Pelly Crossing Wood Chip Boiler Emissions

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Yukon
Government

EMISSION MONITORING SURVEY OF WOODCHIP BOILER EXHAUSTS

Pelly Crossing, Yukon

Prepared For:

GOVERNMENT OF YUKON
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SUMMARY

The following table illustrates the quantitative levels of specific parameters for certain boiler fuels and operating conditions.

Fuel/ Condition	Total Emissions*			Volatiles	NO_x	Overall Boiler Efficiency	Particle Size Dp 50
	(mg/m^3)	(mg/m^3 @ 12% CO_2)	(kg/GJ)	%	(mg/m^3)	(%)	(Microns u)
Dry Chips/ Hot Burn (Avg)	72	154	0.078	44	11	88	2.6
Dry Chips/ Slow Burn (Avg)	102	1420	0.751	92	1.9	57	1.4
Cordwood/ Hot Burn	68	123	0.067	46	14	88	-
Cordwood/ Slow Burn	60	402	0.192	87	0.3	78	-
Green Chips/ Hot Burn	61	167	0.118	40	12	81	-
Green Chips/ Slow Burn	280	3362	33.8	97	2.0	6	-

The most commonly occuring hydrocarbons were phenols and cresols, and their relative amounts were greater in the slow fire mode than the hot fire mode.

The only priority pollutant POM's detected in any of the samples were phenantharene/ anthracene at a concentration of 0.08 mg/m^3 in Test No. 1, a dry/slow burn, and naphthalene at a concentration of 0.16 mg/m^3 for Test No. 8, a green/slow burn. Any other POM's were either below the detectable limit of the method or not present at all.

The British Columbia provincial guidelines for particulate discharges from combustion sources, which would apply to this process during hot burns, allow particulate concentrations of 230 mg/m^3 @ 12% CO_2. The process would most likely be considered a non-combustion source during slow burns and the guideline would be 230 mg/m^3 (uncorrected for CO_2 concentration). The guidelines consider particulate as the "front-half" catch only. The guidelines do not address nitrogen oxides at present.

The results of these survey tests would be well within the B.C. guidelines and the unit would be considered in compliance if operated in B.C.

Studies of woodstoves (Ref. 5 and 7) have indicated particulate discharge (including condensables) at about 15 to 30 grams of particulate/kilogram of fuel (g/kg) at about 95% combustion efficiency. This survey shows results of about 3 g/kg for hot burns and from 3 to 27 g/kg for slow burns. It is evident from these results that the Pelly Crossing boiler operates at a higher combustion efficiency and emits a lower level of particulate discharge that the woodstoves studies in the reference material.

Although not regulated, nitrogen oxides at the concentrations determined during this study, would be considered by the B.C. Waste Management Branch to have a minimal environmental impact.

* (Particulate and Condensed Extractables)

1.0 INTRODUCTION

The Energy and Mines Branch of the Government of Yukon retained A. Lanfranco and Associates to conduct a series of emission measurements on the exhaust of a woodchip boiler located at Pelly Crossing, Yukon.

The primary purpose of the survey was to quantify levels of air contaminants under varying boiler operating conditions. Parameters investigated were particulates and particle size, nitrogen oxides, oxygen, carbon dioxide, carbon monoxide and hydrocarbons including POM and Non-POM.

An additional goal of the survey was to determine boiler efficiencies and present the relationship between emission levels and useful heat output.

This report documents the methods used and the results found for the survey conducted on 4, 5, 6 and 7 March 1985.

2.0 PROCESS DESCRIPTION

The unit tested in this study was a Vyncke WW300S three pass vertical fire tube boiler. The function of the boiler is to provide heat to the Pelly Crossing school.

Heated boiler water is pumped to a water/glycol heat exchanger. The glycol is then pumped throughout the school where heat is released by means of radiators.

Normal boiler fuel is fire killed spruce and some fire killed pine. The fuel is chipped into a holding bin outside the school and fed to the boiler by a series of screw augers. Emissions from firing seasoned cordwood and green woodchips were also investigated in this study.

The boiler operates in two modes which are controlled by a pre-set aquastat. The hot-fire mode operates whenever there is a heat demand, i.e. when the aquastat temperature falls below the set point, and the slow fire or smoldering mode operates when the aquastat temperature is above the set points. During the hot firing only, the chip feed and the exhaust fan run until the upper aquastat limit is achieved. In both modes the boiler exhaust gasses are partially "cleaned" by a cyclonic separator prior to being discharged to the atmosphere through a 25 cm insulated smoke stack.

3.0 METHODS

All sampling and analytical methods conform to those accepted by the B.C. Ministry of Environment, US EPA, or the Oregon DEQ.

3.1 Sampling Techniques

Three independent sampling systems were used to collect the various samples. A Napp (Lear Siegler) stack sampling train (Fig 1), modified for hydrocarbon impingement and without a cyclone was used for particulate sampling. An Anderson Mark V in-stack cascade impactor was used for particle size determinations. A caustic-permanganate impinger train equipped with a glass probe, flow controller, pump and dry gas meter was used for NO_x sampling.

All particulate and particle size sampling was conducted isokinetically. A twelve point equal area sampling regime was used for each test. Points were sampled for 5 minutes each on slow burns and 3.5 minutes each on hot burns. Temperature, pressure, moisture, O_2, CO_2, and CO were measured on an integrated basis for each test. Stack gas velocity pressure was measured with a calibrated S-type pitot tube attached to the heated sampling probe. The low velocity pressures associated with the slow burn mode were measured with a high sensitivity oil manometer. Temperatures were measured with a chromel-alumel type thermocouple. Flue gas analysis for O_2, CO_2 and CO was conducted with a Hayes 601 Orsat analyzer from an integrated bag sample collected at the stack. Low CO Orsat readings were confirmed by Draeger tube analysis.

NO_x samples were extracted from the stack at a constant rate of 0.5 L/min into a series of three impingers each containing 100 mL of 4% potassium permanganate in 2% sodium hydroxide.

Grab samples of fuel were collected for moisture and heat value analysis. Fuel feed rates were measured by collecting the auger discharge over a timed period.

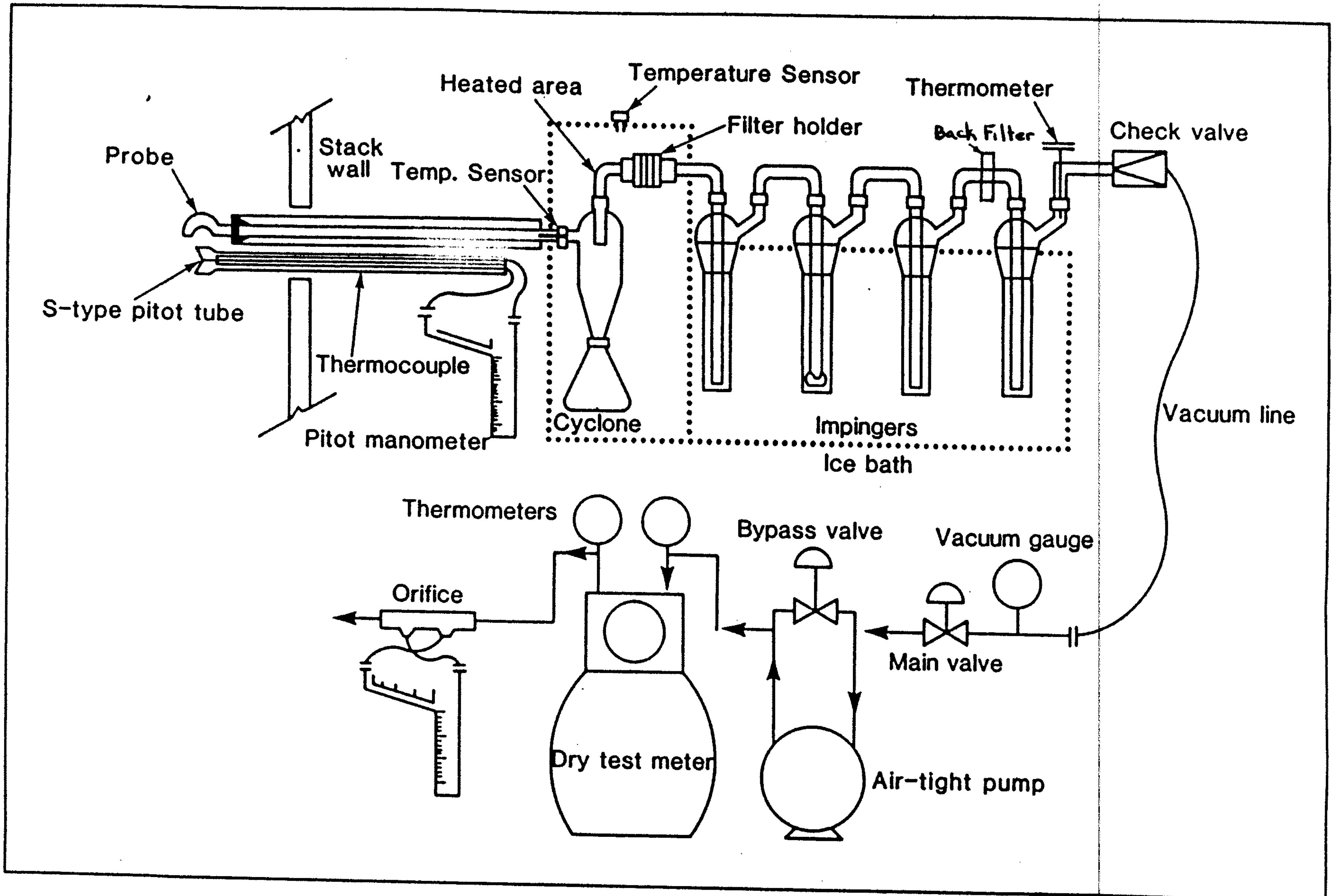

Figure 1 Particulate Sampling Train

3.2 Analytical Techniques

3.2.1 Sample Clean-up

The necessity to provide hydrocarbon analysis of the particulate samples required special clean-up procedures. The particulate sample consisted of four components: a probe wash and filter which comprised the "front half" of the sampling train; and an impinger solution and a back filter which comprised the "back half" of the train. After sampling the front filter was removed from its holder, placed in an aluminum dish and sealed. The probe, nozzle, and pre-filter glassware were washed with acetone and methylene chloride into clean glass sample bottles and sealed. The impinger waters were measured with a glass graduated cylinder and placed in a glass sample bottle. The impingers and connecting glassware were rinsed with acetone which was added to the impinger water. The back filter was removed from its holder and sealed in an aluminum foil dish.

NO_x samples were washed into polyethylene containers and sealed.

3.2.2 Total Emission Analysis

Gravimetric analysis of the front filters was conducted by dessicating to constant weight and weighing. A known portion of the probe wash was evaporated to dryness and weighed. A known portion of the impinger solution and back filters were extracted with freon. The extracts were evaporated and the residues weighed. The combustible fractions of the front-half of the train was analyzed by igniting a portion of the front filters and dried probe wash residues at 600^{o}C and reweighing. Blanks were carried through all procedures.

3.2.3 Hydrocarbon (HC) Analysis

The unused portions (for total emissions) of each sample component were used for HC analysis. Each component was extracted with methylene chloride and the extracts combined and reduced in volume for gas chromatographic (GC) or GC-mass spectrographic (GC-MS) analysis.

Six sample extracts were preliminarily screened using a Hewlett-Packard 5890 GC equipped with a FID detector. A capillary column, 25 m x 0.32 mm/ID 5% phenyl methyl silicon, and helium carrier gas were utilized.

The complex nature of the samples necessitated further examination by GC-MS methodology. The GC-MS technique is one with greater sensitivity and applicability than straight GC analysis. Two of the more complicated samples underwent GC-MS scrutiny with resultant identification and quantification of POM/non-POM compounds. The quantification of POM/non POM compounds in the other four samples was conducted by peak area comparisons for compounds identified by the GC-MS runs. Again, blanks were carried through all procedures.

3.2.4 Nitrogen Oxides (NO_x) Analysis

Nitrogen oxides, expressed as nitrogen dioxide, were determined using the cadmium reduction plus diazotization method. With this method NO_x are quantitatively converted to nitrate which is subsequently reduced to nitrite and determined by diazotizing with sulfanilamide and coupling with N-(1-napthyl) - ethylene diamine. The coloured solution is measured at 529 nm with the result compared to a series of prepared standards in order to calculate the amount of nitrogen in each sample.

3.2.5 Particle-Size Analysis

The particle size analysis was a gravimetric analysis where material deposited on a series of impaction plates is determined by the difference in weight of the plates before and after particle deposition. The particle size associated with each plate is determined from sampling parameters. An Anderson Mark V impactor was used for this analysis.

3.3 Boiler Efficiency Calculations

Overall boiler efficiences were determined by the stack loss method. This method includes the determination of combustion efficiency and heat transfer efficiency. Combustion efficiency is calculated as the percentage represented by the actual heat produced in the firebox relative to the total heat production of the fuel consumed. Heat transfer efficiency is calculated as the percentage represented by the useful heat released to the boiler water relative to the actual heat produced in the firebox. Overall efficiency is calculated as the product of combustion efficiency and heat transfer efficiency.

4.0 RESULTS

Particulate emission results have been calculated in terms of mg/m^3, mg/m^3 @ 12% CO_2, kg/h, and kg/GJ of useful heat output. The total emission concentration ranged from 59.7 to 280 mg/m^3 for the eight tests conducted (Table 1). The total mass emission rate however showed a broader range, from 0.062 to 33.8 kg/GJ of useful heat output.

The gravimetric results (Table 2) indicate that, during the slow burn cycles, between 55 and 75 percent of the collected total emission was contributed by the back-half or condensable component of the sampling train. During the hot burn cycles only 14 to 25 percent of the material collected was condensable matter.

Nitrogen oxides were generally 2 mg/m^3 or less during the slow burn cycles and between 10 and 15 mg/m^3 during the hot burn cycles.

Table 4 and Figure 3 present particle size data for one hot and one slow burn, indicating that the Dp 50 (diameter with 50% by weight less than the stated size) for the hot burn was 2.6 microns (u) compared to 1.4 u for the slow burn.

Boiler efficiencies are presented in Table 3. The results show that overall efficiencies were in the 80-90 percent range for hot burns but ranged from 6 to 78 percent for slow burns depending on the fuel type.

Appendix 1 shows that all samples were collected isokinetically indicating that no bias due to particle size was introduced.

A list of the most commonly occuring hydrocarbons and their concentrations for each test is presented in Table 5. Phenolic compounds were determined to be the most abundant non-POM species. Very little POM material was detected.

TABLE 1 EMISSION RESULTS

Test No.	Condition	Stack Temp. (°C)	Flow Rate (m^3/s)	Velocity (m/s)	O_2 (% dry)	Flue Gas Composition CO_2 (%)	CO (%)	H_2O (%)	NO_x (mg/m^3*)	Total Emissions (mg/m^3*)	(mg/m^3* @ 12% CO_2)	(kg/h) (kg/hr)	(kg/GJ)
1	Dry/Slow	65.8	0.060	1.47	20.0	0.6	0.1	3.2	1.9	68.4	1370	0.015	0.866
2	Dry/Hot	111	0.25	7.00	14.8	5.7	0.05	5.3	10.7	84.0	177	0.074	0.093
3	Dry/Slow	61.1	0.060	1.44	19.1	1.1	0.16	2.5	-	135	1472	0.029	0.635
4	Cord/Hot	104	0.25	7.06	14.0	6.6	0.025	6.1	14.0	67.7	123	0.060	0.067
5	Cord/Slow	57.2	0.058	1.41	18.6	1.8	0.2	2.3	0.3	60.2	402	0.013	0.192
6	Dry/Hot	105	0.23	6.83	14.9	5.5	0.05	6.7	-	59.7	130	0.050	0.062
7	Green/Hot	96.1	0.26	7.21	16.3	4.4	0.1	5.7	12.1	61.1	167	0.056	0.118
8	Green/Slow	51.7	0.054	1.29	19.9	1.0	0.2	2.4	2.0	280	3362	0.054	33.8

* mg/m^3 @ standard conditions of 20°C and 101.3 kPa (dry).

TABLE 2 GRAVIMETRIC RESULTS

Test No.	Condition	Front Half: Front Filter (mg)	Front Half: Probe Wash (mg)	Back Half: Impingers (mg)	Back Half: Back Filter (mg)	Front Half (%)	Back Half (%)	Volatiles (%)
1	Dry/Slow	1.8	4.8	11.2	7.0	26.6	73.4	91.1
2	Dry/Hot	30.0	11.4	7.1	2.2	81.7	18.3	39.0
3	Dry/Slow	2.7	12.3	15.0	19.7	30.2	69.8	92.6
4	Cord/Hot	28.2	3.3	8.3	0.8	77.6	22.4	46.3
5	Cord/Slow	3.1	5.5	8.8	2.9	42.4	57.6	86.7
6	Dry/Hot	17.0	4.2	6.5	0.4	75.4	24.6	48.8
7	Green/Hot	33.2	14.4	7.6	0.4	85.6	14.4	39.6
8	Green/Slow	17.1	7.6	18.7	47.5	27.2	72.8	96.9

TABLE 3 BOILER EFFICIENCIES, EMISSIONS AND USEFUL HEAT

Test No.	Condition	Fuel Heat Value (kJ/ODkg)	Combustion Eff. (%)	Heat Trans Eff. (%)	Overall Eff. (%)	Useful Heat (kW)	Total Emissions (Kg/GJ)
1	Dry/Slow	20386	82.4	57.0	46.9	4.7	0.866
2	Dry/Hot	20386	98.6	88.4	87.2	222	0.093
3	Dry/Slow	20386	83.3	80.0	66.6	13	0.635
4	Cord/Hot	20386	98.9	89.1	88.1	225	0.067
5	Cord/Slow	20386	90.1	86.4	77.8	18	0.192
6	Dry/Hot	20386	98.7	89.4	88.2	225	0.062
7	Green/Hot	20366	97.1	83.6	81.2	132	0.118
8	Green/Slow	20366	34.6	16.4	5.7	0.44	33.8

Fuel Moisture Content

Dry chips & cordwood = 10.7%
Green chips = 29.5%

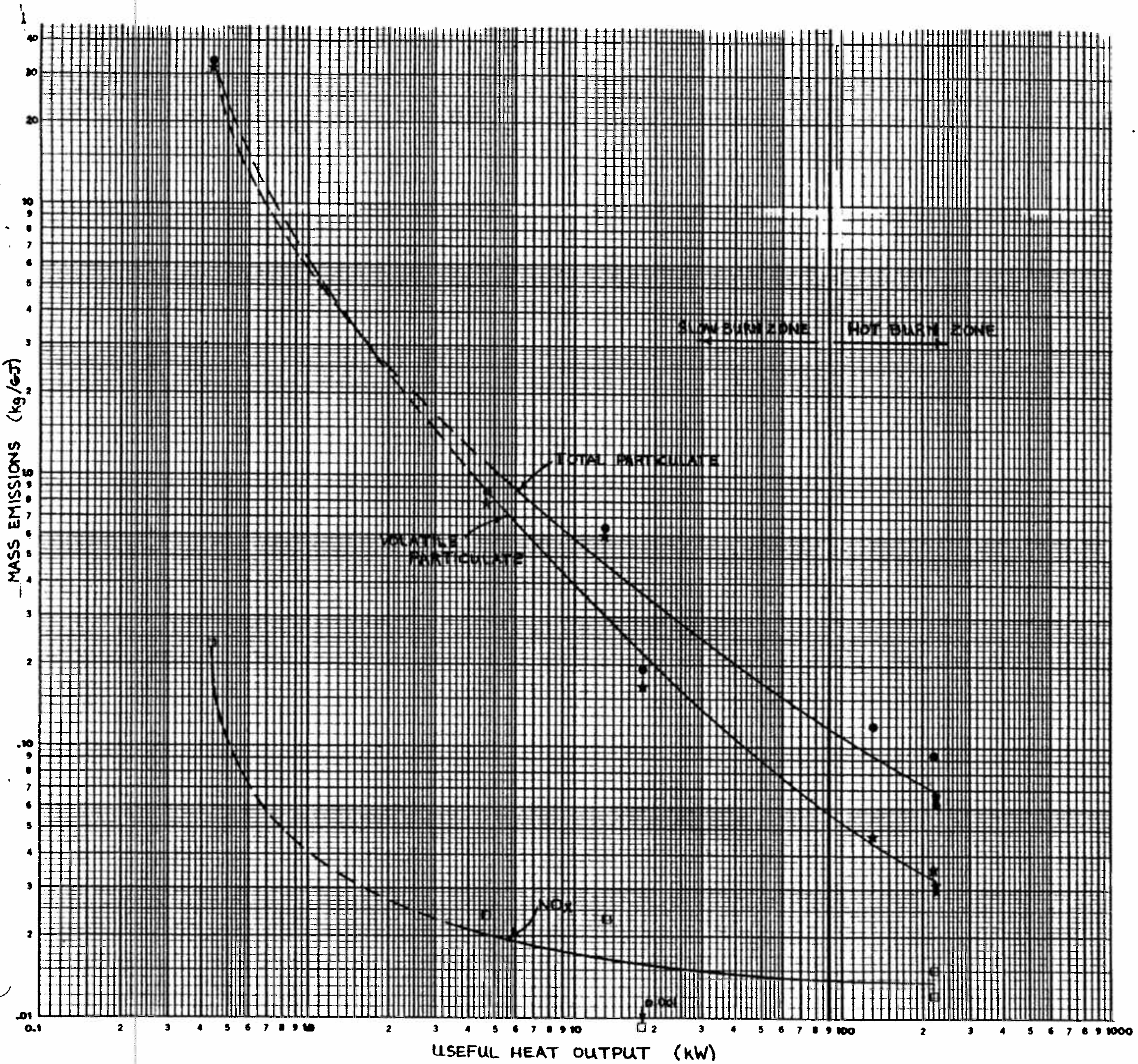

FIG. 2 EMISSION RATE vs HEAT OUTPUT

TABLE 4 PARTICLE SIZING DATA

	Plate	Weight (mg)	% of Total Weight	Cumulative %	Dp (u)
HOT	1	1.1	7.2	100	14.8
FIRE	2	1.1	7.2	92.8	9.3
	3	2.4	15.7	85.6	6.1
	4	2.4	15.7	69.9	4.3
	5	2.4	15.7	54.2	3.2
	6	2.7	17.6	38.5	1.4
	7	1.2	7.8	20.9	0.85
	Filter	2.0	13.1	13.1	0.58
	Total	15.3	100	-	-

	Plate	Weight (mg)	% of Total Weight	Cumulative %	Dp (u)
SLOW	1	0.1	0		
FIRE	2	0.1	0		
	3	0.1	0		
	4	0.05	0.7	100	6.2
	5	1.7	22.5	99.3	4.0
	6	3.3	43.7	76.8	2.0
	7	0.9	11.9	33.1	1.25
	Filter	1.6	21.2	21.2	0.9
	Total	7.55	100	-	-

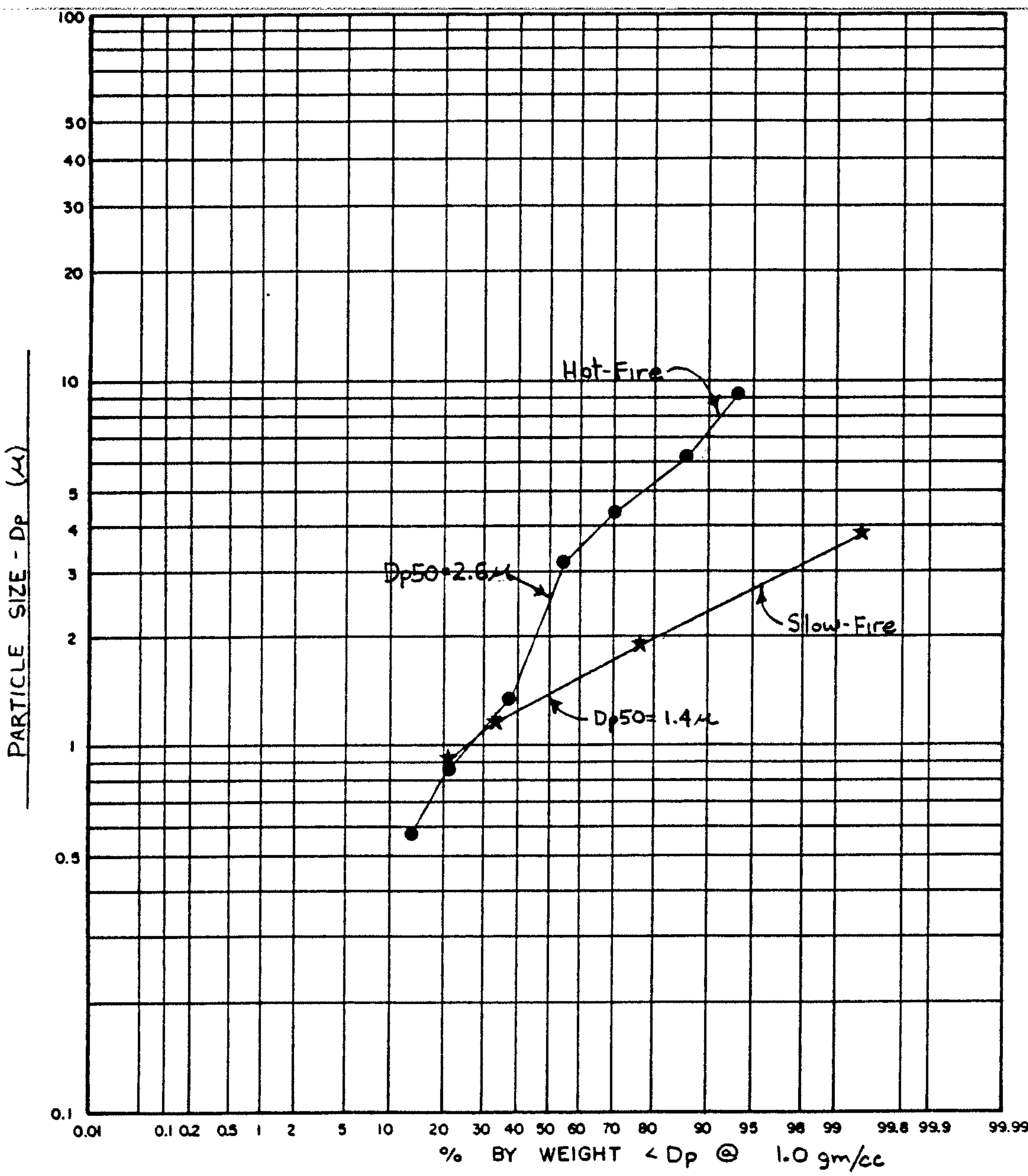

FIG. 3 PARTICLE SIZE vs % LESS THAN Dp

TABLE 5
HYDROCARBON EMISSIONS

Compound	Test No. 1	2	3	6	7	8
			(mg/m^3)			
POMs						
Phenantharene/ Anthracene	0.08	-	-	-	-	-
Naphthalene	-	-	-	-	-	0.16
non-POMs						
Phenol	16	0.4	27	0.3	1.5	20
Methyl Phenol* (isomer)	1.3	-	2.6	-	-	-
Methyl Phenol* (isomer)	3.4	0.07	6.0	0.08	-	-
Methoxy Phenol	6.6	-	12	-	-	16
Dimethyl Phenol (isomer)	3.2	-	6.0	-	-	2.1
Dimethoxy Phenol (isomer)	10.4	-	18	-	-	18
1- (2,4 Dihydroxyphenol) Ethanone	4.6	-	6.0	-	-	6.0
2- Methoxy-4-(2-Propenyl) Phenol	2.2	-	6.3	-	0.2	3.0
2- Methoxy-4-Propyl Phenol	0.4	-	2.3	-	-	1.3
Hydroxymethoxy Benzaldehyde	0.2	-	0.4	-	-	0.03
2- Methoxy-4-(1-Propenyl) Phenol	0.2	-	1.0	-	-	1.3
Bis (2-Ethyl Hexyl) Phthalate	0.7	0.3	0.4	-	-	-

- not detectable

* cresols

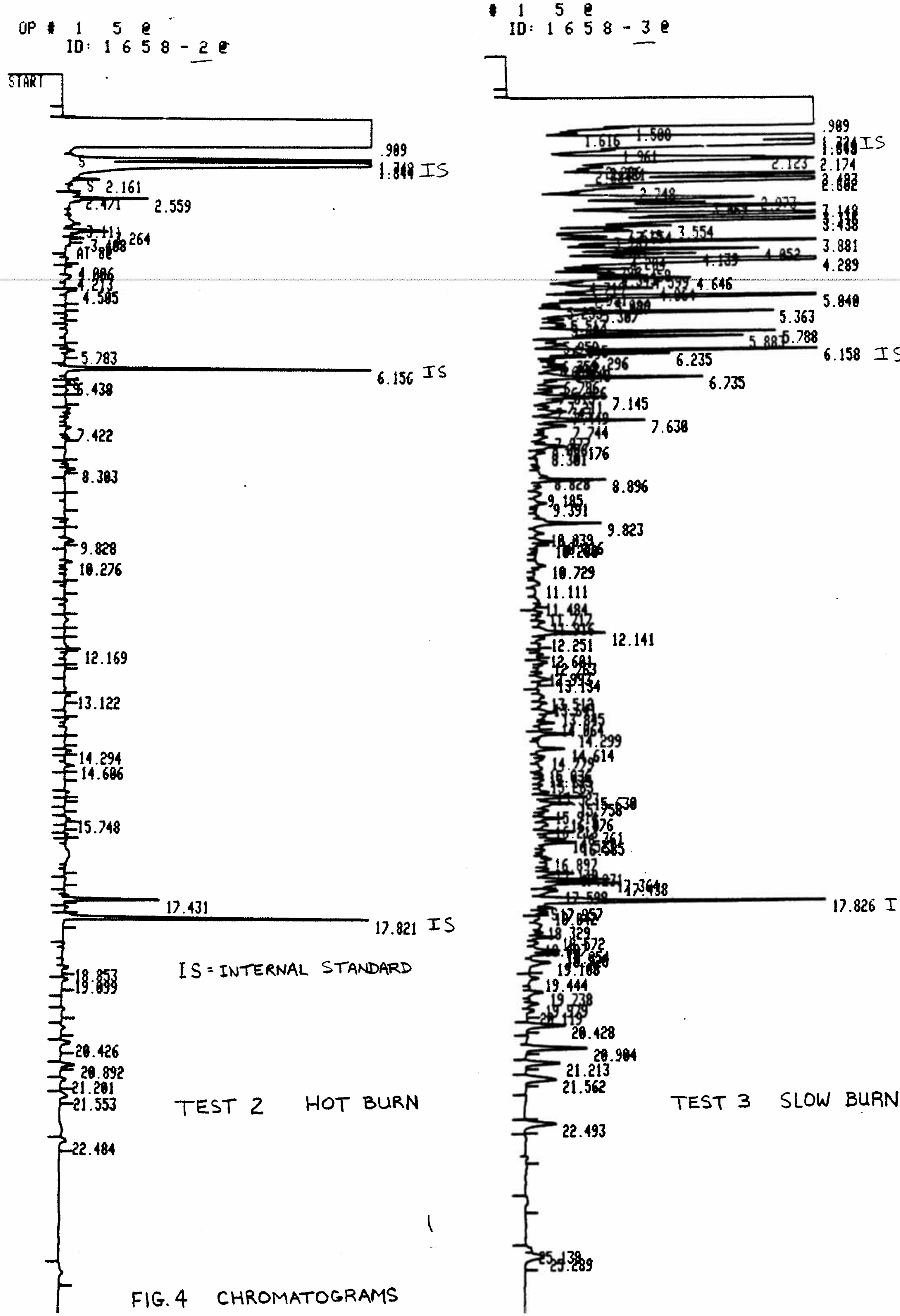

FIG. 4 CHROMATOGRAMS

5.0 DISCUSSION

Total emissions from the wood fired boiler at the Pelly Crossing school are defined as the front half plus the back half (condensable) catch as determined using a modified EPA Method 5 procedure.

During the survey it was observed that visible emissions were continuous for the slow fire mode and intermittent for the hot fire mode. The continuous emissions of the slow fire cycles resulted from the smoldering of the fuel remaining on the combustion chamber following a hot fire cycle. The intermittent visible emissions during the hot fire cycles were caused by the physical disturbance of the fuel bed by the continuous auger feed of raw fuel from beneath the burning layer of fuel.

Slow fire cycles were sampled approximately fifteen minutes following aquastat shut-off, except for Test 1 where sampling commenced immediately following aquastat shut-off. Tests 1 and 3 were therefore duplicate fuel tests but were started at different times in the slow fire cycle.

The overall results of the survey are consistent with those expected from this type of wood fired appliance. Total emissions were generally in the same order of magnitude for all tests on a concentration basis but covered a large range as a function of useful heat output. Nitrogen oxide concentrations were at a maximum during hot fire cycles and hydrocarbons and carbon monoxide were at a maximum during slow fire cycles.

Particle size analysis revealed that emissions were more coarse during hot fire cycles than slow fire cycles. This was primarily due to the effect of the fan on for hot firing. With the fan off during slow firing many large particles would remain in the combustion zone due to gravitational forces. With the fan on, particles similar in size to those of the slow fire cycle would be entrained in the exhaust gases, some of which would be removed by the cyclone prior to discharge.

As expected, the hydrocarbon component of the total emissions increased significantly from hot to slow firing. Most of the components indicated by GC analysis as part of the hot fire cycle particulate were identified in the slow fire particulate for the same fuel. A great many more components were indicated (Figure 4) for slow fire samples however.

Phenols and cresols were found to be the most abundant non-POM hydrocarbons in all analyzed samples. These compounds accounted for 71% of Test 1 volatiles, 61% of Test 3 volatiles and 25% of Test 8 volatiles. They accounted for from 0.5 to 3% of hot fire test volatiles.

The chromatograms shown in Figure 4 represent one hot burn (Test 2) and one slow burn (Test 3). The peaks in each chromatogram are marked by numbers which increase in magnitude from left to right. These numbers represent the time at which the instrument detector sees a particular compound. Ignoring the initial solvent peak at .909 and the internal standars, the instrument detected about 30 compounds in Test 2 and over 100 in Test 3. The compounds detected early in the chromotographic run generally are lower molecular weight hydrocarbons than those detected later in the run.

The phenol and cresol compounds are the major peaks detected before the 8 minute mark and the phthalate was detected at the 17.4 minute mark in both samples. Good examples of compounds identified in both runs are the compounds detected at 9.828 in Test 2 and 9.823 in Test 3, at 12.169 in Test 2 and 12.141 in Test 3, and at 22.484 in Test 2 and 22.493 in Test 3. More significant compound matches occurred in the early part of the chromatograms.

Bis (2-Ethyl Hexyl) Phthalate is not a normal constituent of wood smoke. The presence in Test 1, 2 and 3 of this material, a plasticizer, suggests the combustion of plastic material in the boiler prior to the test program.

POM hydrocarbons were identified in only two of six analyzed samples (Test 1 and Test 8), both slow burns. The results of this portion of the survey are somewhat inconclusive due to the relatively small amounts of sample (12 to 50 mg). A larger sample size may have enabled identification of other POMs. In any event, the cencentrations of any POMs not determined in this study would not exceed those values for naphthalene and phenantharene/anthracene reported in Table 5.

Overall efficiency was very similar for the hot fire modes using dry chips and cordwood. The efficiency for hot fire using green chips was slightly less than those for dry chips/cordwood, indicating the effect of wood moisture on available heat output. The overall boiler efficiencies for slow fire modes were not consistent, indicating the range of available heat output for different fuels in this operating mode.

The Government of Yukon has not established emission guidelines. In the province of British Columbia discharges from this process would fall under the jurisdiction of the Waste Management Branch which has published guidelines for the forest products industry. The "Level A" or most stringent guideline, for wood-fired boilers is 230 mg/m^3 @ 12% CO_2 not including the condensable component. The results of this survey for hot fire cycles would therefore be well within the guidelines for British Columbia. Slow fire cycles would most likely be considered as "unit going down" or non-combustion source, and therefore would not fall under the same criteria.

The results published in this report represent emission characteristics for the fuels and operating conditions encountered on the test dates.

6.0 REFERENCES CONSULTED

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8. Pers. Comm. Merlyn Hough, Oregon DEQ February, 1985.

9. Pers. Comm. Robert Lebens, Oregon DEQ March, 1985.

APPENDIX 1

Computer Outputs

CONSULTANTS EMISSION SURVEY

GOVT OF YUKON

PELLY BOILER-SLOW DRY 11:22-12:30 MARCH 5 , 1985.

LOCATION : STACK EXHAUST TEST RESULTS RUN NO - 1

ROOT DELTA P AVG...........	0.078	INCHES H2O
AVG STACK TEMP...........	610.4	DEGREES R
BAR PRESS	28.75	INCHES HG
ABS STACK PRESS..........	28.75	INCHES HG
FLUE GAS MW..........	28.54	LB/LB MOLE
MOISTURE CONTENT..........	0.032	FRACTION
OXYGEN..........	20.000	PERCENT
CARBON DIOXIDE..........	0.600	PERCENT
AVG VELOCITY..........	4.813	FT/SEC
ISOKINETIC VARIATION..........	101.89	PERCENT
DISCHARGE STANDARD..........	126.8	SCFM
DISCHARGE ACTUAL..........	157.7	ACFM
PARTICULATE LOADING..........	0.0299	GR/SCF
PARTICULATE LOADING..........	1.6455	MG/MOL
PARTICULATE LOADING..........	0.5984	GR/@12%CO2
PARTICULATE LOADING..........	0.03	LBS/HR

CONSULTANTS EMISSION SURVEY

GOVT OF YUKON

PELLY BOILER-HOT DRY 15:00-15:51 MARCH 5 , 1985.

LOCATION : STACK EXHAUST TEST RESULTS RUN NO - 2

ROOT DELTA P AVG...........	0.347	INCHES H2O
AVG STACK TEMP..........	691.0	DEGREES R
BAR PRESS	28.72	INCHES HG
ABS STACK PRESS..........	28.72	INCHES HG
FLUE GAS MW..........	28.90	LB/LB MOLE
MOISTURE CONTENT..........	0.053	FRACTION
OXYGEN..........	14.800	PERCENT
CARBON DIOXIDE..........	5.700	PERCENT
AVG VELOCITY..........	22.952	FT/SEC
ISOKINETIC VARIATION..........	99.58	PERCENT
DISCHARGE STANDARD..........	522.4	SCFM
DISCHARGE ACTUAL..........	751.9	ACFM
PARTICULATE LOADING..........	0.0367	GR/SCF
PARTICULATE LOADING..........	2.0208	MG/MOL
PARTICULATE LOADING..........	0.0774	GR/@12%CO2
PARTICULATE LOADING..........	0.16	LBS/HR

CONSULTANTS EMISSION SURVEY

GOVT OF YUKON

PELLY BOILER-SLOW DRY   16:46-17:50   MARCH 5 , 1985.

LOCATION : STACK EXHAUST   TEST RESULTS   RUN NO - 3

ROOT DELTA P AVG...........	0.077	INCHES H2O
AVG STACK TEMP..........	602.0	DEGREES R
BAR PRESS	28.71	INCHES HG
ABS STACK PRESS..........	28.71	INCHES HG
FLUE GAS MW..........	28.66	LB/LB MOLE
MOISTURE CONTENT..........	0.025	FRACTION
OXYGEN..........	19.100	PERCENT
CARBON DIOXIDE..........	1.100	PERCENT
AVG VELOCITY..........	4.713	FT/SEC
ISOKINETIC VARIATION..........	103.70	PERCENT
DISCHARGE STANDARD..........	126.7	SCFM
DISCHARGE ACTUAL..........	154.4	ACFM
PARTICULATE LOADING..........	0.0590	GR/SCF
PARTICULATE LOADING..........	3.2435	MG/MOL
PARTICULATE LOADING..........	0.6433	GR/@12%CO2
PARTICULATE LOADING..........	0.06	LBS/HR

CONSULTANTS EMISSION SURVEY

GOVT OF YUKON

PELLY BOILER-CORD DRY   10:20-11:06   MARCH 6 , 1985.

LOCATION : STACK EXHAUST   TEST RESULTS   RUN NO - 4

ROOT DELTA P AVG...........	0.349	INCHES H20
AVG STACK TEMP..........	679.0	DEGREES R
BAR PRESS	28.02	INCHES HG
ABS STACK PRESS..........	28.02	INCHES HG
FLUE GAS MW..........	28.91	LB/LB MOLE
MOISTURE CONTENT..........	0.061	FRACTION
OXYGEN..........	14.000	PERCENT
CARBON DIOXIDE..........	6.600	PERCENT
AVG VELOCITY..........	23.159	FT/SEC
ISOKINETIC VARIATION..........	99.78	PERCENT
DISCHARGE STANDARD..........	518.8	SCFM
DISCHARGE ACTUAL..........	758.7	ACFM
PARTICULATE LOADING..........	0.0296	GR/SCF
PARTICULATE LOADING..........	1.6262	MG/MOL
PARTICULATE LOADING..........	0.0538	GR/@12%CO2
PARTICULATE LOADING..........	0.13	LBS/HR

~~CONSULTANTS EMISSION SURVEY~~

GOVT OF YUKON

LLY BOILER-SLOW CORD 12:12-13:15 MARCH 6 , 1985.

OCATION : STACK EXHAUST TEST RESULTS RUN NO - 5

ROOT DELTA P AVG...........	0.075	INCHES H2O
AVG STACK TEMP..........	595.0	DEGREES R
BAR PRESS	28.03	INCHES HG
ABS STACK PRESS..........	28.03	INCHES HG
FLUE GAS MW..........	28.77	LB/LB MOLE
MOISTURE CONTENT..........	0.023	FRACTION
OXYGEN..........	18.600	PERCENT
CARBON DIOXIDE..........	1.800	PERCENT
AVG VELOCITY..........	4.609	FT/SEC
ISOKINETIC VARIATION..........	98.05	PERCENT
DISCHARGE STANDARD..........	122.6	SCFM
DISCHARGE ACTUAL..........	151.0	ACFM
PARTICULATE LOADING..........	0.0263	GR/SCF
PARTICULATE LOADING..........	1.4481	MG/MOL
PARTICULATE LOADING..........	0.1755	GR/@12%CO2
PARTICULATE LOADING..........	0.03	LBS/HR

CONSULTANTS EMISSION SURVEY

GOVVT OF YUKON

PELLY BOILER-HOT DRY 15:05-15:51 MARCH 6 , 1985.

LOCATION : STACK EXHAUST TEST RESULTS RUN NO - 6

ROOT DELTA P AVG...........	0.335	INCHES H2O
AVG STACK TEMP..........	681.0	DEGREES R
BAR PRESS	27.90	INCHES HG
ABS STACK PRESS..........	27.90	INCHES HG
FLUE GAS MW..........	28.71	LB/LB MOLE
MOISTURE CONTENT..........	0.067	FRACTION
OXYGEN..........	14.900	PERCENT
CARBON DIOXIDE..........	5.500	PERCENT
AVG VELOCITY..........	22.390	FT/SEC
ISOKINETIC VARIATION..........	98.29	PERCENT
DISCHARGE STANDARD..........	494.9	SCFM
DISCHARGE ACTUAL..........	733.5	ACFM
PARTICULATE LOADING..........	0.0261	GR/SCF
PARTICULATE LOADING..........	1.4371	MG/MOL
PARTICULATE LOADING..........	0.0570	GR/@12%CO2
PARTICULATE LOADING..........	0.11	LBS/HR

CONSULTANTS EMISSION SURVEY

GOVT OF YUKON

PELLY BOILER-HOT GREEN 09:15-10:01 MARCH 7 , 1985.

LOCATION : STACK EXHAUST TEST RESULTS RUN NO - 7

ROOT DELTA P AVG...........	0.358	INCHES H2O
AVG STACK TEMP..........	665.0	DEGREES R
BAR PRESS	27.91	INCHES HG
ABS STACK PRESS..........	27.91	INCHES HG
FLUE GAS MW..........	28.71	LB/LB MOLE
MOISTURE CONTENT..........	0.057	FRACTION
OXYGEN..........	16.300	PERCENT
CARBON DIOXIDE..........	4.400	PERCENT
AVG VELOCITY..........	23.641	FT/SEC
ISOKINETIC VARIATION..........	100.05	PERCENT
DISCHARGE STANDARD..........	540.9	SCFM
DISCHARGE ACTUAL..........	774.5	ACFM
PARTICULATE LOADING..........	0.0267	GR/SCF
PARTICULATE LOADING..........	1.4671	MG/MOL
PARTICULATE LOADING..........	0.0728	GR/@12%CO2
PARTICULATE LOADING..........	0.12	LBS/HR

CONSULTANTS EMISSION SURVEY

GOVT OF YUKON

PELLY BOILER-SLOW GREEN   10:56-12:00   MARCH 7 , 1985.

LOCATION : STACK EXHAUST   TEST RESULTS   RUN NO - 8

ROOT DELTA P AVG...........	0.069	INCHES H2O
AVG STACK TEMP..........	585.0	DEGREES R
BAR PRESS	27.92	INCHES HG
ABS STACK PRESS..........	27.92	INCHES HG
FLUE GAS MW..........	28.69	LB/LB MOLE
MOISTURE CONTENT..........	0.024	FRACTION
OXYGEN..........	19.900	PERCENT
CARBON DIOXIDE..........	1.000	PERCENT
AVG VELOCITY..........	4.219	FT/SEC
ISOKINETIC VARIATION..........	101.90	PERCENT
DISCHARGE STANDARD..........	113.6	SCFM
DISCHARGE ACTUAL..........	138.2	ACFM
PARTICULATE LOADING..........	0.1224	GR/SCF
PARTICULATE LOADING..........	6.7340	MG/MOL
PARTICULATE LOADING..........	1.4692	GR/@12%CO2
PARTICULATE LOADING..........	0.12	LBS/HR

APPENDIX 2

Formulae and Nomenclature for Emission Calculations

FORMULAE

1. $Wp = Wf + Ww$

2. $Pm = Pb + \frac{\Delta H}{13.6}$

3. $Ps = Pb + \frac{\Delta Ps}{13.6}$

4. $Vm_{STD} = \frac{VmPm}{Tm} \times \frac{T_{STD}}{P_{STD}}$

5. $gr/SCF = \frac{Wp \times 15.43}{Vm_{STD}}$

6. $Vs = 85.48\ Cp\sqrt{\Delta p}\ avg. \sqrt{\frac{Ts}{Ms \times Ps}}$

7. $Md = .44(\%CO_2) + .32(\%O_2) + .28\ (\%CO + \%N_2)$

8. $Ms = Md\ (\frac{100 - \%H_2O}{100}) + .18(\%H_2O)$

9. $V_{TOT} = Vm_{STD} + Vc_{STD}$

10. $\%H_2O = \frac{Vc_{STD} \times 100\%}{V_{TOT}}$

11. $Vc_{STD} = Vc \times .0474$

12. $Q_A = Vs \times 60 \times As$

13. $Q_{STD} = Q_A \times \frac{T_{STD}}{Ts} \times \frac{Ps}{P_{STD}}\ (1 - \frac{\%H_2O}{100})$

14. $I = \frac{1.667\ Ts \left[.00267\ (Vc) + \frac{Vm}{Tm}\ (Pm) \right]}{\theta\ Vs\ Ps\ An}$

NOMENCLATURE

Wf	=	weight of particulate on filter (gm)
Ww	=	weight of particulate in washings (gm)
Wp	=	total weight of particulate (gm)
Vm	=	gas meter sample volume (ft^3)
Vm_{STD}	=	gas meter sample volume @ standard conditions (ft^3)
Pb	=	barometric pressure (mmHg or "Hg)
ΔPs	=	stack static pressure ("H_2O)
Pm	=	meter pressure (mmHg or "Hg)
Ps	=	stack pressure (mmHg or "Hg)
ΔH	=	orifice differential pressure ("H_2O)
Θ	=	sample time total (min)
Tm	=	meter temperature (^oR)
T_{STD}	=	528^oR
P_{STD}	=	760 mm Hg or 29.92 "Hg
Vs	=	average stack gas velocity (ft/sec)
Cp	=	pitot correction factor (dimensionless)
$\sqrt{\Delta p}$ avg.	=	average velocity pressure "$H_2O^{1/2}$
Md	=	molecular weight dry (lb/lb mole)
Ms	=	molecular weight wet (lb/lb mole)
$\%H_2O$	=	percent water vapour
Vc	=	volume of condensate collected (mL)
Vc_{STD}	=	standard volume of moisture (ft^3)
I	=	overall isokinetic variation (%)
Q_A	=	volumetric flowrate at stack conditions (ft^3/min)
An	=	sample nozzle area (ft^2)
Q_{STD}	=	volumetric flowrate at standard conditions (STD ft^3/min)
As	=	area of stack (ft^2)

APPENDIX 3

Field Data Sheets

R-1

STACK SURVEY DATA

PLANT: Pitts [illegible]
RUN NO.: [illegible]
LOCATION: [illegible]
DATE: [illegible]
OPERATOR:
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F:
BAROMETRIC PRESSURE, IN. Hg: 28.75
ASSUMED MOISTURE, Bw:

PROBE TIP DIAMETER, IN.: .406
PROBE LENGTH, FT.:
PROBE HEATER SETTING:

INITIAL LEAK TEST: .04
FINAL LEAK TEST: .02
METER TEMP. COMP.: [illegible]

.546 ft²
Cp - .837

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O: .52
FILTER NUMBER: 1
CONDENSATE COLLECTED, ml: 91
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER: 25
STACK HEIGHT:

POINT	CLOCK TIME	DRY GAS METER, FT.³	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP, °F	IMPINGER TEMP., °F	STACK TEMP., °F	ISOKINETIC % MID	ISOKINETIC % FINAL
	[illegible]	715.575											
1		16.51	1.015	.0[illegible]	.12	[illegible]	[illegible]	1	[illegible]		[illegible]	.077	
2		17.07	1.08	[illegible]	.14	[illegible]	[illegible]		[illegible]		[illegible]	.084	
3		[illegible]	1.06	.007	[illegible]	4[illegible]	[illegible]				[illegible]	.084	
4		19.55	.82	.004	.10	35	35		[illegible]		[illegible]	.063	
5		20.13	1.08	.005	.16	[illegible]	3[illegible]	1			1.52	.089	
	11:52	21.65	1.52	.007	.15	40	34				145	.095	
	11:20	21											
7		22.98	.83	.004	.10	[illegible]	36				140	.063	
8		23.85	.87	.004	.10	[illegible]	37				138	.063	
9		24.74	.89	.005	.11	42	35		300		13[illegible]	.071	
10		25.70	.96	.005	.11	40	37				136	.071	
11		26.75	1.05	.007	.13	35	34		302		135	.084	
12	12:30	727.76	1.01	.008	.15	35	34				134	.089	
	[illegible]												
Total	60.0	12.185			.13	38					150.4	Avg.	Avg.
Average		F = 12.526										.078	

[illegible] 27[illegible]

CO_2 0.6 %

O_2 20.0

CO 0.1 [illegible]

Plant ____________ Date ____________

Location ____________ Operators ____________

Test ____________ Analyst ____________

Moisture data

	Final weight (g m.)	Tare weight (g m.)	Weight of moisture (g m.)
Impinger #1	103	100	3
Impinger #2	100	100	0
Impinger #3	1	0	1
Impinger #4	5		5
	Total		
	Moisture volume		9 ml.

Particulate data

	Final weight (g m.)	Tare weight (g m.)	Weight of particulate (g m.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

STACK SURVEY DATA

1.44√ΔP

P. 2

PLANT: Pelly
RUN NO.: 2 Dry-Hot Fue
LOCATION: [illegible]
DATE: Mar 5/82
OPERATOR:
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F:
BAROMETRIC PRESSURE, IN. Hg: 28.72
ASSUMED MOISTURE, Bw:

PROBE TIP DIAMETER, IN.: .312
PROBE LENGTH, FT.: 10
PROBE HEATER SETTING:

INITIAL LEAK TEST: .01
FINAL LEAK TEST: .01
METER TEMP. COMP.:

C_p = .848

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O: 0
FILTER NUMBER: 2
CONDENSATE COLLECTED, ml: 25
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER:
STACK HEIGHT:

POINT	CLOCK TIME	DRY GAS METER, FT³	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP, °F	IMPINGER TEMP., °F	STACK TEMP., °F	ISOKINETIC % MID	ISOKINETIC % FINAL
		750.30											
1	15:00	2.01	1.71	.12	.75	45	46	3.5	300	ICED	211	.346	
2		3.72	1.71	.12	.76	54	48	3.5			215	.346	
3		5.42	1.70	.12	.76	50	44				217	.346	
4		7.43	2.01	.16	1.1	50	42		310		221	.400	
5		9.47	2.04	.16	1.1	50	41				224	.400	
6	15:21	61.60	2.13	.17	1.2	50	34				227	.412	
7	15:30	2.66	1.06	.04	.3	44	31				234	.200	
8		4.12	1.46	.09	.6	47	39				234	.300	
9		5.61	1.49	.10	.61	48	46	3	310		242	.316	
10		7.33	1.72	.13	.81	48	38				243	.361	
11		69.12	1.79	.14	.92	48	38				246	.374	
12	15:51	7[illegible].55	1.73	.13	.81	48	37				249	.361	
	35' /pt												
Total	42.0	20.55 xF			.81	45					231	Avg.	Avg.
Average		= 21.13										.347	

47% wet
244 dry

Avg
CO_2 5.7
O_2 14.8
CO .1 Orsat .05 Drager

Plant ______ Date ______
Location ______ Operators ______
Test ______ Analyst ______

Moisture data

	Final weight (gm.)	Tare weight (gm.)	Weight of moisture (gm.)
Impinger #1	116	100	16
Impinger #2	106	100	6
Impinger #3	1	0	1
Impinger #4	2	0	2
	Total		
	Moisture volume		25 ml.

Particulate data

	Final weight (gm.)	Tare weight (gm.)	Weight of particulate (gm.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

19

STACK SURVEY DATA

31 wet

PLANT: Polly
RUN NO.: 3 Sizer-Dry
LOCATION: 2nd 5
DATE:
OPERATOR:
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F:
BAROMETRIC PRESSURE, IN. Hg: 33.71
ASSUMED MOISTURE, Bw: 2

PROBE TIP DIAMETER, IN.: .406
PROBE LENGTH, FT.:
PROBE HEATER SETTING:

INITIAL LEAK TEST: .01
FINAL LEAK TEST: .016
METER TEMP. COMP.: 337

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O:
FILTER NUMBER: 3
CONDENSATE COLLECTED, ml: 7
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER: 10"
STACK HEIGHT:

POINT	CLOCK TIME	DRY GAS METER, FT.³	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP, °F	IMPINGER TEMP., °F	STACK TEMP., °F	ISOKINETIC % MID √ΔP	ISOKINETIC % FINAL
	4:40	770.5?											
1		71.74	.89	.004	.10	44	41	41	280	ICED	160	.063	
2		2.62	.88	.004	.10	46	45				157	.063	
3		3.53	.91	.005	.12	36	35	41	320		154	.071	
4		4.59	1.06	.006	.14	34	32				146	.077	
5		5.72	1.13	.007	.16	34	32				147	.084	
6	5:16	6.85	1.13	.007	.16	34	32	41			143	.084	
7	5:20	8.1	1.26	.009	.19	34	32		310		133	.095	
8	fan wall	9.24	1.13	.007	.16	34	32				130	.084	
9		30.37	1.13	.007	.16	34	32	41			138	.084	
10		1.30	.93	.005	.11	33	31		310		136	.071	
11		2.23	.93	.005	.11	33	34				130	.071	
12	5:50 [illegible]	33.16	.93	.005	.11	30	34				129	.071	
	5/pt												
[illegible]	[illegible]	33.17		.007	.5	33	30				1?9		
	72 [illegible]												
	45 min	37.36		Bombed out		on	sizing (fan started)						
Total	60.0	12.31 × F =			.14	34					142	Avg.	Avg.
Average		12.65										.077	

CO_2 1.1
O_2 19.1
CO .1 orsat .16 Drager

Plant ______________ Date ______________
Location ______________ Operators ______________
Test ______________ Analyst ______________

Moisture data

	Final weight (g m.)	Tare weight (g m.)	Weight of moisture (g m.)
Impinger #1	103		3
Impinger #2	101		1
Impinger #3	0		
Impinger #4			3
	Total		
	Moisture volume		7 ml.

Particulate data

	Final weight (g m.)	Tare weight (g m.)	Weight of particulate (g m.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

STACK SURVEY DATA

46 W 3

PLANT: Petty
RUN NO.: 4 Cond Dry
LOCATION: Boiler Stk
DATE: Mar 6
OPERATOR:
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F:
BAROMETRIC PRESSURE, IN. Hg: 28.02
ASSUMED MOISTURE, Bw: 5

PROBE TIP DIAMETER, IN.: .312
PROBE LENGTH, FT.:
PROBE HEATER SETTING:

INITIAL LEAK TEST: .02
FINAL LEAK TEST: .01
METER TEMP. COMP.: ✓ .848

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O: 0
FILTER NUMBER: 4
CONDENSATE COLLECTED, ml: 29
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER:
STACK HEIGHT:

POINT	CLOCK TIME	DRY GAS METER, FT³	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP, °F	IMPINGER TEMP., °F	STACK TEMP., °F	ISOKINETIC % MID	ISOKINETIC % FINAL
		787.54											
	10:20												
1		88.77	1.23	.05	.36	44	51	2	300	197	[illegible]	.224	
2		90.30	1.53	.09	.68	47	49			205		.300	
3		1.89	1.59	.10	.66	45	43			213		.316	
4		3.67	1.78	.13	.85	44	45			215		.361	
5		5.59	1.92	.15	1.0	48	44			222		.387	
6	10:41	797.53	1.94	.15	1.0	45	43			215		.387	
7	10:45 [illegible]	9.48	1.95	.16	1.05	42	38			215		.400	
8		801.44	1.96	.16	1.05	40	35			219		.400	
9		3.24	1.80	.14	.88	40	30	3.5		224		.374	
10		4.96	1.72	.12	.78	40	30			223		.346	
11		6.64	1.68	.12	.75	40	29			227		.346	
12	11:06	808.34	1.70	.12	.78	40	28			228		.346	
Total	42.0	20.8 ·F =			.82	41				219		Avg.	Avg.
Average		21.39										.349	

Avg

CO_2	6.6
O_2	14.0
CO	.025

Plant ____________________ Date ____________________

Location ____________________ Operators ____________________

Test ____________________ Analyst ____________________

Moisture data

	Final weight (gm.)	Tare weight (gm.)	Weight of moisture (gm.)
Impinger #1	114	100	14
Impinger #2	111	100	11
Impinger #3	1	0	1
Impinger #4			3
	Total		
	Moisture volume		29 ml.

Particulate data

	Final weight (gm.)	Tare weight (gm.)	Weight of particulate (gm.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

STACK SURVEY DATA

22 .03

PLANT: Polly
RUN NO.: 5 Idlow Cond
LOCATION: Stack
DATE: Mar 6
OPERATOR:
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F:
BAROMETRIC PRESSURE, IN. Hg: 28.83
ASSUMED MOISTURE, Bw:

PROBE TIP DIAMETER, IN.: .100
PROBE LENGTH, FT.:
PROBE HEATER SETTING:

INITIAL LEAK TEST: .02
FINAL LEAK TEST: .01
METER TEMP. COMP.:

.837

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O: 5
FILTER NUMBER:
CONDENSATE COLLECTED, ml: 6
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER: 10
STACK HEIGHT:

POINT	CLOCK TIME	DRY GAS METER, FT.³	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP. °F	IMPINGER TEMP., °F	STACK TEMP., °F	ISOKINETIC % MID	ISOKINETIC % FINAL
		321.69											
1	12:12	2.48	.79	.003	.09	[illegible]	25	<1	400	ICED	142	.055	
2		3.31	.83	.004	.10	29	27		310		141	.063	
3		4.21	.90	.005	.11	28	27				142	.071	
4		5.17	.96	.006	.12	29	26				140	.077	
5		6.13	.96	.006	.12	29	26				138	.077	
6	12:42	7.15	1.02	.007	.13	29	26				136	.084	
7	12:45	8.28	1.13	.008	.16	28	26				134	.089	
8		9.37	1.09	.007	.15	29	26				134	.084	
9		30.37	1.00	.006	.13	30	26				131	.077	
10		1.36	.99	.006	.13	30	26				129	.077	
11		2.23	.87	.005	.10	30	26				128	.071	
12	13:15	833.08	.85	.005	.10	30	26				120	.071	
Total	60.0	11.39×F=			.12	28					135	Avg.	Avg.
Average		11.71										.075	

Avg

CO_2	1.8
O_2	18.6
CO	0.2

Plant ____________ Date ____________

Location ____________ Operators ____________

Test ____________ Analyst ____________

Moisture data

	Final weight (g m.)	Tare weight (g m.)	Weight of moisture (g m.)
Impinger #1	101	100	1
Impinger #2	101	100	1
Impinger #3	0		0
Impinger #4			4
	Total		
	Moisture volume		6 ml.

Particulate data

	Final weight (g m.)	Tare weight (g m.)	Weight of particulate (g m.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

STACK SURVEY DATA

PLANT: Pelly
RUN NO.: 6 HOT-DRY
LOCATION: Stack
DATE: Mar 4/11
OPERATOR:
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F: 20
BAROMETRIC PRESSURE, IN. Hg: 27.90
ASSUMED MOISTURE, Bw: 5

PROBE TIP DIAMETER, IN.: .312
PROBE LENGTH, FT.:
PROBE HEATER SETTING:
INITIAL LEAK TEST: .02
FINAL LEAK TEST: .06
METER TEMP. COMP.: ok
.848

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O: 0
FILTER NUMBER: 6
CONDENSATE COLLECTED, ml: 25
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER:
STACK HEIGHT:

+3 °C WB
207 °F

POINT	CLOCK TIME	DRY GAS METER, FT.³	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP, °F	IMPINGER TEMP., °F	STACK TEMP., °F	ISOKINETIC % MID	ISOKINETIC % FINAL
		861.27											
1	15:05	2.53	1.26	.06	.4	31	29	3	300	ICED	203	.245	
2		4.04	1.51	.09	.6	43	32	3.5			206	.300	
3		5.54	1.50	.09	.6	44	33				210	.300	
4		7.19	1.65	.11	.75	44	33				215	.332	
5		9.04	1.85	.14	.65	44	33				215	.374	
6	15:26	70.92	1.88	.14	.95	46	32	4.5			223	.374	
7	15:30	2.54	1.62	.10	.67	44	33				226	.316	
8		4.13	1.59	.10	.67	44	32				236	.316	
9		5.73	1.60	.12	.67	44	31				239	.316	
10		77.53	1.80	.14	.65	44	31				237	.374	
11				.15								.387	
12	15:51			.15								.387	
	17:28												
	freezing	813.65		.14	.42	30	28				213		
	25"					34	28				227		
	17:58	904.30		14	.40	36	25				236		
		10.65				31							
18:30	freezing S/o	4.30	3.81	.007	.15	32	30				132		
:50	20 min	908.11											
Total	35.0	16.26 ft³											
Average		16.72			.72	35					221	Avg. .335	Avg.

Avg	
CO_2	5.5
O_2	14.9
CO	0.05

Plant ______________ Date ______________

Location ______________ Operators ______________

Test ______________ Analyst ______________

Moisture data

	Final weight (g m.)	Tare weight (g m.)	Weight of moisture (g m.)
Impinger #1	111	100	11
Impinger #2	106	100	6
Impinger #3	1	0	1
Impinger #4			7
	Total		
	Moisture volume		25 ml.

Particulate data

	Final weight (g m.)	Tare weight (g m.)	Weight of particulate (g m.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

STACK SURVEY DATA

PLANT: Kelly
RUN NO.: 7 [illegible]
LOCATION: [illegible]
DATE: [illegible] 7/85
OPERATOR:
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F:
BAROMETRIC PRESSURE, IN. Hg: 27.91
ASSUMED MOISTURE, Bw: 3

PROBE TIP DIAMETER, IN.: ~~.400~~ .376
PROBE LENGTH, FT.:
PROBE HEATER SETTING:

INITIAL LEAK TEST: .01
FINAL LEAK TEST: .01
METER TEMP. COMP.: No

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O: 0
FILTER NUMBER: 7
CONDENSATE COLLECTED, ml: 41
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER: 10
STACK HEIGHT:

wb
143 44
212 46

POINT	CLOCK TIME	DRY GAS METER, FT^3	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP, °F	IMPINGER TEMP., °F	STACK TEMP., °F	ISOKINETIC % MID	ISOKINETIC % FINAL
	09:15	917.701											
1		19.95	2.25	.09	1.3	30	27	7	300	1(E)	190	.300	
2		22.26	2.31	.10	1.4	41	28				194	.316	
3		24.70	2.44	.11	1.55	42	27				196	.332	
4		27.24	2.54	.13	1.5	42	21				[illegible]	.361	
5		30.00	2.76	.15	2.1	41	27	10			202	.387	
6	9:36	2.80	2.80	.15	2.1	41	27				207	.387	
7	9:40	5.21	2.41	.11	1.55	31	26				209	.332	
8		7.73	2.52	.12	1.7	40	28				212	.346	
9		40.27	2.54	.12	1.7	41	34	9			212	.346	
10		2.97	2.70	.14	2.05	42	30				215	.374	
11		5.88	2.91	.16	2.3	42	31				216	.400	
12	10:01	48.87	2.99	.18	2.4	42	30				219	.412	
Total	42.0	31.17 + F =			1.83	34					205	Avg.	Avg.
Average		32.04										.359	

Avg	
CO_2	4.4
O_2	16.3
CO	0.1

Plant ______________________ Date ______________________

Location ______________________ Operators ______________________

Test ______________________ Analyst ______________________

Moisture data

	Final weight (g m.)	Tare weight (g m.)	Weight of moisture (g m.)
Impinger #1	111	100	11
Impinger #2	124	100	24
Impinger #3	4	0	4
Impinger #4			2
	Total		
	Moisture volume		41 ml.

Particulate data

	Final weight (g m.)	Tare weight (g m.)	Weight of particulate (g m.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

STACK SURVEY DATA

125 ÷ 2 [illegible]

PLANT: Billy
RUN NO.: 8 WR-Cdct
LOCATION: [illegible]
DATE: [illegible]
OPERATOR: [illegible]
SAMPLE UNIT S/N:
CONTROL UNIT S/N:
AMBIENT TEMPERATURE, °F: 30
BAROMETRIC PRESSURE, IN. Hg: 27.92
ASSUMED MOISTURE, Bw: 3

PROBE TIP DIAMETER, IN.: .406
PROBE LENGTH, FT.:
PROBE HEATER SETTING:

INITIAL LEAK TEST: .02
FINAL LEAK TEST: .02
METER TEMP. COMP.: [illegible]

HEATER BOX SETTING, °F:
ASSUMED MOL. WT. (DRY):
ASSUMED MOL. WT. (WET):
STATIC PRESSURE, IN., H_2O: [illegible]
FILTER NUMBER: 5
CONDENSATE COLLECTED, ml: 6
VELOCITY, FT./SEC.:
FLOW, SCFS:
STACK DIAMETER:
STACK HEIGHT:

POINT	CLOCK TIME	DRY GAS METER, FT^3	VOL./PT.	PITOT, IN. H_2O ΔP	ORIFICE ΔH, IN. H_2O	DRY GAS TEMP. °F INLET	DRY GAS TEMP. °F OUTLET	PUMP VACUUM, IN. Hg GAUGE	BOX TEMP, °F	IMPINGER TEMP., °F	STACK TEMP, °F	ISOKINETIC % MID	ISOKINETIC % FINAL
	10.50	49.55											
1		0.65	.83	.003	.09	[illegible]	[illegible]	21	3?0	[illegible]	13[illegible]	.055	
2		1.58	.90	.004	.10	3[illegible]	34				132	.063	
3		2.46	.88	.005	.11	36	34				129	.071	
4		3.36	.90	.005	.11	36	34				127	.071	
5		4.39	1.03	[illegible]	.13	34	31				125	.077	
6	11:20	5.41	1.02	[illegible]	.13	36	3[illegible]	[illegible]			124	.077	
7	11:20	6.43	1.02	.006	.13	36	32				24	.077	
8		7.44	1.01	.006	.13	36	33				123	.077	
9		8.38	.94	.005	.11	36	[illegible]				[illegible]	.071	
10		9.25	.87	.004	.10	35	31				119	.063	
11		0.12	.87	.004	.10	35	31				115	.063	
12	12:00	961.00	.88	.004	.10	36	31				117	.063	
Total	60.0	11.45 ft³			.11	34					125	Avg. .069	Avg.
Average		11.46											

CO_2 1.0
O_2 19.9
CO 0.2

Plant ______ Date ______
Location ______ Operators ______
Test ______ Analyst ______

Moisture data

	Final weight (g m.)	Tare weight (g m.)	Weight of moisture (g m.)
Impinger #1	103	100	3
Impinger #2	101	100	1
Impinger #3	0	0	0
Impinger #4			2
	Total		
	Moisture volume		6 ml.

Particulate data

	Final weight (g m.)	Tare weight (g m.)	Weight of particulate (g m.)
Filter			
Beaker with (probenozzle) washings			
Cyclone flask			
Beaker with (impinger filter—holder) contents and washings			
	Total (gm.)		
	Particulates in (mg.)		

APPENDIX 4

Calibration Data

CALIBRATION CERTIFICATE

DRY GAS METER

Date: Oct 24/84
Tech I.D.: A LANFRANCO
Console I.D.: NAPP

PARAMETER SUMMARY

	RUN NO. 1	RUN NO. 2	RUN NO. 3
T_a = ambient (wet test meter) temp.	66	66	
ΔP = press. diff. at wet test meter	-0.35	-0.40	
P_b = atmospheric pressure	30.23	30.23	
P_v = Vapor press. water at temp. T_a	0.645	0.645	
ΔH = press. diff. at orifice	1.0	1.5	
T_i = dry test inlet temp.	82	82.3	
T_o = dry test outlet temp.	72	72.7	
R_i = initial dry test vol.	955.417	963.868	
R_f = final dry test vol.	963.607	974.184	
V_i = initial wet test vol.	143.444	152.194	
V_f = final wet test vol.	151.923	162.810	
$P_W = P_b - (\Delta P/13.6)$	30.204	30.201	
$P_D = P_b + (\Delta H/13.6)$	30.304	30.340	
$T_W = T_a + 460$	526	526	
$T_D = [(T_i + T_o)/2] + 460$	537	537.4	
$B_w = P_v/P_b$	0.021	0.021	
CALCULATED Y VALUE	1.031	1.025	

CALIBRATION EQUATION

$$Y = \frac{V_f - V_i}{R_f - R_i} \left[(P_w/P_D)(T_D/T_w)\right] \cdot (1 - B_w)$$

Y(MEAN) = 1.028

AUTHORIZATION

A. Lanfranco

Calibration Section

PITOT TUBE CALIBRATION S-TYPE

I.D. 6' Lear

DATE: January 24, 1985

Δ PR	Δ PS	$\sqrt{\frac{\Delta PR}{\Delta PS}}$ (.99)	AVERAGE
.02109	.02439	.8386	
.02144	.03005	.8362	.8374
.02113	.02953	.8374	
.26201	.34552	.8621	
.25887	.34661	.8556	.8584
.25828	.34427	.8575	
.52231	.69327	.8593	
.52098	.69283	.8585	.8586
.51995	.69204	.8581	
1.01826	1.35832	.8572	
1.01559	1.35776	.8562	.8564
1.01374	1.35705	.8557	
1.50160	2.00104	.8576	
1.49960	2.00231	.8568	8565
1.49260	2.00031	.8552	
2.31031	3.18313	.8434	
2.32321	3.18679	.8453	.8463
2.34987	3.18642	.8502	

CALIBRATION EQUATION

$C_R \sqrt{\Delta P_R} = C_P \sqrt{\Delta P_S}$ C_R = 0.99

C_P = ________

ATTACHMENTS:

Calibration Curve ________