EPA-910/9-76-033
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CASE STUDY OF PARTICULATE EMISSIONS FROM SEMI-SUSPENSION INCINERATION OF MUNICIPAL REFUSE

FINAL REPORT

U.S. ENVIRONMENTAL PROTECTION AGENCY
AIR AND HAZARDOUS MATERIAL DIVISION
1200 SIXTH AVENUE, SEATTLE, WASHINGTON 98101

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Errata

Page v	Appendix C, "Page 34" should read "Page 35"
Page 11	Line 12, "7.500 C.F.M." should read "7,500 C.F.M."
Page 18	Table 5, "$9.2x10^9$ ohm-cm" should read "$9.2x10^8$ ohm-cm"
Page 29	"Table 6" should read "Table 7"

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CASE STUDY OF PARTICULATE EMISSIONS FROM SEMI-SUSPENSION INCINERATION OF MUNICIPAL REFUSE

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Prepared for

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Solid Waste Program
Air and Hazardous Material Division
1200 Sixth Ave., Seattle, Washington 98101

November, 1976

This report is issued by Region X, Environmental Protection Agency, to assist state and local air pollution control agencies in carrying out their program activities. Copies of this document may be obtained, for a nominal cost, from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

This report was jointly written by Alsid, Snowden and Associates, 13240 Northrup Way, Suite 21, Bellevue, Washington 98005 in fulfillment of EPA Purchase No. WY-6-99-0872-A and the project officer. It was subsequently reviewed by the Air and Hazardous Materials Division, U. S. Environmental Protection Agency, Region X and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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The genuine cooperation of The Regional Municipality of Hamilton Wentworth and the assistance of Mr. Harold Saunders, Plant Engineer and the staff at the East Hamilton Solid Waste Reduction Unit are gratefully acknowledged. The authors also wish to acknowledge the collaborative data furnished by Mr. Rick Reid, CH_2M/Hill; Mr. Jimmie Wilkerson, Winzler and Kelley; Messrs. Alex Topley and Donald Neal, Babcock and Wilcox Canada Ltd; and Messrs. Bill Reeves and Kurt Glockner, Babcock and Wilcox.

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INTRODUCTION

The concurrent growth of energy demands and increasing cost and scarcity of commonly-used conbustible fuels has prompted national interest in alternative sources of thermal energy. One specific example involves the energy recovery concept of burning municipal refuse in spreader-stoker fed boilers either as a supplement to hogged woodwastes or as the sole fuel. Since the environmental impact of this concept was largely unknown, the State of Oregon, where hog-fuel boilers are widely used by wood products industries to generate steam and electrical energy to serve their plants, requested Region X, U. S. Environmental Protection Agency to provide particulate emission data on hog-fuel type boilers firing refuse.

The Oregon Department of Environmental Quality suggested the East Hamilton Solid Waste Reduction Unit (SWARU), Hamilton, Ontario for a case study. Though this facility was designed to burn 100% refuse while the boilers in Oregon are envisioned to fire small percentages of processed refuse, 10-20%, in combination with hog fuel, the SWARU proved to be the only North American facility designed for semi-suspension combustion similar to Oregon's hog fuel spreader-stoker boilers. In addition, Oregon officials were interested in the application of electrostatic precipitators to such boilers and each of the boilers at the SWARU are equipped with an ESP.

As a result of the cooperation and assistance from The Regional Municipality of Hamilton-Wentworth personnel, source sampling was conducted October 12-15, 1976 by Alsid, Snowden and Associates under contract to EPA at the East Hamilton Solid Waste Reduction Unit. During this period, particulate concentrations and emission rates were determined in accordance with EPA Method 5 equipment and procedures, modified to include the impinger catch as requested by the Oregon DEQ.

Though six EPA Method 5 and two Brinks impactor samples were scheduled to be collected, erratic boiler operation caused by chronic fuel feed problems, precluded this goal. Sampling boiler emissions at variable, yet constant loadings, was intended. However, feed problems greatly inhibited any reasonably steady-state operation and often prompted the supplemental burning of natural gas. Consequently, three complete EPA Method 5 samples and no Brinks impactor sample were obtained.

Since the SWARU facility is rather unique, several equipment manufacturers and governmental agencies were interested in various operating parameters. Individual sampling plans of those organizations identified in the following table, were discussed and an overall sampling scenario developed to minimize disruption of the SWARU operation and yet satisfy respective data needs.

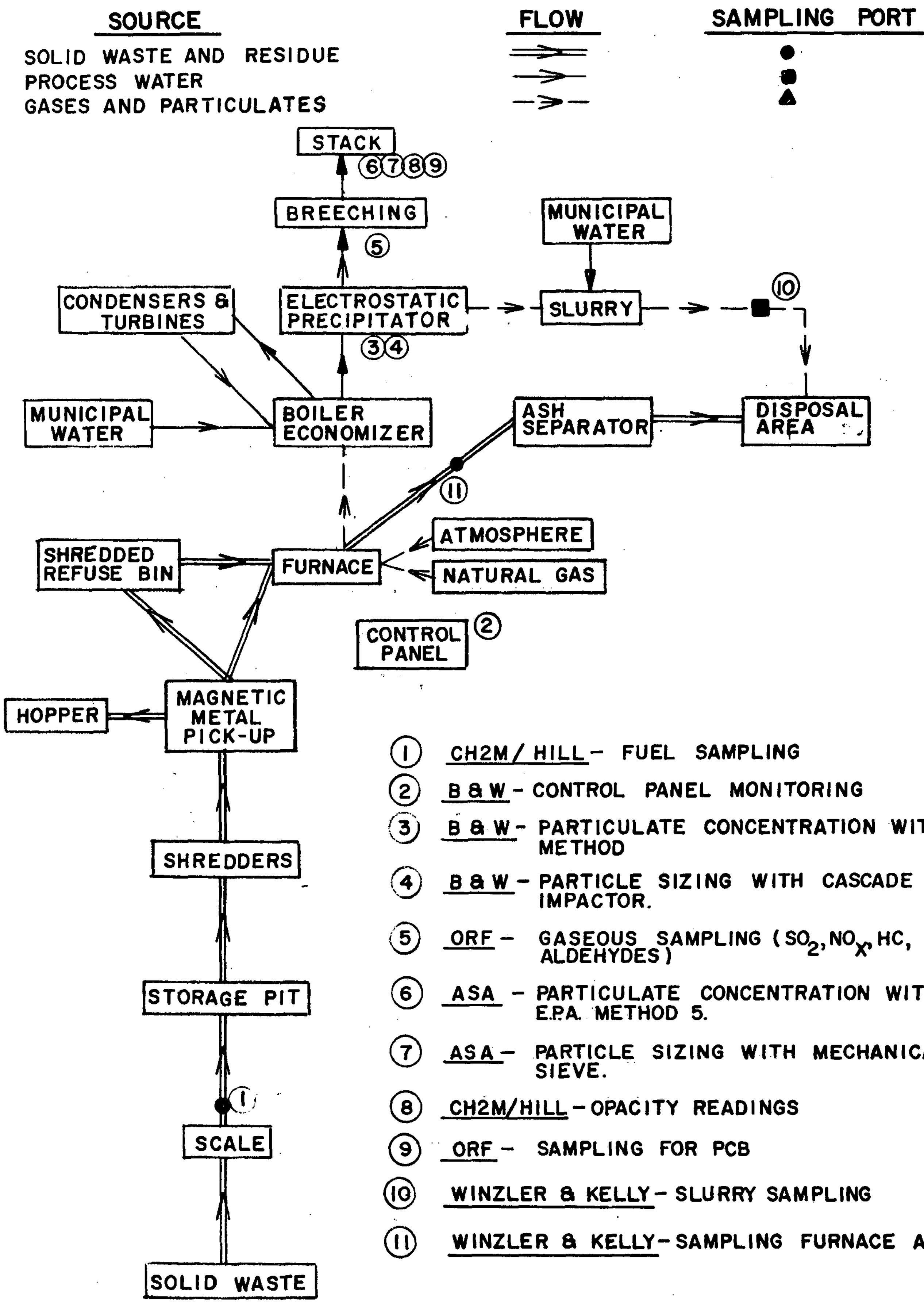
Organization	Role
Winzler & Kelly	Co-contractor for Humbolt County, California
CH_2M/Hill	Co-contractor for Humbolt County, California
Ontario Research Foundation	Subcontractor for CH_2M/Hill and Contractor for the Ontario Ministry of the Environment
Babcock and Wilcox	Boiler manufacturer
Babcock and Wilcox Canada Ltd.	Boiler manufacturer
Alsid, Snowden and Associates	Contractor for U.S. EPA

The SWARU sampling scenario is shown in Figure 1. This figure is intended to inform the reader of (1) the parameters that were measured, (2) where sampling occurred in the system, and (3) who conducted which tests.

The purpose of this report is to document and interpret the emission sampling results of Alsid, Snowden and Associates. In addition, data furnished by the above mentioned organizations were included if they were deemed to be pertinent to the emission results.

If the reader is interested in data beyond the scope of this report, a complete compilation of each organization's data will be jointly prepared by Winzler & Kelly and CH_2M/Hill for Mr. Bill Kuntz, County of Humbolt, Department of Public Works, 1106 Second Street, Eureka, California 95501.

FIGURE I SAMPLING SCENARIO



1. CH2M/HILL – FUEL SAMPLING
2. B & W – CONTROL PANEL MONITORING
3. B & W – PARTICULATE CONCENTRATION WITH SLM METHOD
4. B & W – PARTICLE SIZING WITH CASCADE IMPACTOR.
5. ORF – GASEOUS SAMPLING (SO_2, NO_x, HC, ALDEHYDES)
6. ASA – PARTICULATE CONCENTRATION WITH E.P.A. METHOD 5.
7. ASA – PARTICLE SIZING WITH MECHANICAL SIEVE.
8. CH2M/HILL – OPACITY READINGS
9. ORF – SAMPLING FOR PCB
10. WINZLER & KELLY – SLURRY SAMPLING
11. WINZLER & KELLY – SAMPLING FURNACE ASH

SUMMARY OF RESULTS

The results of sampling the No. 1 boiler at the East Hamilton Solid Waste Reduction Unit for particulate emissions must be prefaced by the fact that boiler operation during each run widely fluctuated. Reasons for this chronic unstable mode of operation are discussed in Section III. However, at this point it should be noted that unstable operating conditions will generally produce higher particulate loadings than stable operating conditions. Therefore, the Alsid, Snowden and Associates emission results summarized in Table 1, reflect not only specific boiler and ESP equipment but the operating conditions of that system.

Since the particulate catch of an EPA Method 5 sampling train can be defined as either the front half (i.e. nozzle, heated probe, and heated filter) or the front half plus the back half (i.e. impingers), results using both interpretations were calculated. Accordingly, the 3-run average particulate concentration, corrected to 12% CO_2, for the front half and for the front and back halves was 0.528 gr/dscf and 0.624 gr/dscf, respectively.

The front half constituted an average of 84.3% of the total sample weight for the three samples.

The mean particle size determined by mechanically sieving Sample Number One was found to be 200 microns.

A resistivity analysis of the electrostatic precipitator inlet ash collected by Babcock & Wilcox indicated a relatively favorable value of less than 10^{11} ohm-cm.

Opacity readings by Mr. Mark Boedigheimer, CH_2M/Hill averaged 15 percent over a 30-minute period coincidental to sampling run 3. Individual readings are furnished in Appendix A.

TABLE 1. SUMMARY OF RESULTS

Run Number [a]	1	3	4
Date	10/13/76	10/14/76	10/14/76
Process Data			
Design Steam Prod. Rate, 1000 lbs/hour	105	105	105
Avg. Steam Prod. Rate, 1000 lbs/hour	88	53	46
Range of Steam Production 1000 lbs/hour	45-115	25-114	25-114
Stack Data			
Temperature, °F	487	498	487
Gas Velocity, ft/sec	38.3	36.0	36.9
Gas Flow Rate, DSCFM[b]	44,265	42,968	46,334
CO_2 Content, percent	10.35	6.4	4.53
Isokineticity, percent	110.6	106.5	103.1
Emission Results (Front Half Catch) (c)			
Particulate Catch, mg.	2103.8	829.2	622.5
Particulate Concentration, grains/DSCF[b]	0.574	0.243	0.175
Particulate Concentration @ 12% CO_2 grains/DSCF[b]	0.666	0.455	0.462
Pollutant Mass Rate, lbs/hour	218.0	89.3	69.2
Emissions Results (Total Train Catch) (d)			
Particulate Catch, mg.	2179.6	976.9	869.8
Particulate Concentration, grains/DSCF[b]	0.595	0.286	0.244
Particulate Concentration @ 12% CO_2 grains/DSCF[b]	0.690	0.536	0.645
Pollutant Mass Rate, lbs/hour	225.9	105.2	96.7

(a) Run number 2 was curtailed.

(b) Dry Standard Cubic Feet with standard defined as 70°F. and 29.92 inches of Hg.

(c) Particulate includes nozzle, heated probe and heated filter catch of EPA Method 5.

(d) Particulate includes front half plus condenser catch after the filter.

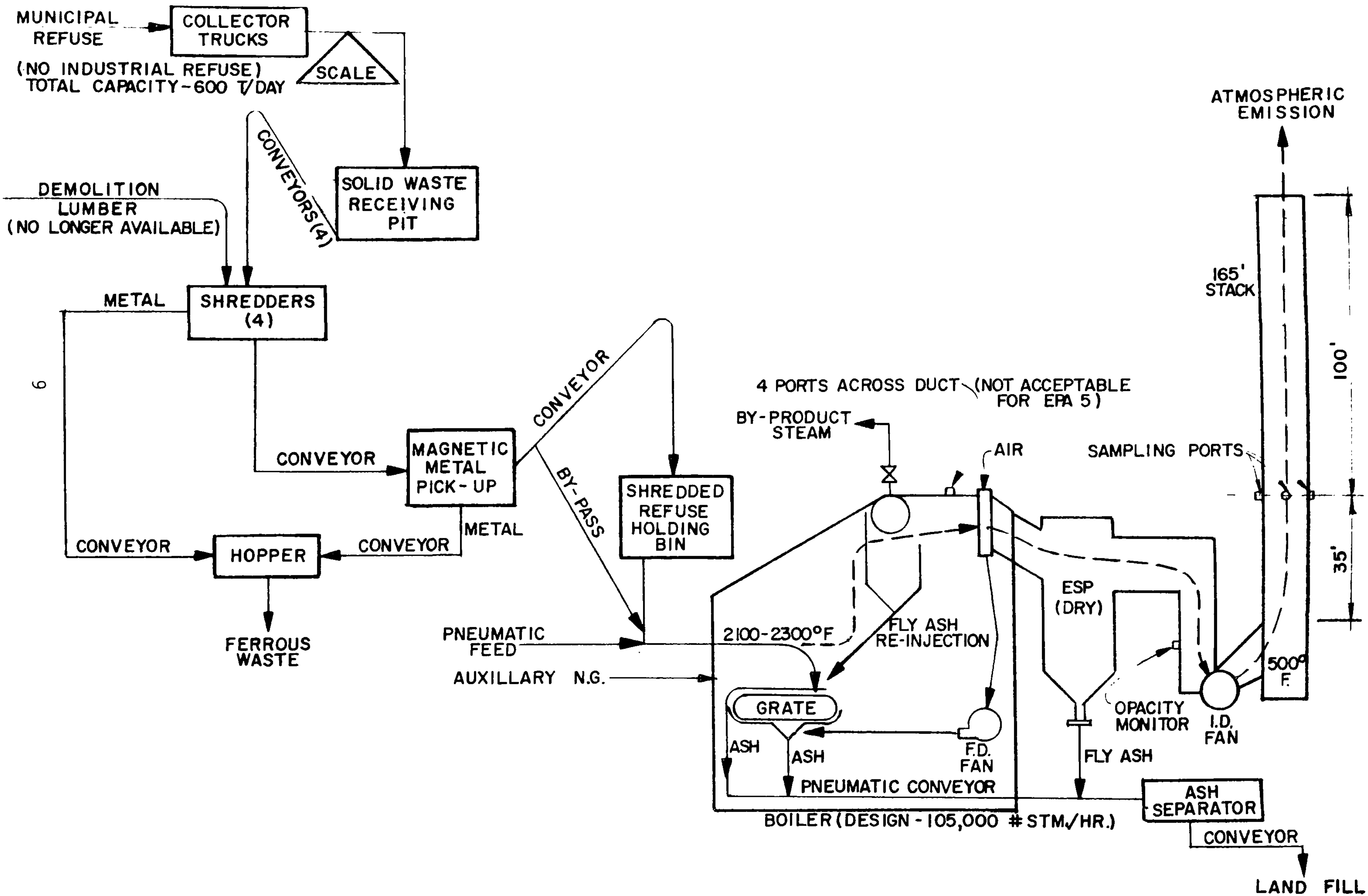
PROCESS DESCRIPTION AND OPERATION

The East Hamilton Solid Waste Reduction Unit includes two identical boilers with a combined capacity of 600 tons per 24 hour day. This facility, engineered by G.L. Sutin and Associates Ltd. and costing $8,250,000 (1972 Canadian Dollars), is based upon the concept of semi-suspension burning of shredded municipal refuse in a water-walled boiler exhausted through an electrostatic precipitator. A process flow diagram showing the common fuel feed system and one of the boiler/ESP systems at this facility is illustrated in Figure 2.

Municipal refuse is delivered in trucks to the receiving pit. Before dumping, the trucks are weighed. Next, the refuse fuel is transported from the pit by four variable-speed, independently operated, conveyor belts. These belts each feed a dedicated shredder. The output of each of the four shredders is combined and transported by conveyor belt to a magnetic metal pick-up. The refuse is then conveyed to the boiler where it is fed into the furnace pneumatically with the overfire air. It should be noted that there is no functional surge capacity in this fuel feed system. Though a shredded refuse holding bin was originally built into the system, it has since been bypassed due to plugging problems and deterioration. As a result, boiler operation is plagued by lagging response to fuel feed rate commands.

Before presenting process and control system conditions during test periods, these systems will be discussed in greater detail. The subsequent boiler and ESP design specifications were respectively furnished by Alex Topley and Donald Neal, Babcock & Wilcox Canada Ltd.

FIGURE 2. EAST HAMILTON SOLID WASTE REDUCTION UNIT FLOW DIAGRAM



Boiler Design Specifications

Babcock & Wilcox Canada Ltd. balanced draught single pass two drum Stirling baffleless boiler with water cooled membraned furnace and vertical tubular air heater.

The boiler is fitted with a Babcock-Detroit Rotograte stoker 12'-1 1/2" wide x 18'-8" shaft centers and two Babcock & Wilcox circular type multi-spud auxiliary gas burners.

The boiler will generate 105,700 lbs. of steam per hour when burning 50,000 lbs. of refuse per hour. The refuse has an average heating value of 6,000 BTU per lb. and contains 10% moisture. The refuse fuel is municipal garbage, shredded in pulverizers and all metal removed prior to injection into the furnace. The fuel is injected into the furnace through three windswept spouts in the furance frontwall above the stoker. The lighter material burns in suspension while the heavier materials falls to the stoker grate and burns there. The stoker grate is continuously moving and constantly discharges the ash into an ash hopper at and under the front of the boiler. The speed of the stoker grate can be adjusted to suit load and fuel conditions. The hot gases generated from the combustion of the fuel pass up the furnace through the generating bank where most of the steam is generated, through an air heater to preheat the combustion air, through an electrostatic precipitator to clean the flue gas and then to the stack through an induced draft fan.

The combustion air is supplied to the boiler - under grate when the stoker is in service and to the gas burners when auxiliary fuel is being fired - by means of a turbine driven forced draught fan. An electric motor drive is also fitted to the fan for use when no steam is available. This fan has a test block rating of 203,400 lbs. of air per hour at a static pressure of 10.6" water gauge and a temperature of 105° F.

The combustion gases are removed from the unit by means of a turbine driven induced draught fan with a test block rating of 234,600 lbs. of flue gas per hour at a static pressure of 2.88" water gauge and a temperature of 615° F. This fan can also be driven by an electric motor when no steam is available.

In order to control and complete combustion overfire air is supplied to the furnace through ports at two levels at front and rear above the stoker grate. The air for this service is supplied by a turbine drive overfire air blower having a test block rating of 7.500 C.F.M. at 30" water gauge static pressure and a temperature of 105° F. This blower also supplies air to the windswept refuse spouts located at the front of the boiler through which the refuse is distributed evenly into the furnace over the grate.

To increase the thermal efficiency of the unit and for more complete carbon burn out cinders collected in the boiler and air heater hoppers are reinjected at the rear of the furnace just over the grate. This is done through nozzles using an electric motor driven blower supplying 700 C.F.M. of air at a pressure of 30" water gauge and 105° F.

Wheelabrator Lurgi Electrostatic Precipitator Design Specifications

Technical Data

1.0 Gas Operating Conditions

1.1 Source	Two (2) 300 ton water wall incinerators
1.2 Quantity	184,200 lbs./hr.
1.3 Temperature	590° F.
1.4 Pressure	± 20 inches WC (design)
1.5 Dust Content	5.33#/1000# gas at 50% excess air

2.0 Precipitator Data (for one (1) unit, two (2) required)

2.1 Cross Section	388 $ft.^2$
2.2 Velocity	3.48 f.p.s.
2.3 Treatment time	5.38 secs.
2.4 Gas Passages	18
2.5 Field height	25 ft.
2.6 No. of fields	Two (2)
2.7 Field length	9'-4"
2.8 Collecting Area	
2.8.1 Projected	17,500 $ft.^2$
2.8.2 Actual	21,000 $ft.^2$
2.9 Collecting Surface	
2.9.1 Type	Pocketed 18-3/4" x 18 ga. x 25 ft.
2.9.2 Material	Cold rolled steel
2.10 Plate Spacing	10" on centers

3.0	Discharge Electrodes	
3.1	Type	Star-shaped, .288" diameter in 1" diameter pipe frame
3.2	Material	Cold rolled mild carbon steel
3.3	Total length of electrodes	16,200
3.4	Supports	8 - fused silica insulators
4.0	Casing	
4.1	Gas distribution devices	3 - 12 ga. perforated plates carbon steel
5.0	Rappers	
5.1	Collecting surface	2 drives - 38 hammers
5.2	Discharge electrode	2 drives - 36 hammers
6.0	Electrical	
6.1	High voltage sets	Full wave (double half wave not required)
6.2	Type	Silicon diode rectifier
6.3	Number and Size	2 - 500 ma, 45 KV
6.4	Transformer coolant	Askarel or Pyranol
6.5	Power supply	500 volt, 60 cycle, 3-phase
6.6	Power consumption (precip., insulator heaters and rappers)	34.4 KW
6.7	Rectifier rating	70 KVA
6.8	High voltage conductors	2
6.9	Automatic power control	2
6.10	Rapper control	1 cabinet with 2 timers Eagle Flexopulse repeat cycle timer adjustable from 2 - 40 secs. operating, 10-300 interval.

Performance Guarantee

When operating with an inlet dust loading of 5.33#/1000# gas with 50% excess air and a gas volume of 81,000 actual cubic feet per minute at 590°F the collection efficiency is guaranteed to be 98.5% resulting in a dust loading at the precipitator outlet of 0.08#/1000# gas at 50% excess air.

Boiler/ESP System Test Conditions

The competence of emission results is a function of the sampling procedure and the operation of process and control equipment during sample periods. The sampling and analytical procedures used at SWARU will be discussed in the next section while operating conditions of the boiler/ESP system will be presently discussed.

Though both boiler/ESP systems, designated No. 1 and No. 2, can be operated simultaneously, only the No. 1 system was operational during the week of testing. Therefore, all subsequent comments pertain to this system.

A temporal relationship between boiler operation and testing is shown in Table 2. The determination of operating conditions results from interpreting steam flow strip charts shown in Appendix B.

Table 2. Boiler Operating Conditions During Test Periods

Test	Date	Time (hours)	STEAM PRODUCTION RATE Average (lbs/hr)	Range (lbs/hr)	Drum Pressure (psi)
1	10/13	1745 1930	88,000	45,000-115,000	220
3	10/14	1500 1615	53,000	25,000-114,000	215
4	10/14	1745 1915	46,000	24,000-114,000	200

It is obvious from the above information that boiler operation widely fluctuated from design specifications during testing. The most apparent factors contributing to the erratic boiler operation are listed in Table 3. The general interruptive effect these, and possibly other factors, had on the operation of boiler No. 1 can be seen in the operating log provided in Appendix C. This log was recorded by Mr. Rick Reid of CH_2M/Hill.

Table 3. Apparent Factors Affecting Boiler Operation

Factor	Reason
1. Fuel Feed	
- Erratic overfire air	Turbine drive impractical with fluctuating steam pressure.
- Improper spread	Rotary drive on feeder inoperative, Erratic overfire air, Too much through center chute.
- Non-uniform feed	Plugging feed chute, No surge in feed system.
- Slow feed rate change response	No surge in feed system.
- Low BTU content	Less than expected paper.
2. Gas Flow	
- Poor ID fan control	Sticking damper, Auto control inoperative
- Insufficient ID fan capacity	Part of damper welded shut.
- Non-uniform spread of fuel on grate	Too much through center chute.
3. Boiler Controls	
- Many instruments not operative most not calibrated.	Maintenance not emphasized.

Unfortunately there is no means to quantitively determine the effect of these factors on stack emissions. Though it is reasonable to assume that erratic boiler operation will result in higher particulate loadings than steady-state operation, operation of the SWARU boiler has been typically erratic, therefore, particulate emissions from the SWARU boiler could be reduced by steady-state operation but such operation has not yet been achievable.

A temporal relationship between ESP operation and testing is shown in Table 4. These data reflect panelboard reading provided by the project officer.

Table 4. ESP Operating C onditions During Test Periods

Test	Date	Time (hrs)	ZONE 1 PRIMARY PRECIP. (volts)	ZONE 1 PRIMARY PRECIP. (amps)	ZONE 1 (milliamps)	ZONE 2 PRIMARY PRECIP. (volts)	ZONE 2 PRIMARY PRECIP. (amps)	ZONE 2 (milliamps)
1	10/13	1745	190	59	290	200	54	270
		1930	190	58	290	210	54	270
3	10/14	1500	180	59	290	205	53	270
		1615	185	59	285	225	56	265
4	10/14	1745	190	59	285	220	55	260
		1915	190	59	290	210	54	250

During each stack sampling period, the electrical input to the precipitator remained constant. However, any attempt to meaningfully establish its collecting efficiency during sampling (design collection efficiency was 98.5%) would be futile due to the large chunks, up to several inches in diameter, being carried into the ESP. In lieu of this information, the following comments, furnished by Mr. Donald Neal, Babcock and Wilcox Canada Ltd., are presented to indicate the condition of the ESP during sampling.

> "On October 26, 1976 Peter Finnis and John Underwood from Wheelabrator and the writer conducted a visual examination of the #1 precipitator. From the visual inspection it was found that collector plates 3, 4, 9 and 17 on the inlet were warped. The walkway grating at the inlet was piled with tin foil, paper and charred material. This effectively stops all the flow from passing through the bottom 18 inches of the collectors. This build-up was removed and the walkway cut out and removed.

"The 9th and 17th collector on the primary field were warped for their total length.
The second field was in good shape. The 13th collector was warped at the outlet. Also there was rapper seized on the outlet field. (This effectively reduces the collector area by 5% on the 2nd field.)
The electrode wires are in good shape and none are down.
Generally the precipitator on #1 unit is in pretty fair shape. It has had about 15 to 20 percent of its collector area negated due to the above reasons."

In summary, the design specifications and operating conditions of the subject boiler/ESP system have been described in this section to properly qualify the particulate emission results of this single case study. Given similar circumstances, similar grain loadings can be expected. Though measured grain loadings could be reduced by design and operational improvements, the magnitude of such reductions must remain a subjective consideration of the reader.

Atmospheric emissions characterizations as to particulate mass and size of emissions were determined from the limited number of samples collected by the EPA Method 5 type train and mechanical sieving respectively. Three complete Method 5 type samples were collected during the available four days of representative incinerator operating times.

Particle sizing via a cascade impactor was planned but the erratic nature of the boiler operation precluded sample collection. A mechanical sieving analysis of the filter catch on Run Number One (approximately 1.2 grams total) was performed to gain some understanding of the size of the particles. The results of the particle sizing analysis indicates that the mean particle size by weight is 200 microns in diameter. The last two stages of the sieve analysis were washed with acetone to facilitate passage of the particles through the respective sieves. The results of the particle sizing analysis are shown in Figure 3.

A boiler flyash sample taken by Babcock & Wilcox at the inlet to the electrostatic precipitator was analyzed as to its charging adaptability reported as "resistivity" in terms of ohm-cm. The ash sample at a 10% moisture by volume condition was found to have a relatively favorable charging characteristic of less than 10^{11} ohm-cm. The resistivity versus temperature data is shown in Table 5.

Table 5. ELECTROSTATIC PRECIPITATOR INLET ASH RESISTIVITY

TEMPERATURE	MOISTURE	RESISTIVITY
400°F	10%	4.1×10^{10} ohm-cm
450°F	10%	1.5×10^{10} ohm-cm
500°F	10%	7.2×10^{9} ohm-cm
550°F	10%	3.4×10^{9} ohm-cm
650°F	10%	9.2×10^{9} ohm-cm

*Moisture in percent by volume. Sample was 7.5 grams allowing one moisture condition.

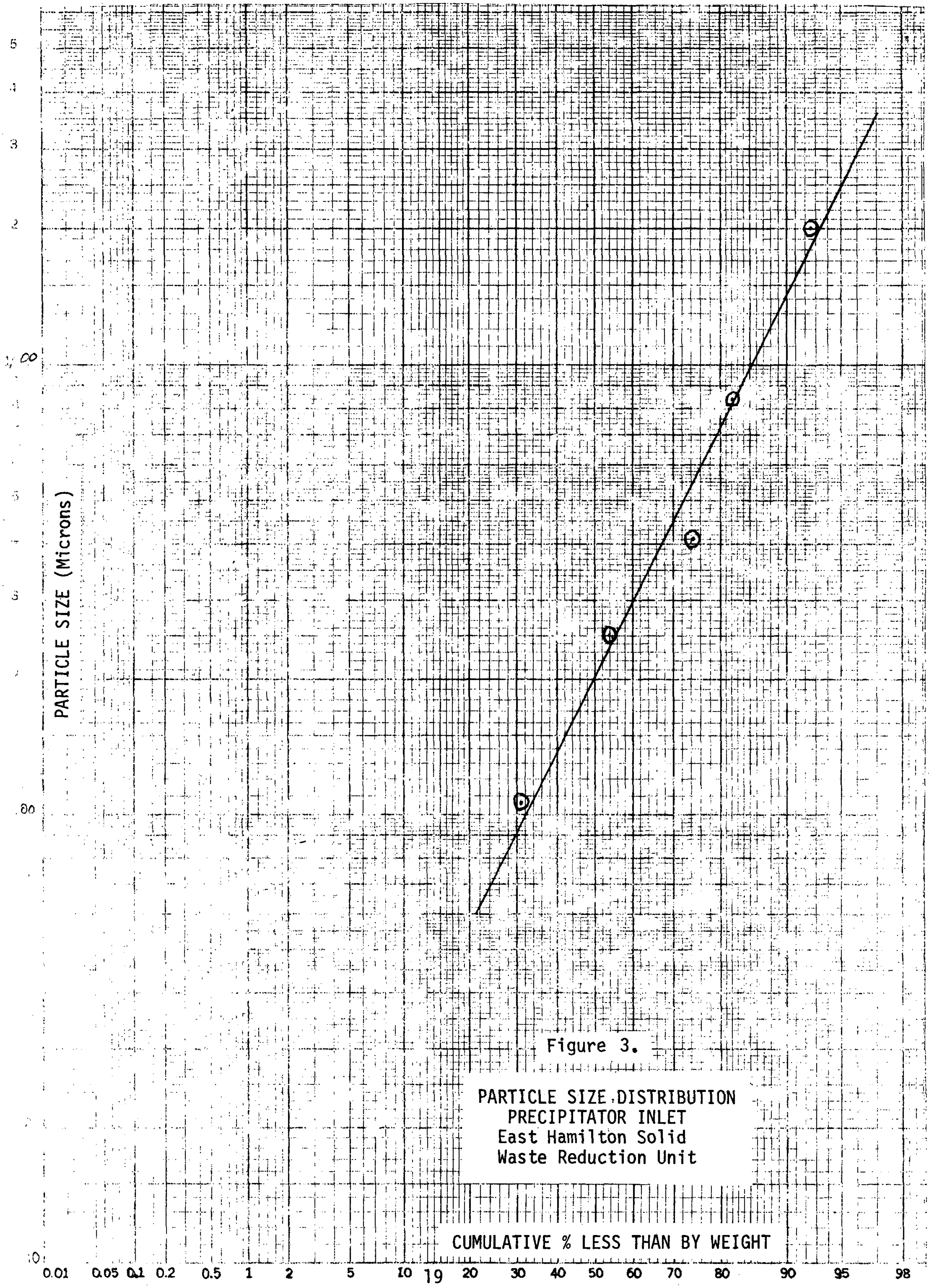


Figure 3.

PARTICLE SIZE DISTRIBUTION
PRECIPITATOR INLET
East Hamilton Solid
Waste Reduction Unit

Stack gas sampling equipment designed by the United States Environmental Protection Agency (EPA), office of Air Programs was used in this evaluation. A schematic of the sampling equipment is shown in Figure 4.

Sampling was performed according to the following:

Sampling ports were existing and locations noted. The number of sampling points were determined considering the number of duct diameters between obstructions in the duct upstream and downstream of the sampling ports. Stack pressure, temperature, moisture content,

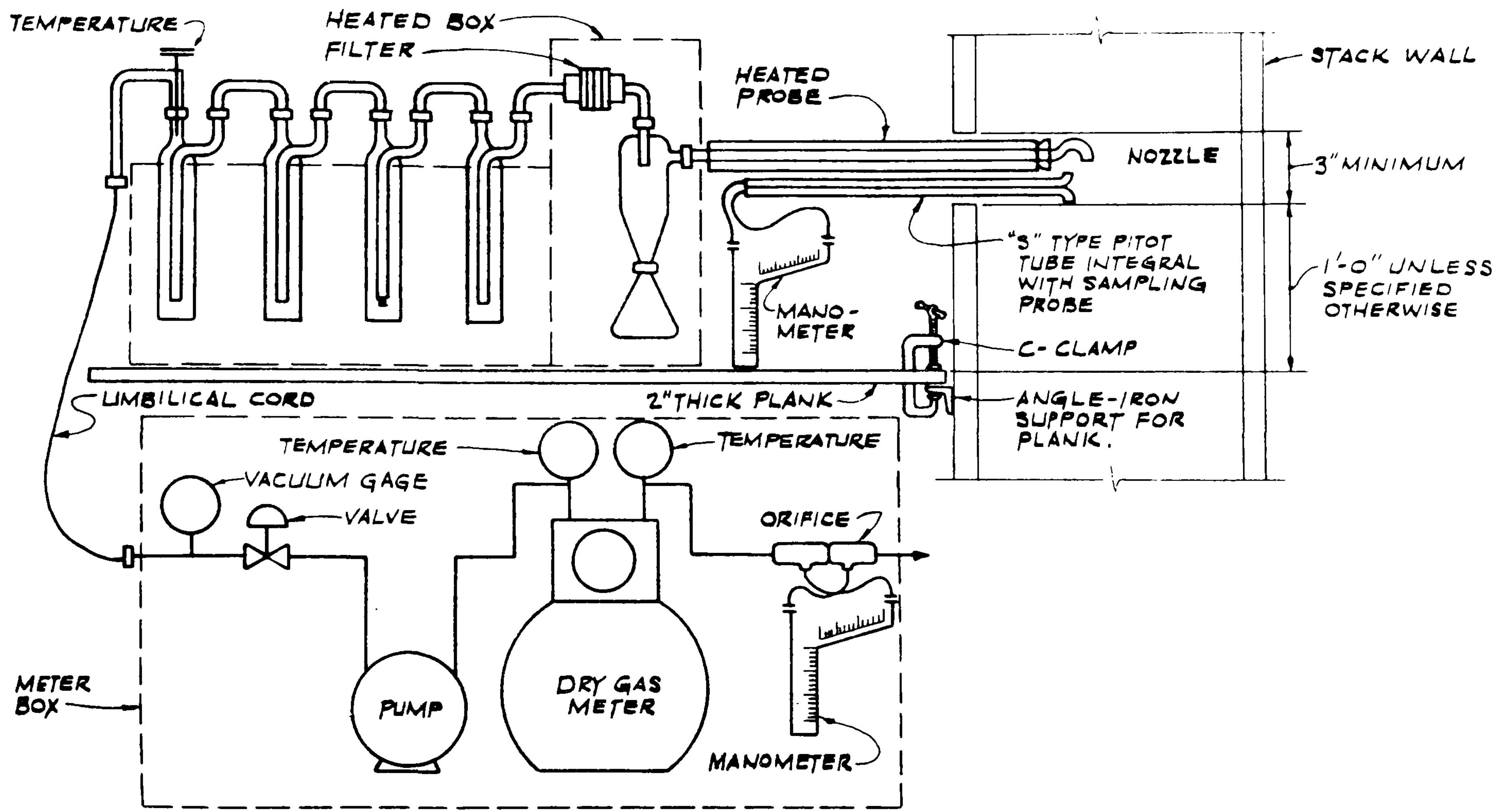


Figure 4.
EPA METHOD 5 PARTICULATE SAMPLING TRAIN

DRAWN RSC	ALSID, SNOWDEN & ASSOCIATES 13240 Northrup Way, Suite 21 Bellevue, WA 98005
CHECKED WS	
DATE 9/30/74	

and maximum velocity head readings were measured. An EPA designed nomograph was set up using this data and the correct nozzle diameter was selected using this nomograph. A sketch of the stack cross section and the equal areas selected is shown in Figure 5.

Thirty-two elemental areas were selected for traverse sampling of the stack. The stack area is composed of a combination of semi-circle, rectangle and another semi-circle. Three ports were already installed and selected for sample collection to collect the most representative sample. The thirty-two elemental areas were divided into two parts, a 22 elemental point traverse along the longest diameter direction and a 10 point elemental point traverse along the shortest diameter. The sampling port installed for sampling the shortest diameter was not at the center of the longest diameter.

The 22 and 10 elemental areas selected are shown in Table 6. The dimensions and centroids of the elemental areas were determined by trial and error calculations knowing that each elemental area along the longest diameter is 1/22 of the total area and each elemental area along the shortest diameter is 1/11 of the total area.

A leak test was performed on the assembled sampling train. The leak rate did not exceed 0.02 cfm at a vacuum of 24 inches Hg. The probe was heated so that the gas temperature at the probe outlet was approximately 250° F. The filter was heated to approximately 250° F. to avoid condensation of moisture on the filter. Crushed ice was placed around the impingers at the beginning of the test with new ice being added as required to keep the gases leaving the sampling train below 70° F.

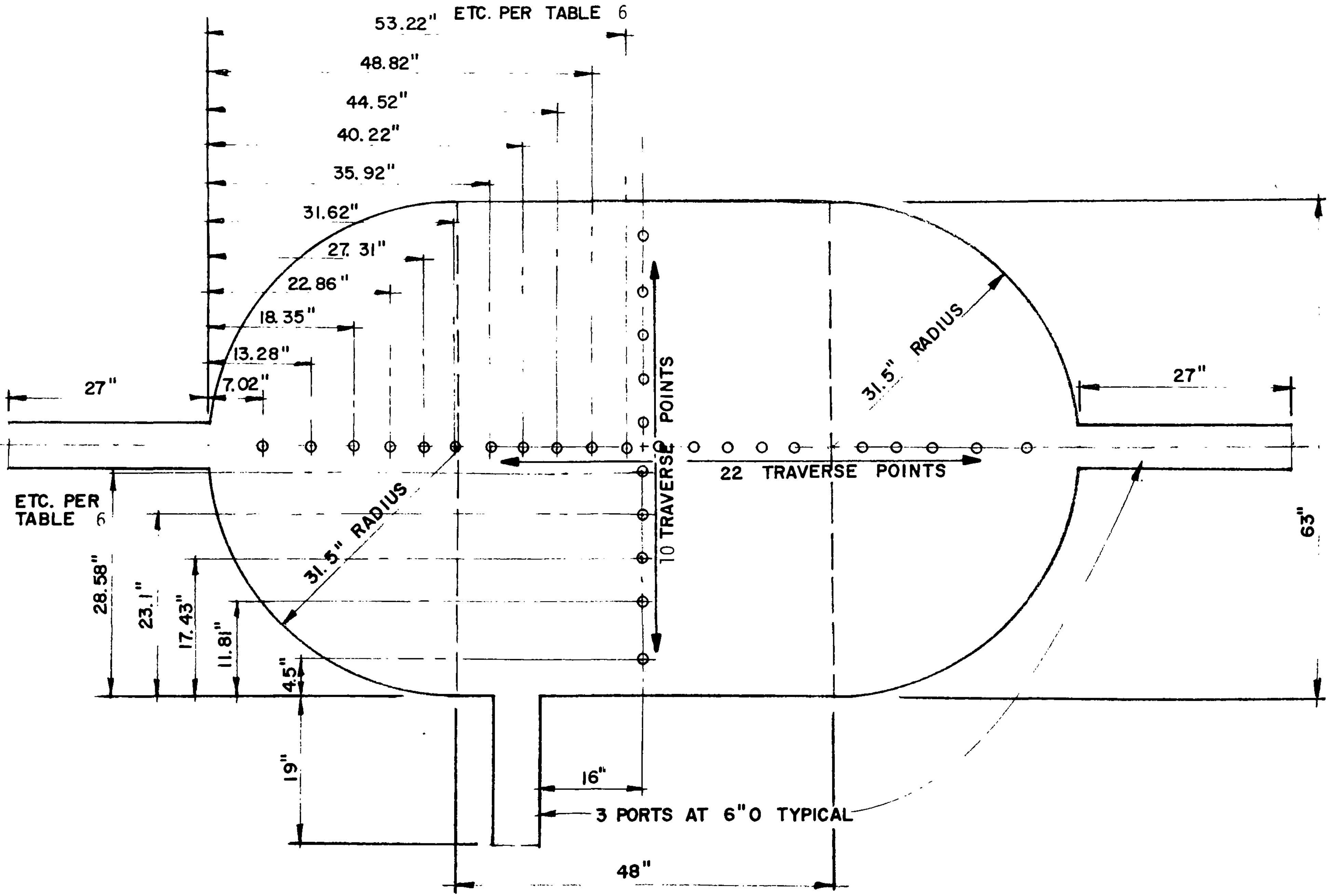


FIGURE 5: CROSS SECTION OF EXHAUST STACK AT THREE SAMPLING PORTS WITH EQUAL ELEMENTAL AREA TRAVERSE POINT LOCATIONS.

Table 6

Centroid Location for Elemental Areas

Shortest Diameter, # Areas = 10		Longest Diameter # Areas = 22 (Enter thru 2 ports @ ends)	
Area No.	Centroid (from inside wall)	Area No.	Centroid (from inside wall)
1	4.5"	1	7.02"
2	11.81"	2	13.28"
3	17.43"	3	18.35"
4	23.00"	4	22.86"
5	28.58"	5	27.31"
6	34.42"	6	31.62"
7	39.9"	7	35.92"
8	45.57	8	40.22"
9	51.19	9	44.52"
10	58.5"	10	48.82"
		11	53.22"

TOTAL AREA - 42.65 ft^2

The train was operated as follows:

The probe was inserted into the stack to the first traverse point with the nozzle tip pointing directly into the gas stream. The pump was started and immediately adjusted to sample at isokinetic velocities. Equal time was spent at selected points of equal elemental areas of the duct with the pertinent data being recorded from each time interval. The EPA nomograph was used to maintain isokinetic sampling throughout the sampling period. At the conclusion of the run the pump was turned off, the probe was removed, and the final readings were recorded.

Clean-up of the EPA train was performed by carefully removing the filter and placing it in a container marked "Run X, Container A". Reagent grade acetone and brushes were used to clean the nozzle, glass probe and pre-filter connections. The acetone wash was placed in a container marked "Run X, Container B". The volume of water in the impinger and bubblers (glassware) was weighed in their respective containers to the nearest 0.1 gram. The original weights which included approximately 100 ml in the bubbler and 100 milliliters in the impinger were then subtracted and the difference added with the water weight gain of the silica gel constituted the amount of water collected during the run. The silica gel was weighed in a bubbler before and after the run. The water from the glassware and a water rinse of the glassware were placed in a container marked "Run X, Container C". An acetone rinse of the glassware and all post-filter glassware (not including the silica gel container) was performed and placed in a container marked "Run X, Container D".

Analysis of the samples in each container was performed according to the following:

Run X, Container A - Transfer the filter and any loose particulate from the sample container to a tared glass weighing dish and desiccate for 24 hours in a desiccator or constant humidity chamber containing a saturated solution of calcium chloride or its equivalent. Weigh to a constant weight and report the results to the nearest 0.1 milligram.

Run X, Container B - Measure the volume to the nearest 0.1 milliliter. Transfer acetone washings from container into a tared beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the result to the nearest 0.1 milligram.

Run X, Container C - Measure the volume to the nearest 0.1 milliliter. Extract organic particulate from the water solution with three 25 milliliter portions of chloroform and three 25 milliliter portions of ethyl ether. Combine the ether and chloroform extracts and transfer to a tared beaker. Evaporate until no solvent remains at about 70° F. This can be accomplished by blowing air that has been filtered through activated charcoal over the sample. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 milligram. After the extraction, evaporate the remaining water to dryness and report the results to the nearest 0.1 milligram.

Run X, Container D - Measure the volume to the nearest 0.1 milliliter. Transfer the acetone washings to a tared beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 milligram.

Blanks were taken on the acetone, ether, chloroform, and deionized water and subtracted from the respective sample volumes. The filter paper used with the EPA train was a Mine Safety Appliance 1106 BH, heat treated glass fiber filter mat.

DETAILED RESULTS

A detailed summary of the test data collected on this project is shown in Table 7. Table 7 was compiled from the computer printouts of the data. The computer printouts for the four samples are placed in the Appendix D.

Table 6 . Summary of Test Data

CLIENT EPA REGION 10 Test Date(s) October 13 & 14, 1976

SAMPLING LOCATION WASTE INCIN. #1 STACK PROCESS INCINERATION OF WASTE

	Run # 1	Run # 2	Run # 3	Run # 4
	Date 10-13-76	Date 10-14	Date 10-14	Date 10-14
Start Time	1751	1133	1458	1743
Finish Time	1829	1144	1621	1917
Elapsed Sampling Time, Min.	64	11	64	64
Volume Sampled, ft^3	56.997		53.363	55.442
Volume Sampled Standard*, ft^3	56.373		52.662	55.001
Moisture Content of Stack Gas, %	17.3	PROCESS INTERRUPTION — SAMPLING CURTAILED	14.08	10.8
Molecular Weight of Stack Gas, lb/lb Mole	27.93		27.94	28.11
Stack Pressure, in Hg	29.214		29.351	29.381
Pitot Coefficient	0.827		0.827	0.823
Velocity of Stack Gas, ft/sec	38.3		36.0	36.9
Stack Gas Flow Rate, ft^3/min	98,006		92,152	94,535
Temperature of Stack, °F	487		498	487
Stack Gas Flow Rate, S* ft^3/min	44,265		42,968	46,334
Diameter and Area of Nozzle, in., ft^3	3/8" .000767		3/8" .000767	3/8" .000767
Percent Isokinetic of Test	110.6		106.5	103.1
Weight Particulate Collected, mg	2179.6		976.9	869.8
Particulate Concentration, grains/S* ft^3	0.595		0.286	0.244
CO_2 Content of Stack Gas, %	10.35		6.4	4.53
Particulate Concentration @ 12% CO_2, gr/S* ft^3	0.690		0.536	0.645
Pollutant Mass Rate (Concentration Method), lb/hr	225.9		105.2	96.7

*Standard, 70°F, 29.92 in Hg, dry

APPENDIX A

PLUME EVALUATION

CH2M HILL
engineers
planners
economists
scientists

Appendix A

PLUME EVALUATION

Date 14 OCT 76

Project No. ______

Name of Firm ______

Plant and Location HAMILTON ONTARIO

Source Identity BOILER NO.1 STACK EXHAUST

~~Opacity~~

Ringelmann

EPA TEST NO. 2 3
STEAM FLOW ≙ 60,000 #/hr.

Time	0	1/4	1/2	3/4
3:35	15	10	25	25
3:36	10	10	25	30
3:37	20	25	15	15
3:38	10	15	10	20
3:39	10	10	10	5
3:40	15	10	15	10
3:41	10	5	10	10
3:42	10	20	25	35
3:43	15	15	10	10
3:44	20	25	20	20
3:45	10	15	10	20
3:46	15	10	20	15
3:47	15	10	15	10
3:48	15	10	10	10
3:49	10	10	20	10
3:50	10	10	5	5
3:51	20	10	10	5
3:52	5	10	10	10
3:53	10	10	10	5
3:54	10	10	5	5
3:55	10	15	15	5
3:56	5	10	15	10
3:57	25	25	15	20
3:58	25	15	20	15
3:59	30	20	20	25
4:00	35	25	25	30
4:01	25	15	30	20
4:02	15	20	15	15
4:03	10	15	20	15
4:04	15	15	25	20

Time	0	1/4	1/2	3/4

Point of Observation ______
STACK EXIT

Distance to Source ≙ 150 YARDS

Direction to Source NORTH

Wind Direction WEST

Wind Velocity 5-15 MPH

Cloud Cover 10%

Comments OFF-WHITE BROWNISH COLOR PLUME, PHOTO 9

No. 5 (100%) Units ______ ______

No. 4 (80%) Units ______ ______

No. 3 (60%) Units ______ ______

No. 2 (40%) Units ______ ______

No. 1 (20%) Units ______ ______

No. 0 (0%) Units ______ ______

Total Units ______ ______

Minutes of Observation ______

Minutes of Violation ______

APPENDIX B.

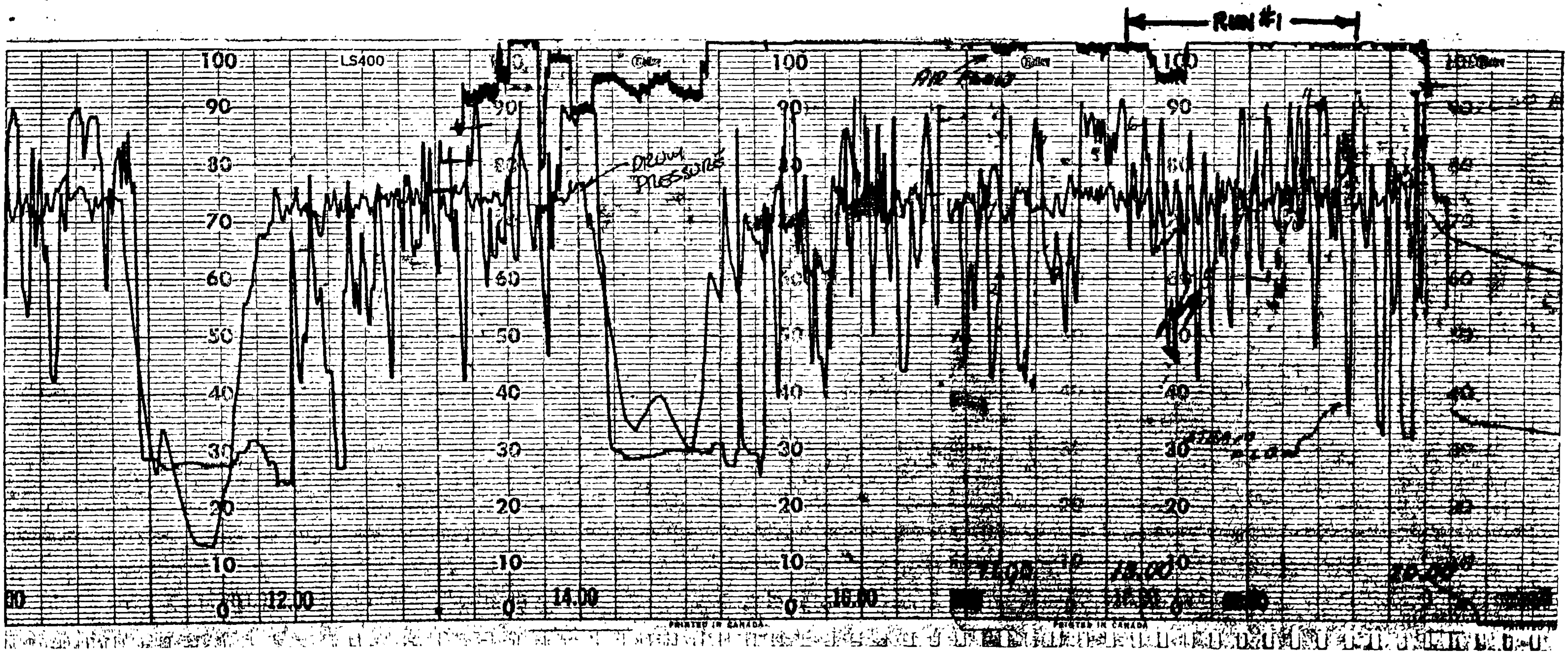
STEAM FLOW CHARTS

Appendix B

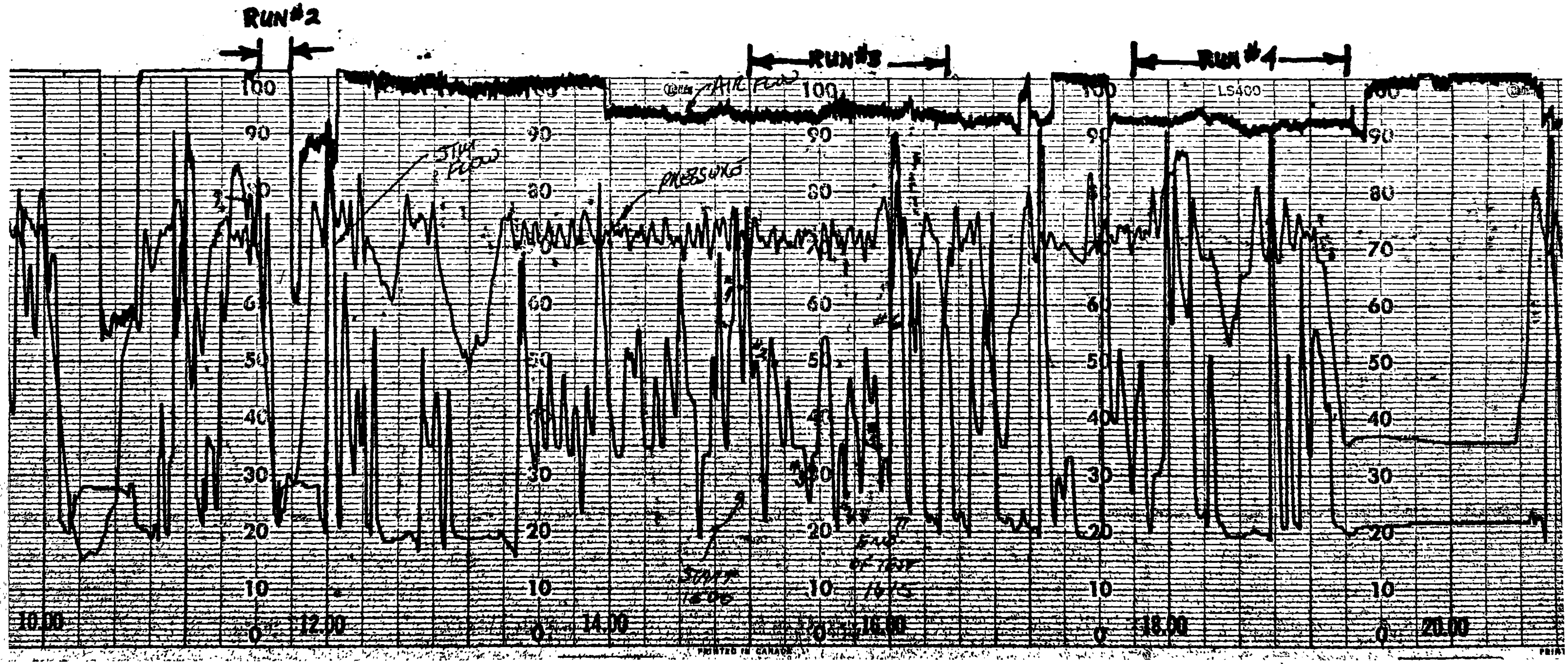
SWARU #1 BOILER

DATE: 10/13/76

STEAM FLOW SCALE: 0-125,000 LBS/HR.



SWARU #1 BOILER
DATE: 10/19/76
STEAM FLOW SCALE: 0-125,000 LBS/HR



APPENDIX C.

OPERATING LOG

Appendix C

OPERATING LOG
EAST HAMILTON SWARU TEST
OCTOBER 12-18 1976

DATE	TIME	OPERATING CONDITION	REMARKS
Tuesday 10/12/76	8:30	Refuse delivery started	Dumped into pit
		Boiler up to temperature on gas	
	9:00	Refuse feed begun 3 pulverizers on line	No air flow control - I.D. fan damper stuck
	10:15	Refuse feed system plugged	Boiler back on gas
	10:45	Refuse feed started	
	11:15	Steam load held reasonably constant at 85% load	Lost it after 15 minutes - inconsistent feed
	12:00	Lunch break - boiler operated by plant personnel	
	13:00	Refuse feed plugged	On gas
	13:30	Refuse feed plugged	On gas
	14:00	Refuse feed plugged	On gas
	14:20	Restart refuse	
	14:50	Lost feed	10 minutes
	15:00	Restart refuse	
	15:30	Attempt to operate at about 70% load	Load swings of ± 20%

	16:00	Attempt to operate at full load	± 4% - good operation
	16:20	Lost feed - partially plugged	Attempted to continue operation at low feed rate
	16:40	Lost feed - chutes plugged	On gas
	17:20	Restart refuse feed	Uneven feed rates
	18:00	Lost feed	Bridge breaker in feed chute stuck
Wednesday 10/13/76	8:30	First refuse truck arrived	166 ton loaded in pit
	9:23	Start refuse feed	Attempted to bring unit up to full load. --Feed variations and minor plugging plagued operation.
	11:00	Lost feed	Bridge breaker stuck on gas
	12:00	Restart refuse feed	1 1/2 hr. operation at 80% Load ± 20%. B&W and EPA doing preliminary measurements.
	13:50	Boiler up to full load	15 minutes - lost feed
	14:05	Lost feed - bridge breakers stopped	Gear box defective. Replacement took just over an hour. Boiler on gas.
	15:20	Restart refuse feed	Boiler brought up to 80% load maintained there ± 20% for 3 1/2 hours. ID fan dampers stuck in open position. Particulate test runs by EPA and B&W. No loss of feed during this period.

	20:00	Boiler shutdown	Out of refuse
Thursday 10/14/76	8:15	Start refuse feed	Boiler up to load 3 times in first hour. Plugged feed each time. Problems with bridge breakers and overfire air turbine drive.
	10:05	Feed chute plugged	On gas. Bridge breaker drives burnt-out. New drives ~~opened~~ ordered for installation tomorrow morning. System operated at reduced load remainder of day w/o bridge breakers.
	10:50	Restart refuse feed	
	11:05	Lose feed	
	11:15	Restart feed	
	11:40	Lose feed	Plugged chutes
	12:00	Restart feed	
	12:20	Lose feed	Plugged chutes
	12:40	Restart feed	
	12:50	Lose feed	Overfire air turbine drive kicking out
	13:20	Restart feed	Operated @ 50% load for 1 1/2 hours w/o loss of feed. Then at 45% load for one hour. Both at ± 30%. Particulate & gas testing during this period.

	16:00	Began to experience kick-out problems with overfire air fan turbine	No consistent operation the remainder of the day.
Friday 10/15/76	8:00	Change bridge breaker drives	New gear motors installed with chain drives to bridge breaker sprockets.
	10:45	Start refuse feed	
	11:10	Lost feed	Bridge breakers stuck. Necessary to cut cleanout holes in chutes.
	15:35	Restart refuse	
	16:05	Shut down feed	Fuel piling on grates-overfire air fan turbine kicking out.
	17:00	Similar kick-out problems to previous day with overfire air turbine	No consistent operation the remainder of the day.
Saturday 10/16/76	8:20	Start refuse feed	Continue to have problems with overfire air turbine and settings on stokers. No consistent operation.
	10:40	Refuse feed shut off	Working on overfire air turbine governor.
	11:15	Restart refuse	Still air problems
	11:35	Shut down feed	Replace worn shaft in turbine governor
	13:20	Restart refuse feed	

	13:45	Begin gas sampling	2 hr. run at 70% load 45 minutes @ full load
	17:00	Erratic operation - chute plugging	
	17:05	Gas on	
Sunday 10/17/76	9:40	Start refuse feed	
	10:30	No. 1 pulverizer plugged	Speed up No. 3 & 4
			B&W ran 2 1/2 hr test at 80 to 90% load
	11:40	Slowed conveyors - blowing off safeties.	Lost control of steam load for 30 minutes.
	13:00	Lost refuse feed	Erratic operation for rest of day.
Monday 10/18/76	8:30	Exercise emergency generation	Required weekly - interrupts electrical circuits
	9:30	Start refuse feed	
	10:15	Stop feed	Bridge breaker stuck
	10:35	Restart feed	
	11:40	Stop feed	Bridge breaker
	11:50	Restart feed	
	12:15	Stop feed	Bridge breaker
	12:25	Restart feed	
	12:40	Start B&W test	Average load $\sim$ 75% $\pm$ 20%

13:30	Stopped two pulverizers to clear feed conveyors	Only one left running
13:35	Restart pulverizers	
14:35	Lost smooth feed	
16:05	Plugged No. 1 pulverizer	Shutdown pulverizer for the day. Last hour of test at about 60% load ± 25%.
17:00	Plugged No. 4 pulverizer	Stopped feed - on gas

APPENDIX D.

SOURCE TESTING DOCUMENTATION

ALSID, SNOWDEN & ASSOCIATES / **COMPUTER PRINT-OUT OF ATMOSPHERIC EMISSION DATA**

JOB NAME *EPA REGION 10 At. HAMILTON ONT.* DATE *10-13-76*

PREPARED BY *D. AIGUARD* APPROVED ______ PAGE *1* OF *2*

SUBJECT *#1 WASTE INCIN. STACK EMISSIONS RUN 1 143-6*

56.997 **VOLm**
29.425 **Pm**
530. **Tstd**
527. **Tm**
56.37312810442 **VOLstd**
11.83 **VOLw**
17.34524548769 **%M**
.8265475451231 **MF**
50.016 **Wd**
27.93179530219 **Ww**
1.018063479999 **Cd**
29.214 **Psn**
1.012011114324 **Cs**
0.07 **VH**
540. **TS**
8.566600265340

0.18
550.
15.46332503254

0.22
550.
14.90637447537

0.28
550.
16.81665840766

0.28 **VH**
540. **TS**
16.73320053068

0.30
540.
17.52050307568

0.30
545.
17.56375535418

0.28
545.
16.77498137107

0.28
550.
16.81665840766

0.28
550.
16.81665840766

0.29
550.
17.11432148815

0.15
525.
12.15524578114

0.21 **VH**
500. **TS**
14.19859147943

0.24
450.
14.77836256152

0.27
450.
15.67482057313

0.29
450.
16.24499923053

0.28
450.
15.96245595138

0.29
450.
16.24499923053

0.29
450.
16.24499923053

0.28
450.
15.96245595138

0.27
450.
15.67482057313

0.24
450.
14.77836256152

0.25
450.
15.08310312899

0.25
450.
15.08310312899

0.26
450.
15.38180743605

0.27
450.
15.67482057313

0.28
450.
15.96245595138

0.26
450.
15.38180743605

ALSID, SNOWDEN & ASSOCIATES / **COMPUTER PRINT-OUT OF ATMOSPHERIC EMISSION DATA**

JOB NAME *EPA* DATE *10-13-76*

PREPARED BY *D.A.* APPROVED PAGE *2* OF *2*

SUBJECT *#1 WASTE INCIN. EMISSIONS CONT'D*

0.27 **VH**	947.0312500000	**$\overline{Ts}$**
450. **TS**		
15.67482057313	15.49959900830	**Ka**
	.504143479O983	**Kb**
0.27 **VH**		
450. **TS**	0.827	**Cp**
15.67482057313	38.29870650246	**Vo**
0.27		
450.	42.65	**As**
15.67482057313	98006.59096339	**Qos**
	44265.28171045	**Qs**
0.28		
450.		
15.96245595138	64.	**T**
	0.000767	**An**
	42.37763442312	**Vn**
	110.6503005993	**I**
	2179.6	**Pt**
	.5954226974566	**Co**
	10.35	**N**
	.6903451564714	**C**
	225.9020195318	**PMRp**
	249.9737630378	**PMRr**
	237.9376912848	**$\overline{PMR}$**
	.7270898160400	**C'**

ALSID, SNOWDEN & ASSOCIATES / **COMPUTER PRINT-OUT OF ATMOSPHERIC EMISSION DATA**

JOB NAME *EPA @ HAMILTON ONTERIO* DATE *10/14/76*

PREPARED BY *Wm E STOLBERG* APPROVED ______ PAGE ______ OF ______

SUBJECT *WASTE INCINERATOR NO1* *RUN 2* *144-6*

10.124 **VOLm**	0.24 **VH**	0.32 **VH**	975.0000000000 **$\overline{Ts}$**
29.586 **Pm**	520. **TS**	540. **TS**	
	15.33625161014	17.33854381999	16.94115846882 **Ka**
530. **Tstd**			
515. **Tm**			.5425679137174 **Kb**
10.54275279231 **VOLstd**	0.30	0.30	
	540.	510.	
	17.32050807568	17.05872210923	0.827 **Cp**
1.39[illegible] **VOLw**			41.27573778169 **Vo**
11.90720359166 **%M**			
		0.30	
.8809275641034 **MF**	0.31		
		490.	42.65 **As**
	490.	16.38194301613	105624.7665233 **Qos**
	17.16100230173		
30.016 **Wd**			
2[illegible].55522320[illegible]02 **Ww**			49534.61073706 **Qs**
1.0063[illegible]028654[illegible] **Cd**			
			11. **T**
			0.000767 **An**
29.551 **Psn**			
1.00347454791 6 **Cs**			43.47658451631 **Vn**
VH			105.3367514451 **I**
TS			
			134.9 **Pt**
			.2008610071950 **Co**
			10.55 **N**
			.2328832547199 **C**
			85.45062253476 **PMRp**
			90.01541065100 **PMRr**
			87.73301665739 **$\overline{PMR}$**
			.2590516329200 **C'**

INCOMPLETE TRAVERSE SAMPLE. SAMPLE PARTICULATE IS RELATIVELY LOW INDICATING STRATIFICATION OF PARTICULATE WITHIN STACK

ALSID, SNOWDEN & ASSOCIATES / **COMPUTER PRINT-OUT OF ATMOSPHERIC EMISSION DATA**

JOB NAME EPA @ HAMILTON, ONTERIO DATE 10/14/76

PREPARED BY Wm E STOLBERG APPROVED PAGE OF

SUBJECT WASTE INCINERATOR BOILER No1 RUN 3 145-6

53.363 **VOLm**	0.24 **VH**	0.23 **VH**	0.17
29.527 **Pm**	510. **TS**	505. **TS**	490.
	15.25773489820	14.89798644112	12.70826502713
530. **Tstd**			
530. **Tm**			
52.56207556815 **VOL std**	0.24	0.24	0.24
	510.	497.	492.
	15.25773489820	15.15519712837	15.11555490215
8.627 **VOLw**			
14.07591796747 **%M**			
	0.24	0.25	0.24
.8592406203253 **MF**			
	510.	497.	492.
	15.25773489820	15.46770829825	15.11555490215
29.564 **Wd**			
27.95626054624 **Ww**			
	0.25	0.25	0.24
1.017982103249 **Cd**	512.	497.	485.
	15.53845726811	15.46770829825	15.05683047761
29.351 **Psn**			
1.0039640498326 **Cs**	0.25	0.24	0.23
	512.	497.	500.
	15.53845726811	15.15519712837	14.85934043680
0.15 **VH**			
424. **TS**			
11.51520733638	0.26	0.24	0.24
	506.	497.	502.
	15.64802526852	15.15519712837	15.19473593057
0.21			
490.			
14.12444689132	0.26	0.25	0.26
	506.	495.	501.
	15.64802526852	14.82059378027	15.80696049213
0.22			
510.			
14.60821383586	0.17	0.22	0.25
	505.	495.	500.
	12.80820049811	14.49482666333	15.49193333494
0.23			
512.			
14.55192293325			

ALSID, SNOWDEN & ASSOCIATES / **COMPUTER PRINT-OUT OF ATMOSPHERIC EMISSION DATA**

JOB NAME EPA @ HAMILTON, ONTARIO DATE 10/14/76

PREPARED BY ______ APPROVED ______ PAGE ______ OF ______

SUBJECT WASTE INCINERATOR BOILER #1 RUN 3 CONT'D

0.23 **VH**	0.17 **VH**	953.0537500000 **$\overline{Ts}$**
499. **TS**	497. **TS**	
14.35159924048	12.75499901999	14.60567559558 **Ka**
		.47184550417[illegible]4 **Kb**
0.22	0.08	
498.	496.	
14.51757555516	8.745284443630	0.827 **Cp**
		55.01104569445 **Vo**

42.65 **As**
92152.26593211 **Qos**

42963.49033318 **Qs**

64. **T**

0.000767 **An**

58.34663916461 **Vn**

106.4857598440 **I**

976.9 **Pt**
.2856754094413 **Co**

6.4 **N**
.5536413427036 **C**

103.2093770026 **PMRp**

112.0386107698 **PMRr**

10[illegible].62[illegible]62 **$\overline{PMR}$**

.5529582351600 **C'**

ALSID, SNOWDEN & ASSOCIATES / **COMPUTER PRINT-OUT OF ATMOSPHERIC EMISSION DATA**

JOB NAME: EPA at Hamilton Ont — DATE: 10-14-76

PREPARED BY: D. Alguard — APPROVED: — PAGE: 1 OF 2

SUBJECT: #1 Incinerator Emissions Run # 4 — 146-6

55.442 **VOLm** 0.26 **VH** 0.23 **VH** 0.22

29.570 **Pm** 491. **TS** 490. **TS** 460.

15.7245031718 14.7317454990 14.2267353950

530. **Tstd**

528. **Tm**

55.0069931298 **VOL std** 0.24 0.26 0.27

498. 490. 475.

15.1631131368 15.7162336455 15.9886752122

6.664 **VOLw**

10.8067736395 **%M**

0.24 0.26 0.27

.8919322111050 **MF**

493. 484. 480.

15.1631131368 15.6665248220 15.9311016568

29.334 **Wd**

28.1051598306 **Ww**

0.23 0.275 0.25

1.0148464870 **Cd** 506. 470. 485.

14.9057036063 15.9921855917 15.3704261489

29.331 **Psn**

1.0091509877 **Cs** 0.23 0.270 0.26

514. 455. 487.

0.19 **VH** 14.9672970352 15.7178242769 15.6913989178

494. **TS**

13.4632895403

0.235 0.280 0.27

525. 450. 487.

0.23 15.1988436406 15.9624559013 15.9903095654

492.

14.7372970504

0.26 0.260 0.28

523. 460. 489.

0.27 15.9868696122 15.4660919453 16.3009202194

490.

14.7817454990

0.19 0.24 0.275

510. 450. 492.

0.25 15.5757136092 14.7786625615 15.1902546561

485.

15.3704261489

ALSID, SNOWDEN & ASSOCIATES / **COMPUTER PRINT-OUT OF ATMOSPHERIC EMISSION DATA**

JOB NAME EPA @ HAMILTON DATE 10-14-76

PREPARED BY D. ALGUARD APPROVED PAGE 2 OF 2

SUBJECT EMISSIONS RUN #4 CONT'D

0•285 **VH**	**VH**	947•1250000000 **$\overline{T}_s$**
493• **TS**	**TS**	
16•48044295521		15•11394015289 **Ka**
		•4911631067654 **Kb**
0•240		
500•		0•823 **Cp**
15•17893276980		56•94225417118 **Vo**
0•18		
459•		42•65 **As**
13•05931254647		94535•22842407 **Qos**
		46555•92573639 **Qs**
0•11		
478•		
10•15775565762		64• **T**
		0•000767 **An**
		59•10119555424 **Vn**
		163•1371543781 **I**
		859•8 **Pt**
		•2435395502931 **Co**
		4•53 **N**
		•0451379610415 **C**
		96•71640113394 **PMRp**

Table 8

PARTICULATE CONCENTRATION AND PMR CALCULATION TERMINOLOGY

VOL_m	= Dry gas meter volume @ meter temperature and pressure, dry - acf
P_m	= Dry gas meter pressure (recorded as inlet deflection accross orifice meter) - "Hg
T_m	= Dry gas meter temperature (average of inlet and outlet)
P_{STD}	= Standard atmospheric pressure (29.92" Hg)
T_{STD}	= Standard Temperature (520 or 530° R)
VOL_w	= Volume of water collected (expressed as vapor at standard temperature and pressure) - scf
% M	= % water, calculated from amount the train collected in impinger, bubblers, and on silica gel
MF	= Mole fraction of dry gas
W_D	= Molecular weight of dry stack gas - lb/lb mole
W_W	= Molecular weight of wet stack gas - lb/lb mole
W_a	= Molecular weight of air - lb/lb mole
C_D	= Velocity correction coefficient for gas density
P_{SN}	= Stack pressure (static + barometric) - "Hg
C_S	= Velocity correction coefficient for stack pressure
VH_n	= Pitot tube pressure differential - "H_2O
V_o	= Stack velocity @ stack conditions - fps
Q_o	= Stack flow rate at stack conditions - acfm
$\overline{T}_s$	= Average stack temperature - °F
Q_S	= Stack flow rate at standard conditions - scfm
T	= Time over which sample was collected - minutes
V_n	= Velocity of gases inside nozzle during sampling - fps
I	= % isokinetic (± 10% desirable)
C_O	= Particulate concentration - grains/scf
N	= % CO_2 by volume in stack (12 indicates no % CO_2 correction is to be made)
T_s	= Temperature of stack gas at sampling point - °F

Table 8 (Continued)

PARTICULATE CONCENTRATION & PMR CALCULATIONS

1. $VOL_{STD} = \frac{(VOL_m)\ (P_m)\ (T_{STD})}{(P_{STD}*)\ (T_m)}$

2. $\%\ M = \frac{(100)\ (VOL_w)}{VOL_{STD} + VOL_w}$

3. $MF = \frac{100 - M}{100}$

4. $W_w = (W_D)\ (MF) + 18\ (1\text{-}MF)$

5. $C_D = \sqrt{\frac{W_a*}{W_w}}$

6. $C_S = \sqrt{\frac{P_{STD}}{P_{SN}}}$

7. $K = \frac{\sum\sqrt{VH_n \times T_{S_n}}}{n}$

8. $V_o = 2.9\ (K_a)\ (C_p)\ (C_D)\ (C_S)$

9. $Q_o = (V_o)\ (A_S)\ (60)$

10. $Q_{OS} = \frac{Q_o\ (T_{STD})\ (P_{SN})\ (MF)}{(T_S)\ (P_{STD})}$

11. $V_n = \frac{(VOL_{STD})\ (P_{STD})(T_S)}{(MF)\ (T_{STD})\ (P_{SN})\ (T)\ (A_N)\ (60)}$

12. $I = (100)\ \frac{V_n}{V_o}$

13. $C_O = \frac{P_T}{VOL_{STD}}\ (0.0154)$

14. $C = \frac{C_O\ (12\%)}{N}$

15. $PMR_p = (C_O)\ (Q_{OS})\ (0.008571)$

* P_{STD} = 29.92" Hg.

* W_a = 28.95 LB/LB MOLE

Table 8 (Continued)

PARTICULATE CONCENTRATION AND PMR CALCULATION TERMINOLOGY

C	=	Particulate concentration corrected to 12% CO_2
PMR_p	=	Pollutant mass rate - "concentration method" - lb/hr
P_T	=	Total Particulate collected by sampling train - mg
A_s	=	Area of Stack - FT^2
A_n	=	Area of Nozzle - FT^2
VH	=	Velocity head readings for pitot tube - inches water
VOL_{STD}	=	Standardized gas that passed through the sampling train - cubic feet, 70° F., 1 atmosphere pressure, and dry.
C_p	=	Velocity correction coefficient for type pitot tube - dimensionless 0.83 to 0.87 for "S" type pitot tube normally and 1.0 for "P" type pitot tube.

[illegible] EPA P[illegible] DATE 10-13-76

ALSID, SNOWDEN & ASSOCIATES

TRAVERSE SAMPLING DATA SHEET

PORT LOCATION [illegible] INCINERATOR STACK

RUN NO. 1 LAB NO. [illegible]

OPERATOR/S AIGUARD SNOWDEN

SAMPLE BOX NO. [illegible] METER BOX ΔH@ 1.763

FILTER NO. 91-15 TARE ____ Mg ____

DISTANCE UPSTREAM & DOWNSTREAM FROM OBSTRUCTION 100' & 35'

BOX AND PROBE HEATER SETTING 75 & [illegible]

BAROMETRIC PRESSURE (P_B) 29.[illegible] "Hg

LEAK RATE .03 CFM @ 24.5 "HG

PORT PRESSURE (P_S) -.2 "H_2O = -.015 "Hg

P_{SN} = P_B + P_S 29.214 "Hg

ASSUMED MOISTURE 12 % MAX VH ____ "H_2O

C FACTOR 1

REF. ΔP .18

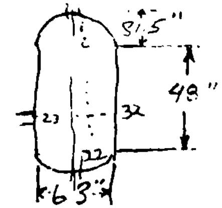
STACK DIMENSIONS 31.50 [illegible] LONG AREA 15.9142.672

PROBE NOZZLE DIA. 3/8 IN; AN ____ F2

PROBE LENGTH 8' NUMBER 12 SIDE 2

	FINAL WT. gm	INITIAL WT. gm	NET WT. gm	INITIAL WT.
#1 BUBBLER	615.3	[illegible]	185.8	429.5
#2 IMPINGER	[illegible]	[illegible]	30.2	437.7
#3 BUBBLER	355.7	349.6	5.1	350.6
#4 SILICA GEL	654.8	604.2	22.5	632.3

TOTAL WATER VOLUME (1gm = 1 ml) 249.6 x 0.0474 = 11.83 FT³



SCHEMATIC OF TRAVERSE POINT LAYOUT

INSTANTANEOUS READINGS: RECORDED @ BEGINNING OF TIME INTERVAL							AVERAGE VALUES READ WITHIN THE TIME INTERVAL						
CLOCK TIME (24 HRS)	ELAP. TIME (MIN)	DRY GAS METER (CUBIC FEET)	DRY GAS TEMP. (°F) INLET	OUTLET	BOX TEMP. (°F)	IMPINGER TEMP. (°F)	POINT	PITOT VH ("H_2O)	ORIFICE ΔH ("H_2O) DESIRED	ACTUAL	PUMP VACUUM ("Hg GA)	STACK TEMP. (°F)	OPACITY OR %CO_2
5:51	0	533.203	61	60	195	40	22	0.07	.7	.70	2.8	540	
	2	534.1	61	60	220	40	21	0.18	1.8	1.8	2.6	550	
	4	535.8	70	60	220	40	20	.23	2.3	2.4	2.8	550	
	6	537.5	74	60	225	40	19	.28	2.8	2.8	2.9	550	
	8	539.0	78	60	230	40	18	.28	2.8	2.8	3.0	540	
	10	540.65	75	60	235	40	17	.3	3.1	3.1	4.0	540	
	12	542.5	83	61	245	42	16	.3	3.1	3.1	4.0	545	
	14	544.6	84	61	260	46	15	.28	2.9	2.9	4.0	545	
	16	546.45	87	61	260	48	14	.28	2.9	2.9	4.0	550	
	18	548.6	90	62	265	50	13	.28	2.9	2.9	4.0	550	
	20	550.45	92	62	265	52	12	.29	3.1	3.1	4.0	550	
	22	552.267	90/74	63/63	265	54	23	.15	1.6	1.6	2.0	525	
6:15/6:25	24	554.0	74	62	250	54	24	.21	2.2	2.2	3.0	500	
	26	555.5	74	62	250	52	25	.24	2.5	2.5	4.0	450	
	28	556.9	76	62	250	50	26	.27	2.8	2.8	4.0	450	
	30	558.9	78	61	250	50	27	.29	3.0	3	3.0	450	
	32	560.8	78	60	250	50	28	.28	2.8	2.9	5.0	450	
	34	562.9	80	60	248	48	29	.29	3.0	3.0	5.0	450	
	36	564.9	80	60	255	48	30	.29	3.0	3.0	5.0	450	
	38	566.7	80	60	255	50	31	.28	2.5	2.5	5.0	450	
	40	568.65	80	60	255	50	32	.27	2.8	2.8	5.0	450	
	42	570.442	80/60	60/54	250	50	1	.24	2.5	2.5	5.0	450*	
	44	572	60	54	250	50	2	.25	2.7	2.7		450 est	
	46	573.6	63	54	250	50	3	.25	2.7	2.7	5.0	450 est	
	48	575.5	66	54	240	50							
TOTAL										"H_2O			
AVERAGE			°F = °R						"H_2O = "Hg				

°R

CLIENT EPA[c] Ham Art.

Run 1 10-13-76

SEATTLE, WASHINGTON

TRAVERSE SAMPLING DATA SHEET

IMPORTANT: FILL IN ALL BLANKS.

INSTANTANEOUS READINGS: RECORDED @ BEGINNING OF TIME INTERVAL							AVERAGE VALUES READ WITHIN THE TIME INTERVAL						
CLOCK TIME (24 HRS.)	ELAP. TIME (MIN)	DRY GAS METER (CUBIC FEET)	DRY GAS TEMP. (°F) INLET	DRY GAS TEMP. (°F) OUTLET	BOX TEMP. (°F.)	IMPINGER TEMP. °F.	POINT	PITOT VH ("H_2O)	ORIFICE ΔH ("H_2O) DESIRED	ORIFICE ΔH ("H_2O) ACTUAL	PUMP VACUUM ("Hg.GA.)	STACK TEMP. (°F.)	OPACITY OR %CO_2
7:25	50 ~~8~~	577.6	70	55	240	50	4	.26	2.7	2.7	5.0	450 est*	
	52 ~~10~~	[illegible].1	73	54	240	50	5	.27	2.8	2.8	5.0	450	
	54 ~~12~~	581	75	54	230	50	6	.28	2.8	2.8	5.0	" "	
	56 ~~14~~	582.8	76	54	230	50	7	.26	2.7	2.7	5.0	450 "	
	58 ~~16~~	584.9	78	54	230	50	8	.27	2.8	2.8	5.0	450 "	
	60 ~~18~~	586.6	80	55	225	50	9	.27	2.8	2.8	5.0	450 "	
	62 ~~20~~	588.3	83	56	225	50	10	.27	2.8	2.8	5.5	450 "	
7:29	64 ~~22~~	590.200	84	56	225	50	11	.28	2.5	2.5	6	450 est	
TOTAL	64	56.997	[illegible]	2093						86.5 "H_2O			
AVG.			°F =	°R.					2.67 "H_2O	= .196 "Hg			

*Estimate assumed at this point & beyond as thermocouple was blown off stack platform at this time.

$P_m = P_B + \Delta H =$ 29.425 "Hg

°R

54

VFT/AP1E

ORSAT DATA AND CALCULATION SHEET

CLIENT EPA Hamilton

SAMPLING POINT LOCATION Incin. Stack #1 Boiler

DATE 10/13 RUN NO. 1 HOW COLLECTED Grab

TIME OF SAMPLE COLLECTION 6 15-7.40 TIME OF ANALYSIS 8:30

CUMULATIVE % BY VOL.(DRY)	ANALYSIS #1	ANALYSIS #2	ANALYSIS #3	ANALYSIS #4
CO_2	10.4	10.4	10.3	
$CO_2 + O_2$	18.2	19.4	19.3	
$CO_2 + O_2 + CO$	18.6	19.6	19.3	

COMPONENT % BY VOL.(DRY)	#1	#2	#3	#4	AVG.	RATIO MOLE WT	WT./MOLE (DRY)
CO_2		10.4	10.3		10.35	44/100	4.554
O_2		9.0	9.0		9.0	32/100	2.880
CO		0.2	0.0		.1	28/100	.028
N_2 (100-Above)					80.55	28/100	22.554

AVG. MOLECULAR WT. DRY STACK GAS: 30.016

VFT/AP4B

	Initial	Final	Net
#1 Bubbler	449.8	463.5	13.7
2 Impinger	441.2	444.2	3.0
3 Dry	334.9	335.1	.2
4 Silica Gel	604.4	617.0	12.6
		TOTAL	29.5

$\times .0474 = 1.398 \, ft^3$

144-6

CLIENT EPA Hamilton Ont

PORT LOCATION Incinerator

DATE 10-14-76

OPERATOR/S Alguard, Snowden

RUN NO. 2

SAMPLE & METER BOX NUMBERS Red & ____

METER BOX ΔH 1.763

FILTER NO. 91-5 @ TARE ____ mg

CLEAN-UP NO. ____; BLANKS ____ & ____

BOX & PROBE HEATER SETTING 250° & 60%

SEATTLE, WASHINGTON

TRAVERSE SAMPLING DATA SHEET

IMPORTANT: FILL IN ALL BLANKS

SCHEMATIC OF TRAVERSE POINT LAYOUT

BAROMETRIC PRESSURE (P_B) 29.379 "Hg

AMBIENT CONDITIONS Windy 48°

PORT PRESSURE (P_S) -.25 "H_2O = -.018 "Hg

$P_{SN} = P_B + P_S$ 29.361 "Hg

ASSUMED MOISTURE 17 %

C FACTOR .8

REF. ΔP .19

STACK DIMENSIONS ____; AREA ____ F^2

PROBE NOZZLE DIA. 3/4 IN; A_N ____ F^2

PROBE LENGTH 8' FT. #12 IN. S2+

CLOCK TIME (24 HRS)	ELAP. TIME (MIN)	DRY GAS METER (CUBIC FEET)	DRY GAS TEMP. (°F) INLET	DRY GAS TEMP. (°F) OUTLET	BOX TEMP. (°F)	IMPINGER TEMP. (°F)	POINT	PITOT VH ("H_2O)	ORIFICE ΔH ("H_2O) DESIRED	ORIFICE ΔH ("H_2O) ACTUAL	PUMP VACUUM ("Hg GA)	STACK TEMP. (°F)	OPACITY OR %CO_2
1133	0	550.826	48	46	210		1	.24	2.2	2.2	3	520	
	2	552.35	52	46	220		2	.3	2.8	2.8	3	540	
	4	554.25	56	46	200		3	.32	3.1	3.1	3.5	540	
	6	556.1	60	47	210		4	.3	2.8	2.8	3	510	
	8	558	64	47	210		5	.31	3.0	3.0	3.5	450	
	10*	600	65	47			6	.3	3.0	3.0	3.5	490	
	11	600.950	66	48									
TOTAL		10.124	411	327						16.9 "H_2O			
AVERAGE			53 °F = 513 °R						2.816 "H_2O = .207 "Hg			°R	

* STOPPED @ 11 min ET

$P_m = P_B + \Delta H$ = 29.586 "Hg

VFT/APIE

145-6

FINAL **SEATTLE, WASHINGTON**

552.0

TRAVERSE SAMPLING DATA SHEET

IMPORTANT: FILL IN ALL BLANKS

494.2
344.3
659.4

Net
130.5
25.4
6.1
20.0
TOTAL 182.0
x.0474 = 8.627 ft³

CLIENT ______

PORT LOCATION WASTE [illegible] Boiler #1

DATE ______

OPERATOR/S ______

RUN NO. ______

SAMPLE & METER BOX NUMBERS [illegible] & ______

METER BOX ΔH ______

FILTER NO. 8?-5 @ TARE ______ mg

CLEAN-UP NO. ______; BLANKS ______ & ______

BOX & PROBE HEATER SETTING ______ & ______

BAROMETRIC PRESSURE (P_B) 29.369 "Hg

AMBIENT CONDITIONS WINDY 50°

PORT PRESSURE (P_S) -.25 "H_2O = -.018 "Hg

$P_{SN} = P_B + P_S$ 29.351 "Hg

ASSUMED MOISTURE 17 %

C FACTOR .8

REF. ΔP .19

STACK DIMENSIONS ______; AREA 42.65 F²

PROBE NOZZLE DIA. ______ IN; A_N .000767 F²

PROBE LENGTH 8 FT. #12 IN. 52+

SCHEMATIC OF TRAVERSE POINT LAYOUT

INSTANTANEOUS READINGS: RECORDED @ BEGINNING OF TIME INTERVAL							AVERAGE VALUES READ WITHIN THE TIME INTERVAL						
CLOCK TIME (24 HRS)	ELAP. TIME (MIN)	DRY GAS METER (CUBIC FEET)	DRY GAS TEMP. (°F) INLET	DRY GAS TEMP. (°F) OUTLET	BOX TEMP. (°F)	IMPINGER TEMP. (°F)	POINT	PITOT VH ("H_2O)	ORIFICE ΔH ("H_2O) DESIRED	ORIFICE ΔH ("H_2O) ACTUAL	PUMP VACUUM ("Hg GA)	STACK TEMP. (°F)	OPACITY OR %CO_2
1458	0	601.112	60	56	250	50	1	0.[illegible]	1.4	1.4	9.2	[illegible]	
[illegible]	2	60?.65	64	56			2	0.21	1.[illegible]	1.?5	5.5	490	
[illegible]	4		[illegible]	[illegible]	290		3	0.22	2.10	2.[illegible]	6.2	510	
[illegible]	6	605.78	71	57			4	0.23	2.15	2.15	6.5	51?	
1500	8	607.45	74	58			5	0.24	2.30	2.30	7.0	510	
1508	10	609.1	74	58	220		6	0.24	2.30	2.30	7.0	510	
1510	12	610.83	24	57			7	0.24	2.30	2.30	7.0	510	
1512	14	612.7	76	57			8	.25	2.4	2.4	7.0	512	
1514	16	614.4	78	57	250		9	.25	2.4	2.4	7.0	512	
1516	18	616.2	79	58			10	.26	2.4	2.6	7.0	506	
1518	20	617.7	80	59	260	70	11	.26	2.4	2.4	7.0	506	
1520/1526	22	619.47	82/64	60/60			22	.17	1.6	1.6	5.0	505	
1528	24	621	76	61	300	50	24	.23	2.2	2.2	6.5	505	
1530	26	62?.?	99	61			25	.24	2.3	2.3	7.0	497	
1532	28	624.4	89	62	325		26	.25	2.35	2.35	7.0	497	
1534	30	626.2	85	63	325		27	25	2.35	2.35	7.0	497	
1536	32	627.8	86	63	280	50	28	.24	2.3	2.3	7.0	497	
1538	34	629.5	88	64	250		29	.24	2.3	2.3	7.0	497	
1540	36	631.1	88	64			30	.23	2.2	2.2	7.0	495	
	38	632.9	90	64	210		31	.22	2.05	2.05	6.5	455	
	40	634.6	88	65	215	50	32	.17	1.6	1.6	5.0	490	
/1538	42(1)	636.0	75	65			12	.24	2.3	2.2	7.8	492	
	44 2	637.96	78	65			13	.24	2.3	2.3	7.8	492	
	(9)	639.35	79	64			14	.24	2.3	2.3		485	
	6	641.05	80	63									
TOTAL										"H_2O			
AVERAGE			°F =	°R					"H_2O =	"Hg			
								$P_m = P_B + \Delta H$ =		"Hg		°R	

VFT/APIE

CLIENT EPA @ Hamilton

Run # 3 - 10/14/76

SEATTLE, WASHINGTON

TRAVERSE SAMPLING DATA SHEET

IMPORTANT: FILL IN ALL BLANKS.

INSTANTANEOUS READINGS: RECORDED @ BEGINNING OF TIME INTERVAL							AVERAGE VALUES READ WITHIN THE TIME INTERVAL						
CLOCK TIME (24 HRS.)	ELAP. TIME (MIN)	DRY GAS METER (CUBIC FEET)	DRY GAS TEMP. (°F) INLET	DRY GAS TEMP. (°F) OUTLET	BOX TEMP. (°F.)	IMPINGER TEMP. °F.	POINT	PITOT VH ("H_2O)	ORIFICE ΔH ("H_2O) DESIRED	ORIFICE ΔH ("H_2O) ACTUAL	PUMP VACUUM ("Hg.GA.)	STACK TEMP. (°F.)	OPACITY OR %CO_2
	50 (8)	[illegible]	80	63	250	50	15	0.23	2.2	2.2	7.1	500	
	52 (10)	644.48	[illegible]	6[illegible]	245	50	16	0.24	2.3	2.3	7.5	502	
1611	54 (12)	646.15	83	63	250	50	17	0.26	2.5	2.5	8.2	501	
	56 (14)	647.92	85	62	250	50	18	0.25	2.4	2.4	8.0	500	
	58 (16)	649.71	85	62	270	50	19	0.23	2.2	2.2	7.5	499	
	60 (18)	651.37	85	63	280	50	20	0.22	2.1	2.1	6.8	498	
	62 (20)	652.96	85	63	280	50	21	0.17	1.6	1.6	5.8	497	
	64 (22)	654.475	85	63	280	50	22	0.08	0.78	0.9	5.0	496	
TOTAL	64	53.363	2689	2076			32			68.55"H_2O			
AVG.			70 °F = 530°R.						2.142 "H_2O = .158 "Hg				

$P_m = P_B + \Delta H = 29.527$ "Hg

°R

VFT/AP1E

ORSAT DATA AND CALCULATION SHEET

CLIENT E.A.I. @ Hamilton, Ontario

SAMPLING POINT LOCATION Stack Boiler No 1

DATE 10/19/76 RUN NO. Three HOW COLLECTED Integrated Bag

TIME OF SAMPLE COLLECTION 1458-1633 TIME OF ANALYSIS 2000

CUMULATIVE % BY VOL. (DRY)	ANALYSIS #1	ANALYSIS #2	ANALYSIS #3	ANALYSIS #4
CO_2	6.3	6.4	6.4	
$CO_2 + O_2$	20.9	19.9	19.9	
$CO_2 + O_2 + CO$	20.9	20.0	20.0	

COMPONENT % BY VOL. (DRY)	#1	#2	#3	#4	AVG.	RATIO MOLE WT	WT./MOLE (DRY)
CO_2		6.4	6.4		6.4	44/100	2.816
O_2		13.5	13.5		13.5	32/100	4.32
CO		0.1	0.1		.1	28/100	.028
N_2 (100-Above)					80	28/100	22.4

AVG. MOLECULAR WT. DRY STACK GAS 29.564

VFT/AP4B

ALSID, SNOWDEN & ASSOCIATES

TRAVERSE SAMPLING DATA SHEET

CLIENT Waste Incinerator Stack DATE 10-74

PORT LOCATION EPA @ Hamilton

RUN NO. 4 LAB NO. 146-6

OPERATOR/S Snowden Alsid

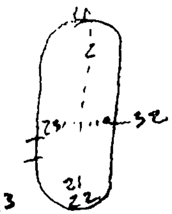
SAMPLE BOX NO. Red METER BOX ΔH@ 1.763

FILTER NO. 906 TARE ____ Mg ____

	FINAL WT. gm	INITIAL WT. gm	NET WT. gm
#1 BUBBLER	551.3 -	451.9 =	99.4
#2 IMPINGER	466.2 -	447.9 =	18.3
#3 BUBBLER	338.7	336.8 =	1.9
#4 SILICA GEL	638.0 -	617.0 =	21.0

TOTAL WATER VOLUME (1gm = 1 ml) 140.6 x.0474 = 6.664 Ft^3

DISTANCE UPSTREAM & DOWNSTREAM FROM OBSTRUCTION ____ & ____



SCHEMATIC OF TRAVERSE POINT LAYOUT

BOX AND PROBE HEATER SETTING 250, 75%

BAROMETRIC PRESSURE (P_B) 29.399 "Hg

LEAK RATE 0.01 CFM @ 24.5 "HG

PORT PRESSURE (P_S) -.25 "H_2O = -.018 "Hg

$P_{SN} = P_B + P_S$ 29.381 "Hg

ASSUMED MOISTURE 17 % MAX VH ____ "H_2O

C FACTOR 0.88

REF. ΔP 0.19

STACK DIMENSIONS ____ AREA ____ F^2

PROBE NOZZLE DIA. 3/8 IN; A_N ____ F^2

PROBE LENGTH 8' NUMBER 13 SIDE 2

INSTANTANEOUS READINGS: RECORDED @ BEGINNING OF TIME INTERVAL. | AVERAGE VALUES READ WITHIN THE TIME INTERVAL

CLOCK TIME (24 HRS)	ELAP. TIME (MIN)	DRY GAS METER (CUBIC FEET)	DRY GAS TEMP. (°F) INLET	DRY GAS TEMP. (°F) OUTLET	BOX TEMP. (°F)	IMPINGER TEMP. (°F)	POINT	PITOT VH ("H_2O)	ORIFICE ΔH ("H_2O) DESIRED	ORIFICE ΔH ("H_2O) ACTUAL	PUMP VACUUM ("Hg GA)	STACK TEMP. (°F)	OPACITY OR %CO_2
1743	0	654.450	60	58	190	50	1	0.19	1.8	1.8	2	494	
	2		64	58			2	0.23	2.4	2.4	2.8	492	
47	4	657.75	68	57			3	0.23	2.2	2.4	2.8	490	
	6	659.95	70	57	220		4	0.25	2.4	2.4	2.9	485	
	8	661.28	73	57			5	0.26	2.45	2.45	2.9	491	
	10	663.03	75	57			6	0.24	2.25	2.25	3.0	498	
	12	664.77	77	57	230	50	7	0.24	2.25	2.25	3.0	498	
	14	666.40	79	58			8	0.23	2.20	2.26	3.1	506	
	16	668.09	81	58			9	0.23	2.20	2.20	3.2	514	
	18	669.72	82	58	250	50	10	0.235	2.20	2.20	3.5	523	
	20	671.38	83	58			11	0.26	2.45	2.45	3.45	523	
	22	673.14	85/72	59/58			23	0.19	1.80	1.80	3.0	~~5~~ 510	
	24	674.70	75	58			24	0.23	2.20	2.20	3.5	490	
1820	26	676.30	77	59	270	50	25	0.26	2.45	2.45	3.9	490	
1828	28	678.10	79	59			26	0.26	2.45	2.45	3.9	484	
1830	30	680.00	82	60			27	0.275	2.65	2.65	4.3	470	
1832	32	681.78	84	60			28	0.270	2.60	2.60	4.2	455	
1834	34	683.65	87	60	280	50	29	.28	2.7	2.7	4.5	450	
1836	36	685.7	88	60			30	.26	2.45	2.45	4.5	460	
1838	38	687.2	88	60			31	.24	2.25	2.25	4.5	450	
1840	40	688.9	89	61			32	.22	2.1	2.1	4.0	460	
1842/1854	42	690.5	88/72	61/59			12	0.27	2.6	2.6	4.5	475	
	44	692.35	73	59			13	0.27	2.6	2.6	4.5	480	
	*(45) 46	694.00	75	59			14	0.25	2.4	2.4	4.5	485	
	48	695.80	76	59									
TOTAL										"H_2O			
AVERAGE			°F =	°R					"H_2O =	"Hg			

$P_m = P_B + \Delta H$ = "Hg

°R

STOPPED 1 MIN @ 1857 START @ 1858

CLIENT *EPA II @ Hamilton, Ontario*
Run #4 10/14/--

SEATTLE, WASHINGTON
TRAVERSE SAMPLING DATA SHEET
IMPORTANT: FILL IN ALL BLANKS.

INSTANTANEOUS READINGS: RECORDED @ BEGINNING OF TIME INTERVAL							AVERAGE VALUES READ WITHIN THE TIME INTERVAL						
CLOCK TIME (24 HRS.)	ELAP. TIME (MIN)	DRY GAS METER (CUBIC FEET)	DRY GAS TEMP. (°F) INLET	DRY GAS TEMP. (°F) OUTLET	BOX TEMP. (°F.)	IMPINGER TEMP. °F.	POINT	PITOT VH ("H_2O)	ORIFICE ΔH ("H_2O) DESIRED	ORIFICE ΔH ("H_2O) ACTUAL	PUMP VACUUM ("Hg.GA.)	STACK TEMP. (°F.)	OPACITY OR %CO_2
	50	697.68	77	58	300	50	15	0.26	2.45	2.45	5.2	487	
	52	699.58	77	58	300	50	16	0.27	2.55	2.55	5.2	487	
1907	54	701.19	78	58	[illegible]0	50	17	0.28	2.65	2.65	5.2	489	
	56	703.07	78	57	250	50	18	0.275	2.60	2.60	5.3	492	
	58	705.15	78	57	230	50	19	0.285	2.70	2.70	5.5	493	
	60	706.65	79	57	230	50	20	0.240	2.30	2.30	5.0	500	
	62	708.27	78	57	240	50	21	0.18	1.75	1.75	4.0	489	
	64	709.892	77	56	250	50	22	0.11	1.05	1.05	3.8	478	
TOTAL		535.442	2725	2042						743 "H_2O			
AVG.			68.1 °F = 528°R.						2.32 "H_2O = .171 "Hg				

$P_r = P_B + \Delta H =$ 29.570 "Hg

°R

VFT/APIE

ORSAT DATA AND CALCULATION SHEET

CLIENT [illegible]

SAMPLING POINT LOCATION [illegible]

DATE [illegible] RUN NO. 4 HOW COLLECTED [illegible]

TIME OF SAMPLE COLLECTION ______ TIME OF ANALYSIS ______

CUMULATIVE % BY VOL.(DRY)	ANALYSIS #1	ANALYSIS #2	ANALYSIS #3	ANALYSIS #4
CO_2	4.6	4.6	4.5	
$CO_2 + O_2$	19.8	19.9	19.7	
$CO_2 + O_2 + CO$	19.8	19.9	19.8	

COMPONENT % BY VOL.(DRY)	#1	#2	#3	#4	AVG.	RATIO MOLE WT	WT./MOLE (DRY)
CO_2	4.6	4.6	4.5		4.53	44/100	1.993
O_2	15.2	15.3	15.2		15.23	32/100	4.874
CO	0.0	0.0	0.1		.03	28/100	.008
N_2 (100-Above)					80.21	28/100	22.459

AVG. MOLECULAR WT. DRY STACK GAS: 29.334

VFT/AP4B

ALSID, SNOWDEN & ASSOCIATES

LABORATORY ANALYSIS AND TOTAL PARTICULATE SHEET

CLIENT EPA Region 10 DATE OF ANALYSIS 10-25-76

EVALUATION LOCATION HAMILTON, ONT. WASTE INCIN. #1 RUN NO. 1

EVALUATION DATE 10-13-76 LAB NO. 143-6

I. EVAPORATION OF 200 (ml) OF Acetone

RINSE & BRUSHING OF NOZZLE, PROBE AND GLASSWARE BEFORE FILTER.

FINAL 78391.8 (mg) - TARE 77537.3 (mg)

-BLANK ((.019 mg/ml) (200 ml) = 3.8 mg) = 850.7 mg.

II. FILTER CATCH MSA 1106-BH #81-5 (Media Type & #)

FINAL 1633.3 (mg) - TARE 380.2 (mg) = 1253.1 mg.

III. HYDROCARBON OBTAINED BY ETHER-CHLOROFORM EXTRACTION ON WATER IN IMPINGER AND BUBBLERS.

FINAL 78020.6 (mg) - TARE 78016.9 (mg)

-BLANK (0.1 mg) = 3.6 mg.

IV. PARTICULATE FROM EVAPORATION OF 430 (ml) WATER IN IMPINGER AND BUBBLERS FOLLOWING EXTRACTION -

FINAL 79014.2 (mg) - TARE 78943.9 (mg)

-BLANK ((.0025 mg/ml) (430 ml initial

- 249.6 ml CONDENSED = 180.4 ml) = 0.5 mg) = 69.8 mg.

V. PARTICULATE FROM 55 (ml) OF Acetone RINSE OF IMPINGER, BUBBLERS, AND CONNECTORS AFTER FILTER:

3.48%

FINAL 77820.5 (mg) - TARE 77817.1 (mg)

-BLANK ((.019 mg/ml) (55 ml) = 1.0 mg) = 2.4 mg.

VI. TOTAL PARTICULATE = I + II + III + IV + V = 2179.6 mg.

BLANKS

ACETONE = 1.9 mg/100 ml = 0.019 mg/ml FINAL 77467.5 mg. TARE 77465.6 mg.

ETHER-CHLOROFORM = 0.1 mg.(FINAL 77402.9 mg - TARE 77402.8 mg)

WATER = .5 mg/200 ml = .0025 mg/ml. FINAL 79471.8 mg. TARE 79471.3 mg.

ALSID, SNOWDEN & ASSOCIATES
LABORATORY ANALYSIS AND TOTAL PARTICULATE SHEET

CLIENT EPA Region 10 DATE OF ANALYSIS 10-25-76

EVALUATION LOCATION HAMILTON, ONT. WASTE INCIN. #1 RUN NO. 2

EVALUATION DATE 10-14-76 LAB NO. 144-6

I. EVAPORATION OF 65 (ml) OF Acetone

RINSE & BRUSHING OF NOZZLE, PROBE AND GLASSWARE BEFORE FILTER.

FINAL 78220.1 (mg) - TARE 78181.5 (mg)

-BLANK ((.019 mg/ml) (55 ml) = 1.0 mg) = 37.6 mg. FH 120.5

II. FILTER CATCH MSA 1106-BH #91-5 (Media Type & #)

FINAL 462.0 (mg) - TARE 379.1 (mg) = 82.9 mg.

III. HYDROCARBON OBTAINED BY ETHER-CHLOROFORM EXTRACTION ON WATER IN IMPINGER AND BUBBLERS.

FINAL 78443.7 (mg) - TARE 78443.0 (mg)

-BLANK (0.1 mg) = 0.6 mg.

IV. PARTICULATE FROM EVAPORATION OF 303 (ml) WATER IN IMPINGER AND BUBBLERS FOLLOWING EXTRACTION -

FINAL 78100.5 (mg) - TARE 78088.3 (mg)

-BLANK ((.0025 mg/ml) (303 ml initial

- 29.5 ml CONDENSED = 273.5 ml) = 0.7 mg) = 11.5 mg.

V. PARTICULATE FROM 33 (ml) OF Acetone RINSE OF IMPINGER, BUBBLERS, AND CONNECTORS AFTER FILTER:

FINAL 77992.0 (mg) - TARE 77989.1 (mg)

-BLANK ((.019 mg/ml) (33 ml) = 0.6 mg) = 2.3 mg. 14.4

VI. TOTAL PARTICULATE = I + II + III + IV + V = 134.9 mg. 10

BLANKS SAME AS RUN 1

ACETONE = ______ mg/______ ml = ______ mg/ml FINAL ______ mg. TARE ______ mg.

ETHER-CHLOROFORM = ______ mg.(FINAL ______ mg - TARE ______ mg)

WATER = ______ mg/______ ml = ______ mg/ml. FINAL ______ mg. TARE ______ mg.

ALSID, SNOWDEN & ASSOCIATES
LABORATORY ANALYSIS AND TOTAL PARTICULATE SHEET

CLIENT EPA Region 10 DATE OF ANALYSIS 10-25-76

EVALUATION LOCATION HAMILTON ONT. WASTE INCIN. #1 RUN NO. 3

EVALUATION DATE 10-14-76 LAB NO. 145-6

I. EVAPORATION OF 158 (ml) OF Acetone

RINSE & BRUSHING OF NOZZLE, PROBE AND GLASSWARE BEFORE FILTER.

FINAL 77982.8 (mg) - TARE 77522.3 (mg)

-BLANK ((.019 mg/ml) (158 ml) = 3.0 mg) = 457.5 mg. pH 829.2

II. FILTER CATCH MSA 1106-BH # 82-5 (Media Type & #)

FINAL 751.2 (mg) - TARE 379.5 (mg) = 371.7 mg.

III. HYDROCARBON OBTAINED BY ETHER-CHLOROFORM EXTRACTION ON WATER IN IMPINGER AND BUBBLERS.

FINAL 77882.3 (mg) - TARE 77875.2 (mg)

-BLANK (0.1 mg) = 7.0 mg.

IV. PARTICULATE FROM EVAPORATION OF 489 (ml) WATER IN IMPINGER AND BUBBLERS FOLLOWING EXTRACTION -

FINAL 79378.9 (mg) - TARE 79242.0 (mg)

-BLANK ((.0025 mg/ml) (489 ml initial

- 182 ml CONDENSED = 307 ml) = .8 mg) = 136.1 mg.

V. PARTICULATE FROM 35 (ml) OF Acetone RINSE OF IMPINGER, BUBBLERS, AND CONNECTORS AFTER FILTER:

FINAL 78903.2 (mg) - TARE 78897.9 (mg)

-BLANK ((.019 mg/ml) (35 ml) = .7 mg) = 4.6 mg.

VI. TOTAL PARTICULATE = I + II + III + IV + V = 976.9 mg.

BLANKS

ACETONE = ____ mg/____ ml = ____ mg/ml FINAL ____ mg. TARE ____ mg.

ETHER-CHLOROFORM = ____ mg.(FINAL ____ mg - TARE ____ mg)

WATER = ____ mg/____ ml = ____ mg/ml. FINAL ____ mg. TARE ____ mg.

ALSID, SNOWDEN & ASSOCIATES
LABORATORY ANALYSIS AND TOTAL PARTICULATE SHEET

CLIENT EPA Region 10 DATE OF ANALYSIS 10-25-76

EVALUATION LOCATION Hamilton Ont. Waste Incin. #1 RUN NO. 4

EVALUATION DATE 10-14-76 LAB NO. 146-6

I. EVAPORATION OF 70 (ml) OF Acetone

RINSE & BRUSHING OF NOZZLE, PROBE AND GLASSWARE BEFORE FILTER.

FINAL 76560.9 (mg) - TARE 76391.5 (mg)

-BLANK ((.019 mg/ml) (70 ml) = 1.3 mg) = 168.1 mg. pH 5 622.5

II. FILTER CATCH MSA 1106-BH #90-5 (Media Type & #)

FINAL 832.6 (mg) - TARE 378.2 (mg) = 454.4 mg.

III. HYDROCARBON OBTAINED BY ETHER-CHLOROFORM EXTRACTION ON WATER IN IMPINGER AND BUBBLERS.

FINAL 80090.0 (mg) - TARE 80072.5 (mg)

-BLANK (0.1 mg) = 17.4 mg.

IV. PARTICULATE FROM EVAPORATION OF 404 (ml) WATER IN IMPINGER AND BUBBLERS FOLLOWING EXTRACTION -

FINAL 78045.3 (mg) - TARE 77834.2 (mg)

-BLANK ((.0025 mg/ml) (404 ml initial

- 140.6 ml CONDENSED = 263.4 ml) = .7 mg) = 210.4 mg.

V. PARTICULATE FROM 60 (ml) OF Acetone RINSE OF IMPINGER, BUBBLERS, AND CONNECTORS AFTER FILTER:

FINAL 76106.7 (mg) - TARE 76086.1 (mg)

-BLANK ((.019 mg/ml) (60 ml) = 1.1 mg) = 19.5 mg. 247.3

VI. TOTAL PARTICULATE = I + II + III + IV + V = 869.8 mg. 26.9

BLANKS

ACETONE = ______ mg/______ ml = ______ mg/ml FINAL ______ mg. TARE ______ mg.

ETHER-CHLOROFORM = ______ mg.(FINAL ______ mg - TARE ______ mg)

WATER = ______ mg/______ ml = ______ mg/ml. FINAL ______ mg. TARE ______ mg.

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13240 Northrup Way, Suite 21, Bellevue, Washington 98005 (206) 641-5130

SAMPLE CHAIN-OF-CUSTODY RECORD

Client: EPA V @ Hamilton Ontario Municipal Incin.

Run Number: 1 Laboratory Number: 143-6

Sample Phase	Personnel	Date(s)
Sample Box Preparation	DAA	10/12/76
Sample Collection	WDS/DAA	10/13/76
Sample Clean-up	WDS	10/13/76
Sample Analysis	DAA	10/18-27/76
Calculation of Results	DAA	10/28-29/76
Report Preparation	WDS	11/1-30/76

Comments:

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13240 Northrup Way, Suite 21, Bellevue, Washington 98005 (206) 641-5130

SAMPLE CHAIN-OF-CUSTODY RECORD

Client: EPA V @ HAMILTON, ONTARIO CANADA

Run Number: 2 Laboratory Number: 144-6

Sample Phase	Personnel	Date(s)
Sample Box Preparation	WDS	10/13/76
Sample Collection *	DAA/WDS	10/13/76
Sample Clean-up	DAA	10/14/76
Sample Analysis	DAA	10/18-27/76
Calculation of Results	DAA	10/28-29/76
Report Preparation	WDS	11/1-30/76

Comments: * INCOMPLETE TRAVERSE - BOILER COULD NOT MAINTAIN STEAM PRODUCTION RATE @ MAXIMUM.

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13240 Northrup Way, Suite 21, Bellevue, Washington 98005 (206) 641-5130

SAMPLE CHAIN-OF-CUSTODY RECORD

Client: EPA Region X @ Hamilton Ontario, Canada

Run Number: 3 Laboratory Number: 145-6

Sample Phase	Personnel	Date(s)
Sample Box Preparation	DAA	10/12/76
Sample Collection	WOS/DAA	10/14/76
Sample Clean-up	DAA	10/17/76
Sample Analysis	DAA	10/18-27/76
Calculation of Results	DAA	10/28-29/76
Report Preparation	WOS	11/1-30/76

Comments:

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CONSULTANTS IN AIR, WATER, SAFETY, HYGIENE & MANAGEMENT

13240 Northrup Way, Suite 21, Bellevue, Washington 98005 (206) 641-5130

SAMPLE CHAIN-OF-CUSTODY RECORD

Client: EPA Region X @ Hamilton, Ontario, Canada

Run Number: 4 Laboratory Number: 146-6

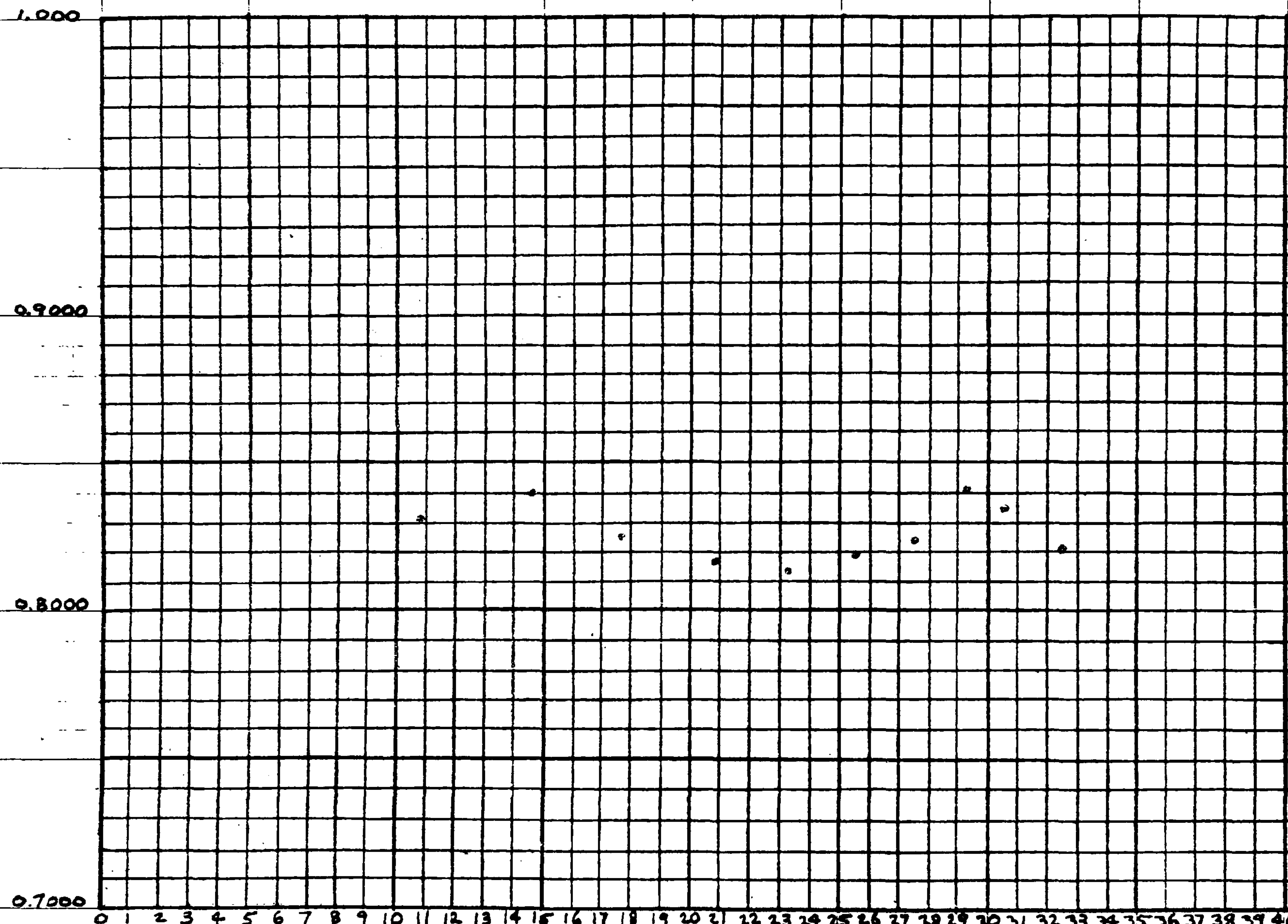
Sample Phase	Personnel	Date(s)
Sample Box Preparation	DAA	10/13/76
Sample Collection	DAA/WDS	10/14/76
Sample Clean-up	DAA	10/14/76
Sample Analysis	DAA	10/18-27/76
Calculation of Results	DAA	10/28-29/76
Report Preparation	WDS	11/1-30/76

Comments:

PROBE TYPE	NOZZLE DIAM.	BAR PRESSURE	Δ H	REF Δ P	C FACTOR	DATE 10/1/76
#12, 7'						

SIDE		ORIFICE Δ P	P-TYPE	S-TYPE	Δ H TRAIN	PUMP	DUCT	METER TEMP IN	METER TEMP OUT	√ΔHp	√ΔHs	√ΔHp / √ΔHs	√ΔHs x T̄s	
1	1		0.155	0.225			22			0.394	0.474	0.831	10.94	
	2		0.285	0.405			22			0.534	0.636	0.84	14.67	
	3		0.41	0.60			21.5			0.64	0.775	0.826	17.84	
	4		0.55	0.825			21			0.742	0.908	0.817	20.91	
	5		0.67	1.01			24			0.818	1.005	0.814	23.25	
	6		0.825	1.23			22			0.908	1.109	0.819	25.57	
	7		0.975	1.43			21.5			0.987	1.196	0.825	27.55	
	8		1.15	1.62			21			1.072	1.273	0.842	29.3	
	9		1.23	1.76			23			1.109	1.327	0.836	30.64	
	10		1.34	1.99			23			1.158	1.411	0.821	32.58	0.827
2	1		0.155	0.228			24			0.394	0.478	0.824	11.05	
	2		0.28	0.41			23.5			0.529	0.64	0.827	14.8	
	3		0.405	0.59			23			0.636	0.768	0.828	17.74	
	4		0.535	0.825			25.5			0.731	0.908	0.805	21.07	
	5		0.68	1.05			24			0.825	1.025	0.805	23.71	
	6		0.83	1.24			23.5			0.911	1.114	0.818	25.74	
	7		0.965	1.44			23			0.982	1.2	0.818	27.71	
	8		1.09	1.60			23			1.044	1.265	0.825	29.21	
	9		1.23	1.79			23			1.109	1.338	0.829	30.9	
	10		1.33	2.00			25			1.153	1.414	0.815	32.77	0.819
AVERAGES														

#12, 8', Side 1 0.827 10/1/76



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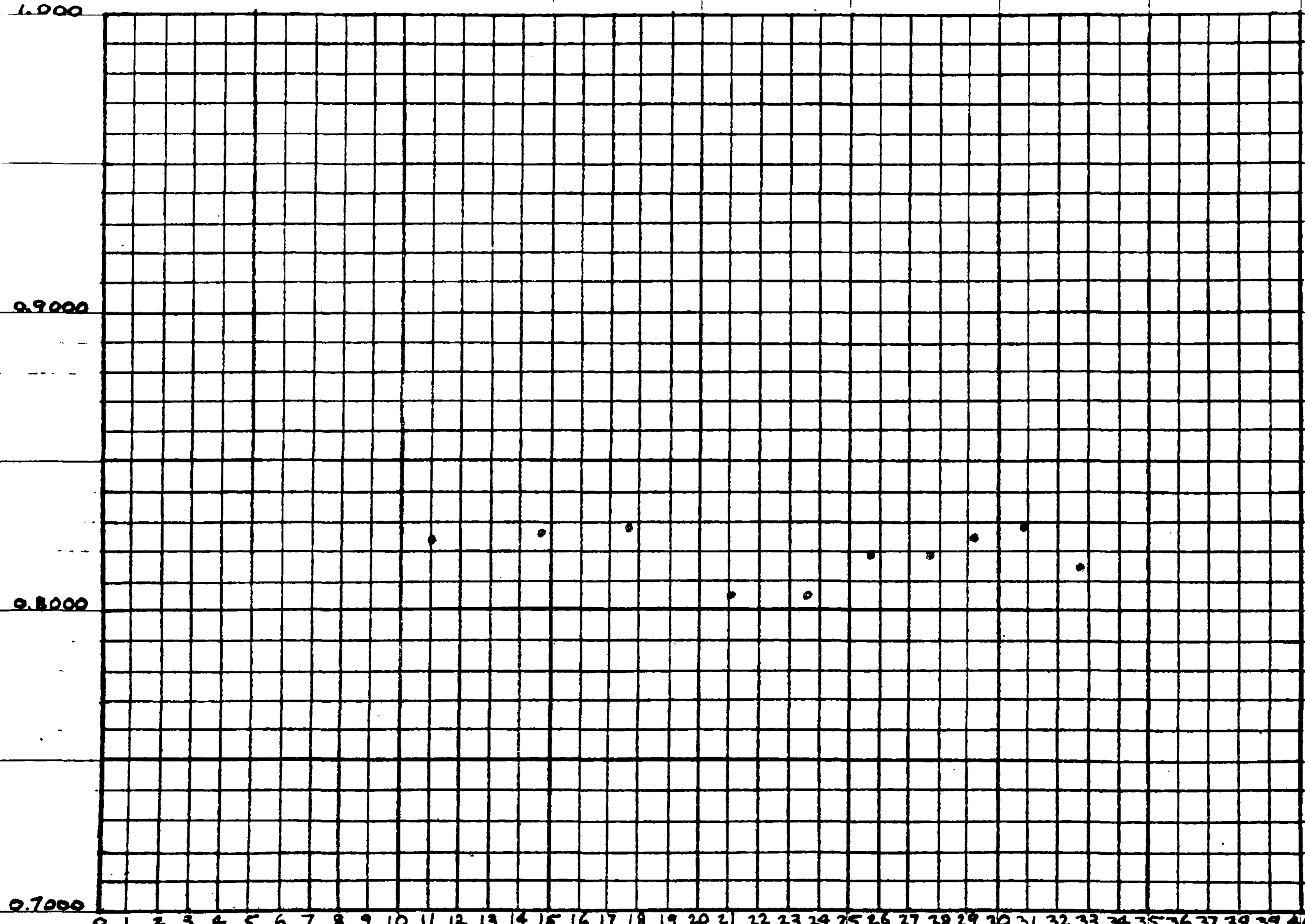
#12, 8', Side 2 0.819 10/1/76



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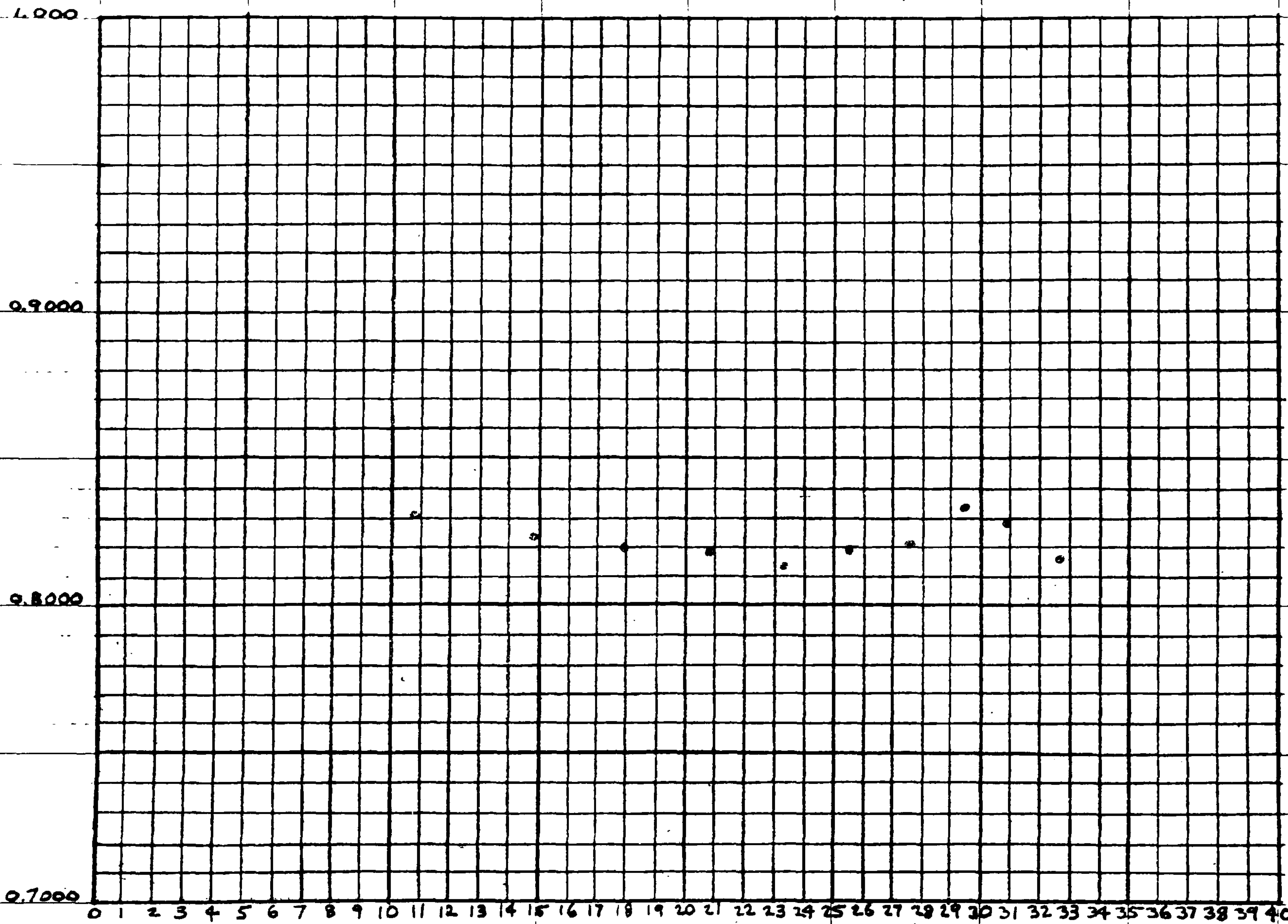
PROBE TYPE	NOZZLE DIAM.	BAR. PRESSURE	Δ H	REF Δ P	C FACTOR
#13, 8'					

DATE 10/1/76

SIDE		ORIFICE Δ P	P-TYPE	S-TYPE	Δ H TRAIN	PUMP	DUCT	METER TEMP IN	METER TEMP OUT	√VHp	√VHs	√VHp / √VHs	√VHs × Ts	
1	1		0.155	0.225			22	531.6		0.394	0.474	0.83	10.94	
	2		0.285	0.42			22			0.534	0.648	0.824	14.94	
	3		0.41	0.61			21.5	530.7		0.64	0.781	0.82	17.99	
	4		0.555	0.83			21	529.8		0.745	0.911	0.818	20.97	
	5		0.67	1.01			24	535.2		0.818	1.0050	0.814	23.25	
	6		0.825	1.23			22	531.6		0.908	1.109	0.819	25.57	
	7		0.975	1.44			21.5	530.7		0.987	1.2	0.822	27.64	
	8		1.14	1.64			21	529.8		1.068	1.281	0.834	29.48	
	9		1.23	1.79			23	533.4		1.109	1.338	0.829	30.9	
	10		1.34	2.01			23			1.158	1.418	0.817	32.74	0.823
2	1		0.155	0.228			24	535.2		0.394	0.478	0.824	11.05	
	2		0.28	0.42			23.5	534.3		0.529	0.648	0.816	14.98	
	3		0.405	0.605			23	533.4		0.636	0.778	0.818	17.96	
	4		0.535	0.83			25.5	537.9		0.731	0.911	0.803	21.13	
	5		0.655	1.02			24	535.2		0.809	1.01	0.801	23.36	
	6		0.83	1.23			23.5	534.3		0.911	1.109	0.822	25.64	
	7		0.965	1.47			23	533.4		0.982	1.212	0.81	28.0	
	8		1.09	1.65			23			1.044	1.284	0.813	29.62	
	9		1.23	1.83			23			1.109	1.353	0.82	31.24	
	10		1.33	2.01			25	537		1.153	1.418	0.813	32.85	0.814
AVERAGES														

#13, 8', Side 1   0.823   10/1/76



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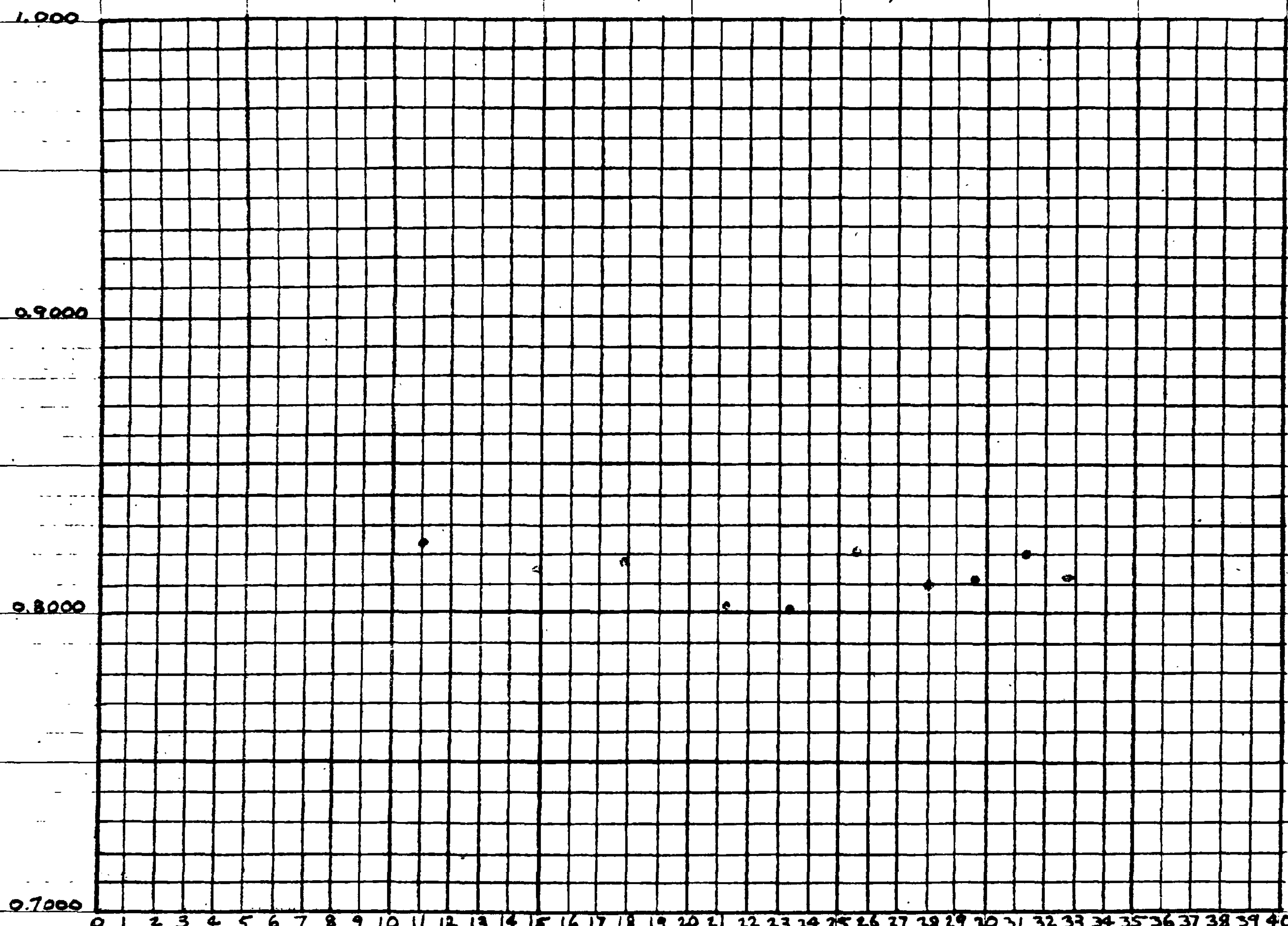
#13, 8', Side 2 0.814 10/1/76



ALSID, SNOWDEN & ASSOCIATES

Box # 3

ALSID, SNOWDEN & ASSOCIATES
13240 Northrup Way, Suite 21
Bellevue, Washington 98005

DATE 11-13-75

CLIENT

By David Alguard

Run # 1

BAROMETRIC PRESSURE 29.838

Meter Box w/ Dry Meter						Standard Wet Test Meter			
ITd	Td Avg	OTd	CFd	Main Orifice	Time (Min)	CFw	Tw (CP)	Tw (GM)	Pb
77 / 81 / 79	74.75	70 / 71 / 70.5	403.190 / 408.185 / 4.995	0.5	12:36	5	73		
74 / 83 / 78.5	73.5 / 533.5	68 / 69 / 68.5	394.612 / 388.690 / 5.922	1.0	10:23	6	73	533	29.838
75 / 85 / 80	74.75 / 534.75	69 / 70 / 69.5	402.469 / 397.500 / 4.969	2.0	6:09	5	73 S. / 73 F	533	
[illegible]	80.25 / 540.25	71 / 73 / 72	408.439 / 418.464 / 10.025	4.0	8:46	10	73	533	
90 / 104 / 97	85.25 / 545.25	72 / 75 / 73.5	428.737 / 418.696 / 10.041	6.0	7:13	10	73	533	
[illegible] / 96 / 104	85.75 / 545.75	74 / 77 / 75.5	419.443 / 429.384 / 10.059	8.0	6:18	10	73		

$Y = \frac{(5)(29.838)(534.75)}{4.995(29.838 + 0.037)(533)}$ = 1.0030 (29.875)

$\Delta H = \frac{0.01585}{29.838 \times 530.5}\left(\frac{533 \times 12.6}{5}\right)^2$ = 1.8065

$Y = \frac{(6)(29.838)(533.0)}{5.992(29.838 + 0.0735)(533)}$ = .99886 (29.912)

~~$\Delta H = \frac{0.0277}{528.5 \times 29.838}\left(\frac{533 \times 10.38}{6}\right)^2$ = 1.7092~~ USE 1.7477 from run #2

$Y = \frac{5(29.838)(534.75)}{4.969(29.838 + 0.147)533}$ = 1.0046 (29.985)

$\Delta H = \frac{0.0634}{(529.5)\,29.838}\left(\frac{533 \times 6.15}{5}\right)^2$ = 1.7247

$Y = \frac{10(29.838)(540.25)}{10.025(29.838 + 0.294)(533)}$ = 1.0012 (30.132)

$\Delta H = \frac{0.1263}{(532)(29.838)}\left(\frac{533 \times 8.77}{10}\right)^2$ = 1.7385

$Y = \frac{10(29.838)(545.25)}{10.041(29.838 + 0.441)533}$ = 1.0043 (30.269)

$\Delta H = \frac{0.1902}{(533.5)\,29.838}\left(\frac{533 \times 7.22}{10}\right)^2$ = 1.7694

$Y = \frac{10(29.838)(545.75)}{10.059(29.838 + 0.588)533}$ = .9982 (30.426)

$\Delta H = \frac{0.2536}{(535.5)\,29.838}\left(\frac{533 \times 6.3}{10}\right)^2$ = 1.7896

Y AVG. 1.0017

ΔH AVG. = 1.763

$Y = \frac{CF_w P_b (T_{d\,avg} + 460)}{CF_d (P_b + \text{Main Orifice})(460 + T_w)}$

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$\Delta H = \frac{0.0317(\text{Pressure Main Orifice})}{P_b (OT_d + 460)}\left(\frac{(T_w + 460)\,t}{CF_w}\right)^2$

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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2.

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE
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16. ABSTRACT

One aspect of the environmental impact of semi-suspension incineration of municipal refuse is the emission of particulate matter to the atmosphere. In order to provide this essential, but nonexisting data, sampling was conducted at the only known operating facility of this type, the East Hamilton Solid Waste Reduction Unit, Hamilton, Ontario. Based upon three runs of EPA Method 5 during the period October 13-14, 1976, the no. 1 boiler and electrostatic precipitator at the subject facility emitted 0.528 grains per dry standard cubic foot, corrected to 12% carbon dioxide.

17. KEY WORDS AND DOCUMENT ANALYSIS

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