1	2.0	0.7	0.3	0.9	0.1	3.8	1.0	1.4	0.28	11.5	10.2
NCAT 20	122	G2	5.6	0.1	1.9	0.7	0.4	1.2	0.1	3.8	1.2	1.4	0.25	11.0	10.0

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	CO2 PM&CO g/hr& g/kg	m PM&CO g/hr	MC PM&CO g/hr	T PM g/hr& g/kg	P1 PM g/hr& g/kg	P2 PM g/hr& g/kg	t PM&CO g/hr	XC PM&CO g/hr& g/kg	HC PM&CO g/hr& g/kg	OX PM&CO g/hr& g/kg	w PM&CO g/hr& g/kg	CO CO g/hr& g/kg	PM RATE %
			............MAXIMUM PROBABLE % ERROR DUE TO INDIVIDUAL PARAMETERS...............												.....
NCAT 20	132	G2	5.0	0.1	2.1	0.7	0.3	1.0	0.1	3.8	0.9	1.4	0.30	11.4	13.0
NCAT 23	87	H2	4.7	0.1	1.8	0.7	0.5	1.4	0.1	3.8	1.2	1.4	0.33	10.2	15.5
NCAT 23	98	H2	4.4	0.1	1.9	0.7	0.5	1.5	0.1	3.8	1.2	1.4	0.36	10.0	13.0
NCAT 23	106	H2	5.4	0.1	2.0	0.7	0.4	1.1	0.1	3.8	1.3	1.4	0.26	10.5	13.4
NCAT 23	118	H2	5.4	0.1	1.9	0.7	0.3	1.0	0.1	3.8	1.3	1.4	0.26	10.5	10.5
NCAT 23	126	H2	5.6	0.1	1.9	0.7	0.9	2.7	0.1	3.8	1.5	1.4	0.25	10.2	14.5
NCAT 23	137	H2	5.0	0.1	1.9	0.7	0.5	1.4	0.1	3.8	1.4	1.4	0.30	10.0	13.6
NCAT 25	127	H3	6.0	0.3	2.5	0.7	1.3	4.0	0.3	3.8	1.4	1.4	0.23	10.7	33.4
NCAT 25	135	H3	5.3	0.1	1.8	0.7	0.3	1.0	0.1	3.8	1.5	1.4	0.27	10.1	8.4
NCAT 25	143	H3	5.5	0.1	2.4	0.7	0.3	1.0	0.1	3.8	1.6	1.4	0.25	9.9	8.2
NCAT 25	149	H3	6.3	0.1	1.8	0.7	0.4	1.1	0.1	3.9	1.9	1.4	0.21	9.7	8.9
NCAT 25	155	H3	5.7	0.1	2.0	0.7	0.5	1.5	0.1	3.8	1.5	1.4	0.24	10.3	10.1
HIGHEST COAL VALUE			12.3	0.1	1.4	0.7	0.4	1.3	0.1	2.8	1.5	1.4	0.20	33.7	119.0
LOWEST COAL VALUE			5.3	0.0	0.7	0.7	0.3	0.9	0.1	2.6	0.1	1.4	0.06	12.1	13.5
HIGHEST WOOD VALUE			16.5	0.3	4.3	0.7	1.3	4.0	0.3	3.9	2.5	1.4	0.46	19.4	34.5
LOWEST WOOD VALUE			3.7	0.0	1.2	0.7	0.2	0.7	0.1	3.8	0.3	1.4	0.07	8.0	6.6
CATALYTIC AVERAGE			5.6	0.1	2.2	0.7	0.4	1.2	0.1	3.8	0.9	1.4	0.27	12.9	11.3
NONCATALYTIC AVERAGE			5.3	0.1	1.9	0.7	0.5	1.5	0.1	3.8	1.2	1.4	0.28	10.7	13.6
CONVENTIONAL AVERAGE			6.4	0.1	2.1	0.7	0.4	1.3	0.1	3.8	1.8	1.4	0.25	10.2	10.6
BLANK AVERAGE															
COAL AVERAGE			9.1	0.1	1.1	0.7	0.4	1.1	0.1	2.7	0.7	1.4	0.11	23.4	32.3

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	.....MAXIMUM PROBABLE % ERRORS (VIA SQUARE ROOT OF THE SUM OF THE SQUARES) PM RATE g/hr	CO RATE %	CO RATE g/hr	PM FACTOR %	PM FACTOR g/kg	CO FACTOR %	CO FACTOR g/kg	..........UNCORRECTED VALUES PM g/hr	CO g/hr	CO g/kg	PM g/kg	FUEL MC dry %	DRY STACK FLOW g/s
COAL 02	2	R	1.5	15.6	14.0	14.1	2.2	15.5	20.6	11.1	90	133	16.5	10.6	12.3
COAL 02	5	R	2.0	15.1	15.9	13.8	2.4	15.0	18.8	15.4	105	125	18.3	10.6	13.8
COAL 02	10	R	2.6	18.6	19.4	21.2	3.2	18.6	24.6	13.4	104	132	17.0	10.6	20.0
COAL 02	12	R	1.6	15.8	13.3	15.6	2.1	15.8	17.3	11.1	84	109	14.5	10.6	12.7
COAL 02	18	R	1.6	15.4	13.0	13.4	1.9	15.3	16.0	12.4	84	104	15.3	10.6	12.2
COAL 06	11	S	2.2	35.0	12.7	52.4	1.9	35.0	10.9	5.6	36	31	4.9	6.4	26.0
COAL 06	16	S	3.5	30.6	17.1	40.2	2.8	30.6	13.7	10.8	56	45	8.6	6.4	32.0
COAL 06	19	S	4.2	35.0	16.0	47.4	2.9	35.0	10.9	11.5	46	31	7.9	6.4	32.9
COAL 06	24	S	3.3	30.3	18.8	119.0	2.0	30.2	11.7	4.9	62	39	3.0	6.4	35.8
COAL 06	28	S	2.4	30.3	13.5	33.5	2.1	30.2	11.7	8.5	44	39	7.4	6.4	25.6
COAL 07	23	T	3.7	29.3	17.0	16.1	1.1	29.3	4.9	25.5	58	17	7.4	4.7	33.6
COAL 07	27	T	3.9	29.3	17.3	17.9	1.0	29.3	4.4	24.0	59	15	6.1	4.7	34.5
COAL 07	31	T	3.5	34.2	16.0	14.9	0.9	34.2	3.9	25.6	47	12	6.3	4.7	34.1
BLANK	55														
BLANK	56														
BLANK	75														
BLANK	76														
BLANK	88														
BLANK	107														
BLANK	144														
BLANK	146														
BLANK	152														
BLANK	153														
BLANK	154														
CAT 08	30	A1	0.8	13.2	8.2	8.1	0.6	13.1	5.9	10.5	63	45	7.6	13.1	6.15
CAT 08	35	A1	1.0	12.6	7.7	7.3	1.0	12.3	7.9	13.6	61	64	14.2	20.1	4.6
CAT 08	40	A1	1.4	11.5	12.5	11.7	1.0	11.2	8.7	12.7	110	78	9.1	21.3	5.2
CAT 12	38	B	0.8	14.7	5.9	13.0	0.7	14.6	5.6	6.5	41	38	6.0	11.0	5.7
CAT 12	44	B	0.4	13.0	4.9	11.5	0.5	12.9	6.8	3.6	39	53	5.0	9.8	3.5
CAT 12	49	B	0.7	12.5	5.9	8.4	0.8	12.5	6.8	8.3	48	54	9.4	8.5	3.8
CAT 12	54	B	1.4	14.3	9.5	10.9	0.9	14.2	5.8	13.9	67	41	8.5	8.6	8.7
CAT 12	61	B	0.6	13.9	5.9	8.2	0.6	13.8	5.5	7.7	43	40	7.2	11.0	5.0
CAT 12	67	B	0.7	13.1	7.4	10.5	0.6	13.0	6.3	7.4	57	49	6.3	9.8	5.4
CAT 14	46	C1	0.2	14.1	2.3	8.4	0.4	13.9	4.1	3.0	17	29	5.3	13.6	2.1
CAT 14	51	C1	0.4	14.9	3.0	8.8	0.6	14.8	4.4	4.6	20	30	6.8	12.8	3.0
CAT 14	57	C1	0.6	17.5	3.1	10.8	0.7	17.4	3.6	5.7	18	21	6.6	11.6	4.1
CAT 14	60	C1	0.6	14.9	4.4	8.3	0.5	14.8	4.2	7.2	30	28	6.7	14.1	4.5
CAT 14	66	C1	0.5	17.0	4.3	9.8	0.4	16.9	3.9	4.9	25	23	4.4	14.2	5.3
CAT 14	73	C1	0.6	16.5	3.8	11.1	0.6	16.4	3.9	5.9	23	24	6.1	15.9	4.5
CAT 16	59	D1	1.9	13.7	11.7	8.9	1.8	13.5	11.1	21.5	86	83	20.5	19.2	8.4
CAT 16	65	D1	2.2	13.8	11.3	8.3	2.0	13.7	10.1	26.9	83	74	24.2	14.7	8.6
CAT 16	72	D1	1.8	13.4	9.8	8.3	1.8	13.1	10.2	20.4	73	78	21.8	24.3	6.6
CAT 16	81	D1	1.1	17.9	5.9	9.8	1.1	17.7	6.0	11.3	33	34	11.7	23.9	7.4
CAT 16	90	D2	0.8	15.6	5.3	10.0	0.9	15.4	5.7	8.1	34	37	8.9	19.0	5.5
CAT 16	100	D2	0.8	16.4	5.2	9.3	0.9	16.2	6.5	8.2	32	40	10.3	15.2	5.8
CAT 16	111	D2	0.5	20.0	3.6	15.5	0.7	19.9	5.4	3.4	18	27	5.0	15.8	5.3
CAT 16	120	D2	0.5	21.2	3.3	14.0	0.9	21.1	5.9	3.9	16	28	7.0	18.6	5.0
CAT 16	129	D2	0.4	19.9	2.9	18.7	0.7	19.8	4.5	2.6	15	23	4.0	19.2	4.2

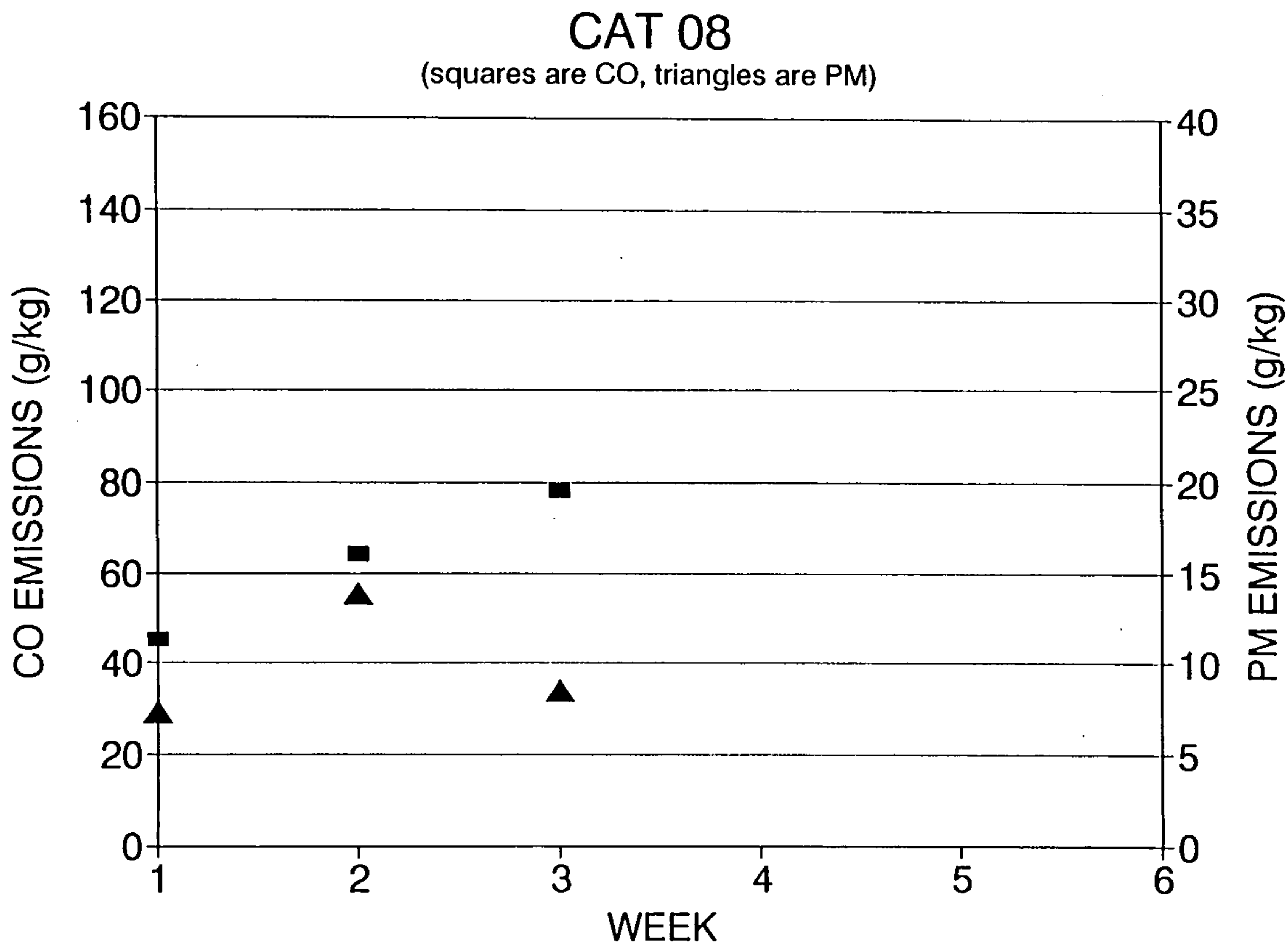
APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	.....MAXIMUM PROBABLE % ERRORS (VIA SQUARE ROOT OF THE SUM OF THE SQUARES)							..........UNCORRECTED VALUES					
			PM RATE g/hr	CO RATE %	CO RATE g/hr	PM FACTOR %	PM FACTOR g/kg	CO FACTOR %	CO FACTOR g/kg	PM g/hr	CO g/hr	CO g/kg	PM g/kg	FUEL MC dry %	DRY STACK FLOW g/s
CAT 17	64	E1	0.8	13.5	5.9	7.0	0.8	13.4	6.1	11.9	44	46	12.3	11.5	4.6
CAT 17	71	E1	0.8	15.0	4.4	7.5	1.0	14.8	5.5	11.2	29	37	14.3	14.7	4.3
CAT 17	80	E1	1.0	13.8	5.8	7.9	1.1	13.6	7.0	12.1	42	51	14.9	13.9	4.6
CAT 17	89	E1	0.8	14.4	4.3	8.1	1.0	14.2	5.7	10.0	30	40	13.2	16.4	3.9
CAT 17	99	E1	0.7	14.6	4.8	7.6	0.8	14.5	6.1	8.7	33	42	11.3	12.9	4.4
CAT 17	110	E1	0.9	13.4	5.3	7.9	1.3	13.3	7.4	11.6	39	56	16.5	15.4	3.9
CAT 17	139	E1	1.0	12.6	5.9	7.4	1.6	12.4	9.7	12.7	46	78	21.5	17.7	3.5
CAT 17	140	E1	1.0	12.7	5.9	7.5	1.6	12.5	9.9	13.2	47	79	22.3	17.7	3.6
CAT 17	147	E1	0.7	13.5	3.9	8.2	1.1	13.3	6.5	8.5	29	49	14.4	15.2	3.0
CAT 17	148	E1	0.6	13.5	3.9	7.5	1.0	13.3	6.5	8.5	29	49	14.3	15.2	3.0
CAT 18	68	A2												32.5	
CAT 18	74	A2	1.7	15.0	8.0	8.3	1.1	14.6	5.8	19.3	53	39	14.3	27.5	7.5
CAT 18	82	A2	2.5	14.5	10.8	8.6	1.7	14.4	7.5	29.8	74	52	21.0	14.1	9.6
CAT 18	92	A2	2.1	14.5	13.2	9.3	1.5	14.1	10.1	21.6	91	72	16.9	29.3	10.4
CAT 18	101	A2	1.6	14.5	11.3	8.5	1.4	13.8	10.5	17.3	78	76	16.9	39.7	8.3
CAT 18	113	A2	1.9	15.2	11.2	9.7	1.8	14.6	11.3	18.5	74	77	19.4	40.2	9.0
CAT 18	119	A2	2.4	15.5	12.0	9.8	2.0	15.0	10.7	23.4	78	72	21.5	35.7	10.3
CAT 18	128	A2	1.5	13.5	10.4	8.5	1.2	13.2	8.4	17.4	77	63	14.3	20.1	7.5
CAT 18	141	A2	1.6	14.7	11.1	11.2	1.5	14.5	10.4	15.0	76	72	14.1	17.1	9.3
CAT 18	150	A2	1.9	15.3	12.1	13.5	1.7	15.2	10.5	15.0	79	69	13.1	14.3	11.0
CAT 19	69	F1	0.5	13.7	4.6	7.4	0.5	13.5	5.0	6.9	34	37	7.4	15.0	3.8
CAT 19	78	F1	0.6	14.7	3.9	10.1	0.6	14.5	4.4	5.7	27	30	6.5	15.3	3.8
CAT 19	86	F1	0.6	14.9	3.9	11.1	0.8	14.8	4.7	5.8	26	32	7.2	15.5	3.9
CAT 19	96	F1	0.4	14.9	4.7	17.6	0.4	14.8	5.1	2.3	31	35	2.5	13.3	4.6
CAT 19	105	F1	0.5	15.2	4.1	10.5	0.7	15.1	5.4	5.1	27	36	6.9	14.6	4.2
CAT 19	116	F1	0.5	14.5	4.0	8.3	0.6	14.4	5.1	5.7	28	36	7.4	13.4	3.7
CAT 21	83	D3	2.6	16.7	11.7	14.5	2.2	16.4	10.2	18.6	70	62	16.4	24.7	11.9
CAT 21	94	D3	1.1	15.2	7.8	12.7	1.4	15.1	9.9	9.5	52	65	12.0	12.8	7.2
CAT 21	103	D3	1.7	15.8	11.7	19.5	1.4	15.7	10.2	9.4	74	65	8.2	13.1	11.3
CAT 21	112	D3	1.8	21.3	8.5	34.5	1.4	21.2	6.4	6.4	40	30	4.9	13.2	12.9
CAT 21	121	D3	1.4	20.4	6.3	19.7	1.7	20.3	7.6	7.8	31	38	9.5	13.2	8.9
CAT 21	131	D3	1.5	19.4	7.6	18.3	1.4	19.3	7.1	8.7	39	37	8.2	15.1	10.3
CAT 22	84	E2	1.0	14.5	7.8	11.5	1.2	14.3	8.7	9.3	54	61	10.6	18.2	6.6
CAT 22	95	E2	1.0	15.0	6.9	9.8	1.1	14.8	7.1	10.7	46	48	11.3	19.0	6.4
CAT 22	104	E2	1.0	15.4	8.0	11.3	1.1	15.2	8.7	9.3	52	57	10.2	22.0	7.6
CAT 22	117	E2	1.0	14.9	7.1	9.7	1.2	14.7	8.3	10.6	48	57	12.5	20.9	6.4
CAT 22	125	E2	1.3	16.4	8.2	10.4	1.4	16.2	9.0	12.4	50	55	13.8	21.5	8.5
CAT 22	134	E2	1.2	17.2	6.8	16.6	1.5	17.0	8.6	7.9	40	51	10.2	18.7	7.7
CAT 24	97	C2	0.6	13.7	5.7	14.4	0.8	13.5	7.5	4.5	42	55	5.8	12.9	4.5
CAT 24	109	C2	0.8	14.3	5.3	15.2	1.2	14.2	7.9	5.5	37	56	8.3	12.9	4.6
CAT 24	115	C2	0.7	14.7	4.7	12.9	1.1	14.6	7.5	5.4	32	52	8.7	13.3	4.3
CAT 24	123	C2	0.9	14.6	4.8	16.7	1.3	14.5	6.8	5.9	33	47	8.5	14.2	4.4
CAT 24	133	C2	0.7	13.9	6.1	13.6	1.0	13.7	8.0	5.7	44	58	7.6	14.5	4.8
CAT 24	142	C2	0.9	14.6	5.0	12.7	1.5	14.5	8.1	7.5	34	56	12.2	13.0	4.4
CAT 26	130	F2	1.3	12.4	13.7	8.1	1.0	12.2	10.5	16.2	110	86	12.7	20.8	7.6
CAT 26	138	F2	1.3	13.0	10.6	9.4	1.3	12.7	10.7	13.7	81	84	14.1	22.2	6.6
CAT 26	145	F2	1.6	13.2	12.0	8.5	1.5	12.8	11.4	18.2	91	89	17.9	29.9	7.4
CAT 26	151	F2	1.8	13.1	10.7	8.5	1.8	12.7	10.7	20.9	82	84	21.4	25.7	6.6

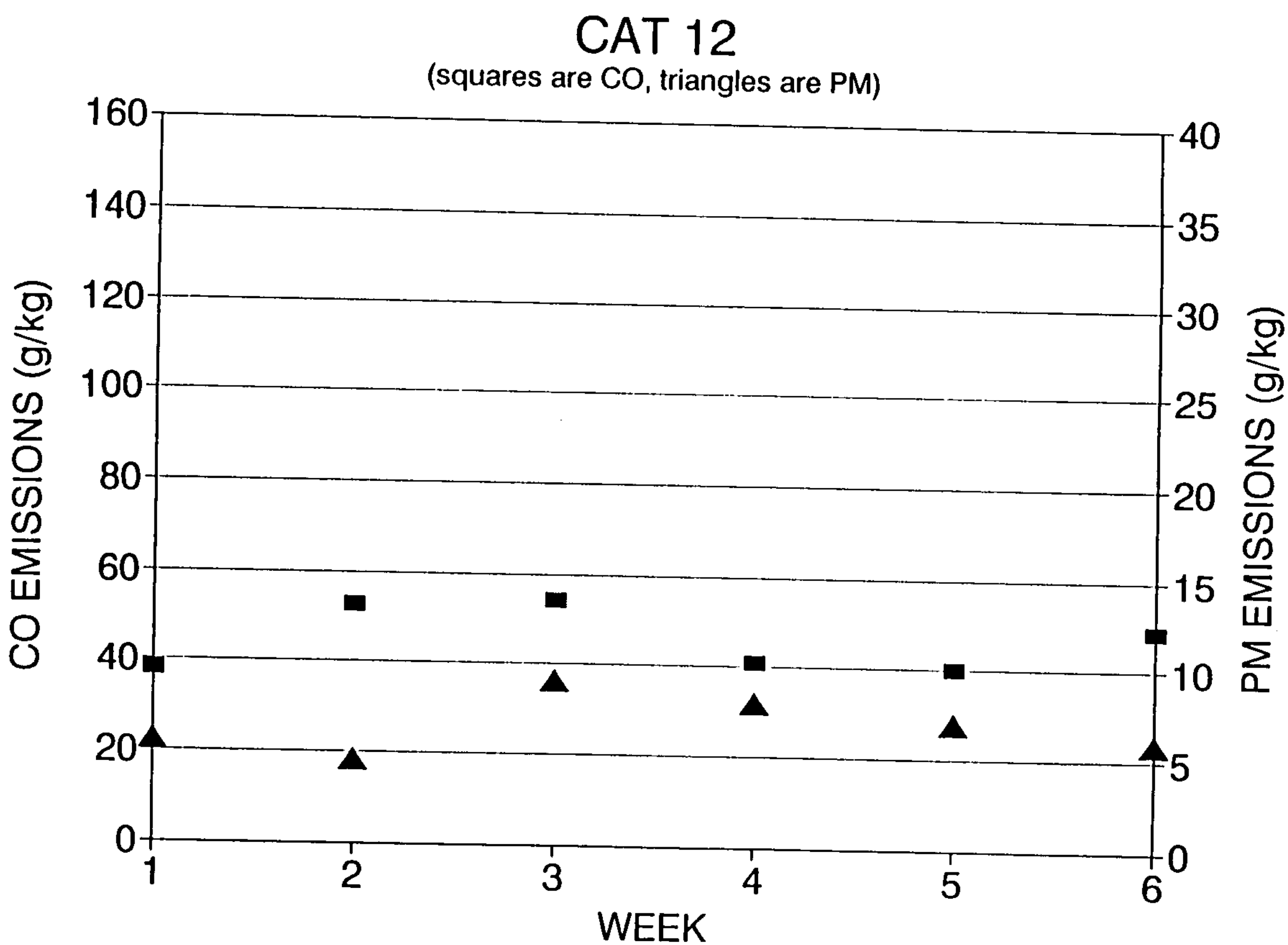
APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	.....MAXIMUM PROBABLE % ERRORS (VIA SQUARE ROOT OF THE SUM OF THE SQUARES) PM RATE g/hr	CO RATE %	CO RATE g/hr	PM FACTOR %	PM FACTOR g/kg	CO FACTOR %	CO FACTOR g/kg	..........UNCORRECTED VALUES PM g/hr	CO g/hr	CO g/kg	PM g/kg	FUEL MC dry %	DRY STACK FLOW g/s
CAT 26	156	F2	1.7	11.8	13.9	7.5	1.4	11.5	12.4	21.2	118	108	19.4	21.3	6.3
CONV 01	1	I	2.1	14.5	17.3	11.9	1.4	14.4	11.9	18.5	121	82	12.5	7.3	14.0
CONV 01	6	I	2.8	15.8	18.3	18.5	1.6	15.7	10.4	17.1	118	66	9.6	7.5	17.9
CONV 01	15	I	2.9	15.7	19.6	12.5	1.7	15.7	11.9	24.4	126	76	14.6	9.9	18.3
CONV 01	22	I	1.4	13.0	17.9	13.0	0.8	12.9	10.4	11.3	139	80	6.5	10.2	12.0
CONV 03	3	J1	3.2	14.9	19.5	14.2	1.9	14.8	11.6	24.4	133	79	14.4	10.7	16.7
CONV 03	9	J1	2.9	14.9	19.3	14.6	1.7	14.8	11.3	21.8	132	76	12.6	10.0	16.6
CONV 03	17	J1	2.6	14.5	21.1	11.6	1.5	14.4	11.9	23.6	147	82	13.2	9.9	17.1
CONV 03	21	J1	3.5	14.4	19.0	11.8	2.0	14.3	10.9	31.2	134	76	17.7	9.6	15.6
CONV 04	4	K	3.4	12.4	22.4	7.8	1.9	12.0	13.3	41.5	183	111	25.2	24.3	11.3
CONV 04	8	K	3.7	12.4	28.4	9.0	1.7	12.0	13.9	40.0	231	116	20.0	25.2	14.3
CONV 04	14	K	2.7	12.5	21.6	8.5	1.6	12.0	13.3	30.8	175	111	19.5	30.2	10.8
CONV 04	26	K	4.3	12.9	23.6	8.8	2.8	12.5	15.4	47.6	185	123	31.7	26.0	12.8
CONV 05	7	L												9.6	
CONV 05	13	L	9.0	22.8	43.5	22.5	5.0	22.8	24.1	44.2	194	106	24.2	10.6	46.4
CONV 05	20	L	8.1	16.2	39.5	13.3	5.0	16.1	24.4	62.8	247	151	38.5	11.0	27.3
CONV 05	25	L	3.9	12.1	22.4	8.8	3.1	11.9	18.2	44.6	188	153	36.2	12.9	10.3
CONV 05	29	L	5.5	14.3	30.8	11.2	3.8	14.1	21.5	50.1	219	152	35.0	12.9	18.6
CONV 09	32	J2	2.9	10.5	23.7	6.9	1.6	10.4	12.9	42.6	230	124	23.0	7.9	7.2
CONV 09	36	J2	2.9	10.3	25.6	6.4	1.5	10.2	13.3	45.2	252	131	23.5	10.4	7.0
CONV 09	42	J2	2.4	10.8	20.1	6.7	1.6	10.6	13.5	35.9	190	128	24.2	13.6	6.6
CONV 09	53	J2	3.6	10.1	24.4	6.7	2.2	10.1	15.0	55.0	244	149	33.6	7.8	6.3
CONV 09	48	J2												11.3	
CONV 10	33	M	5.0	11.9	26.7	8.5	2.6	11.6	14.0	58.2	227	120	30.8	20.6	12.2
CONV 10	37	M	3.1	11.9	23.7	8.5	1.6	11.5	12.2	36.3	202	106	19.1	25.2	10.6
CONV 10	43	M	3.0	12.4	24.1	10.3	1.5	12.0	11.9	29.4	197	99	14.8	26.5	12.4
CONV 11	34	N	3.0	10.9	18.2	6.7	2.2	10.7	13.3	44.4	169	124	32.6	13.8	6.4
CONV 11	39	N	2.3	11.0	16.5	7.0	1.8	10.9	13.3	32.2	152	122	26.0	13.9	6.1
CONV 11	45	N	2.5	11.0	18.3	6.9	1.7	10.8	13.0	35.6	169	121	25.5	13.9	6.6
CONV 11	50	N	3.0	10.8	18.4	6.6	2.1	10.7	13.3	44.6	172	124	32.3	12.7	6.3
NCAT 13	41	G1	1.0	13.2	11.4	26.9	0.7	13.1	7.3	4.4	88	56	2.8	13.4	8.3
NCAT 13	47	G1	1.4	12.8	13.7	9.7	0.8	12.6	7.4	15.1	108	59	8.2	11.9	9.1
NCAT 13	52	G1	1.9	12.9	13.6	17.4	1.0	12.8	6.7	12.4	107	52	6.1	12.3	9.5
NCAT 13	58	G1	1.3	13.1	12.2	13.3	0.7	13.0	6.7	10.2	94	52	5.6	10.9	8.9
NCAT 13	63	G1	1.1	14.2	11.7	21.2	0.6	14.1	6.9	5.9	83	49	3.5	14.6	10.2
NCAT 13	70	G1	1.4	13.8	10.6	14.9	0.8	13.7	5.9	10.3	76	43	5.9	16.5	8.6
NCAT 15	62	H1	1.0	12.2	9.1	15.6	1.2	12.1	10.6	7.0	76	88	8.1	10.9	5.1
NCAT 15	77	H1	1.1	13.9	7.9	21.0	1.2	13.8	9.0	5.8	56	65	6.7	14.1	6.2
NCAT 15	91	H1	1.2	12.4	10.0	13.1	1.3	12.3	11.1	9.4	81	91	10.5	14.4	5.7
NCAT 15	108	H1	1.3	12.9	8.8	10.3	1.8	12.8	12.7	12.7	68	100	18.6	12.8	5.3
NCAT 15	124	H1	1.8	12.8	9.4	10.2	2.7	12.6	14.4	17.8	73	114	27.8	15.0	5.3
NCAT 15	136	H1	1.1	13.5	6.9	10.2	1.9	13.3	12.5	10.7	52	94	19.4	13.4	4.7
NCAT 20	79	G2												15.1	
NCAT 20	85	G2	1.1	14.0	11.0	9.3	0.8	13.9	8.1	12.6	79	58	9.4	13.7	9.0
NCAT 20	93	G2	0.8	12.3	9.7	8.7	0.6	12.1	7.4	9.6	79	61	7.3	15.8	5.6
NCAT 20	102	G2	1.0	12.6	11.1	8.2	0.7	12.5	8.1	12.7	88	65	9.4	13.7	7.0
NCAT 20	114	G2	0.8	13.5	9.5	10.0	0.7	13.3	7.9	8.6	70	60	7.3	15.6	7.0
NCAT 20	122	G2	1.0	13.2	9.0	9.9	1.0	13.1	9.4	10.3	68	72	10.8	14.3	6.2

APPL. TYPE +SITE CODE	TEST NO.	STOVE MODEL	.....MAXIMUM PROBABLE % ERRORS (VIA SQUARE ROOT OF THE SUM OF THE SQUARES) PM RATE g/hr	CO RATE %	CO RATE g/hr	PM FACTOR %	PM FACTOR g/kg	CO FACTOR %	CO FACTOR g/kg	..........UNCORRECTED VALUES PM g/hr	CO g/hr	CO g/kg	PM g/kg	FUEL MC dry %	DRY STACK FLOW g/s
NCAT 20	132	G2	0.7	13.3	8.6	12.9	0.6	13.2	7.6	5.5	64	58	4.9	16.2	6.2
NCAT 23	87	H2	0.8	12.2	9.6	15.4	0.7	12.0	9.1	5.4	79	76	5.2	13.7	5.3
NCAT 23	98	H2	0.8	11.9	10.2	12.8	0.7	11.7	9.0	6.6	86	77	5.9	14.3	5.1
NCAT 23	106	H2	0.6	12.7	9.1	13.2	0.7	12.5	10.3	5.2	72	82	5.9	15.5	5.6
NCAT 23	118	H2	0.7	12.7	9.5	10.3	0.8	12.5	10.3	7.3	75	82	7.9	14.1	5.8
NCAT 23	126	H2	1.6	12.6	9.7	14.4	1.9	12.4	11.2	12.0	77	90	14.1	14.7	5.7
NCAT 23	137	H2	0.8	12.1	9.6	13.5	0.8	12.0	10.4	6.1	80	87	6.7	14.3	5.1
NCAT 25	127	H3	2.1	13.2	8.5	33.3	2.7	13.0	11.0	7.6	65	85	9.9	20.3	5.5
NCAT 25	135	H3	1.0	12.3	9.3	8.2	1.1	12.2	11.1	11.8	76	91	14.1	13.6	5.2
NCAT 25	143	H3	1.2	12.4	8.8	7.9	1.6	12.1	12.0	15.1	71	99	21.2	19.3	4.7
NCAT 25	149	H3	1.6	12.6	10.5	8.7	2.2	12.4	14.5	18.7	84	117	26.1	13.8	5.7
NCAT 25	155	H3	1.2	12.8	9.2	9.9	1.4	12.6	11.3	11.9	72	89	14.8	15.3	5.6
HIGHEST COAL VALUE			4.2	35.0	19.4	119.0	3.2	35.0	24.6	25.6	105	133	18.3	10.6	35.8
LOWEST COAL VALUE			1.5	15.1	12.7	13.4	0.9	15.0	3.9	4.9	36	12	3.0	4.7	12.2
HIGHEST WOOD VALUE			9.0	22.8	43.5	34.5	5.0	22.8	24.4	62.8	252	153	38.5	40.2	46.4
LOWEST WOOD VALUE			0.2	10.1	2.3	6.4	0.4	10.1	3.6	2.3	15	21	2.5	7.3	2.1
CATALYTIC AVERAGE			1.1	14.9	7.1	11.0	1.1	14.7	7.5	10.9	49.6	52.3	11.5	17.4	6.1
NONCATALYTIC AVERAGE			1.1	12.9	9.9	13.5	1.2	12.7	9.7	10.0	77.5	76.2	10.5	14.4	6.5
CONVENTIONAL AVERAGE			3.5	13.1	23.1	10.3	2.1	13.0	14.1	36.8	180	111	22.9	14.3	13.6
BLANK AVERAGE															
COAL AVERAGE			2.8	25.7	15.7	32.3	2.0	25.7	13.0	13.8	67.2	63.9	10.2	7.6	25.0

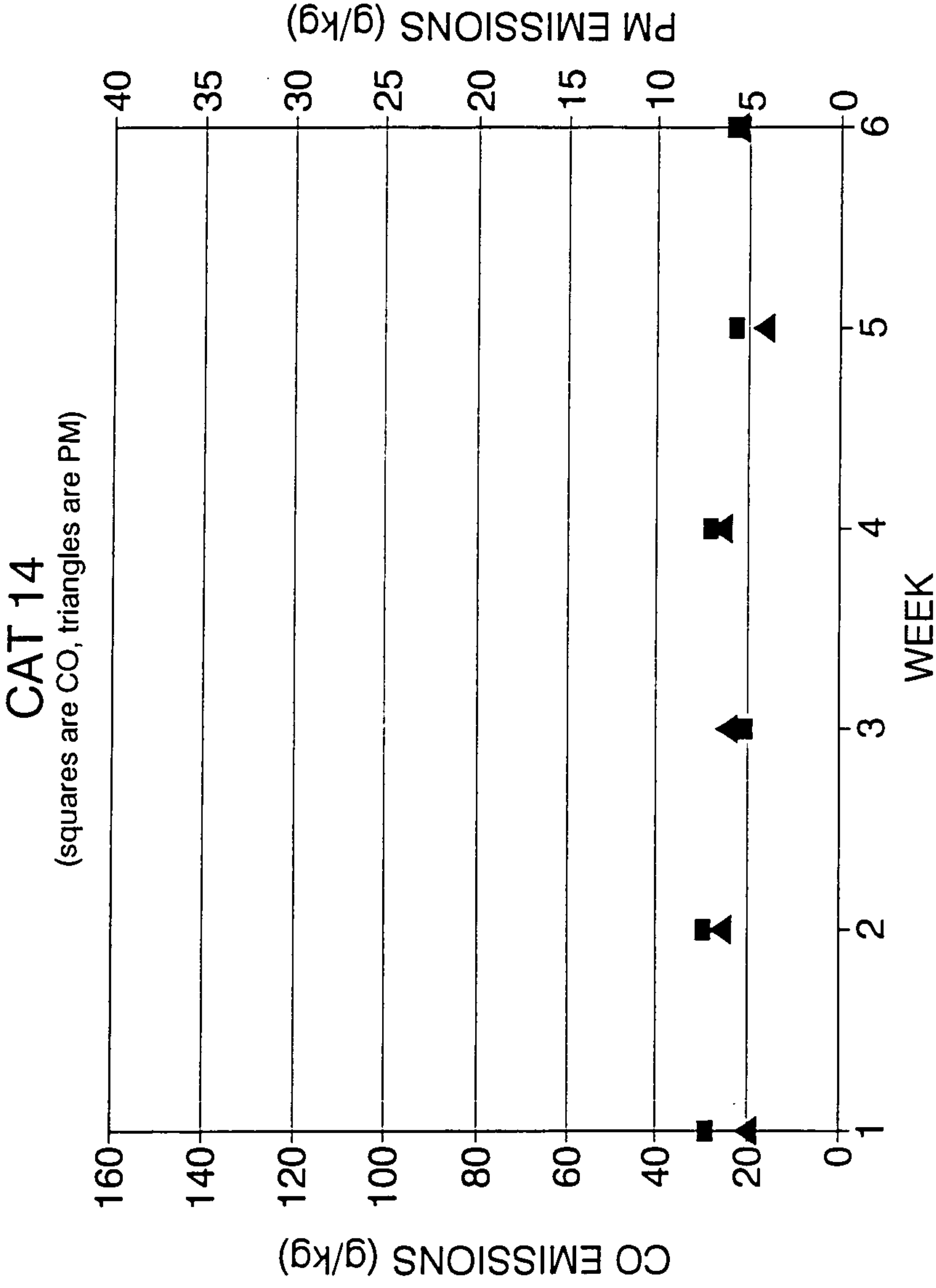
Appendix J

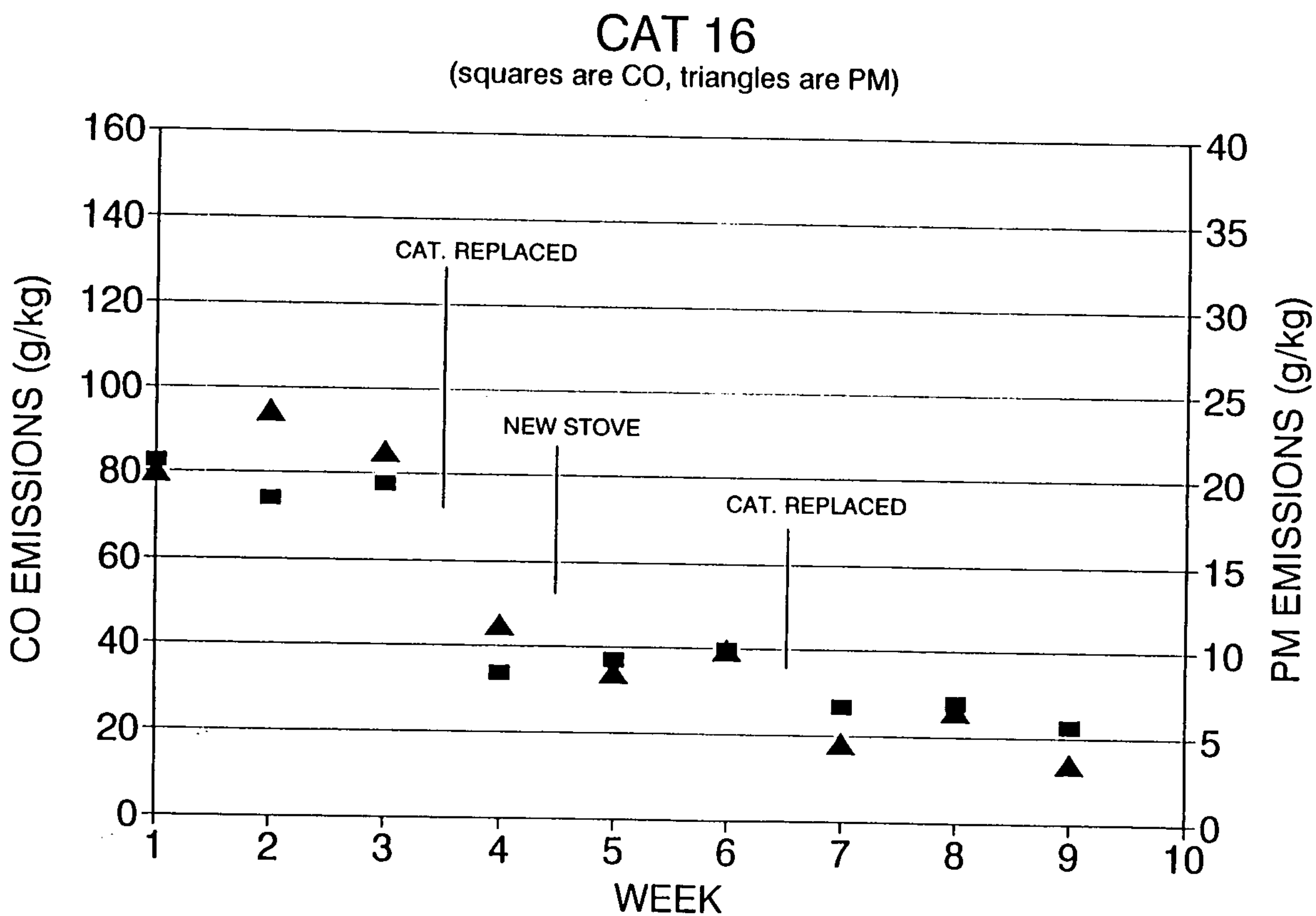
GRAPHS OF WEEK-TO-WEEK DATA BY SITE


CAT 08
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
160
140
120
100
80
60
40
20
0
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6



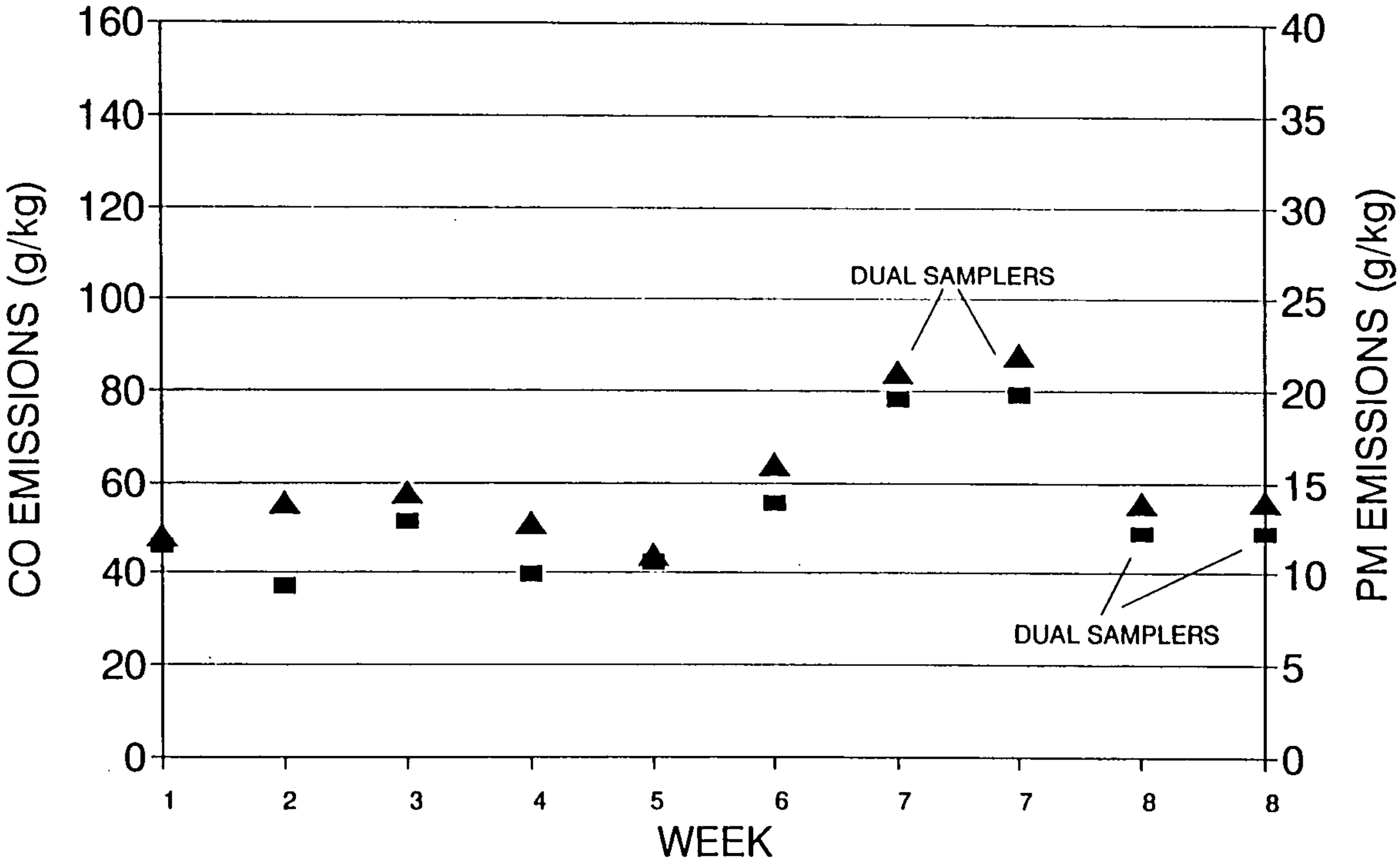
CAT 12
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
160
140
120
100
80
60
40
20
0
PM EMISSIONS (g/kg)
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
WEEK

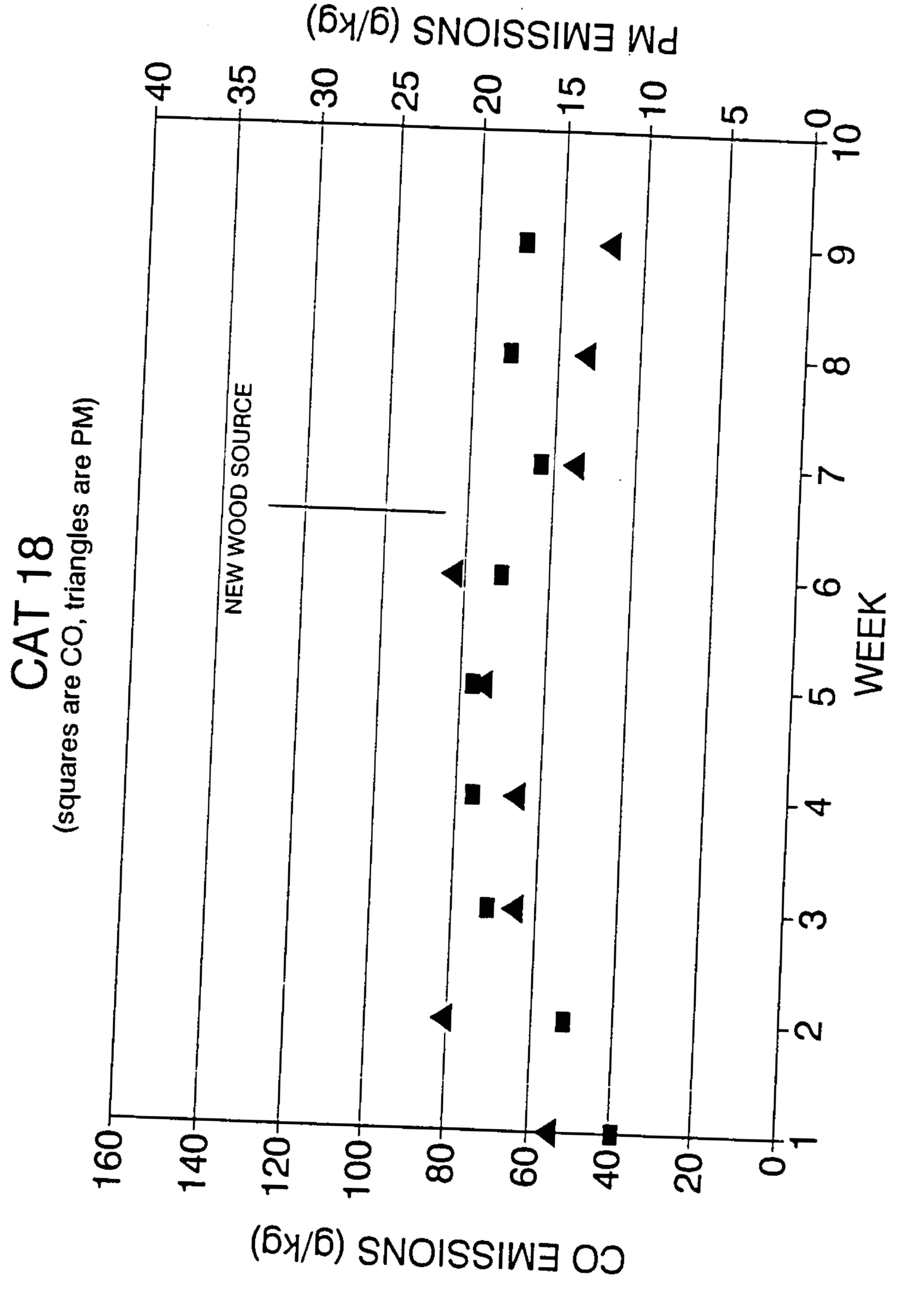

CAT 14
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6


CAT 16
(squares are CO, triangles are PM)
CAT. REPLACED
NEW STOVE
CAT. REPLACED
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
0
20
40
60
80
100
120
140
160
5
10
15
25
30
35
40
1
2
3
4
6
7
8
9

CAT 17

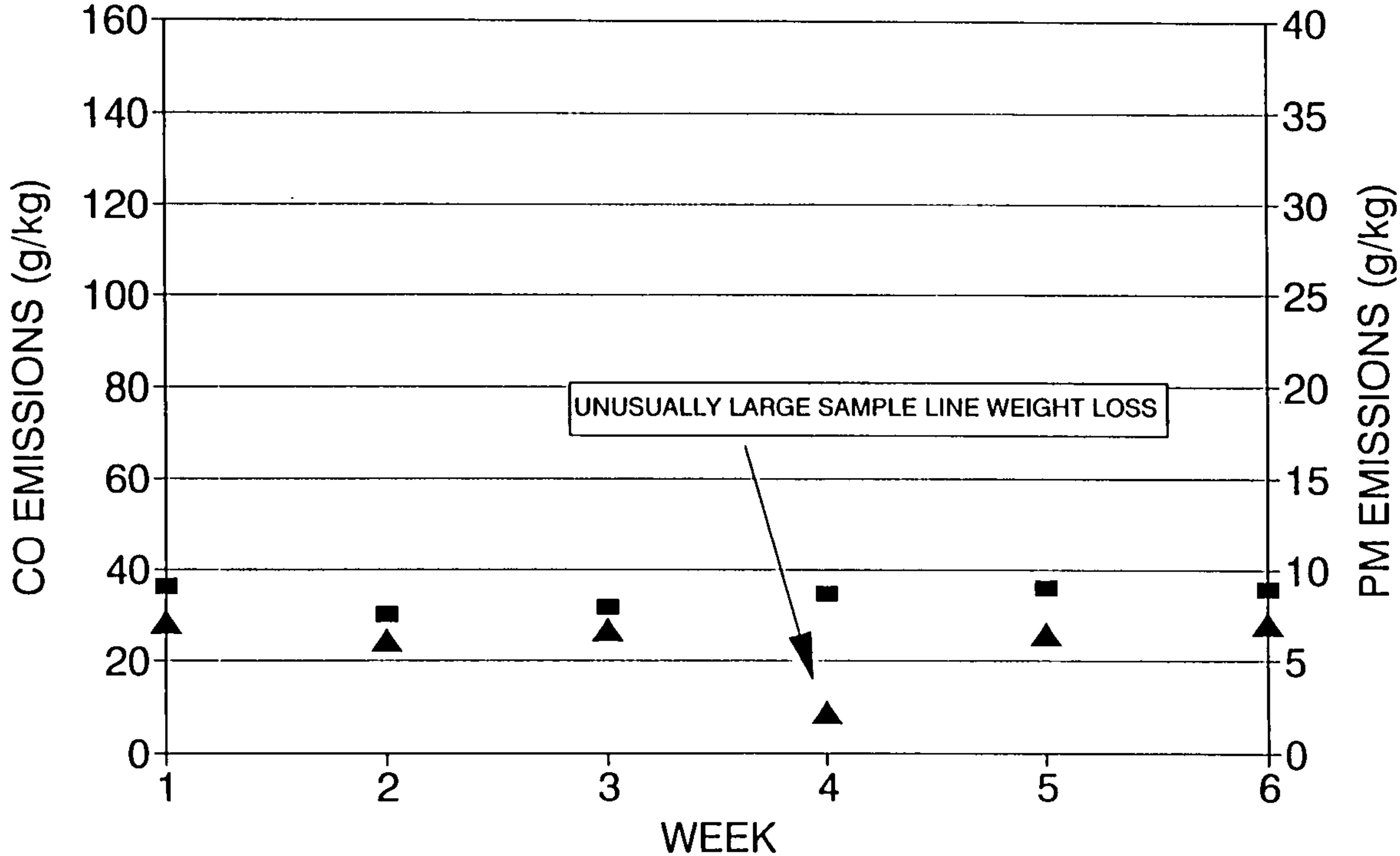
(squares are CO, triangles are PM)

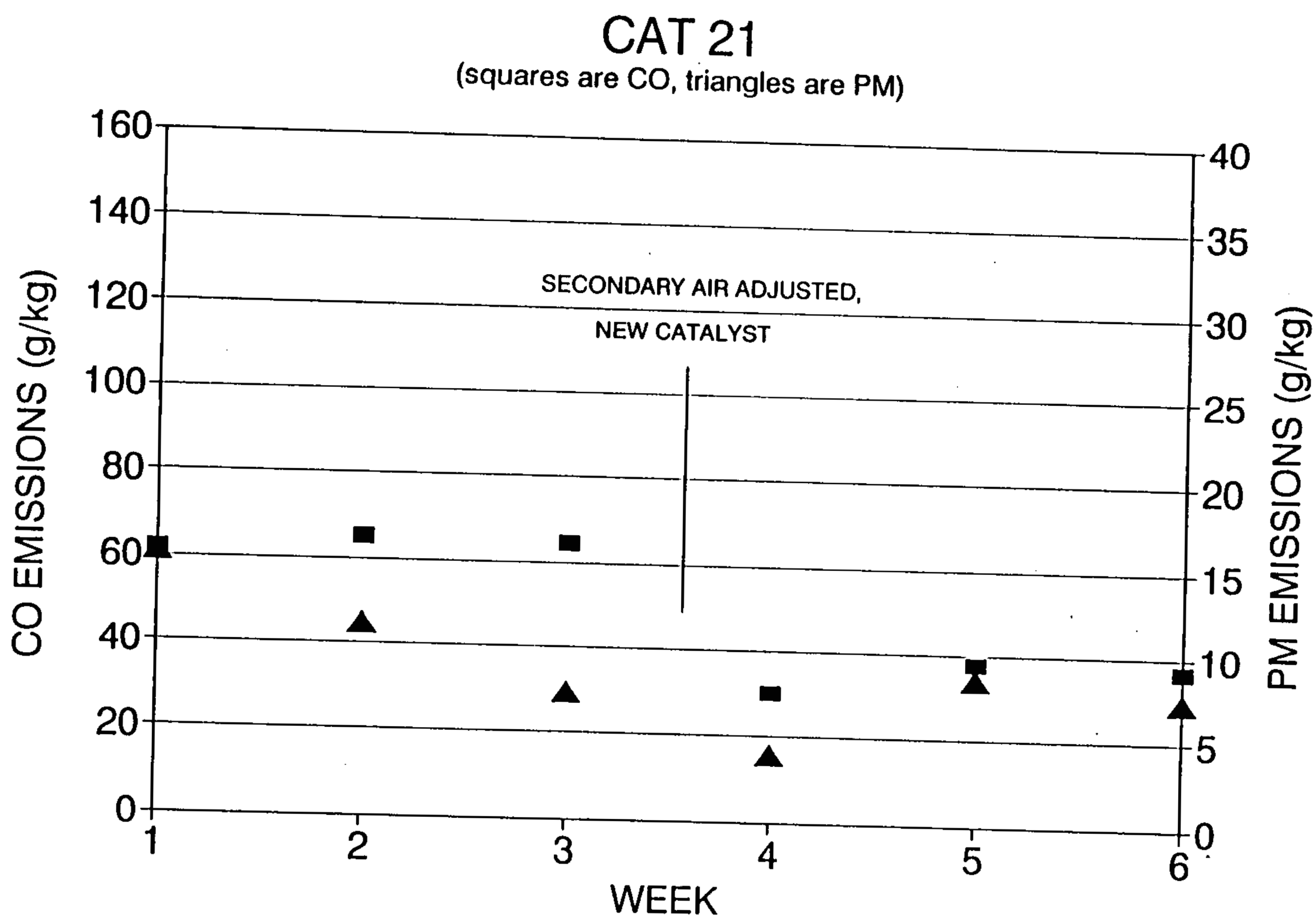


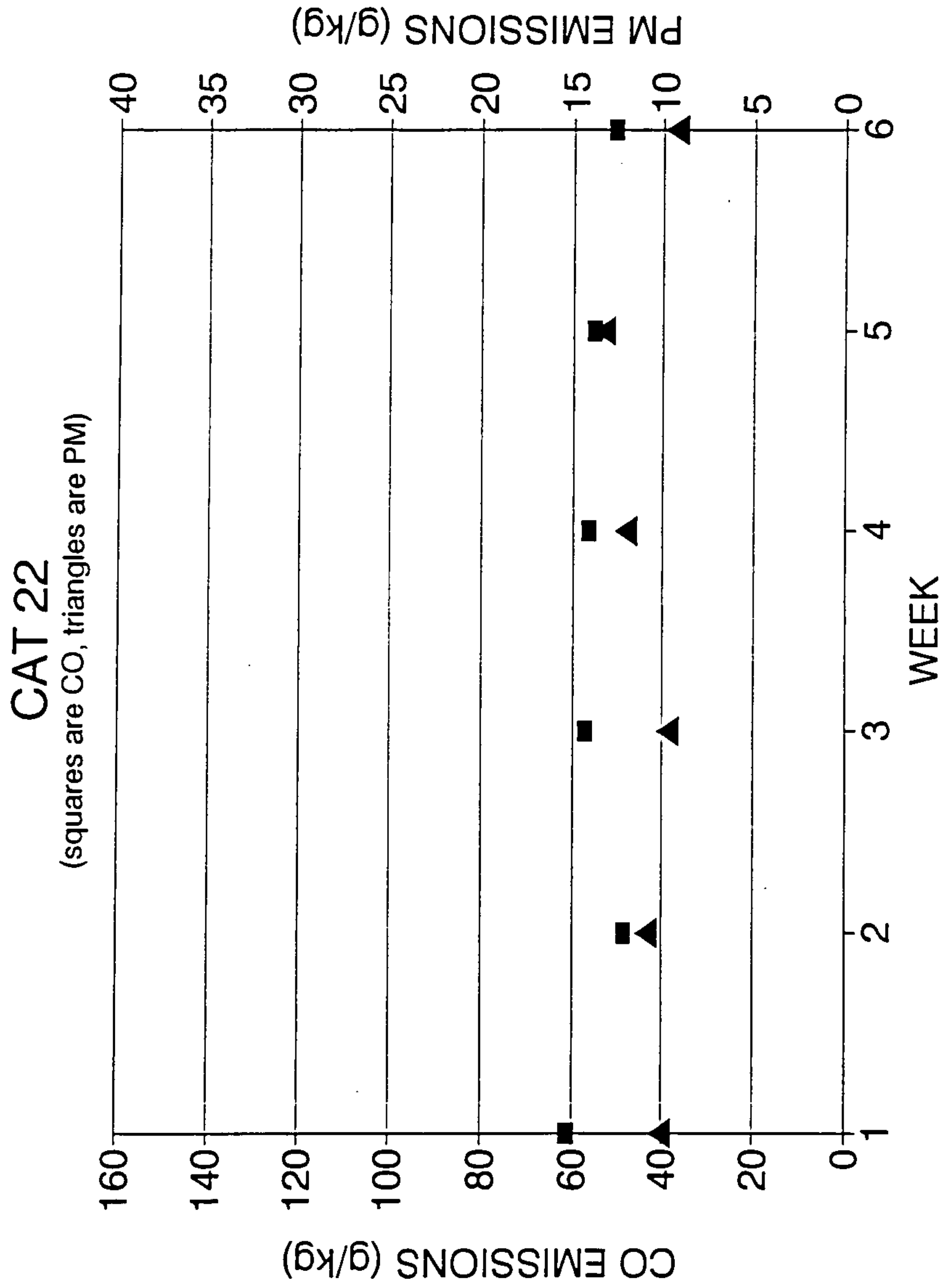

CAT 18
(squares are CO, triangles are PM)
NEW WOOD SOURCE
WEEK
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
0
20
40
60
80
100
120
140
160
5
10
15
20
25
30
35
40
1
2
3
4
5
6
7
8
9
10

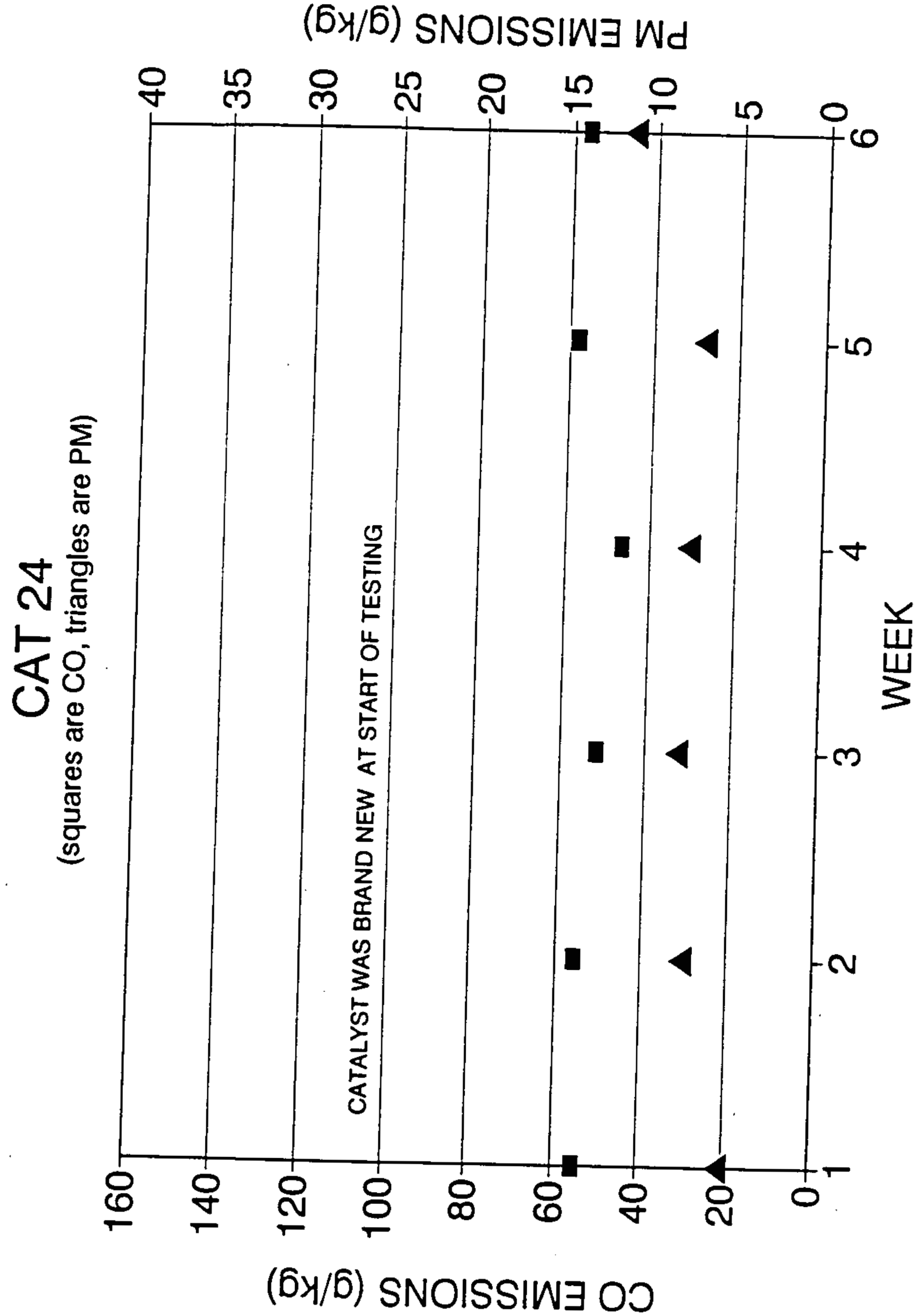
CAT 19

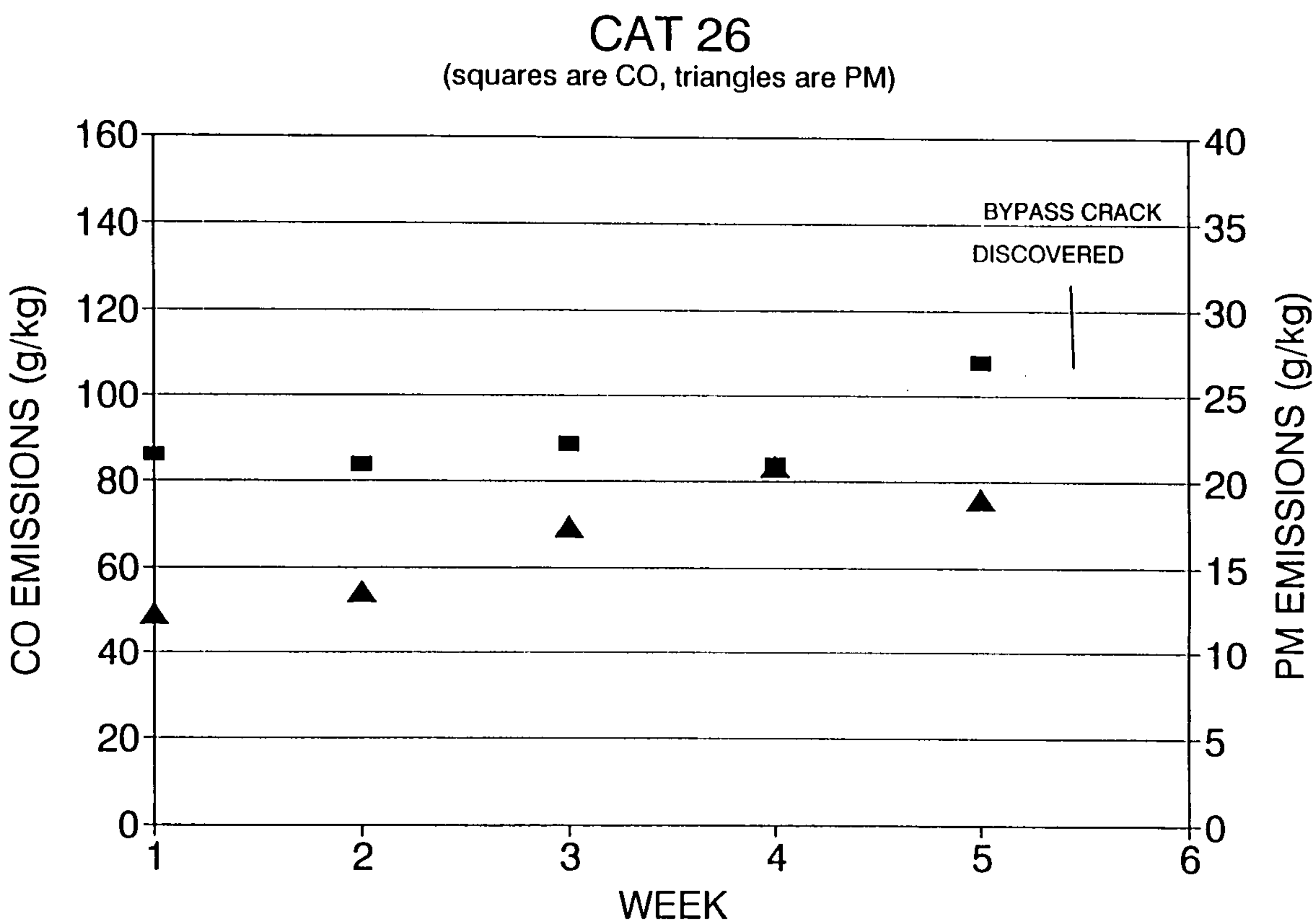
(squares are CO, triangles are PM)

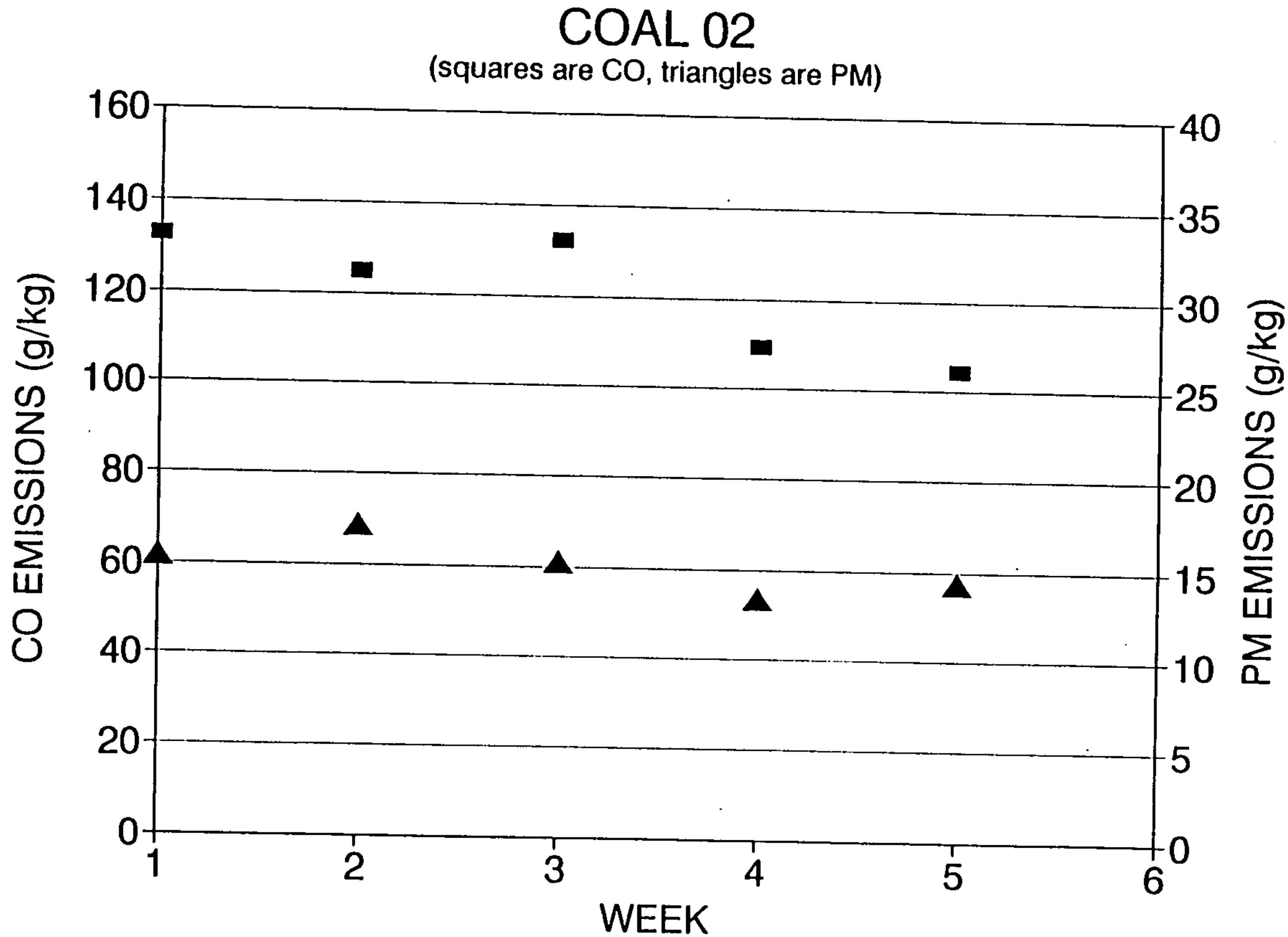


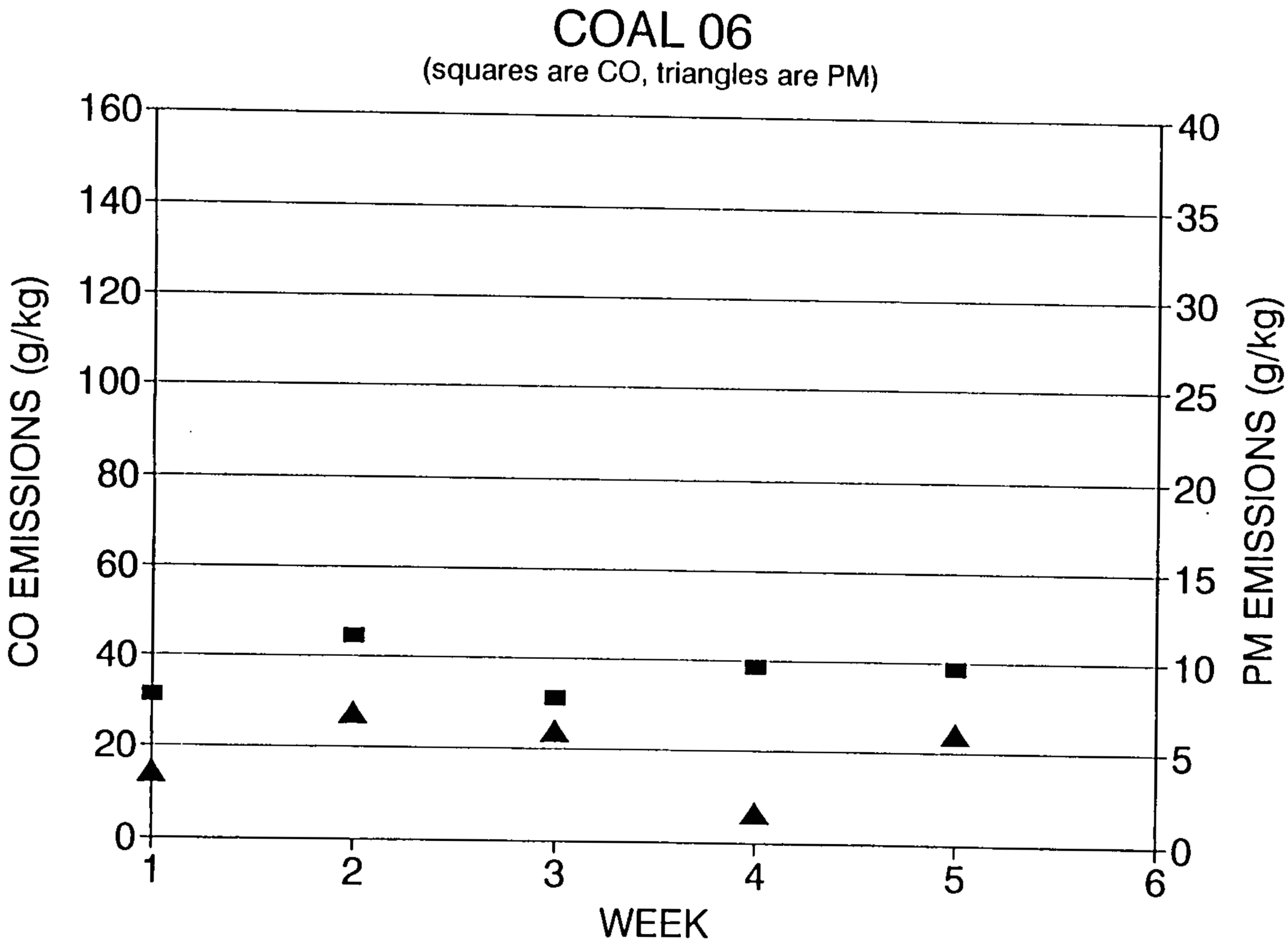

CAT 21
(squares are CO, triangles are PM)
SECONDARY AIR ADJUSTED,
NEW CATALYST
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
160
140
120
100
80
60
40
20
0
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6


CAT 22
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6


CAT 24
(squares are CO, triangles are PM)
CATALYST WAS BRAND NEW AT START OF TESTING
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK

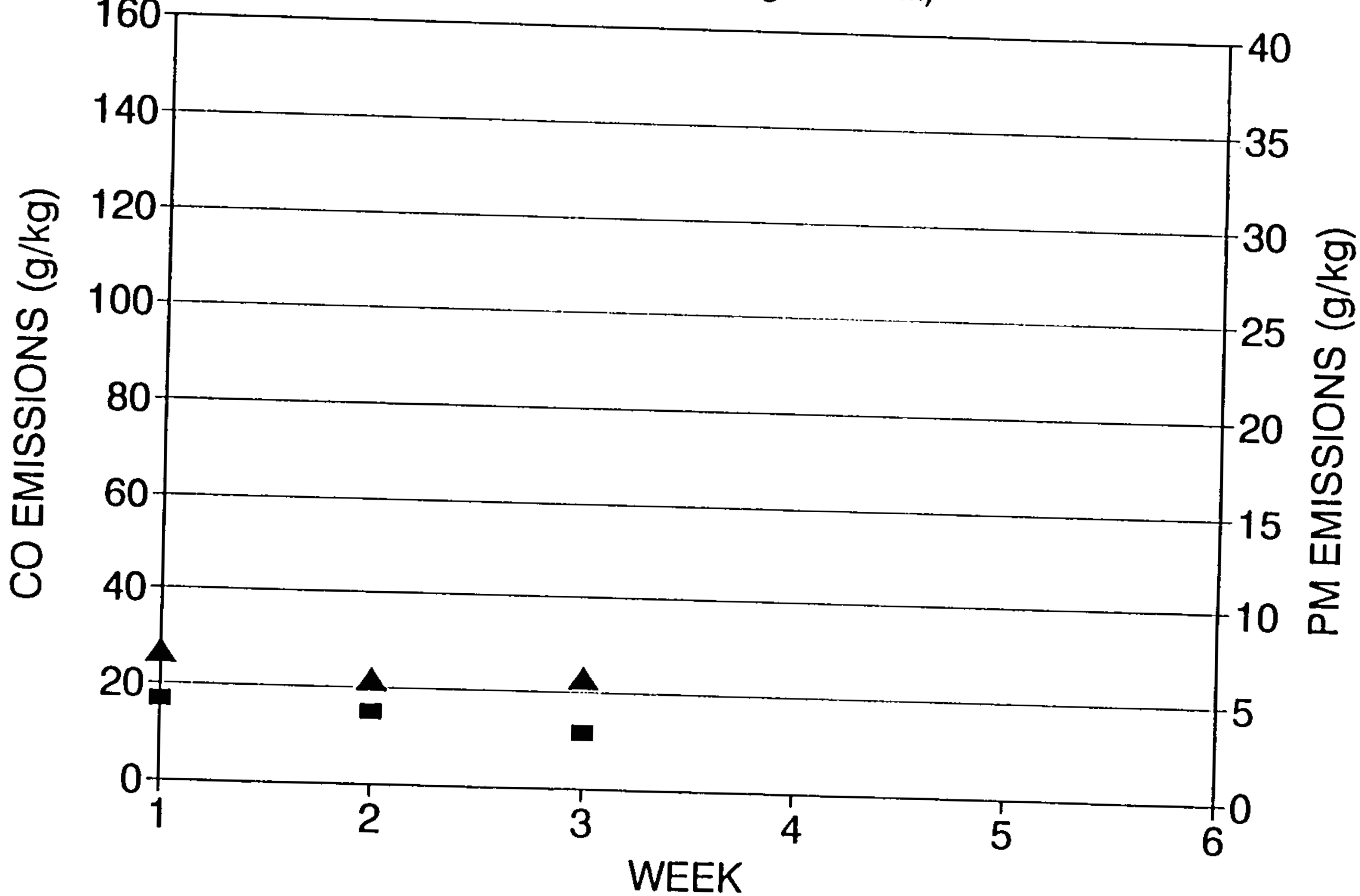

CAT 26
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
BYPASS CRACK
DISCOVERED
160
140
120
100
80
60
40
20
0
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6

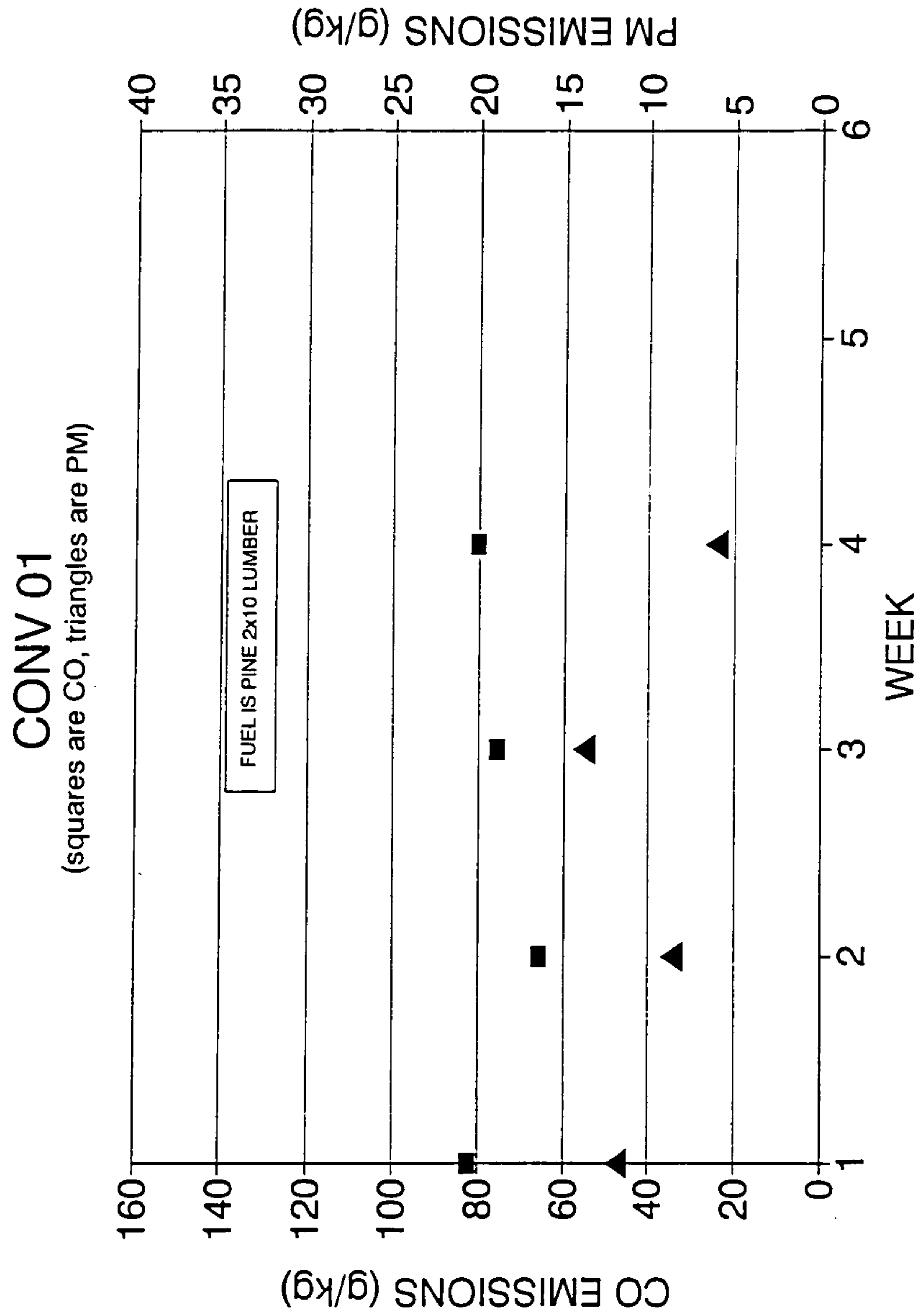

COAL 02
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
160
140
120
100
80
60
40
20
0
PM EMISSIONS (g/kg)
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
WEEK

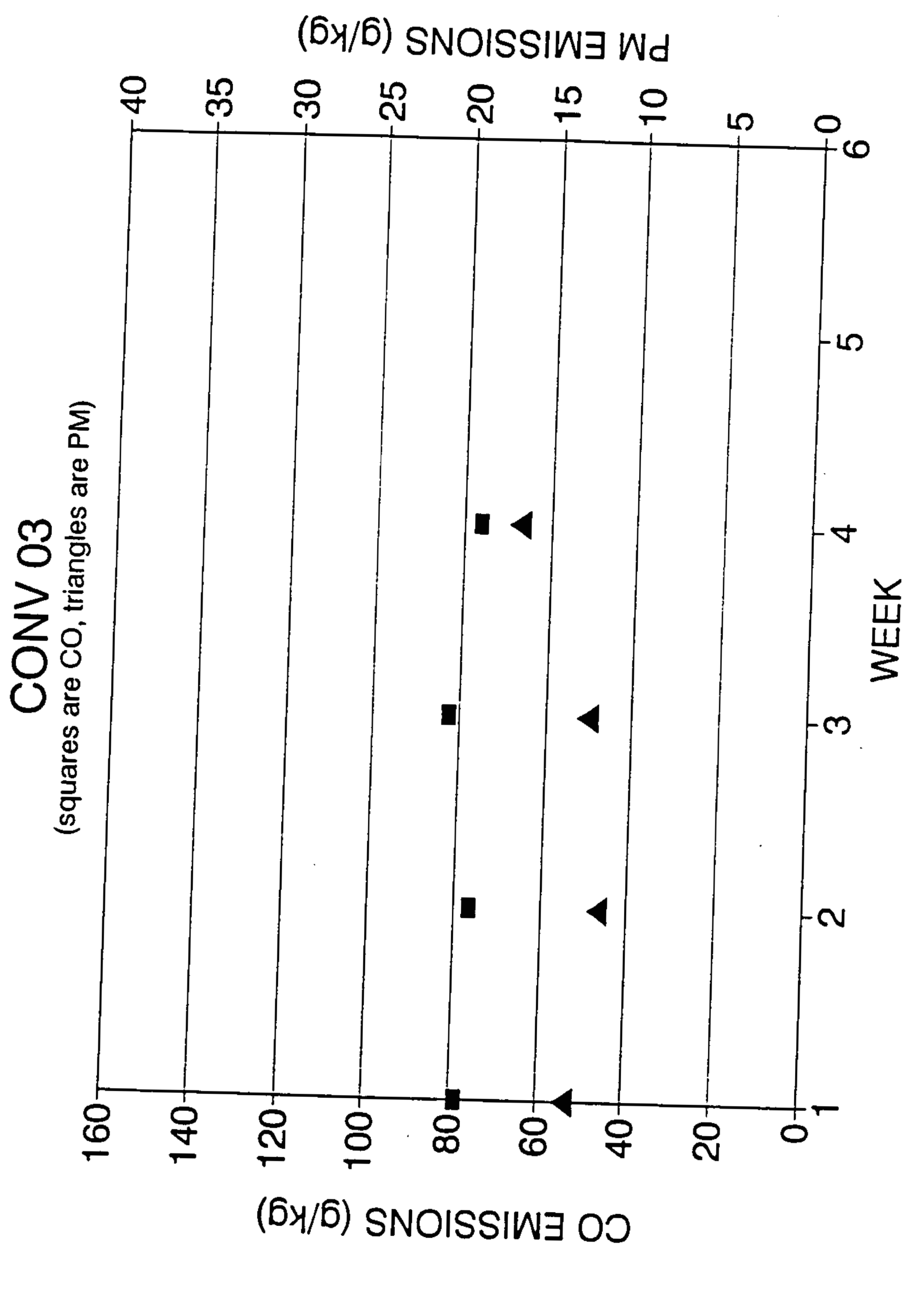

COAL 06
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
160
140
120
100
80
60
40
20
0
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6

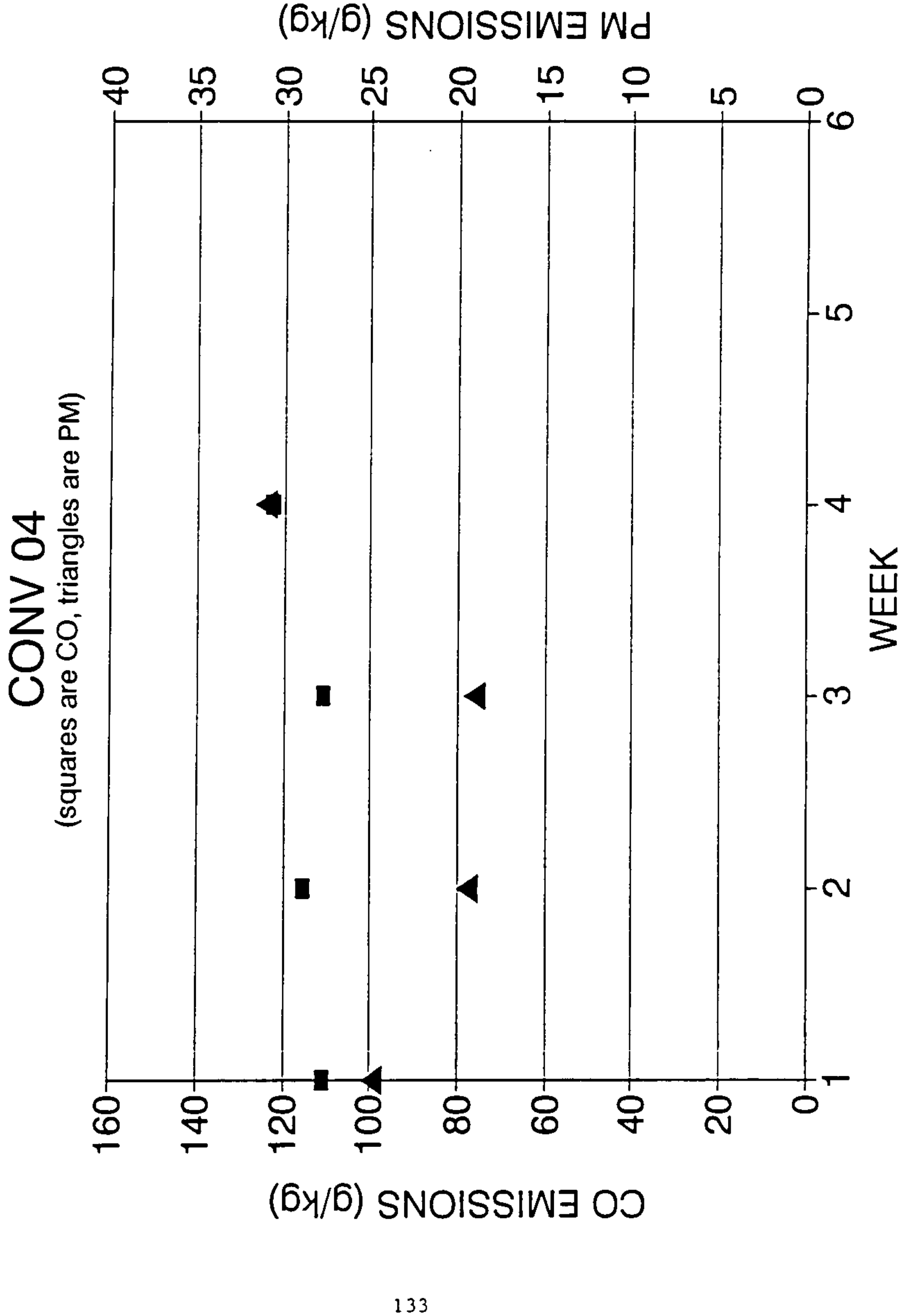
COAL 07

(squares are CO, triangles are PM)



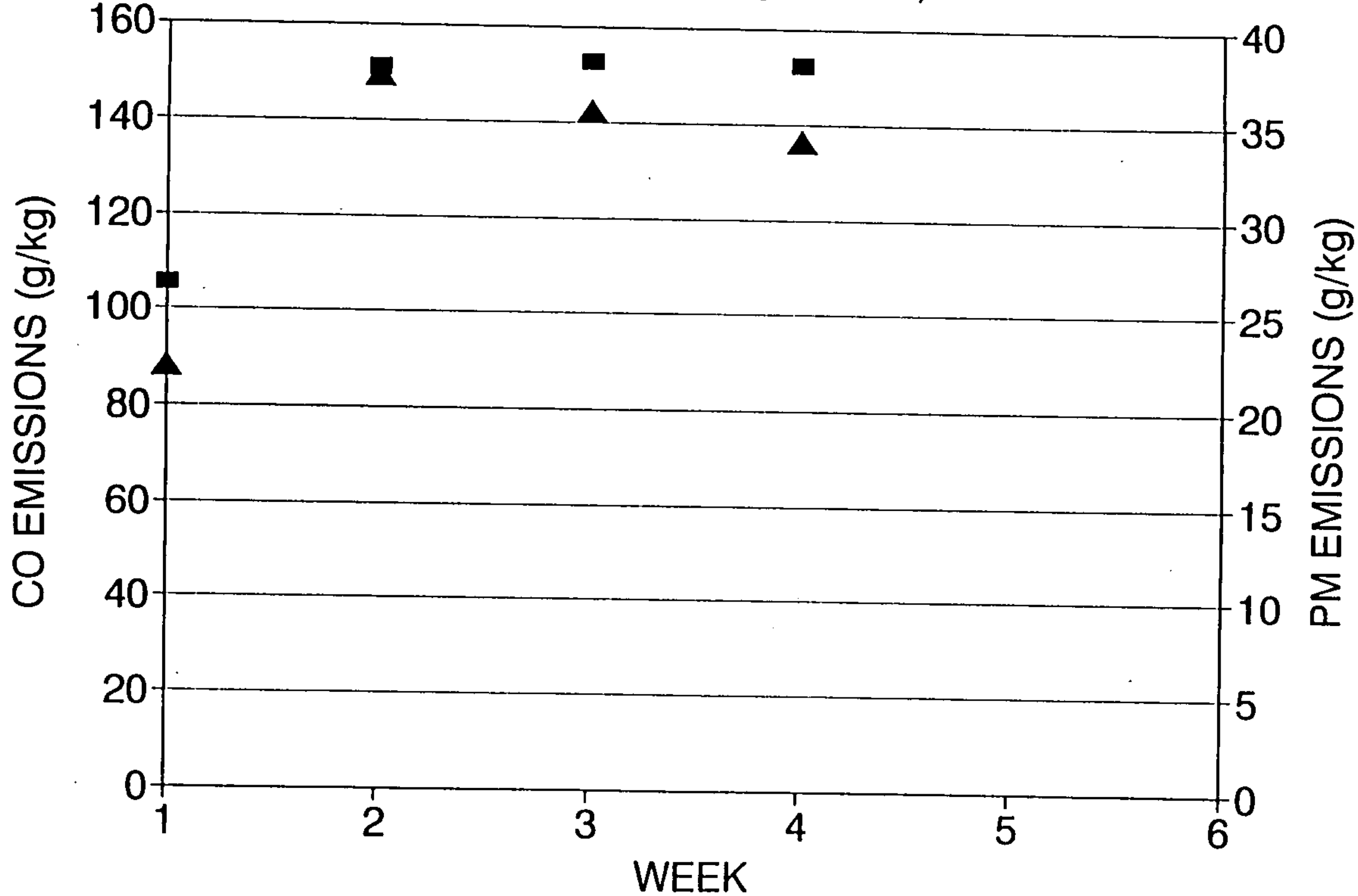

CONV 01
(squares are CO, triangles are PM)
FUEL IS PINE 2x10 LUMBER
CO EMISSIONS (g/kg)
0
20
40
60
80
100
120
140
160
PM EMISSIONS (g/kg)
0
5
10
15
20
25
30
35
40
WEEK
1
2
3
4
5
6

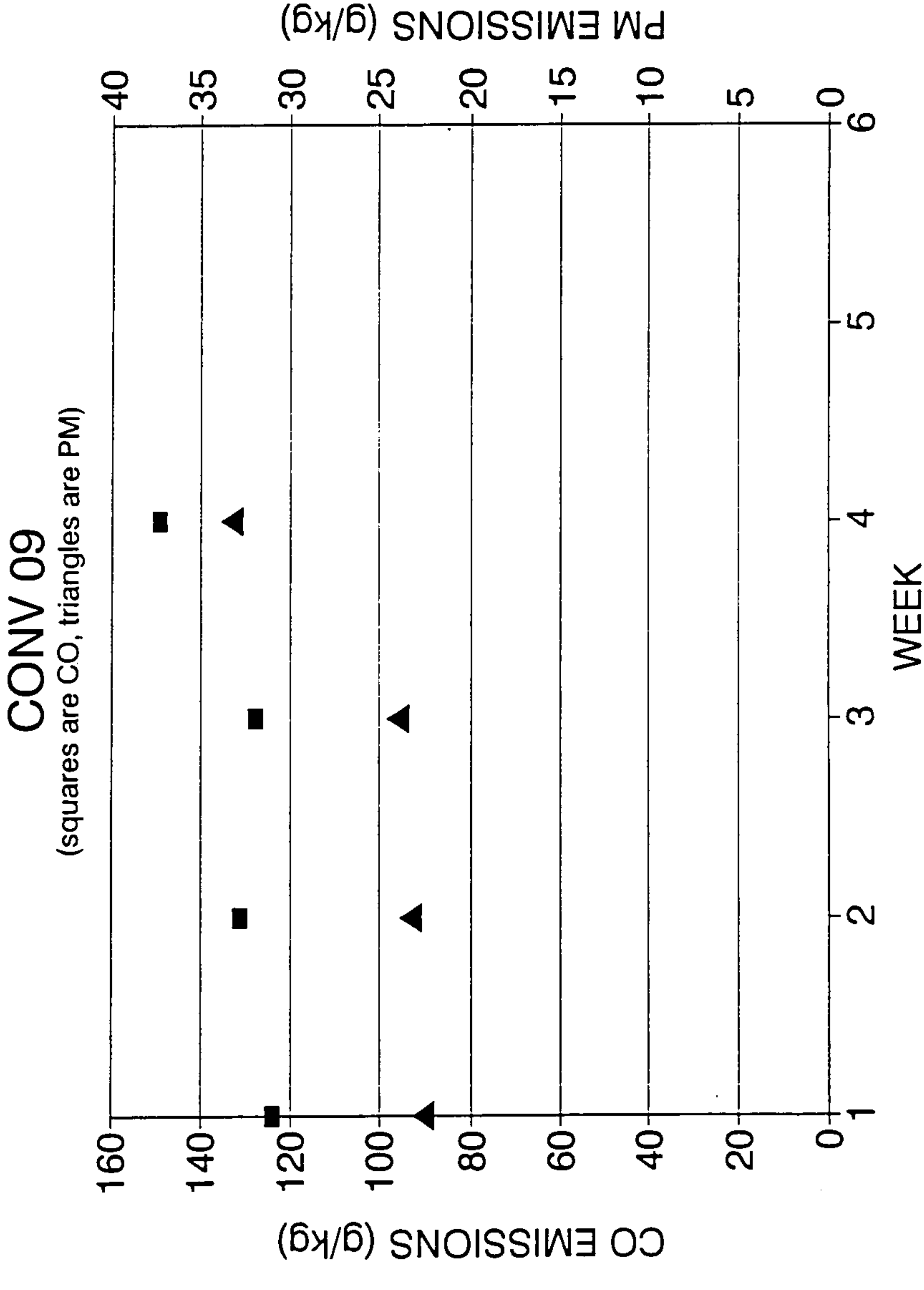

CONV 03
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6


CONV 04
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6

CONV 05

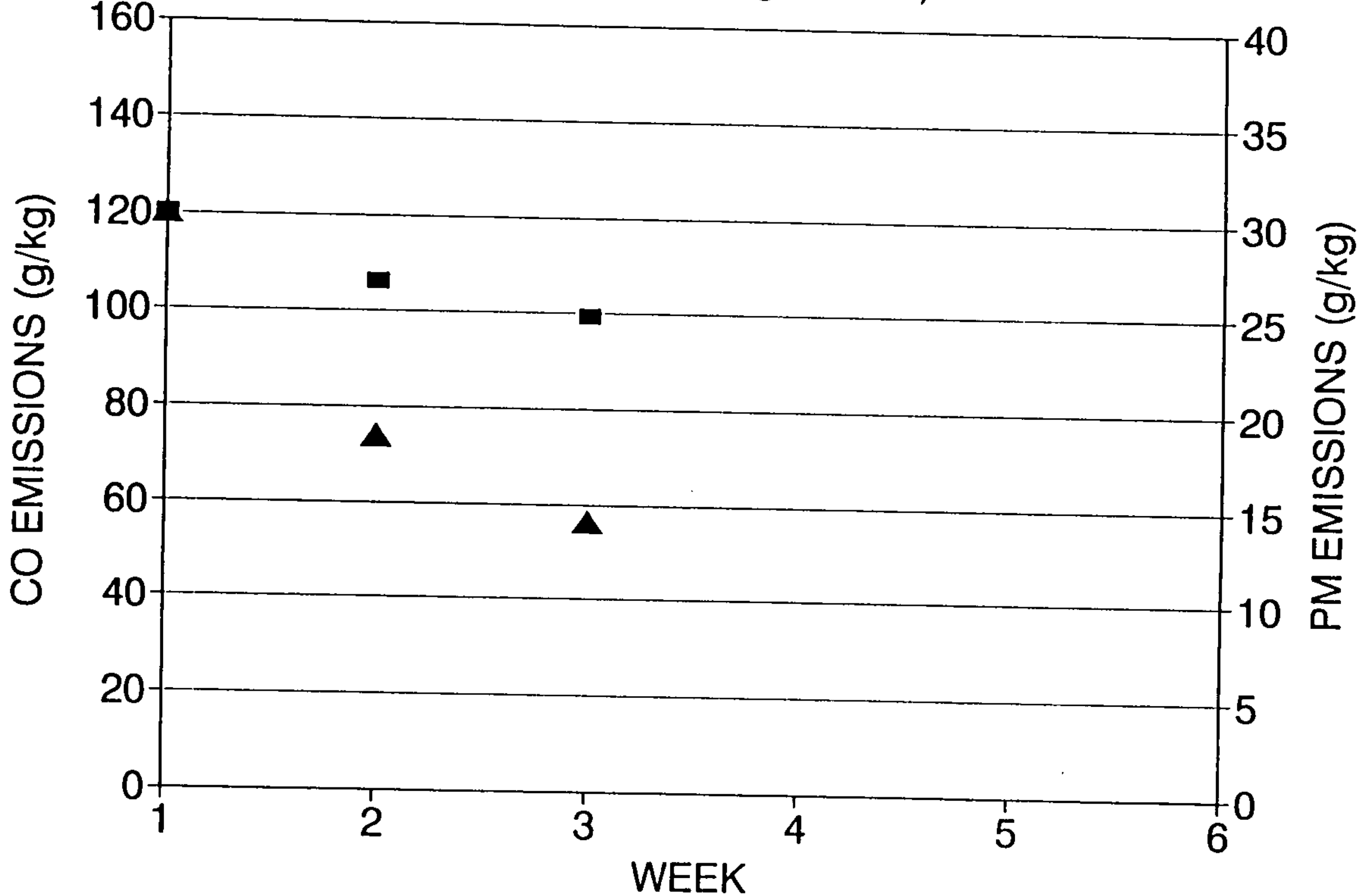
(squares are CO, triangles are PM)

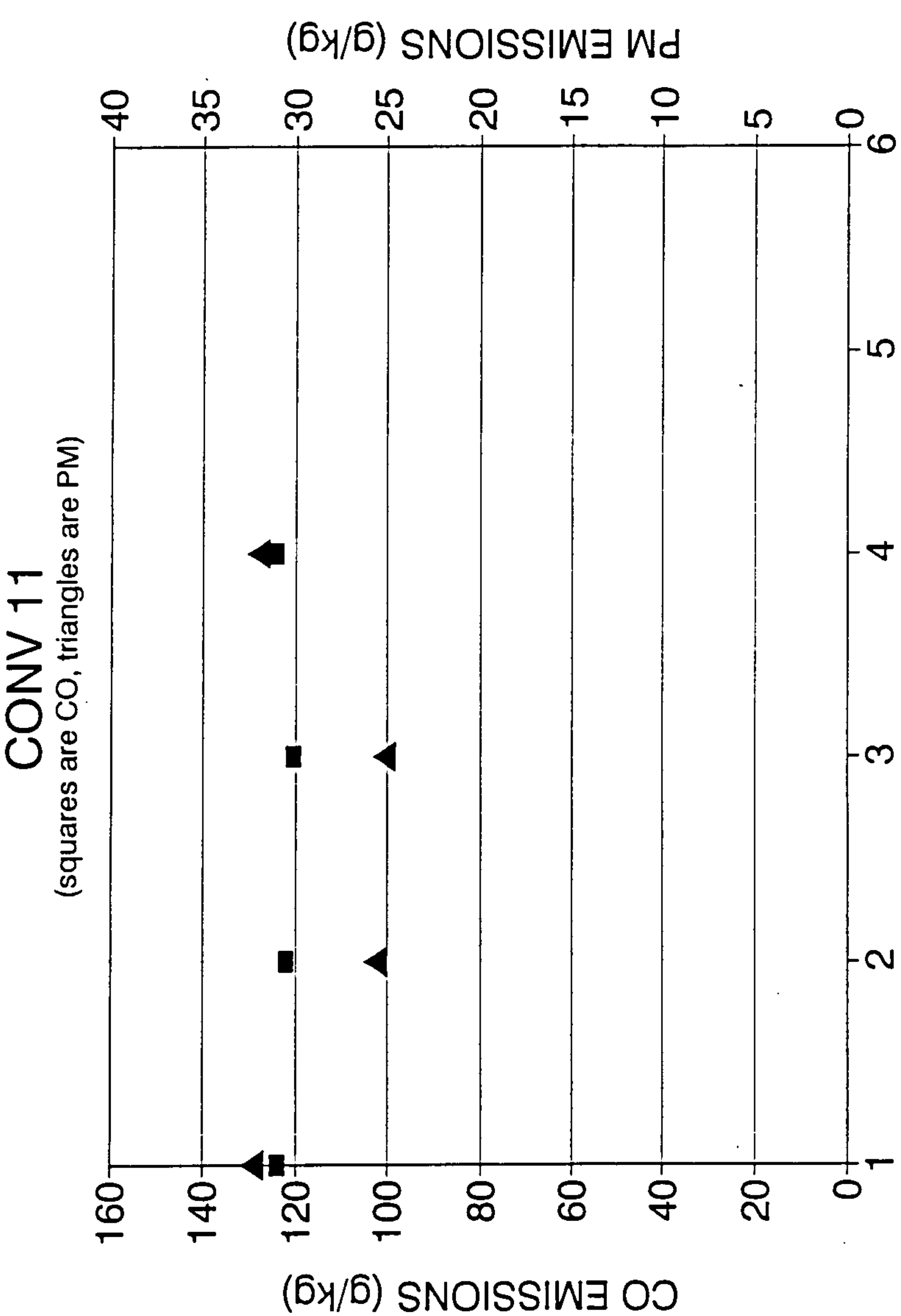


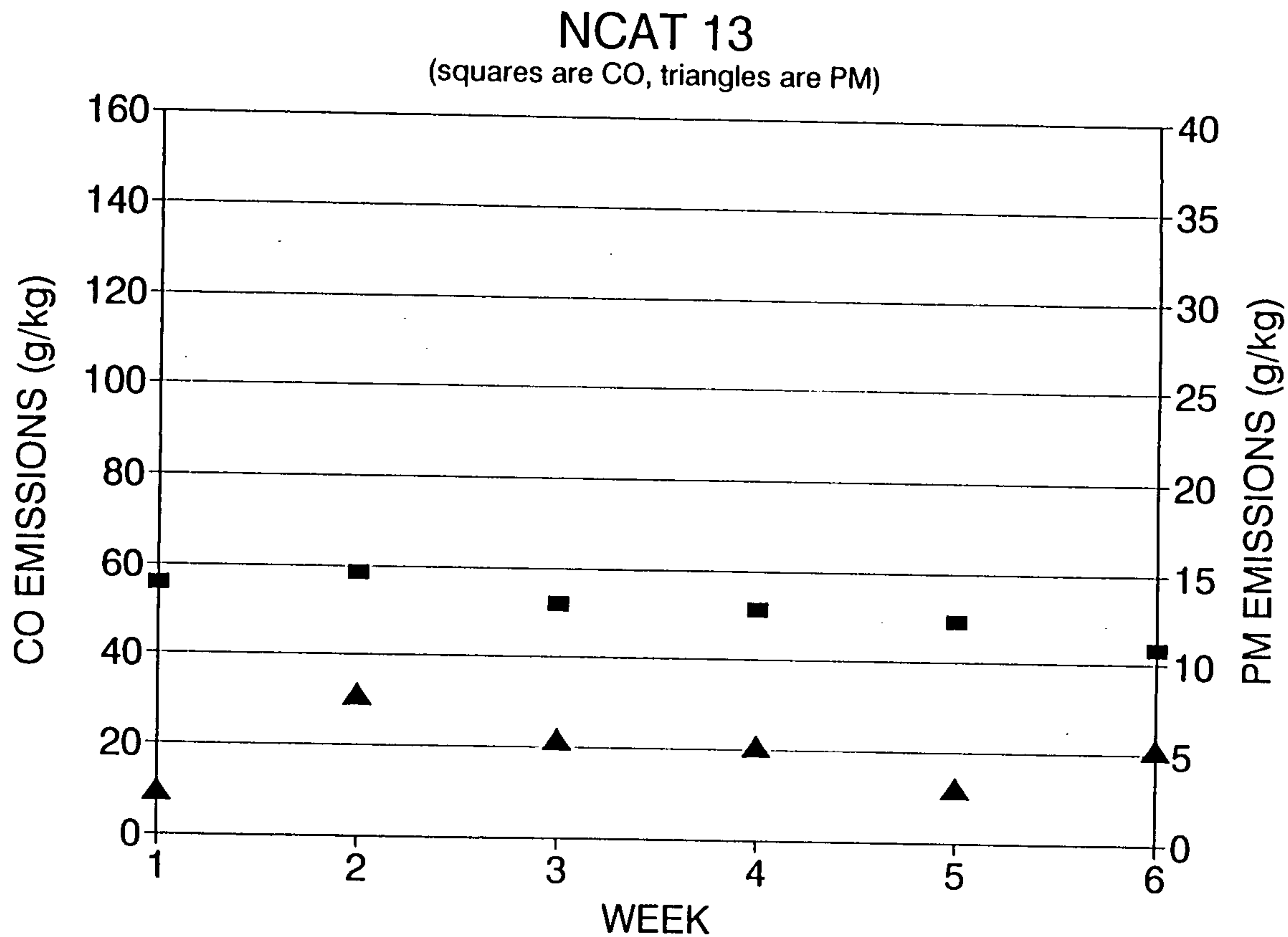

CONV 09
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
160
140
120
100
80
60
40
20
0
PM EMISSIONS (g/kg)
40
35
30
25
20
15
10
5
0
WEEK
1
2
3
4
5
6

CONV 10

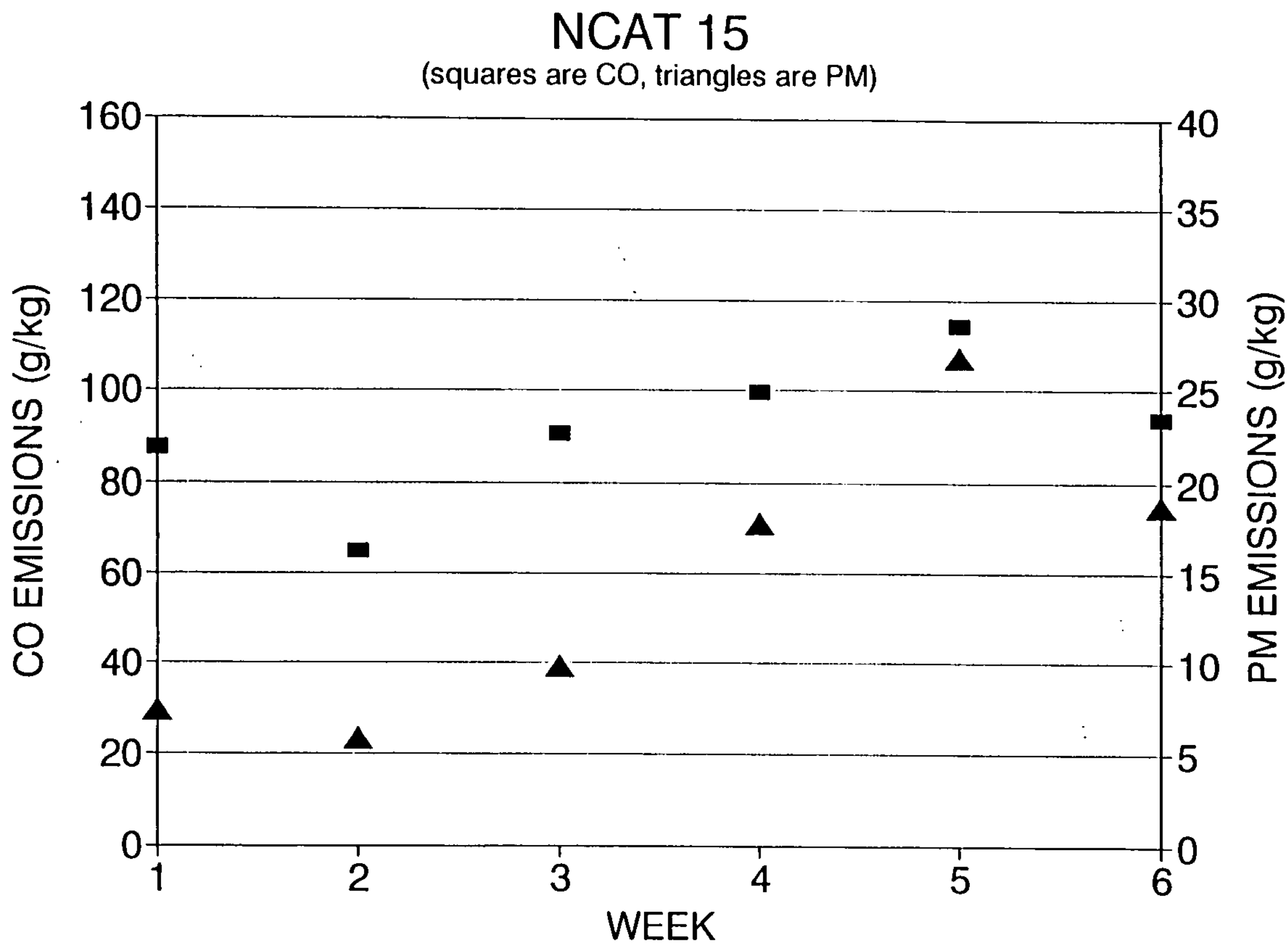
(squares are CO, triangles are PM)

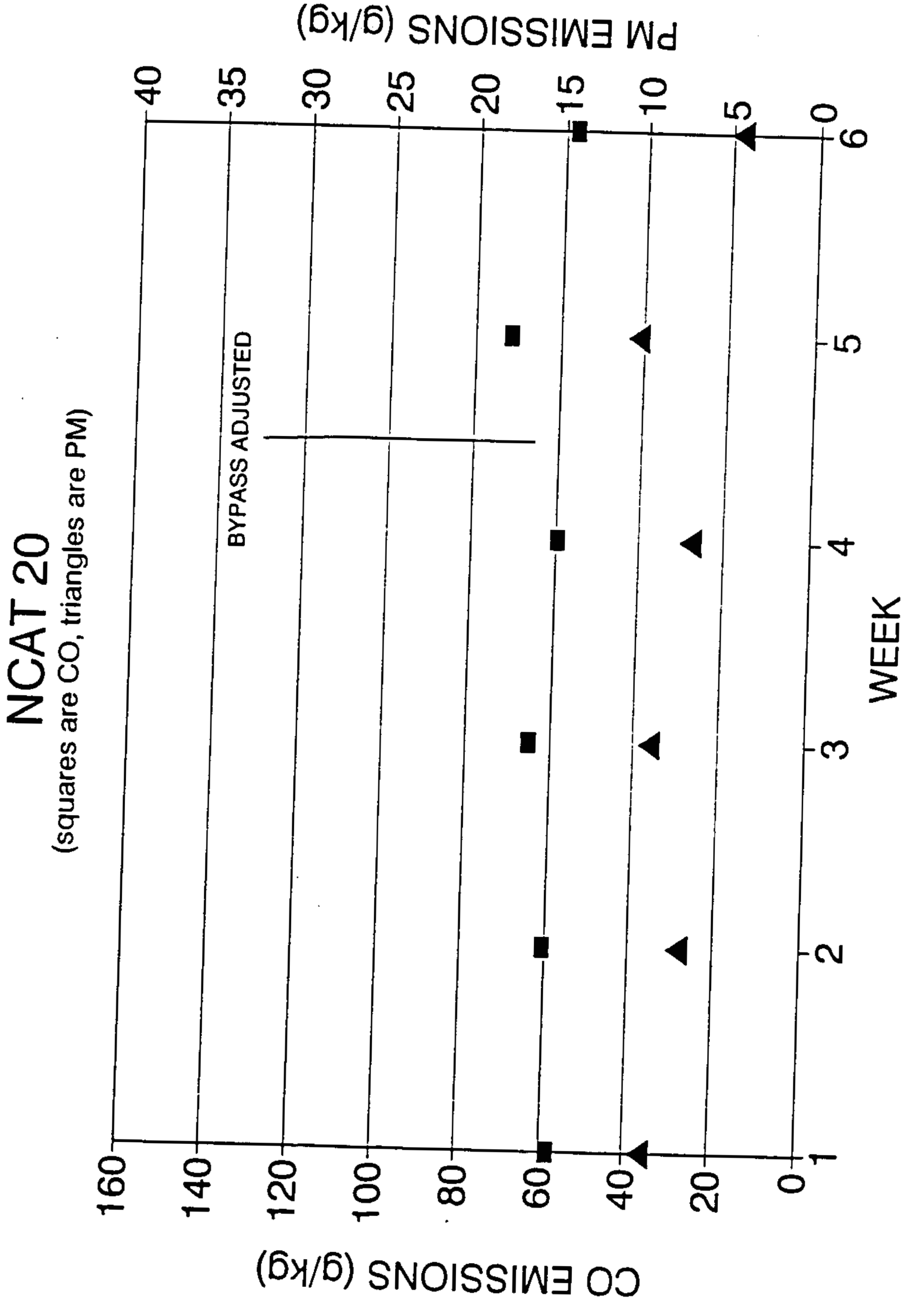


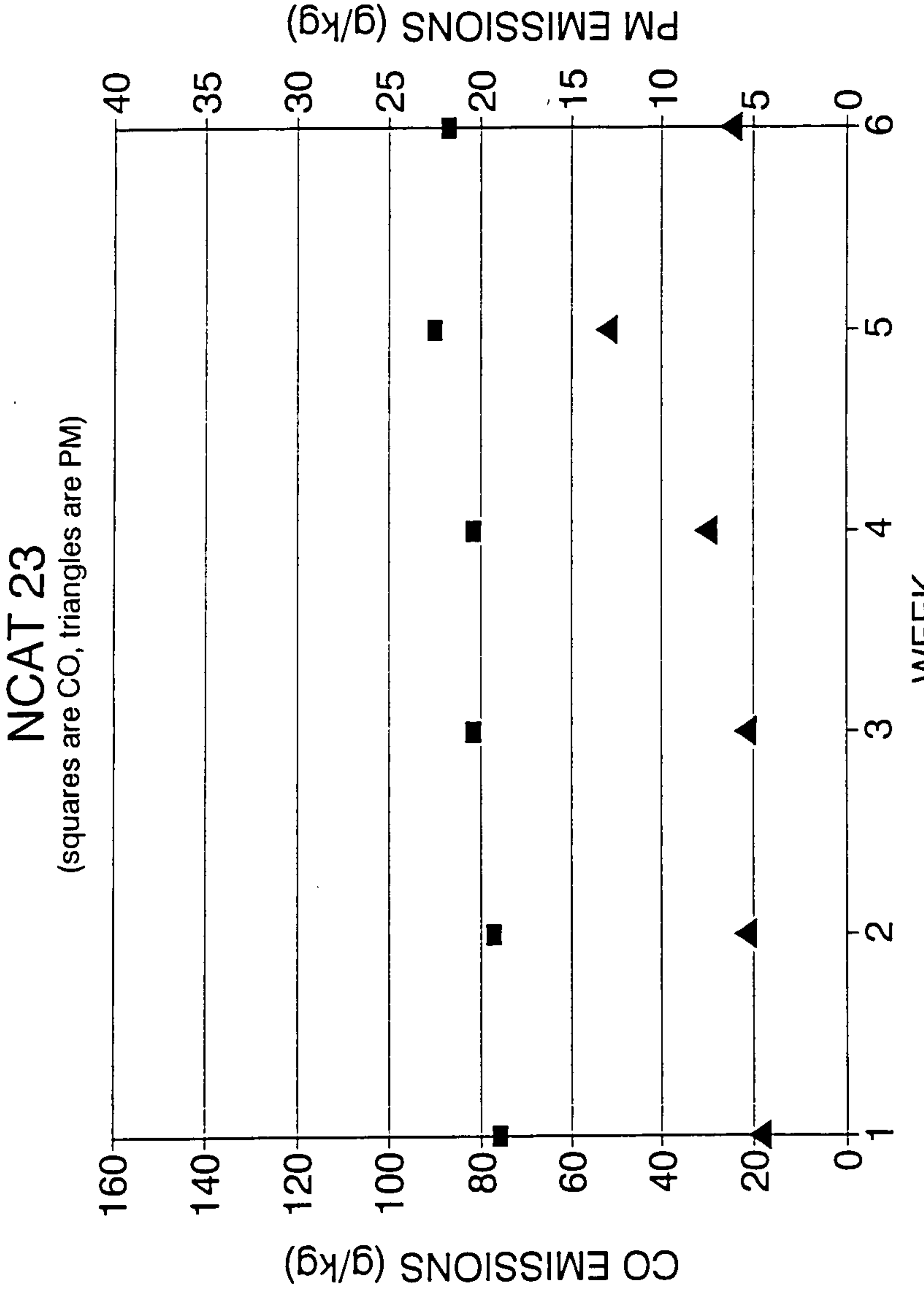

CONV 11
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6

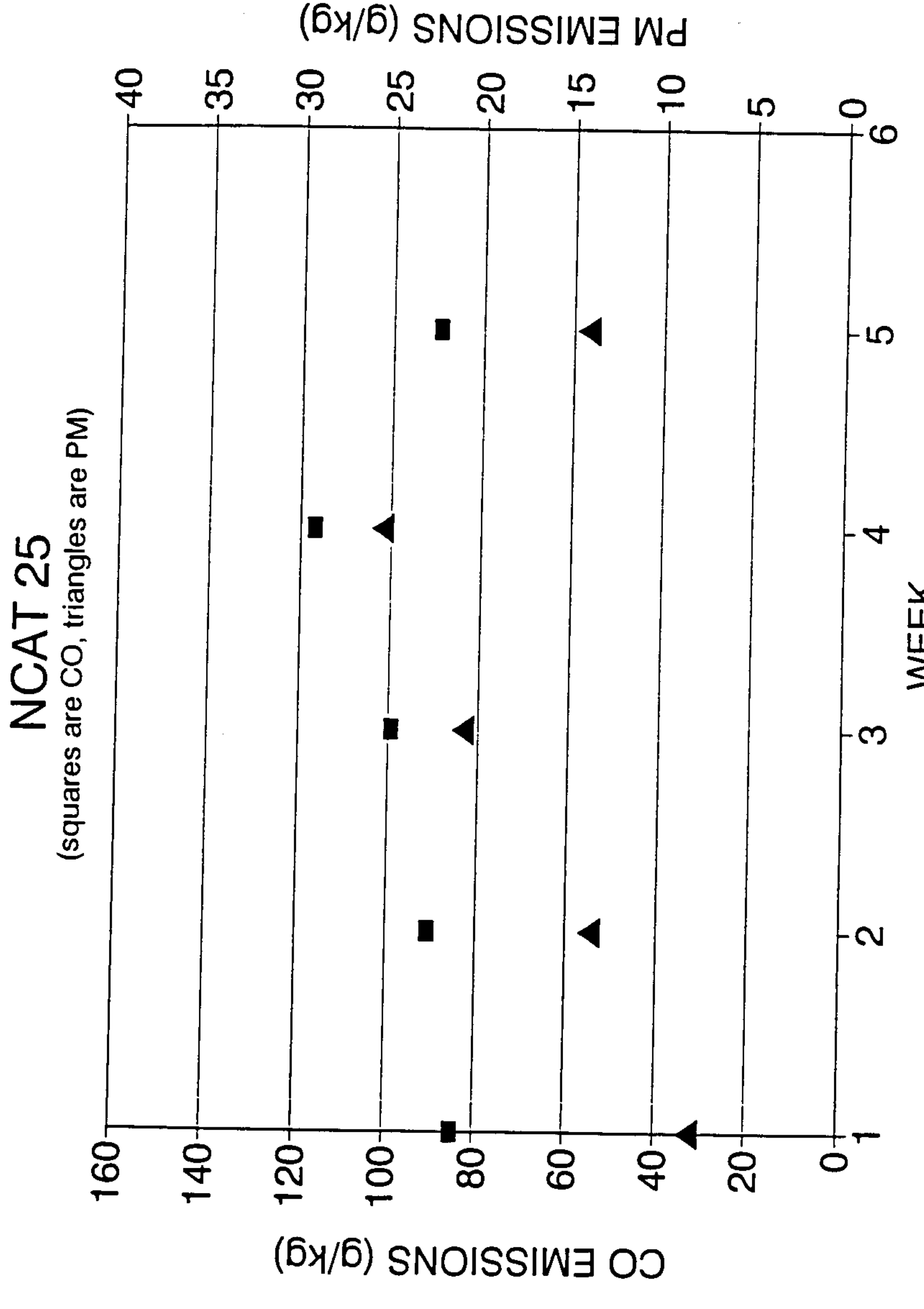


NCAT 13
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
160
140
120
100
80
60
40
20
0
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6


NCAT 15
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
PM EMISSIONS (g/kg)
WEEK
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40
1
2
3
4
5
6


NCAT 20
(squares are CO, triangles are PM)
BYPASS ADJUSTED
CO EMISSIONS (g/kg)
160
140
120
100
80
60
40
20
0
PM EMISSIONS (g/kg)
40
35
30
25
20
15
10
5
0
WEEK
1
2
3
4
5
6


NCAT 23
(squares are CO, triangles are PM)
CO EMISSIONS (g/kg)
0
20
40
60
80
100
120
140
160
PM EMISSIONS (g/kg)
0
5
10
15
20
25
30
35
40
WEEK
1
2
3
4
5
6


NCAT 25
(squares are CO, triangles are PM)
PM EMISSIONS (g/kg)
0
5
10
15
20
25
30
35
40
CO EMISSIONS (g/kg)
0
20
40
60
80
100
120
140
160
WEEK
1
2
3
4
5
6

Appendix K

EQUATIONS FOR ERROR ANALYSIS

The uncertainty in reported values of each of the emission parameters of interest was determined from uncertainty estimates of each of the independent (measured or assumed) variables in the study. For this purpose the final result was expressed explicitly in terms of the independent variables. The standard partial derivative approach was used to calculate the propogated error in the final result due to the uncertainty in each of the independent variables. For example, if

$$Z = f(x_1, x_2, \ldots x_n),$$

where Z - final value,

and $x_1 \ldots x_n$ are the independent variables

then

$$dZ = \left\{\left[\left(\frac{\partial Z}{\partial x_1}\right)\Delta x_1\right]^2 + \left[\left(\frac{\partial Z}{\partial x_2}\right)\Delta x_2\right]^2 + \cdots + \left[\left(\frac{\partial Z}{\partial x_n}\right)\Delta x_n\right]^2\right\}^{1/2} \qquad (1)$$

where, dZ - absolute uncertainty in final value, and

$\Delta x_1, \Delta x_2 \ldots \Delta x_n$ are uncertainties in each of the independent variables.

The uncertainty estimate dZ can also be expressed as a fraction of the final result as

$$\frac{dZ}{Z} = \left\{ \left[\left(\frac{\partial Z}{\partial x_1} \right) \frac{\Delta x_1}{Z} \right]^2 + \left[\left(\frac{\partial Z}{\partial x_2} \right) \frac{\Delta x_2}{Z} \right]^2 + \cdots + \left[\left(\frac{\partial Z}{\partial x_n} \right) \frac{\Delta x_n}{Z} \right]^2 \right\}^{1/2} \qquad (2)$$

The uncertainty in each of the independent variables is estimated from one or more of the following:

(1) Instrument specifications

(2) Field and laboratory experience

(3) Calibration against standards

(4) Repetitive measurements of a single sample

(5) Technical audit performed by RTI

The uncertainties in each of the independent variables are given in Table 4. These are based on a confidence interval of 95%.

The PM rate can be expressed explicitly in terms of the independent variables as

$$\text{PMRATE} = \frac{(C)\,(XC)\,[3.059\,(1-z) - (1.530 - (1+y)\,(\frac{W}{XC})\,(CO) + (\frac{W}{XC})\,(CO_2)]\,(m)\,(\frac{1}{1+MC})\,(T)}{(t)\,[P_2-P_1]\,[(12)\,(CO_2) - (2)\,(CO) + (4)\,(z) + 28]\,[CO_2 + (1+y)\,(CO)]\,(V)} \qquad (3)$$

The symbols in this discussion are defined on page 11 of the body of the report.

The partial derivative of the PMRATE was taken with respect to each of the 14 independent variables shown above. Expressing the result in the form of equation (2) we obtain for the PMRATE

$$\frac{dPMRATE}{PMRATE} = \Bigg[\left(\frac{\Delta C}{C}\right)^2 + \left\{ - \left(\frac{k1}{k2}\right) - \frac{[(1+y)\,k4 - (2)\,(k5)]}{(k4)\,(k5)} \right\}^2 (\Delta CO)^2$$

$$+ \left\{ \frac{(w/XC)}{k2} - \frac{[(12)\,(k5) + k4]}{(k4)\,(k5)} \right\}^2 (\Delta CO_2)^2 + \left(\frac{\Delta m}{m}\right)^2$$

$$+ (\Delta MC(-MC)(k_3))^2 + (\frac{\Delta V}{-V})^2 + (\frac{\Delta T}{T})^2 + \left(\frac{\Delta P_1}{P_2 - P_1}\right)^2 + \left(\frac{\Delta P_2}{P_1 - P_2}\right)^2$$

$$+ \left(\frac{\Delta t}{-t}\right)^2 + \left\{ (CO)\left[\frac{(w/XC)}{k2} - \frac{1}{k5}\right] \right\}^2 (\Delta y)^2$$

$$+ \left\{ -\frac{3.059}{k2} - \frac{4}{k4} \right\}^2 (\Delta z)^2 + \left\{\frac{k5}{(k2)(XC)}\right\}^2 (\Delta w)^2$$

$$+ \left\{\frac{(3.059)(1-z-CO/2)}{(k2)(XC)}\right\}^2 (\Delta XC)^2 \Bigg]^{1/2} \quad (4)$$

where

$$k1 = 1.53 - (1+y)\left(\frac{W}{XC}\right)$$

$$k2 = (3.059)(1-z) - (10)(k1) + \left(\frac{W}{XC}\right)(CO_2)$$

$$k3 = \frac{1}{1+MC}$$

$$k4 = (12)(CO_2) - (2)(CO) + (4)(z) + 28$$

$$k5 = CO_2 + (1+y)(CO)$$

The PM emission factor (in terms of the independent variables) is given by

$$PMEF = \frac{(C)(XC)(K2)(T)}{(P_2 - P_1)(K4)(K5)(V)} \quad (5)$$

where k2, k4 and k5 are as defined above.

The uncertainty in the PM emission factor can be evaluated from

$$dPMEF = \left[\left(\frac{\Delta c}{c}\right)^2 + \left\{ -\frac{k1}{k2} - \frac{[(1+y)(k4)-(2)(k5)]}{(k4)(k5)} \right\}^2 (\Delta CO)^2 \right.$$

$$+ \left\{ \frac{(w/XC)}{k2} - \frac{[(12)(k5)+k4]}{(k4)(k5)} \right\}^2 (\Delta CO_2)^2 + \left(\frac{\Delta V}{-V}\right)^2$$

$$+ \left(\frac{\Delta T}{t}\right)^2 + \left(\frac{\Delta P_1}{P_2 - P_1}\right)^2 + \left(\frac{\Delta P_2}{P_1 - P_2}\right)^2 + \left\{ (CO)\left[\frac{(W/XC)}{K2} - \frac{1}{k5}\right] \right\}^2 (\Delta y)^2$$

$$+ \left\{ -\frac{3.059}{k2} - \frac{4}{k4} \right\}^2 (\Delta z)^2 + \left\{ \frac{K5}{(k2)(XC)} \right\}^2 (\Delta w)^2$$

$$\left. + \left\{ \frac{(3.059)(1-z-CO/2)}{(k2)(XC)} \right\}^2 (\Delta XC)^2 \right]^{1/2} \qquad (6)$$

The carbon monoxide emission rate is given by

$$CORATE = \frac{(XC)(k2)(m)(k3)(28)(CO)(1000)}{(t)(k4)(k5)} \qquad (7)$$

The uncertainty in the CORATE measurement is

$$\frac{dCORATE}{CORATE} = \left[\left\{ \frac{[k2-(k1)(CO)]}{(k2)(CO)} - \frac{[(1+y)(k4)-(2)(k5)]}{(k4)(k5)} \right\}^2 (\Delta CO)^2 \right.$$

$$+ \left\{ \frac{(w/XC)}{k2} - \frac{[(12)(k5)+k4]}{(k4)(k5)} \right\}^2 (\Delta CO_2)^2$$

$$+ \left(\frac{\Delta m}{m}\right)^2 + \{ (\Delta MC(-MC)\ (k_3)) \}^2 + \left(\frac{\Delta t}{-t}\right)^2$$

$$+ \left\{(CO)\left[\frac{(w/XC}{k2} - \frac{1}{k5}\right]\right\}^2 (\Delta y)^2$$

$$+ \left\{\frac{-3.059}{k2} - \frac{4}{k4}\right\}^2 (\Delta z)^2 + \left\{\frac{k5}{(k2)\ (XC)}\right\}^2 (\Delta w)^2$$

$$+ \left\{\frac{(3.059)\ (1-z-CO/2)}{(k2)\ (XC)}\right\}^2 (\Delta XC)^2 \Bigg]^{1/2} \tag{8}$$

Finally the CO emission factor is obtained by

$$\text{COEF} = \frac{(XC)\ (k2)\ (28)\ (CO)\ (1000)}{(k4)\ (k5)} \tag{9}$$

The uncertainty in this result is given by

$$\frac{\text{dCOEF}}{\text{COEF}} = \Bigg[\left\{\frac{[k2-(k1)\ (CO)]}{(k2)\ (CO)} - \frac{[(1+y)\ (k4)-(2)\ (k5)]}{(k4)\ (k5)}\right\}^2 (\Delta CO)^2$$

$$+ \left\{\frac{(w/XC}{k2} - \frac{[(12)\ (k5)+k4]}{(k4)\ (k5)}\right\}^2 (\Delta CO_2)^2$$

$$+ \left\{(CO)\left[\frac{(W/XC)}{k2} - \frac{1}{k5}\right]\right\}^2 (\Delta Y)^2$$

$$+ \left\{\frac{-3.059}{k2} - \frac{4}{k4}\right\}^2 (\Delta z)^2 + \left\{\frac{k5}{(k2)(XC)}\right\}^2 (\Delta w)^2$$

$$\left. + \left\{\frac{(3.059)(1-z-CO/2)}{(k2)(XC)}\right\}^2 (\Delta XC)^2 \right]^{1/2} \qquad (10)$$

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT The report gives results of an evaluation of the field performance of woodburning and coalburning appliances in and around Crested Futte, CO. Measurements included particulate matter (PM), carbon monoxide (CO), and weekly average burn rates. Woodburning appliances included conventional airtight stoves, EPA-certified catalytic stoves, and EPA-certified noncatalytic stoves. Compared to the emissions measured from conventional stoves, the certified stoves reduced PM emission factors (grams/kilogram) by 53% and CO emission factors by 49%. Coalburning appliances included a commercial scale boiler, a residential stoker, and a hand-fired coalstove. The coalburning appliances were compared to conventional woodstoves on a grams of pollutant per joule of heat output basis. The automatically stoked coal appliances reduced PM and CO emissions by roughly 84 and 85%, respectively. The hand-fired stove was cleaner than expected, reducing PM by 55% and CO by 27%.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Carbon Monoxide	Pollution Control	13B	07B
Stoves	Catalysis	Stationary Sources	13A	07D
Wood	Boilers	Particulate	11L	
Coal	Stokers		21D	
Combustion			21B	
Particles			14G	

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