C/F OK

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SOURCE

EMISSION

EVALUATION

September 20, 1994

Prepared For:

Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

LOOKER & ASSOCIATES
HOT MIX ASPHALT BATCH PLANT
BAGHOUSE STACK
METHOD 5 TESTING
PUYALLUP, WASHINGTON
SEPTEMBER 8, 1994

Submitted by:

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We certify that the information contained herein is accurate and complete to the best of our knowledge.

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1.0
INTRODUCTION

The purpose of this source emission evaluation was to quantify particulate and condensible matter emissions from a hot mix asphalt batch plant located at Looker & Associates' facility in Puyallup, Washington. The asphalt plant was manufactured by Stansteel and is equipped with an Alcon baghouse to control particulate matter emissions prior to exhausting to the atmosphere. Looker & Associates contracted Am Test-Air Quality Inc. based in Preston, Washington to conduct these source tests. These tests were performed to demonstrate compliance with a regulatory order from the Puget Sound Air Pollution Control Agency (PSAPCA).

Testing and analysis procedures used for this project are presented in the July 1, 1993 edition of the Environmental Protection Agency (EPA) document Title 40, Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A, Methods 1, 2, 3A, 4, 5 and the PSAPCA back-half method. Methods 1 and 2 were performed to measure the stack gas temperature and velocity for calculating volumetric flow rate. Method 3A was performed to determine the molecular weight of the stack gas based on measurements of the oxygen (O_2), carbon dioxide (CO_2) and carbon monoxide (CO) concentration in the stack gas. Method 4 was performed to measure the moisture content of the stack gas. Method 5 was performed to quantify particulate and condensible matter emissions. PSAPCA requires that the condensible particulate matter present in the gas stream be quantified by performing an extraction of the back-half portion of the Method 5 sample train. Three (3) Method 1, 2, 3A, 4 and 5 tests were performed at the baghouse stack on September 8, 1994.

Mr. Stanley B. Moye and Mr. Jeffrey S. Harris of Am Test-Air Quality, Inc. performed the field sampling. Sample recovery and gravimetric laboratory analysis of the Method 5 samples were performed by Ms. Stacy Akin and Ms. Annika M. Woehr of Am Test-Air Quality, Inc. Data reduction, quality assurance review and final report preparation were performed by Mr. Kris A. Hansen, Ms. Angela F. Blaisdell and Ms. Amy M. Brotherton of Am Test. This testing program was coordinated by Mr. Pat Harkins of Looker & Associates.

2.0

SUMMARY OF RESULTS

The following section of this report presents results from the particulate and condensible matter emissions testing performed at the hot mix asphalt batch plant baghouse stack. Refer to the Table of Contents to locate specific information for each type of test. The summary table in this section contains information obtained from computer printouts of results for each individual run which are included in Appendix A of this report. Appendix B of this report contains example calculations of results and copies of the original field data sheets. Appendix C of this report contains miscellaneous supporting information.

The results of the three (3) Method 5 tests for quantifying particulate and condensible matter emissions at the hot mix asphalt batch plant baghouse exhaust are summarized in Table 2.0 below, and on the following computer printout titled "Summary of Results - Methods 1, 2, 3A, 4 and 5".

Table 2.0. Summary of particulate and condensible matter emissions test results from samples collected on September 8, 1994 at the hot mix asphalt batch plant stack at Looker & Associates' facility in Puyallup, Washington.

Sample Run #	Front-half P.M. Emission Conc. (gr/dscf)	Back-half P.M. Emission Conc. (gr/dscf)	Total P.M. Emission Conc. (gr/dscf)	Total P.M. Emission Conc. (mg/dscm)	Total P.M. Emission Rate (lb/hr)
1	0.015	0.004	0.020	45.0	2.82
2	0.008	0.001	0.009	21.1	1.26
3	0.012	0.003	0.015	34.8	1.98
Average	0.012	0.003	0.015	33.6	2.02

The front-half, back-half and total particulate matter emission concentration is presented in units of grains per dry standard cubic foot (gr/dscf) and milligrams per dry standard cubic meter (mg/dscm) of gas sampled. The particulate matter emission standard for this source is 0.02 gr/dscf. The particulate matter emission rate is presented in units of pounds per hour (lb/hr).

AMTEST
AIR QUALITY, INC.

SUMMARY OF RESULTS - METHODS 1, 2, 3A, 4 AND 5
AM TEST - AIR QUALITY, INC.

FILE NAME: R311\LOOKERSM
CLIENT: LOOKER & ASSOCIATES
LOCATION: PUYALLUP, WASHINGTON

	ASPHALT BATCH PLANT BAGHOUSE STACK			
	RUN #1	RUN #2	RUN #3	AVERAGE
LAB #:	6574	6575	6576	
DATE:	9/8/94	9/8/94	9/8/94	
START TIME:	09:00	11:48	13:47	
STOP TIME:	11:09	12:54	15:10	
SAMPLE LENGTH (minutes):	60.0	60.0	60.0	
VOLUME SAMPLED (cubic feet):	46.485	46.854	43.932	45.757
VOLUME SAMPLED (dry std. cubic feet):	46.628	46.419	43.379	45.475
VOLUME SAMPLED (dry std. cubic meters):	1.321	1.315	1.229	1.288
STACK GAS MOISTURE (percent):	23.80	24.39	26.16	24.78
BAROMETRIC PRESSURE (inches of Hg):	29.70	29.75	29.80	29.75
STATIC PRESSURE (inches of H2O):	-0.38	-0.36	-0.52	-0.42
STACK PRESSURE (inches of Hg):	29.67	29.72	29.76	29.72
STACK TEMPERATURE (degrees F.):	241.0	245.3	239.8	242.0
STACK TEMPERATURE (degrees R.):	701.0	705.3	699.8	702.0
CARBON DIOXIDE (percent):	4.1	4.3	4.8	4.4
OXYGEN (percent):	14.1	13.6	13.1	13.6
CARBON MONOXIDE (ppm):	80.4	126.3	417.5	208.1
MOLECULAR WEIGHT (dry, lb/lb-mole):	29.22	29.23	29.29	29.25
MOLECULAR WEIGHT (wet, lb/lb-mole):	26.55	26.49	26.34	26.46
AVERAGE VELOCITY HEAD (inches of H2O):	1.24	1.15	1.07	1.15
PITOT TUBE Cp:	0.84	0.84	0.84	
STACK GAS VELOCITY (feet per second):	75.5	72.9	70.3	72.9
STACK DIAMETER (inches):	29.25x32	29.25x32	29.25x32	
STACK AREA (square feet):	6.50	6.50	6.50	
STACK GAS AIRFLOW (dry std. cubic feet per min.):	16751.8	15996.4	15194.4	15980.9
STACK GAS AIRFLOW (actual cubic feet per min.):	29429.1	28447.7	27420.5	28432.4
NOZZLE DIAMETER (inches):	0.242	0.242	0.242	
ISOKINETICS (percent):	94	98	97	
FRONT-HALF PARTICULATE EMISSION CONC. (gr/dscf):	0.015	0.008	0.012	0.012
BACK-HALF PARTICULATE EMISSION CONC. (gr/dscf):	0.004	0.001	0.003	0.003
TOTAL PARTICULATE EMISSION CONC. (gr/dscf):	0.020	0.009	0.015	0.015
TOTAL PARTICULATE EMISSION CONC. (mg/dscm):	45.0	21.1	34.8	33.6
TOTAL PARTICULATE MATTER EMISSION RATE (lb/hr):	2.82	1.26	1.98	2.02

3.0
PROJECT OVERVIEW/EXCEPTIONS

An acceptable leak check of less than 0.02 cfm at the highest vacuum rate (or greater) used during the test preceded and followed each run. The average percentage isokinetics for all three runs were within the acceptable limits of 100 $\pm$ 10%. Process and production conditions were considered to be representative, according to plant personnel.

4.0
SOURCE OPERATION

Looker & Associates operates a Stansteel hot mix asphalt batch plant in Puyallup, Washington. Emissions are controlled by an Alcon Spectrum 108A reverse pulse baghouse prior to exhausting to the atmosphere. The baghouse contains 512 14-ounce Nomex bags. The pressure drop across the baghouse averaged 5 inches of water column ("H_2O) on the day of testing. According to plant personnel, the plant operated at an average asphalt production rate of 160 tons per hour (tph), with a gravel moisture content of 5-7% and gravel containing 5% fines. The plant was fired with diesel at a rate of 1.85 gallons per ton per hour. Process information sheets, completed by ??????, are included in Appendix C of this report.

5.0
SAMPLING AND ANALYSIS PROCEDURES

5.1 EPA Methods 1 and 2 - Velocity, Temperature and Airflow

EPA Method 1 procedures were used to assure that representative measurements of volumetric flow rate were obtained by dividing the cross-section of the stack or duct into a number of equal areas, and then locating a traverse point within each of the equal areas. Refer to the "Stack Schematic and Location of Sample Points" data sheet and/or the figure titled, "Location of Sampling Ports and Traverse Points", located in the appendices of this report for a schematic of the stack and the point locations selected for testing. Method 2 was performed to measure the stack gas velocity using a type S or a standard pitot tube, and the gas temperature using a calibrated thermocouple probe connected to a digital thermocouple indicator. The type S pitot tubes were connected with tubing to an oil-filled inclined manometer, a hook gauge manometer or magnehelic gauges to obtain velocity measurements. The pitot tube lines were leak-checked and the pressure measurement device was leveled and zeroed prior to use. Calibration information for each pressure and temperature measurement device used are included in the appendices of this report.

5.2 EPA Method 3A - Molecular Weight

The stack gas composition was evaluated during each Method 5 test by collecting integrated samples of the stack gas in multilayer bags. The integrated bag samples were analyzed using a paramagnetic analyzer to measure the percent (%) O_2, a non-dispersive infrared (NDIR) analyzer to measure the % carbon dioxide (CO_2), and an NDIR or a gas filter correlation NDIR analyzer to measure the parts per million (ppm) carbon monoxide (CO) in the gas stream. The manufacturer and model

number of each of the analyzers used is included in the appendices of this report on the "Continuous Analyzer Checklist" and/or the "Gas Bag Sample Data Sheet". The average measured O_2 concentration and CO_2 concentration were used to calculate the molecular weight of the stack gas.

5.3 EPA Method 4 - Moisture

The percent moisture in the gas stream was quantified by weighing the impingers to 0.1 grams before and after each Method 5 run on a digital top-loading balance. The net weight (final minus initial) was used to calculate the amount of moisture condensed from the known volume of stack gas collected.

5.4 EPA Method 5 - Particulate Matter

The sample train used for particulate matter sampling was an EPA Method 5 design as illustrated in the figure titled "Method 5 Sample Train" in the appendices of this report. The "Sample Train Information Sheet" (also in the appendices) details the type of nozzle, probe, probe liner and filter used along with the contents of the sample train impingers. The probe was equipped with S-type pitot tubes for measuring gas velocity and a thermocouple sensor for measuring stack gas temperature. The thermocouple sensor was connected to a digital thermocouple indicator which was used to measure the stack gas temperature at each sample point. A glass filter assembly was enclosed in a temperature-controlled heated sample box. The average box temperature was maintained at 248° F $\pm$ 25° F. The nozzle, probe liner, prefilter connective glassware and filter are referred to as the "front-half" of the sample train. Following the filter is a condenser section which, by convention, is referred to as the "back-half". The back-half was maintained at a temperature below 68° F by adding ice to the condenser section during sampling. Note: Some subparts or methods specify alternate temperatures for the probe liner,

filter holder box and impinger ice bath. The "Sample Train Information Sheet" details any exceptions.

The Method 5 sample train was connected to a control box by means of an umbilical cord which contained a vacuum hose, pitot lines, thermocouple wires and a 4-wire electrical cord. The control box (meter box) was used to monitor stack conditions and to facilitate isokinetic sampling. The control box consisted of a diaphragm pump used to pull the stack gas through the sample train, fine and coarse metering valves to control the sampling rate, a vacuum gauge to measure the pressure drop from the sample nozzle to the metering valves, and a calibrated dry gas meter readable to 0.001 cubic feet. At the outlet of the dry gas meter was a calibrated orifice which was used to isokinetically control the flow of gas through the metering system. The pitot tubes utilized to measure stack gas velocity were connected to the control box via the umbilical cord. The control box contained a manometer or magnehelic gauges which were used for the velocity measurement and for monitoring orifice pressure.

Stack condition measurements were made prior to collecting a sample, including measurements of velocity, temperature and a check for cyclonic flow in the stack. A sample nozzle was chosen and isokinetic operating parameters were established utilizing a Hewlett-Packard programmable calculator. The sampling nozzle, probe and prefilter connective glassware were cleaned and rinsed prior to use. The sample train was assembled and determined to be leak free following the procedures outlined in Method 5. Before each test, a final check was made to assure that the process was operating at the desired production rate and operating parameters. A final check was made of the sample box and probe heat temperatures. Crushed ice was added to the condenser section. The sample nozzle

was positioned in the stack at the first sample point. The sample pump was then turned on and the gas sampling rate was adjusted for isokinetic sampling. Isokinetic sampling proceeded at each of the traverse points. Upon completion of the test, the sample probe was removed from the stack and a post-test leak check was performed according to Method 5 procedures. Care was taken to assure that the nozzle tip did not touch the port nipple.

Following sample collection, the Method 5 sample trains were transferred to an area free from air disturbances and airborne particulate matter. The filters were transferred to petri dishes labeled with the sample date, client name and run number. Am Test refers to the front-half filter portion of the particulate catch as the "A" section. Care was taken to assure that any loose particulate matter and filter mat were quantitatively transferred to the petri dish. In the laboratory, the filters were placed in an oven and baked at 105° C for two (2) hours, then transferred to a constant humidity desiccator containing silicon dioxide (SiO_2) for at least 24 hours of desiccation prior to obtaining weights. The same weighing procedures were followed to obtain the tare weights for the filters. The tare and final weights were made using an electronic balance set to a time integrating mode with a readability of 0.1 milligrams. The filters were weighed to a constant weight of $\pm$0.5 milligrams. The interval between weighings was at least 6 hours. These weights were recorded in a bound laboratory notebook.

Following each run, the contents of the nozzle, probe liner and prefilter connective glassware were quantitatively transferred to the "B" section storage container labeled with sample date, client name and run number. Several rinses of acetone, with simultaneous loosening of particulate matter using a clean nylon brush, were used for the front-half clean-up. An iodine flask with a female ball joint end was

attached to the male ball joint end of the probe to assure that no particulate matter was lost during the rinsing and brushing of the probe. The contents of the iodine flask were quantitatively transferred to the "B" section storage container. In the laboratory, the "B" section acetone rinse was transferred to a tared, graduated 150 milliliter (mL) beaker. The volume of acetone was recorded and the beakers were placed in an evaporation chamber at a temperature of approximately 75-80° F until dry. Note: Some subparts or methods specify alternate "B" section cleanup solvents. The "Sample Train Information Sheet" details any exceptions.

The bubblers and impingers utilized for the condenser section, or "back-half" of the sample train were weighed with a readability of 0.1 grams before and after sampling using an electronic top loading balance. The difference between the initial and final weights of the condenser section constitute the amount of moisture gain during the run. The contents of the bubblers and impingers were transferred to a 1000 mL graduated cylinder. The bubblers and impingers were rinsed with deionized water into the graduated cylinder and the liquid level was recorded. A 20 milliliter aliquot of each impinger catch was archived for potential future analysis. The remaining impinger catch was extracted and the C and Cx section net weights were factored to represent the total impinger catch. This liquid was transferred to a separatory funnel and the contents were extracted with three (3) 50 mL portions of dichloromethane (CH_2Cl_2). The organic layer was transferred to a tared 150 mL beaker labeled the "C_x" section and was allowed to evaporate to dryness in an evaporation chamber at a temperature of 75-80° F. The water layer was transferred to a tared 150 mL beaker with glass boiling beads labeled the "C" section, and was heated on a drum plate to boiling until approximately 20 mL remained in the beaker. The remaining 20 mL in the beaker was evaporated to dryness in an evaporation chamber set at 105° C. The bubblers, impingers and graduated

cylinder were given a final rinse with acetone into another tared, graduated beaker ("D" Section) and was allowed to evaporate to dryness in an evaporation chamber at 75-80° F. Sample blanks containing deionized water, dichloromethane, and acetone were analyzed in an identical fashion as the representative "section". All beakers were desiccated for at least 24 hours and weighed to constant weights of $\pm$0.5 milligrams at 6 hour or greater intervals. This is the same procedure used to obtain tare weights for each beaker. The total particulate matter weight is the sum of the net weights of the particulate matter found on the filter, plus the net weights found in the B, C, Cx and D section beakers, minus the acetone, water, and dichloromethane blank contributions. The particulate matter weights are included on the Method 5 computer printouts and in copies of the laboratory analysis forms in the appendices of this report. Note: Some subparts or methods specify alternate back-half section cleanup solvents. The "Sample Train Information Sheet" details any exceptions.

6.0
QUALITY ASSURANCE PLAN

The purpose of the quality assurance plan is to provide guidelines for achieving quality control in air pollution measurements. The detailed procedures which are utilized are included in the Environmental Protection Agency's (EPA's) reference manual titled Quality Assurance Handbook for Air Pollution Measurement Systems, Volume 3, EPA-600/4-77-027b. These procedures are followed throughout equipment preparation, field sampling, sample recovery, analysis and data reduction. Am Test-Air Quality, Inc.'s quality assurance procedures are discussed below.

6.1 Calibration Procedures and Frequency

Field equipment utilized for on-site measurements is calibrated at a frequency recommended by the equipment manufacturer or industry practice. Prior to field use, each instrument is calibrated and the calibration value is recorded. If any measuring or test device requiring calibration cannot immediately be removed from service, the Project Manager may extend the calibration cycle providing a review of the equipment's history warrants the issuance of an extension. No equipment will be extended more than twice a calibration cycle, nor will the extension exceed one-half the prescribed calibration cycle. Test equipment consistently found to be out of calibration will be repaired or replaced.

The sample nozzles used to collect isokinetic samples are calibrated on-site before sampling using digital inside calipers readable to 0.001 inch. Three (3) measurements were taken at varying points around the inside of the nozzle tip and

averaged. The dry gas meters used to accurately measure sample volumes are calibrated using a standard laboratory dry gas meter. The type S pitot tubes utilized for velocity determination are calibrated using Method 2, Section 4.1, and are inspected regularly for wear. The magnehelic gauges used for pressure measurements are checked against an oil-filled manometer. The digital thermocouple indicator used for temperature measurement has a readability of 1 degree Fahrenheit and is periodically re-certified by the manufacturer. Each thermocouple probe used to monitor temperature is checked periodically at three (3) temperature settings. Copies of calibration information for each measurement device used are included in the appendices of this report. A barometer readable to 0.01 inches of mercury is used in the field to obtain barometric pressure readings.

In the laboratory reagent blanks are carried throughout the gravimetric analysis procedures. The samples were weighed to constant weights of $\pm$0.5 milligrams following desiccation in a cabinet desiccator. This desiccator is an electronic dehumidifier which automatically maintains the humidity inside the desiccator. The dehumidifier automatically recharges the internal desiccant every 5.5 hours. An Airguide humidity indicator accurate to $\pm$1% is used to check the humidity inside the desiccator when obtaining tare and final weights. A small container of indicating silica gel is placed in the desiccators to maintain the desired humidity. The Mettler AE163 electronic balance used to obtain weights is set to a time integrating mode (100,000 readings per minute) with a readability of 0.01 milligrams. The balance is calibrated prior to every weighing session and an audit is performed with class S weights once a week. The calibration of Am Test's Mettler balances is checked by the manufacturer on a yearly basis.

Support equipment is defined as all equipment, not previously discussed, that is required for completing an environmental monitoring or measurement task. This equipment may include storage and transportation containers, sample recovery glassware, and communications gear. Support equipment is periodically inspected to maintain the performance standards necessary for proper and efficient execution of all tasks and responsibilities.

During a project, a systems audit is performed, consisting of an on-site qualitative inspection and review of the total measurement system. This inspection is conducted on a daily basis by the Project Leader. During the systems audit, the auditor observes the procedures and techniques of the field team in the following general areas:

- Setting up and leak testing the sample train
- Isokinetic sampling check
- Final leak check of the sample train
- Sample recovery

Visual inspections of pitot tubes, glassware, and other equipment are also made. The main purpose of a systems audit is to ensure that the measurement system will generate valid data, if operated properly.

6.2 Sample Recovery and Field Documentation

Data collected during each test, are immediately inspected for completeness and placed under the custody of the Project Leader until custody is transferred when the samples were returned to the Air Quality laboratory. Sample recovery is carried out in a suitable area free from particulate matter contamination. Each sample is assigned an identifying lab number to assist the chemists in tracking the sample.

6.3 Data Reduction, Validation and Reporting

Raw data are handled according to strict guidelines when being transposed into computer files or to other logs. The guidelines include document receipt control procedures, file review, and sign-off by a project assistant. Raw data are entered into the appropriate computer spreadsheet by a "processor", then the entered figures are checked for accuracy by a "checker", different from the "processor". Any mistakes are corrected, and figures are rechecked and signed off by the "checker". In addition, a by-hand calculation check of each spreadsheet is made using a hand-held calculator to validate the computer output. All data generated by each phase of a laboratory or field sampling program are reviewed by the senior reviewer. The data package is signed off by the senior reviewer prior to releasing the data for report preparation.

The test results are calculated in accordance with current EPA 40 CFR 60 criteria. Copies of the pertinent equations used to derive the results for this test are included in the appendices of this report. Standard conditions are 29.92 inches of mercury and 68° F.

7.0

METHODOLOGY REFERENCES

EPA. Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A, Reference Methods 1, 2, 3A, 4 and 5. July 1, 1993.

EPA. EPA 450/2-79-006, APTI Course, "Course 450 - Source Sampling For Particulate Pollutants", December 1979.

EPA. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume 3, EPA-60/4-77-027b.

APPENDIX A

Computer Printouts of Results

METHODS 1, 2, 3A, 4 AND 5
AM TEST-AIR QUALITY, INC.

FILE NAME:	R311\LOOKM5R1	LAB #:	6574
CLIENT:	LOOKER & ASSOCIATES	START TIME:	09:00 o'clock
LOCATION:	PUYALLUP, WASHINGTON	STOP TIME:	11:09 o'clock
SAMPLE SITE:	ASPHALT BATCH PLANT BAGHOUSE STACK	SAMPLE LENGTH:	60.0 minutes
SAMPLE DATE:	SEPTEMBER 8, 1994		
RUN #:	1 - METHOD 5		
OPERATORS:	MOYE/HARRIS		

IMPINGER WEIGHTS

FINAL grams	INITIAL grams	NET grams
862.1	638.8	223.3
700.8	638.9	61.9
554.4	546.6	7.8
873.5	857.7	15.8

TOTAL H2O GAIN:	308.8	PITOT TUBE Cp:	0.84
TOTAL VOLUME (scf):	14.56	NOZZLE DIAMETER:	0.242 inches
PERCENT MOISTURE:	23.80	NOZZLE AREA:	0.0003 sq. feet
Bws:	0.2380	STACK DIAMETER:	29.25x32 inches
		STACK AREA:	6.50 sq. feet
		METER TEMPERATURE:	66.0 degrees F
		BAROMETRIC PRES.:	29.70 inches Hg
		STATIC PRESSURE:	-0.38 inches H2O
		STACK PRESSURE:	29.67 inches Hg
		ORIFICE PRESSURE:	2.296 inches H2O
		METER PRESSURE:	29.87 inches Hg
INIT. METER VOLUME:	272.084	AVERAGE CONC. CO2:	4.1 percent
FINAL METER VOLUME:	318.569	AVERAGE CONC. O2:	14.1 percent
VOLUME SAMPLED:	46.485	AVERAGE CONC. CO:	80.4 ppm
STD VOLUME (dscf):	46.628	MOLECULAR WEIGHT:	29.22 g/g-mole-dry
STD VOLUME (dscm):	1.321	MOLECULAR WEIGHT:	26.55 g/g-mole-wet
Y FACTOR:	1.001	Fo FACTOR:	1.659

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE °F	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE °F
A 1	1.28	247	B 5	1.28	244
2	1.54	248	6	2.00	241
3	1.46	247	7	1.86	241
4	1.54	246	8	1.42	240
5	1.68	245	C 1	0.50	232
6	1.92	242	2	0.96	247
7	1.68	238	3	0.96	249
8	1.92	238	4	0.72	247
B 1	0.96	228	5	0.80	246
2	1.12	236	6	0.82	231
3	1.18	240	7	0.78	234
4	1.16	241	8	1.10	236

PERCENT ISOKINETICS:	94 %	
STACK TEMPERATURE:	241.0 degrees F	701.0 degrees R
AVERAGE VELOCITY HEAD:	1.24 " of H2O	
STACK GAS VELOCITY:		75.5 ft/second
STACK GAS AIR FLOW:	29429.1 acf/min	16751.8 dscf/min
PARTICULATE EMISSION CONCENTRATION (front-half):		0.015 gr/dscf
PARTICULATE EMISSION CONCENTRATION (back-half):		0.004 gr/dscf
TOTAL PARTICULATE EMISSION CONC. (front & back-half):		0.020 gr/dscf
TOTAL PARTICULATE EMISSION CONCENTRATION:		45.0 mg/dscm
TOTAL PARTICULATE MATTER EMISSION RATE:		2.82 lb/hr

FRONT-HALF PARTICULATE MATTER MASS LOADING

FILTER NUMBER:	#110-452
TARE WEIGHT OF FILTER (grams):	1.4321
FINAL WEIGHT OF FILTER (grams):	1.4635
NET WEIGHT OF PARTICULATE MATTER (grams):	0.0314
BEAKER NUMBER:	#150-1779
TARE WEIGHT OF BEAKER (grams):	64.4903
FINAL WEIGHT OF BEAKER (grams):	64.5054
NET WEIGHT OF PARTICULATE MATTER (grams):	0.0151
VOLUME OF ACETONE (milliliters):	110.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):	0.0000
TOTAL FRONT-HALF PARTICULATE MATTER (grams):	0.0465

BACK-HALF PARTICULATE MATTER MASS LOADING

"C" SECTION - CONDENSER PARTICULATE	#150-1772
TARE WEIGHT OF BEAKER (grams):	65.1121
FINAL WEIGHT OF BEAKER (grams):	65.1226
NET WEIGHT OF PARTIC. MATTER (grams):	0.0109
TOTAL VOLUME OF WATER (milliliters):	520.0
VOLUME OF ALIQUOT (milliliters):	20.0
VOLUME OF WATER CONDENSED (milliliters):	293.0
NET VOLUME OF WATER FOR BLANK (milliliters):	227.0
WT./VOL. OF WATER BLANK (milligrams/ml):	0.0012
NET WEIGHT OF PARTIC. DUE TO WATER (grams):	0.0003
"Cx" SECTION - HYDROCARBON EXTRACTION	#150-1781
TARE WEIGHT OF BEAKER (grams):	64.0801
FINAL WEIGHT OF BEAKER (grams):	64.0810
NET WEIGHT OF PARTIC. MATTER (grams):	0.0009
TOTAL VOLUME OF CH2Cl2 (milliliters):	150.0
WT./VOL. OF CH2Cl2 BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO CH2Cl2 (grams):	0.0000
"D" SECTION - ACETONE RINSE OF CONDENSER	#150-1780
TARE WEIGHT OF BEAKER (grams):	64.5463
FINAL WEIGHT OF BEAKER (grams):	64.5476
NET WEIGHT OF PARTIC. MATTER (grams):	0.0013
TOTAL VOLUME OF ACETONE (milliliters):	95.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):	0.0000
TOTAL BACK-HALF PARTICULATE MATTER (grams):	0.0129
TOTAL WEIGHT OF PARTICULATE MATTER (grams):	0.0594

METHODS 1, 2, 3A, 4 AND 5
AM TEST-AIR QUALITY, INC.

FILE NAME:	R311\LOOKM5R2	LAB #:	6575
CLIENT:	LOOKER & ASSOCIATES	START TIME:	11:48 o'clock
LOCATION:	PUYALLUP, WASHINGTON	STOP TIME:	12:54 o'clock
SAMPLE SITE:	ASPHALT BATCH PLANT BAGHOUSE STACK	SAMPLE LENGTH:	60.0 minutes
SAMPLE DATE:	SEPTEMBER 8, 1994		
RUN #:	2 - METHOD 5		
OPERATORS:	MOYE/HARRIS		

IMPINGER WEIGHTS

FINAL grams	INITIAL grams	NET grams
873.1	631.5	241.6
700.1	640.9	59.2
545.5	540.9	4.6
881.3	869.1	12.2

TOTAL H2O GAIN:	317.6	PITOT TUBE Cp:	0.84
TOTAL VOLUME (scf):	14.97	NOZZLE DIAMETER:	0.242 inches
PERCENT MOISTURE:	24.39	NOZZLE AREA:	0.0003 sq. feet
Bws:	0.2439	STACK DIAMETER:	29.25x32 inches
		STACK AREA:	6.50 sq. feet
		METER TEMPERATURE:	73.5 degrees F
		BAROMETRIC PRES.:	29.75 inches Hg
		STATIC PRESSURE:	-0.36 inches H2O
		STACK PRESSURE:	29.72 inches Hg
		ORIFICE PRESSURE:	2.329 inches H2O
		METER PRESSURE:	29.92 inches Hg
INIT. METER VOLUME:	318.863	AVERAGE CONC. CO2:	4.3 percent
FINAL METER VOLUME:	365.717	AVERAGE CONC. O2:	13.6 percent
VOLUME SAMPLED:	46.854	AVERAGE CONC. CO:	126.3 ppm
STD VOLUME (dscf):	46.419	MOLECULAR WEIGHT:	29.23 g/g-mole-dry
STD VOLUME (dscm):	1.315	MOLECULAR WEIGHT:	26.49 g/g-mole-wet
Y FACTOR:	1.001	Fo FACTOR:	1.698

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE °F	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE °F
A 1	1.60	236	B 5	1.30	250
2	1.48	241	6	1.18	249
3	1.32	244	7	1.42	249
4	1.64	244	8	1.32	250
5	1.82	244	C 1	0.40	240
6	1.90	243	2	0.44	246
7	2.05	244	3	0.52	247
8	2.12	244	4	0.58	247
B 1	0.86	241	5	0.68	247
2	1.15	246	6	0.78	247
3	1.12	247	7	0.90	246
4	1.20	249	8	1.16	246

PERCENT ISOKINETICS:	98 %	
STACK TEMPERATURE:	245.3 degrees F	705.3 degrees R
AVERAGE VELOCITY HEAD:	1.15 " of H2O	
STACK GAS VELOCITY:		72.9 ft/second
STACK GAS AIR FLOW:	28447.7 acf/min	15996.4 dscf/min
PARTICULATE EMISSION CONCENTRATION (front-half):		0.008 gr/dscf
PARTICULATE EMISSION CONCENTRATION (back-half):		0.001 gr/dscf
TOTAL PARTICULATE EMISSION CONC. (front & back-half):		0.009 gr/dscf
TOTAL PARTICULATE EMISSION CONCENTRATION:		21.1 mg/dscm
TOTAL PARTICULATE MATTER EMISSION RATE:		1.26 lb/hr

FRONT-HALF PARTICULATE MATTER MASS LOADING

FILTER NUMBER:	#110-040
TARE WEIGHT OF FILTER (grams):	0.6183
FINAL WEIGHT OF FILTER (grams):	0.6352
NET WEIGHT OF PARTICULATE MATTER (grams):	0.0169
BEAKER NUMBER:	#150-1782
TARE WEIGHT OF BEAKER (grams):	65.1542
FINAL WEIGHT OF BEAKER (grams):	65.1606
NET WEIGHT OF PARTICULATE MATTER (grams):	0.0064
VOLUME OF ACETONE (milliliters):	110.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):	0.0000
TOTAL FRONT-HALF PARTICULATE MATTER (grams):	0.0233

BACK-HALF PARTICULATE MATTER MASS LOADING

"C" SECTION - CONDENSER PARTICULATE	#150-1773
TARE WEIGHT OF BEAKER (grams):	64.8128
FINAL WEIGHT OF BEAKER (grams):	64.8157
NET WEIGHT OF PARTIC. MATTER (grams):	0.0030
TOTAL VOLUME OF WATER (milliliters):	650.0
VOLUME OF ALIQUOT (milliliters):	20.0
VOLUME OF WATER CONDENSED (milliliters):	305.4
NET VOLUME OF WATER FOR BLANK (milliliters):	344.6
WT./VOL. OF WATER BLANK (milligrams/ml):	0.0012
NET WEIGHT OF PARTIC. DUE TO WATER (grams):	0.0004
"Cx" SECTION - HYDROCARBON EXTRACTION	#150-1784
TARE WEIGHT OF BEAKER (grams):	64.8575
FINAL WEIGHT OF BEAKER (grams):	64.8577
NET WEIGHT OF PARTIC. MATTER (grams):	0.0002
TOTAL VOLUME OF CH2Cl2 (milliliters):	150.0
WT./VOL. OF CH2Cl2 BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO CH2Cl2 (grams):	0.0000
"D" SECTION - ACETONE RINSE OF CONDENSER	#150-1783
TARE WEIGHT OF BEAKER (grams):	64.4681
FINAL WEIGHT OF BEAKER (grams):	64.4697
NET WEIGHT OF PARTIC. MATTER (grams):	0.0016
TOTAL VOLUME OF ACETONE (milliliters):	105.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):	0.0000
TOTAL BACK-HALF PARTICULATE MATTER (grams):	0.0044
TOTAL WEIGHT OF PARTICULATE MATTER (grams):	0.0277

METHODS 1, 2, 3A, 4 AND 5
AM TEST-AIR QUALITY, INC.

FILE NAME:	R311\LOOKM5R3	LAB #:	6576		
CLIENT:	LOOKER & ASSOCIATES	START TIME:	13:47	o'clock	
LOCATION:	PUYALLUP, WASHINGTON	STOP TIME:	15:10	o'clock	
SAMPLE SITE:	ASPHALT BATCH PLANT BAGHOUSE STACK	SAMPLE LENGTH:	60.0	minutes	
SAMPLE DATE:	SEPTEMBER 8, 1994				
RUN #:	3 - METHOD 5				
OPERATORS:	MOYE/HARRIS				

IMPINGER WEIGHTS

FINAL grams	INITIAL grams	NET grams
922.0	653.1	268.9
678.3	636.7	41.6
532.6	529.5	3.1
783.7	771.3	12.4

TOTAL H2O GAIN:	326.0	PITOT TUBE Cp:	0.84	
TOTAL VOLUME (scf):	15.37	NOZZLE DIAMETER:	0.242	inches
PERCENT MOISTURE:	26.16	NOZZLE AREA:	0.0003	sq. feet
Bws:	0.2616	STACK DIAMETER:	29.25x32	inches
		STACK AREA:	6.50	sq. feet
		METER TEMPERATURE:	75.8	degrees F
		BAROMETRIC PRES.:	29.80	inches Hg
		STATIC PRESSURE:	-0.52	inches H2O
		STACK PRESSURE:	29.76	inches Hg
		ORIFICE PRESSURE:	2.043	inches H2O
		METER PRESSURE:	29.95	inches Hg
INIT. METER VOLUME:	366.058	AVERAGE CONC. CO2:	4.8	percent
FINAL METER VOLUME:	409.990	AVERAGE CONC. O2:	13.1	percent
VOLUME SAMPLED:	43.932	AVERAGE CONC. CO:	417.5	ppm
STD VOLUME (dscf):	43.379	MOLECULAR WEIGHT:	29.29	g/g-mole-dry
STD VOLUME (dscm):	1.229	MOLECULAR WEIGHT:	26.34	g/g-mole-wet
Y FACTOR:	1.001	Fo FACTOR:	1.625	

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE °F	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE °F
A 1	1.52	220	B 5	1.12	247
2	1.58	231	6	1.25	246
3	1.30	237	7	1.38	245
4	1.40	238	8	1.56	248
5	1.60	240	C 1	0.92	232
6	1.64	239	2	0.62	238
7	1.75	237	3	0.70	236
8	1.75	240	4	0.80	234
B 1	0.42	236	5	0.86	230
2	0.48	244	6	0.76	250
3	0.52	245	7	0.88	248
4	1.10	247	8	0.88	248

PERCENT ISOKINETICS:	97 %		
STACK TEMPERATURE:	239.8 degrees F	699.8	degrees R
AVERAGE VELOCITY HEAD:	1.07 " of H20		
STACK GAS VELOCITY:		70.3	ft/second
STACK GAS AIR FLOW:	27420.5 acf/min	15194.4	dscf/min
PARTICULATE EMISSION CONCENTRATION (front-half):		0.012	gr/dscf
PARTICULATE EMISSION CONCENTRATION (back-half):		0.003	gr/dscf
TOTAL PARTICULATE EMISSION CONC. (front & back-half):		0.015	gr/dscf
TOTAL PARTICULATE EMISSION CONCENTRATION:		34.8	mg/dscm
TOTAL PARTICULATE MATTER EMISSION RATE:		1.98	lb/hr

FRONT-HALF PARTICULATE MATTER MASS LOADING

FILTER NUMBER:	#110-478
TARE WEIGHT OF FILTER (grams):	0.7983
FINAL WEIGHT OF FILTER (grams):	0.8193
NET WEIGHT OF PARTICULATE MATTER (grams):	0.0210
BEAKER NUMBER:	#150-1785
TARE WEIGHT OF BEAKER (grams):	65.3464
FINAL WEIGHT OF BEAKER (grams):	65.3600
NET WEIGHT OF PARTICULATE MATTER (grams):	0.0136
VOLUME OF ACETONE (milliliters):	170.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):	0.0000
TOTAL FRONT-HALF PARTICULATE MATTER (grams):	0.0346

BACK-HALF PARTICULATE MATTER MASS LOADING

"C" SECTION - CONDENSER PARTICULATE	#150-1774
TARE WEIGHT OF BEAKER (grams):	65.1710
FINAL WEIGHT OF BEAKER (grams):	65.1786
NET WEIGHT OF PARTIC. MATTER (grams):	0.0078
TOTAL VOLUME OF WATER (milliliters):	630.0
VOLUME OF ALIQUOT (milliliters):	20.0
VOLUME OF WATER CONDENSED (milliliters):	313.6
NET VOLUME OF WATER FOR BLANK (milliliters):	316.4
WT./VOL. OF WATER BLANK (milligrams/ml):	0.0012
NET WEIGHT OF PARTIC. DUE TO WATER (grams):	0.0004
"Cx" SECTION - HYDROCARBON EXTRACTION	#150-1787
TARE WEIGHT OF BEAKER (grams):	65.0329
FINAL WEIGHT OF BEAKER (grams):	65.0329
NET WEIGHT OF PARTIC. MATTER (grams):	0.0000
TOTAL VOLUME OF CH2Cl2 (milliliters):	150.0
WT./VOL. OF CH2Cl2 BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO CH2Cl2 (grams):	0.0000
"D" SECTION - ACETONE RINSE OF CONDENSER	#150-1786
TARE WEIGHT OF BEAKER (grams):	64.2633
FINAL WEIGHT OF BEAKER (grams):	64.2640
NET WEIGHT OF PARTIC. MATTER (grams):	0.0007
TOTAL VOLUME OF ACETONE (milliliters):	75.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):	0.000
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):	0.0000
TOTAL BACK-HALF PARTICULATE MATTER (grams):	0.0082
TOTAL WEIGHT OF PARTICULATE MATTER (grams):	0.0428

APPENDIX B

Example Calculations and Field Data Sheets

EXAMPLE CALCULATION SHEET
EPA METHODS 1, 2, 3A, 4 AND 5

CLIENT: Looker + Associates LOCATION: Puyallup, Washington DATE: 9/8/94

RUN #: 2 LAB #: 6575 SITE LOCATION: Asphalt Batch Plant Baghouse Stack

Particulate Matter Emission Concentration - Equation 5-1

Vm_{std} = 17.647°R/"$Hg_{(constant)}$ * volume sampled * Y_{factor} * (P_B + $\Delta H/13.6$)/(460 + T_m)

= 17.647°R/"Hg * 46.854 ft^3 * 1.001 * (29.75 "Hg + (2.329 "H_2O/13.6))/(460 + 73.5° F)

= 46.419 dscf

dscm = 46.419 dscf/35.31 ft^3/m^3

= 1.315 dscm

Substitution of Equation 5-4 into 5-5

W_a = mg/ml blank * ml sample = mg sample due to acetone blank

W_a = 0.0 mg = 0.0 mg/ml * 110 ml

M_n = (net weight filter catch) + (net weight "B" section) - Wa + Back-half

= 27.7 mg = 16.9 mg + 6.4 mg - 0.0 mg + 4.4 mg

C_s = (0.001 g/mg) * (15.43 grains/gram) * M_n / Vm_{std}

C_s = (0.001 g/mg) * (15.43 grains/gram) * 27.7 mg / 46.419 dscf

= 0.009 gr/dscf (Equation 5-6)

gr/dscf @ ___ % O_2 = _____ gr/dscf * (20.9% - _____ %O_2)/(20.9% - _____ %O_2)
(% correction; % measured)

= N/A gr/dscf @ ___ % O_2

gr/dscf @ ___ %CO_2 = _____ gr/dscf * _____ % / _____ %CO_2
(% correction; % measured)

= N/A gr/dscf @ ___ % CO_2

mg/dscm = 27.7 mg/ 1.315 dscm

= 21.1 mg/dscm

Particulate Matter Emission Rate

pounds/hour = C_s * dscf/min * 60 min/hr * 1 lb/7000 grains

pounds/hour = 0.009 gr/dscf * 1596.4 dscf/min * 60 min/hr * 1 lb/7000 grains

= 1.26 lb/hr

EXAMPLE CALCULATION SHEET (continued)
EPA METHODS 1, 2, 3A, 4 and 5

Moisture - Equation 5-2 and 5-3

Vw_{std} = 0.04715 ft^3/g * 317.6 grams of H_2O collected in impingers

= 14.97 scf

B_{ws} = (14.97 scf)/(14.97 scf + 46.419 dscf)

= 0.2439

% Moisture = 24.39 % = B_{ws} * 100

Molecular weight - Equation 3-2

M_d = 0.440*(4.3 $\%CO_2$) + 0.320*(13.6 $\%O_2$) + 0.280*(100% - 4.3 $\%CO_2$ - 13.6 $\%O_2$($\%CO + \%N_2$))

= 29.23 g/g-mole (dry)

M_s = M_d * (1-B_{ws}) + 18.0 * B_{ws} = 29.23 g/g-mole * (1 - 0.2439) + 18.0 g/g-mole * 0.2439

= 26.49 g/g-mole (wet)

F_o = 1.698 = (20.9 - 13.6)$\%O_2$/ 4.3 $\%CO_2$

Stack gas velocity and volumetric flow rate - Equation 2-9 and 2-10

$V_s = 85.49 * C_p * \sqrt{\Delta P * T_s / (M_s * P_s)}$

V_s = 85.49 * 0.84 * $\sqrt{\dfrac{1.15 * 705.3\,^\circ R}{(245.3\,^\circ F + 460)\,^\circ R} \Big/ \dfrac{26.46\ g/g\text{-mole} * 29.72\ "Hg}{(29.75 P_B + .36 P_s/13.6)}}$

V_s = 72.9 ft/sec (std)

$Q_{sd} = 3600 * (1 - B_{ws}) * V_s * A_s * (T_{std}/T_s) * (P_s / P_{std})$ / 60 min/hr

Q_{sd} = 3600 * (1 - 0.2439) * 72.9 ft/sec * 6.50 ft^2 * (528° R/ 705.3° R) * (29.72"Hg / 29.92"Hg) / 60

(6.50 = 29.25×32/144)

= 15996.4 dscf/min (dry standard cubic feet per minute)

acfm = 72.9 ft/sec * 6.50 ft^2 * 60 sec/min

= 28447.7 acfm (actual cubic feet per minute)

Isokinetic variation - Equation 5-8

$I = 0.09450 * Vm_{std} * T_s \div [P_s * V_s * \text{sample time} * A_n * (1 - B_{ws})]$

I = 0.09450 * 46.419 dscf * 705.3° R/[29.72"Hg * 72.9 ft/sec * 60.0 min * 0.0003 ft^2 * (1 - 0.2439)]

(0.0003 = .242 $N_{dia}/12/2)^2 * Pi$)

I = 98 %

All of the above numbered equations are from the 40 CFR 60 and assume English units.

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EXAMPLE CALCULATION SHEET (continued)
EPA METHODS 1, 2, 3A, 4 and 5

BACKHALF PARTICULATE

Final Wt - Initial Wt = Net Wt
873.1 - 631.5 = 241.6
700.1 - 640.9 = 59.2
545.5 - 540.9 = 4.6
305.4

"C" Section

a 3.0 mg particulate in "C" Section Beaker
b 650 ml of water in condensers, including rinses
c 305.4 ml condensation in 1st, 2nd and 3rd bubblers (final wt - initial wt, assumes 1g/1ml water density)
d 344.6 ml DI water used in bubblers including rinses = *b - c*
e 0.0012 mg/ml blank particulate = 0.3 mg blank / 250 ml blank
f 0.4 mg blank particulate = *e * d*
2.6 **mg of "C" particulate** = *a - f* = 3.0 mg - 0.4 mg

"Cx" Section

a 0.2 mg particulate in "Cx" Section Beaker
b 150 ml CH_2Cl_2 used for sample
c 0.0 mg/ml blank particulate = 0.0 mg blank / 150 ml blank
d 0.0 mg blank particulate = *b * c*
0.2 **mg of "Cx" particulate** = *a - d* = 0.2 mg - 0.0 mg

"D" Section

a 1.6 mg particulate in "D" Section Beaker
b 105 ml Acetone used for sample
c 0.0 mg/ml blank particulate (Same as "B" Section)
d 0.0 mg blank particulate = *b * c*
1.6 **mg of "D" particulate** = *a - d* = 1.6 mg - 0.0 mg

TOTAL BACK-HALF PARTICULATE

\+ 2.6 mg "C" Section Particulate
\+ 0.2 mg "Cx" Section Particulate
\+ 1.6 mg "D" Section Particulate
\+ N/A mg Back-half Filter Particulate (If applicable)

= 4.4 **mg Back-half Particulate**

STACK SCHEMATIC AND LOCATION OF SAMPLE POINTS

Client LOOKER ASSOC.

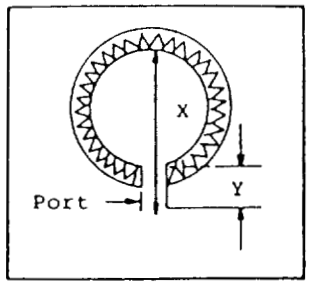
Location PUYALLUP WA

Sampling Location ASPHALT PLANT STACK

Inside of far wall to outside of port (distance, X) 33 1/4"

Inside of near wall to outside of port (distance, Y) 4"

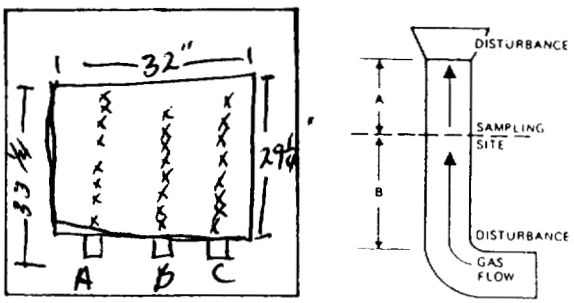
Stack I.D. (distance X - distance Y) 29 1/4" X 32"



Schematic of Sampling Location

1 *Traverse Point #*	2 *Fractional Percent of Stack I.D.*	3 ~~*Length Stack I.D.*~~ *inches*	4 *Column 2 x 3*	5 *Distance Y*	6 *Traverse Point Location from Outside of Port columns 4 + 5*
1	NA	~~1.85~~	0	4"	5.85
2		5.55			9.55
3		9.25			14.25
4		12.95			17.95
5		16.65			20.65
6		20.35			24.35
7		24.05			28.05
8		27.75			31.75
9					
10					
11					
12					

CROSS SECTION



24 pt TRAVERSE (3 Ports X 8 pt)

Distance A = 22 1/4" downstream

Distance B = 96" upstream

STACK, CONTROL DEVICE AND PROCESS FLOW DIAGRAM

TRAVERSE SAMPLING DATA SHEET

Page ___ of ___

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Client Cooker Assoc
Location Puyallup WA
Sample Site Asphalt Plant STACK
Stack Diameter 29¾ x 32
Date 9-8-94
Operators SGM JSH
Run I.D. #1 M5 w/BP

EQUIPMENT CHECKS

	Initial/Final
Leak Rate cfm	0.008 / 0.006
Leak Test Vacuum	12" / 12"
✓ Pitots, Pre Leak Ck	
✓ Pitots, Post Leak Ck	
NA Gas Sampling System	
✓ Integrated Bag	
M5 Rinse Acetone/H_2O/Other	

QA FORMS COMPLETED

Stack Schematic ✓
Sample Train ✓
Pitot Tube Insp. ✓
Magnehelic Cal. ✓
Temp. Probe Cal. T2D
Gas Meter Calib. ✓

Filter # ___ Box # W-1

	Final Wt. gram	Initial Wt. gram	Net Wt. gram
#1 Imp.	862.1	638.8	=
#2 Imp.	700.8	638.9	=
#3 Imp.	554.4	546.6	=
#4 Imp.			=
#5 Imp.			=
#6 S.G.	873.5	857.7	=

Total H_2O Volume 308.8 ✓ g

Start Time 0900
Stop Time 1109
Barometric Pressure "Hg 29.70
Static Pres "H_2O -0.38
Production Rate 160 TPH
AK Box

SAMPLING PARAMETERS

% Moisture 26
Meter Temp. 64
Stack Temp. 220
ΔH@ 2.074 Y 1.001
Pitot # P24 / Side # A
Cp 0.84
Nozzle Diameter 0.242 inch
D_1 0.241 D_2 0.242 D_3 0.243
K Factor 0.9007 1.78'

WB-15
DB-41

Sample Point		Elap Time Min.	Dry Gas Meter Reading Cu.Ft.	Pitot Reading ΔP " H_2O	Orifice Setting (ΔH) " H_2O Ideal	Orifice Setting (ΔH) " H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vac. Gauge " Hg	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	O_2 %	
A	1	0	272.084	1.28	2.43	2.43	62	62	2	240	48	247		
	2			1.54	2.93	2.93	62	62	2½	237	51	248		
	3	5	276.33	1.46	2.77	2.77	62	62	2½	251	49	247		
	4			1.54	2.74	2.74	63	62	3	255	49	246		
	5	10	280.59	1.68	2.99	2.99	63	62	3	257	50	245	CO_2	4.1%
	6			1.92	3.43	3.43	64	62	4	255	54	242	O_2	14.1%
	7	15	285.29	1.68	2.99	2.99	65	63	4	256	58	238	CO	80.4 ppm
	8		289.91	1.92	3.43	3.43	66	63	4+	253	62	238		
B	1	20	~~294.46~~	0.96	1.71	1.71	66	63	2	261	65	228		
	2			1.12	2.00	2.00	66	64	2	261	64	236		
	3	25	293.45	1.18	2.10	2.10	67	64	2½	260	63	240		
	4			1.16	2.07	2.07	67	64	2½	260	60	241		
	5	30	297.24	1.28	2.28	2.28	68	65	3	260	58	244		
	6			2.00	3.56	3.56	68	66	3½	258	56	241		
	7	35	301.62	1.86	3.31	3.31	68	67	4	260	52	241		
	8			1.42	2.53	2.53	68	67	3	262	49	240		
C	1	40	306.07	0.50	0.89	0.89	68	67	1	251	55	232		
	2			0.96	1.71	1.71	69	68	2½	253	50	247		
	3	45	308.92	0.96	1.71	1.71	69	68	2½	253	49	249		
	4			0.72	1.28	1.28	69	68	2	253	49	247		
	5	50	312.12	0.80	1.43	1.43	71	69	2	253	50	246		
	6			0.82	1.46	1.46	70	70	2	256	60	231		
	7	55	315.24	0.78	1.39	1.39	70	70	2	245	51	234		
	8			1.10	1.96	1.96	70	70	4	247	50	236		
		60	318.569											
			41.485 ✓	1.21		2.296 ✓	66.0 ✓							

DN @ 0936 WRE 1012

DN @ 103 WRE 110

METHOD 5
LABORATORY ANALYSIS

Client Looker Assoc. Run Number 1

Sample Location Asphalt Plant Stack

Date 8-9-94

"A" Section (Filter)

Filter # 110-452 Tare Weight 1.4321 grams
Final Weight 1.4635 grams
Net Weight 0.0314 grams

"B" Section (Probe Wash)

Beaker # 150-1779 Tare Weight 64.4903 grams
Volume Acetone 110 mls Final Weight 64.5054 grams
Net Weight 0.0151 grams

"C" Section (Condenser Particulate - Inorganic Catch)

Beaker # 150-1772 Tare Weight 65.1121 grams
Volume Water 500/520 mls Final Weight 65.1226 grams
520/500 = 1.040 Net Weight 0.0105 grams * 1.040
0.0109

"Cx" Section (Condenser Particulate - Organic Catch)

Beaker # 150-1781 Tare Weight 64.0801 grams
Volume CH_2Cl_2 150 mls Final Weight 64.0810 grams
Net Weight 0.0009 grams * 1.040
0.0009

"D" Section (Final Acetone Rinse of Impingers)

Beaker # 150-1780 Tare Weight 64.5463 grams
Volume Acetone 95 mls Final Weight 64.5476 grams
Net Weight 0.0013 grams

6574

TRAVERSE SAMPLING DATA SHEET

Page ___ of ___

6575

Client Cooker Assoc.
Location Puyallup WA
Sample Site Asphalt Pt. STACK
Stack Diameter 29¼ x 32
Date 9-8-94
Operators SBM JSH
Run I.D. R2 M5 w/BH

EQUIPMENT CHECKS

	Initial/Final
Leak Rate cfm	0.004/0.002
Leak Test Vacuum	12"/12"
✓ Pitots, Pre Leak Ck	
✓ Pitots, Post Leak Ck	
NA ✓ Gas Sampling System	
___ Integrated Bag	

M5 Rinse (Acetone)/H_2O/Other

QA FORMS COMPLETED

Stack Schematic	✓
Sample Train	✓
Pitot Tube Insp.	✓
Magnehelic Cal.	✓
Temp. Probe Cal.	T2D
Gas Meter Calib.	—

Filter # ___ Box # W-2

	Final Wt. gram	Initial Wt. gram	Net Wt. gram
#1 Imp.	873.1	631.5	
#2 Imp.	700.1	640.9	
#3 Imp.	545.5	540.9	
#4 Imp.			
#5 Imp.			
#6 S.G.	881.3	869.1	

Total H_2O Volume 317.6 ✓ g

Start Time 1148
Stop Time 1254
Barometric Pressure "Hg 29.75"
Static Pres "H_2O -0.36
Production Rate 160 TPH

SAMPLING PARAMETERS

% Moisture 26%
Meter Temp. 72
Stack Temp. 242
Δ H@ 2.074 Y 1.001
Pitot # P2Y Side # A
Cp 0.84
Nozzle Diameter 0.242 inch
D_1 ___ D_2 ___ D_3 ___
K Factor 1.931

Sample Point		Elap Time Min.	Dry Gas Meter Reading Cu.Ft.	Pitot Reading Δ P " H_2O	Orifice Setting (Δ H) " H_2O Ideal	Orifice Setting (Δ H) " H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vac. Gauge " Hg	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	O_2 %	
A	1	0	318.863	1.60	3.09	3.09	71	71	2	251	62	236		
	2			1.48	2.86	2.86	71	71	2	243	54	241		
	3	5	323.32	1.32	2.55	2.55	71	71	2	251	51	244		
	4			1.64	3.17	3.17	72	71	2½	254	50	244		
	5	10	327.82	1.82	3.52	3.52	72	71	3	253	51	244		
	6			1.90	3.67	3.67	73	71	3	251	54	243	CO_2	4.3%
	7	15	332.74	2.05	3.96	3.96	74	71	3½	254	55	244	O_2	13.6%
	8			2.12	4.09	4.09	74	71	4	251	56	244	CO	126.3 ppm
B	1	20	337.93	0.86	1.66	1.66	74	71	2½	253	64	241		
	2			1.15	2.22	2.22	74	72	2	253	59	246		
	3	25	341.59	1.12	2.16	2.16	75	72	2½	251	57	247		
	4			1.20	2.32	2.32	75	72	2½	251	57	249		
	5	30	345.58	1.30	2.51	2.51	76	72	3	254	56	250		
	6			1.18	2.28	2.28	76	72	2½	251	56	249		
	7	35	349.64	1.42	2.74	2.74	76	73	3	251	57	249		
	8			1.32	2.55	2.55	77	73	3	252	57	250		
C	1	40	353.86	0.40	0.77	0.77	76	73	2	255	63	240		
	2			0.44	0.85	0.85	76	74	1½	254	57	246		
	3	45	356.25	0.52	1.00	1.00	76	74	2	253	54	247		
	4			0.58	1.12	1.12	76	74	2	253	53	247		
	5	50	358.96	0.68	1.31	1.31	76	74	2	255	52	247		
	6			0.78	1.51	1.51	76	74	2½	254	52	247		
	7	55	362.03	0.90	1.74	1.74	77	74	2	254	54	246		
	8			1.16	2.24	2.24	77	74		254	54	246		
		60	365.717											
			46.854 ✓	1.152		2.329 ✓	73.5 ✓					245.3 ✓		

METHOD 5
LABORATORY ANALYSIS

Client LOOKER + ASSOC Run Number 2

Sample Location BAGHOUSE EXHAUST

Date 9/8/94

"A" Section (Filter)

Filter # 110-04C (glass)
Tare Weight 0.6183 grams
Final Weight 0.6352 grams
Net Weight 0.0169 grams

"B" Section (Probe Wash)

Beaker # 150-1782
Volume Acetone 110 mls
Tare Weight 65.1542 grams
Final Weight 65.1606 grams
Net Weight 0.0064 grams

"C" Section (Condenser Particulate - Inorganic Catch)

Beaker # 150-1773
Volume Water 630/650 mls
650/630 = 1.032
Tare Weight 64.8128 grams
Final Weight 64.8157 grams
Net Weight 0.0029 grams * 1.032
0.0030

"Cx" Section (Condenser Particulate - Organic Catch)

Beaker # 150-1784
Volume CH_2Cl_2 150 mls
Tare Weight 64.8575 grams
Final Weight 64.8577 grams
Net Weight 0.0002 grams * 1.032
0.0002

"D" Section (Final Acetone Rinse of Impingers)

Beaker # 150-1783
Volume Acetone 105 mls
Tare Weight 64.4681 grams
Final Weight 64.4697 grams
Net Weight 0.0016 grams

6575

TRAVERSE SAMPLING DATA SHEET

Page ___ of ___

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Client Looker Assoc
Location Puyallup WA
Sample Site Asphalt plant stack
Stack Diameter 29¼ x 32
Date 9-8-94
Operators SBM JSH
Run I.D. R3 M5 w/BH

EQUIPMENT CHECKS

	Initial/Final
Leak Rate cfm	0.002 / 0.002
Leak Test Vacuum	15" / 12"
✓ Pitots, Pre Leak Ck	
✓ Pitots, Post Leak Ck	
NA Gas Sampling System	
✓ Integrated Bag	
M5 Rinse Acetone/H_2O/Other	

QA FORMS COMPLETED
Stack Schematic ✓
Sample Train ✓
Pitot Tube Insp. ✓
Magnehelic Cal. ✓
Temp. Probe Cal. T2D
Gas Meter Calib. ___

Filter # ___ Box # U-3

	Final Wt. gram	Initial Wt. gram	Net Wt. gram
#1 Imp.	922.0	653.1	
#2 Imp.	678.3	636.7	
#3 Imp.	532.6	529.5	
#4 Imp.			
#5 Imp.			
#6 S.G.	785.7	771.3	
Total H_2O Volume			326.0 ✓ g

Start Time 1347
Stop Time 1510
Barometric Pressure "Hg 29.80
Static Pres "H_2O -0.52
Production Rate 160 TPH

SAMPLING PARAMETERS

% Moisture 28
Meter Temp. 76
Stack Temp. 245
Δ H@ 2.074 Y 1.001
Pitot # P24 Side # A
Cp 0.84
Nozzle Diameter 0.242 inch
D_1 ___ D_2 ___ D_3 ___
K Factor 1.856

Sample Point		Elap Time Min.	Dry Gas Meter Reading Cu.Ft.	Pitot Reading Δ P " H_2O	Orifice Setting (Δ H) " H_2O Ideal	Orifice Setting (Δ H) " H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vac. Gauge " Hg	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	O_2 %	
				1.52	2.82	2.82								
A	1	0	366.058	~~0.98~~	~~1.82~~	~~1.82~~	75	74	1½	255	57	220		
	2			1.58	2.93	2.93	74	74	2½	249	56	231		
	3	5	370.51	1.30	2.41	2.41	75	74	2½	252	53	237		
	4			1.40	2.60	2.60	75	74	3	252	54	238		
	5	10	374.70	1.60	2.97	2.97	76	75	3	255	55	240		
	6			1.64	3.04	3.04	76	74	3	255	57	239	CO_2	4.8%
	7	15	~~3~~79.25	1.75	3.25	3.25	76	74	3	254	60	237	O_2	13.1%
	8			1.75	3.25	3.25	77	75	3	252	59	240	CO	417.5 ppm
B	1	20	383.90	0.42	0.78	0.78	77	75	2	255	62	236		
	2			0.48	0.89	0.89	77	75	1	256	62	244		
	3	25	386.37	0.52	0.97	0.97	77	75	1	255	60	245		
	4			1.10	2.04	2.04	77	75	1	254	58	247		
	5	30	389.53	1.12	2.08	2.08	77	75	2	256	55	247		
	6			1.25	2.32	2.32	78	75	3	254	55	246		
	7	35	393.43	1.38	2.56	2.56	78	76	3	254	55	245		
	8			1.56	2.93	2.93	78	76	3	250	56	248		
C	1	40	397.84	0.52	0.97	0.97	78	76	3	250	59	232		
	2			0.62	1.15	1.15	78	76	2	256	58	238		
	3	45	400.54	0.70	1.30	1.30	78	76	2	255	56	236		
	4			0.80	1.49	1.49	78	76	2	256	56	234		
	5	50	403.57	0.86	1.60	1.60	77	76	2	253	56	230		
	6			0.76	1.41	1.41	76	75	2	258	255	250		
	7	55	406.71	0.88	1.63	1.63	75	75	2	257	54	248		
	8			0.88	1.63	1.63	75	74	2	256	55	248		
		60	409.990											
			43.932 ✓			2.043 ✓	75.8 ✓					239.8 ✓		

dw @ 14.50 a.r.p. 1503

METHOD 5
LABORATORY ANALYSIS

Client Lockheed Assoc Run Number 3

Sample Location Baghouse Exhaust

Date 9/8/94

"A" Section (Filter)

Filter # 110-478 Tare Weight 0.7983 grams
Final Weight 0.8193 grams
Net Weight 0.0210 grams

"B" Section (Probe Wash)

Beaker # 150-1785 Tare Weight 65.3464 grams
Volume Acetone 170 mls Final Weight 65.3600 grams
Net Weight 0.0136 grams

"C" Section (Condenser Particulate - Inorganic Catch)

Beaker # 150-1774 Tare Weight 65.1710 grams
Volume Water 610/630 mls Final Weight 65.1786 grams
630/610 = 1.033 Net Weight 0.0076 grams * 1.033
0.0078

"Cx" Section (Condenser Particulate - Organic Catch)

Beaker # 150-1787 Tare Weight 65.0329 grams
Volume CH_2Cl_2 150 mls Final Weight 65.0233 grams
Net Weight -0.0096 grams * 1.033

"D" Section (Final Acetone Rinse of Impingers)

Beaker # 150-1786 Tare Weight 64.2633 grams
Volume Acetone 75 mls Final Weight 64.2640 grams
Net Weight 0.0007 grams

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METHOD 5
LABORATORY ANALYSIS

Acetone Blank

Beaker # 150-1788 Tare Weight 63.9264 grams
Volume Acetone 100 mls Final Weight 63.9263 grams
Net Weight 0.0 grams

Distilled, Deionized Water Blank

Beaker # 150-1775 Tare Weight 65.1804 grams
Volume Water 250 mls Final Weight 65.1807 grams
Net Weight 0.0003 grams
.3/250 = 0.0012 mg/ml

Methylene Chloride (CH_2Cl_2) Blank

Beaker # 150-1789 Tare Weight 64.4589 grams
Volume CH_2Cl_2 150 mls Final Weight 64.4582 grams
Net Weight 0.0 grams

AMTEST AIR QUALITY, INC. 35

SAMPLE TRAIN INFORMATION

Fill out one sheet per site and per test type.

CLIENT: Looker + Assoc

LOCATION: Puyallup WA

SITE: Asphalt Plant

TEST TEAM: SBM JSH DATE(S): 9-8-94

RUN #'S: 3 TYPE: M5 w/BH

Probe/Filter Temperature: ✓ 248+25 F _____320 F _____Other

Impinger Temperature: ✓ <68 F _____Other

THIMBLE: _____ yes ✓ no NOZZLE TYPE: _____quartz ✓ steel _____none

PROBE LINER: _____quartz _____glass ✓ steel _____teflon

PROBE TYPE: ✓ regular _____water-cooled

FRONT-HALF FILTER: ✓ yes ____no SIZE (mm): ___90 ✓ 110 ___125 ___other_____
FRONT-HALF FILTER MEDIA: ✓ quartz fiber _____glass fiber _____teflon

SUPPORT: _____steel ✓ glass frit _____teflon GASKET: ✓ silicon _____teflon

BACK-HALF FILTER: ____yes ✓ no
BACK-HALF FILTER MEDIA: ____quartz fiber ____glass fiber ____telfon ____tared ____untared
NOTE: Show the back-half filter location with an arrow on the table below.

CONTENTS	Initial Volume (mL)	Clean-up Solution Used	Bottle Type	Comments
Nozzle/Probe Rinse		ACE	500mL	
Filter				
#1 D.I	100	D.I/ACE	14/25 amb	
#2 D.I.	100	↓	↓	
#3 M.T.	-	↓	↓	
#4 S.G	-			
#5				
#6				
#7				

IF THIS INFORMATION IS NOT ACCURATE FOR ALL RUNS, NOTE ALL EXCEPTIONS.

AMTEST
AIR QUALITY, INC

GAS BAG SAMPLE DATA SHEET

CLIENT: Looker Assc.

LOCATION: Fredrickson, WA

SAMPLE SITE: Baghouse Outlet Stack

DATE: 9/8/94

NUMBER/TYPE OF TESTS: Runs 3 M5 NUMBER OF BAGS: 6

SAMPLED BY: SBM

SUBMITTED BY: SBM

ANALYZED BY: JSH DATE: 9/9/94

BAG NUMBER/IDENTIFICATION	CO_2 %	O_2 %	CO ppm	F_o	NOTES
R1 Bag1 M5	4.0	14.0	61.1	avg 4.1% CO_2 14.1% O_2 80.4 ppm CO	
R1 Bag2 M5	4.1	14.1	99.6		
R2 Bag1 M5	4.5	13.3	109.3	avg 4.3% CO_2 13.6% O_2 126.3 ppm CO	
R2 Bag2 M5	4.1	13.9	143.2		
R3 Bag1 M5 5.1	[redacted]	12.7	489	avg 4.8% CO_2 13.1% O_2 417.5 ppm CO	
R3 Bag2 M5	4.4	13.4	346		

CO_2 ANALYZER: Teco M48 CALIBRATION GAS: 6.00%

O_2 ANALYZER: Servomex 1400 CALIBRATION GAS: 15.03%

CO ANALYZER: " " CALIBRATION GAS: 302 ppm

APPENDIX C

Supporting Information

SOURCE AND PROCESS INFORMATION

Client Looker Assoc. Test Dates 9-8-94

Location Puyallup WA

Process Information

Type of Source Stanley Steel Batch Asphalt plant Model No. 4000LB

Control Equipment _____ Model No. _____

Sampling Locations Exhaust stack

Type of Testing Performed M5 w/ Backhalf

No. of Tests Performed 3 Emission Standard 0.02 grs/DSCF

Purpose of Testing Particulate matter Emission

Test Team SBM TSH

Observer(s)/Affiliation JACK FAY (Sale Engineer for AESCO)

Client(s) Representative _____

Other Representatives _____

Source Operation

Description of Process The Looker Asphalt plant is a Batch style plant with a Bag ~~Hos~~ House control device. ~~Scrubber system~~ (512 bags w/ this unit)

Production Rate 160 TPH Type of Raw Material/Fuel Gravel (5% fines) / #1 Diesel

Operating Conditions S.O.P.

Stack Diameter 29¼" x 32' Distance Upstream/Downstream 22¼"

No. Ports 3 No. Points 24

Process Shutdowns/Problems 1½ Hr down do to to Lack of Trucks

Operation Personnel Greg Rouse

SOURCE TEST OBSERVATION CHECKLIST
ASPHALT BATCH PLANTS WITH BAGHOUSE

Client LOOKER 2 ASSOC Date 9-8-94

Location 5825 176 TH STREET

Process Information

Type of Plant STAN STEEL BATCH

Manufacturer STAN STEEL

Model 4000 LB Constructed/Installed 8/91

Identification No. _____ Date Last Tested 1986 ?

Operation Personnel Greg Rouse

Process Rate 160 Tons/Hr Discharge Temp 305 °F

Type of Fuel #1 Diesel Firing Rate 1.85 PER TON Gal/Hr

A/C Injection Location Pug Mill

Fines In Gravel (-200 mesh) 5%

Gravel Moisture _____ % Asphalt Type AR 4000

Density 12 GAL PER ton #/Gal Flash Point 450 °F

Control Equipment

Manufacturer ALCON Model SPECTRUM 1.00A

Bag Material Nomex #Bags 512 Bag Size _____

Date Bags Last Changed 1993 NEW BAG HOUSE Air/Cloth Ratio _____

Type of Bag Cleaning PULSE

Baghouse Press ΔP = 5 "H_2O Static Press -0.4" "H_2O

Cleaning Cycle Duration _____

Disposition of Collected Dust AUGERS

Additional Information Sketch of System

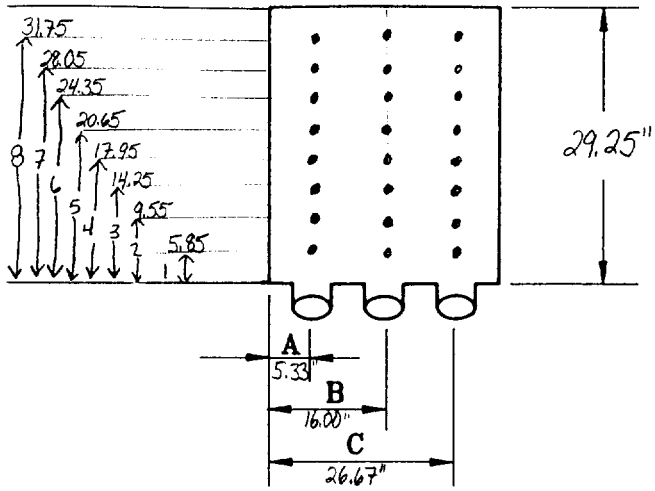
_____

_____

_____
Authorized Signature

CROSS SECTIONAL AREA

Traverse Point	Distance (inches)
1	5.85
2	9.55
3	14.25
4	17.95
5	20.65
6	24.35
7	28.05
8	31.75



Port	Distance (inches)
A	5.33
B	16.00
C	26.67

STACK DIMENSIONS

29.25 inch x 32 inch rectangular vent

3 ports located along the 32 inch side

A = 22.25 inches downstream

B = 96 inches upstream

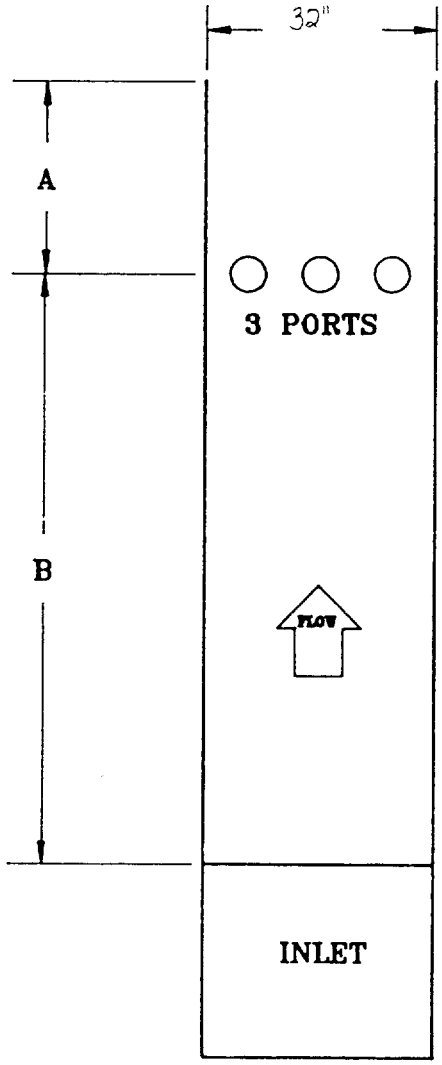


Figure 1. Location of sampling ports and traverse points.

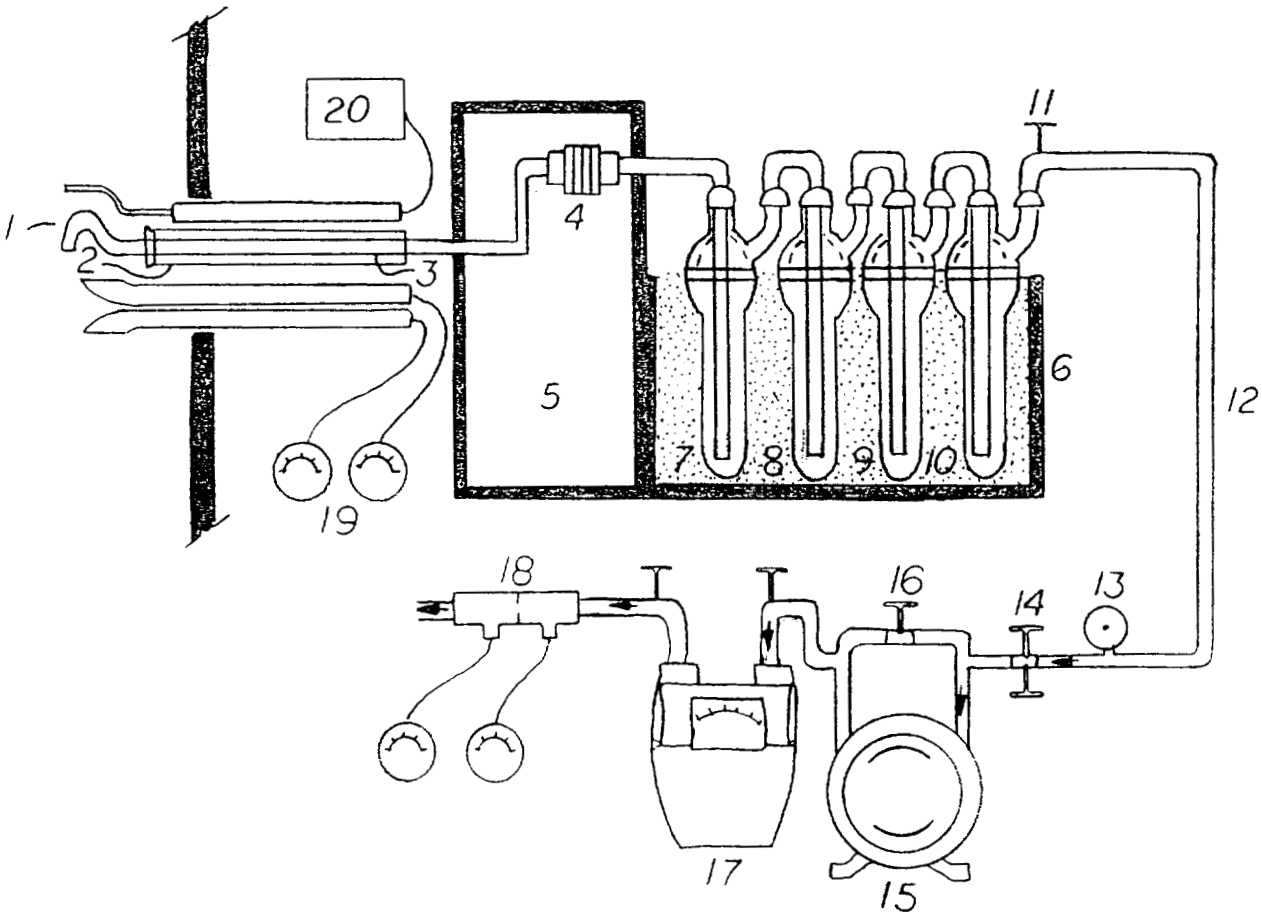


Figure 2 . Method 5 Sample Train.

1. Sampling nozzle
2. Sampling probe sheath
3. Heated sample probe liner
4. Out of stack filter assembly
5. Heated filter compartment maintained at 248°F ± 25°F (or temperature specified in 40 CFR subpart)
6. Impinger case - contains ice during sampling
7. First impinger containing 100 ml H_2O
8. Modified Greenburg-Smith impinger containing 100 ml H_2O
9. Third impinger - empty
10. Fourth impinger containing indicating silica gel desiccant
11. Impinger exit gas temperature sensor
12. Umbilical cord - vacuum line
13. Vacuum gauge
14. Fine and coarse adjustment valves
15. Leak free pump
16. By-pass valve
17. Dry gas meter with inlet and outlet temperature sensors
18. Orifice meter with magnehelic gauges
19. S-type pitot tube with magnehelic gauges
20. Fluke multi-channel digital thermocouple indicator

METHOD 1 - LOCATION OF TRAVERSE POINTS

Circular Stacks

TRAVERSE POINT	DISTANCE, % of diameter
1	4.4
2	14.7
3	29.5
4	70.5
5	85.3
6	95.6

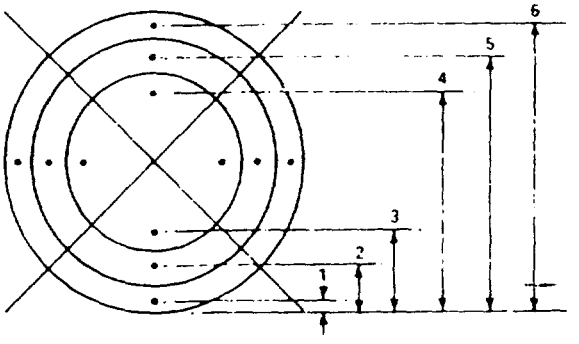


Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

TABLE 1-2. LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

[Percent of stack diameter from inside wall to traverse point]

Traverse point number on a diameter	Number of traverse points on a diameter—											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.8	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9

Rectangular Stacks

For a rectangular cross section, an equivalent diameter (D_e) shall be calculated from the following equation, to determine the upstream and downstream distances:

$$D_e = \frac{2LW}{(L+W)}$$

where L=length and W=width.

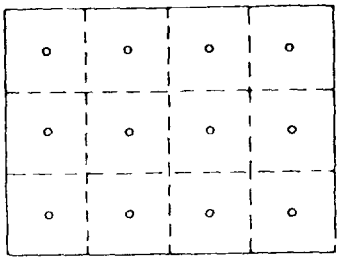


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

METHOD 1 - MINIMUM NUMBER OF TRAVERSE POINTS

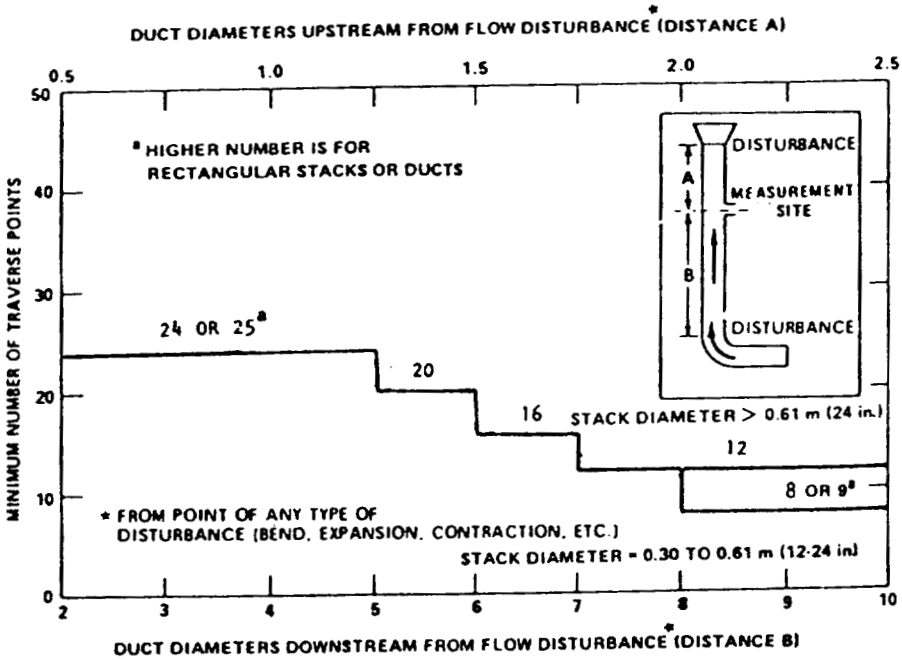


Figure 1-1. Minimum number of traverse points for particulate traverses.

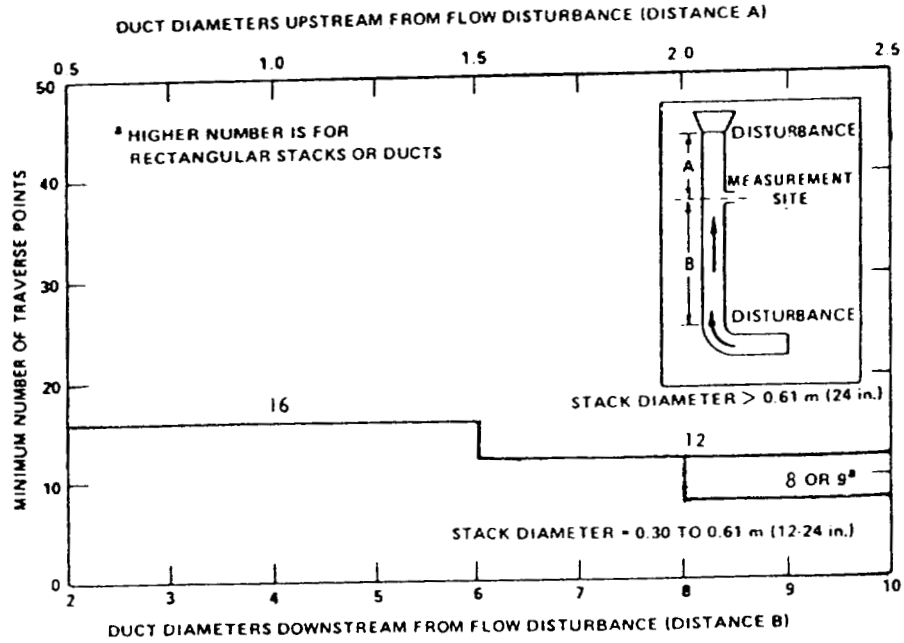


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

METHOD 2 - STACK GAS VELOCITY AND VOLUMETRIC FLOW CALCULATIONS

5.1 Nomenclature.

A = Cross-sectional area of stack, m^2 (ft^2).
B_{ws} = Water vapor in the gas stream (from Method 5 or Reference Method 4), proportion by volume.
C_p = Pitot tube coefficient, dimensionless.
K_p = Pitot tube constant,

$$34.97 \frac{m}{sec}\left[\frac{(g/g\text{-mole})(mm\ Hg)}{(°K)(mm\ H_2O)}\right]^{1/2}$$

for the metric system and

$$85.49 \frac{ft}{sec}\left[\frac{(lb/lb\text{-mole})(in.\ Hg)}{(°R)(in.\ H_2O)}\right]^{1/2}$$

for the English system.

M_d = Molecular weight of stack gas, dry basis (see Section 3.6) g/g-mole (lb/lb-mole).
M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

$$= M_d(1-B_{ws}) + 18.0\,B_{ws} \qquad \text{Eq. 2-5}$$

P_{bar} = Barometric pressure at measurement site, mm Hg (in. Hg).
P_g = Stack static pressure, mm Hg (in. Hg).
P_s = Absolute stack gas pressure, mm Hg (in. Hg).

$$= P_{bar} + P_g \qquad \text{Eq. 2-6}$$

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).
Q_{sd} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr).
t_s = Stack temperature, °C (°F).
T_s = Absolute stack temperature, °K, (°R).

$$= 273 + t_s \text{ for metric.} \qquad \text{Eq. 2-7}$$

$$= 460 + t_s \text{ for English.} \qquad \text{Eq. 2-8}$$

T_{std} = Standard absolute temperature, 293 °K (528° R).
v_s = Average stack gas velocity, m/sec (ft/sec).
Δ_p = Velocity head of stack gas, mm H_2O (in. H_2O).
3,600 = Conversion factor, sec/hr.
18.0 = Molecular weight of water, g/g-mole (lb/lb-mole).

5.2 Average Stack Gas Velocity.

$$v_s = K_p C_p (\sqrt{\Delta p})_{avg} \sqrt{\frac{T_{s(avg)}}{P_s M_s}} \qquad \text{Equation 2-9}$$

5.3 Average Stack Gas Dry Volumetric Flow Rate.

$$Q_{sd} = 3{,}600(1-B_{ws})v_s A\left(\frac{T_{std}}{T_{s\,(avg)}}\right)\left(\frac{P_s}{P_{std}}\right) \qquad \text{Eq. 2-10}$$

METHOD 3 - MOLECULAR WEIGHT AND EXCESS AIR CALCULATIONS

6.1 Nomenclature.

M_d = Dry molecular weight, g/g-mole (lb/lb-mole).
%EA = Percent excess air.
$\%CO_2$ = Percent CO_2 by volume (dry basis).
$\%O_2$ = Percent O_2 by volume (dry basis).
%CO = Percent CO by volume (dry basis).
$\%N_2$ = Percent N_2 by volume (dry basis).
0.264 = Ratio of O_2 to N_2 in air, v/v.
0.280 = Molecular weight of N_2 or CO, divided by 100.
0.320 = Molecular weight of O_2 divided by 100.
0.440 = Molecular weight of CO_2 divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O_2, CO, and N_2 (obtained from Section 4.1.3 or 4.2.4) into Equation 3-1.

$$\%\,EA = \frac{\%O_2 - 0.5\%\ CO}{0.264\%\ N_2(\%O_2 - 0.5\%\ CO)} \times 100 \qquad \text{Eq. 3-1}$$

NOTE: The equation above assumes that ambient air is used as the source of O_2 and that the fuel does not contain appreciable amounts of N_2 (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N_2 are present (coal, oil, and natural gas do not contain appreciable amounts of N_2) or when oxygen enrichment is used, alternate methods, subject to approval of the Administrator, are required.

6.3 Dry Molecular Weight. Use Equation 3-2 to calculate the dry molecular weight of the stack gas

$$M_d = 0.440(\%CO_2) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO) \qquad \text{Eq. 3-2}$$

METHOD 4 - STACK GAS MOISTURE CALCULATIONS

2.3.1 Nomenclature.

B_{ws} = Proportion of water vapor, by volume, in the gas stream.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

P_m = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 (mm Hg) (m^3)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft^3)/(lb-mole) (°R) for English units.

T_m = Absolute temperature at meter, °K (°R).

T_{std} = Standard absolute temperature, 293° K (528°R).

V_m = Dry gas volume measured by dry gas meter, dcm (dcf).

ΔV_m = Incremental dry gas volume measured by dry gas meter at each traverse point, dcm (dcf).

$V_{m(std)}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{wc(std)}$ = Volume of water vapor condensed corrected to standard conditions, scm (scf).

$V_{wsg(std)}$ = Volume of water vapor collected in silica gel corrected to standard conditions, scm (scf).

V_f = Final volume of condenser water, ml.

V_i = Initial volume, if any, of condenser water, ml.

W_f = Final weight of silica gel or silica gel plus impinger, g.

W_i = Initial weight of silica gel or silica gel plus impinger, g.

Y = Dry gas meter calibration factor.

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

2.3.2 Volume of Water Vapor Condensed.

$$V_{wc(std)} = \frac{(V_f - V_i)\rho_w R T_{std}}{P_{std} M_w}$$

$$= K_1 (V_f - V_i)$$

Eq. 4-1

$K_1 = 0.001333$ m^3/ml for metric units
$= 0.04707$ ft^3/ml for English units

2.3.3 Volume of Water Vapor Collected in Silica Gel.

$$V_{wsg(std)} = \frac{(W_f - W_i)R T_{std}}{P_{std} M_w}$$

$$= K_2 (W_f - W_i)$$

Eq. 4-2

Where:

$K_2 = 0.001335$ m^3/g for metric units
$= 0.04715$ ft^3/g for English units

2.3.4 Sample Gas Volume.

$$V_{m(std)} = V_m Y \frac{(P_m)(T_{std})}{(P_{std})(T_m)}$$

$$= K_3 Y \frac{V_m P_m}{T_m}$$

Eq. 4-3

Where:

$K_3 = 0.3858$ °K/mm Hg for metric units
$= 17.64$ °R/in. Hg for English units

NOTE: If the post-test leak rate (Section 2.2.6) exceeds the allowable rate, correct the value of V_m in Equation 4-3, as described in Section 6.3 of Method 5.

2.3.5 Moisture Content.

$$B_{ws} = \frac{V_{wc(std)} + V_{wsg(std)}}{V_{wc(std)} + V_{wsg(std)} + V_{m(std)}}$$

Eq. 4-4

NOTE: In saturated or moisture droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one using a value based upon the saturated conditions (see Section 1.2), and another based upon the results of the impinger analysis. The lower of these two values of B_{ws} shall be considered correct.

METHOD 5 - PARTICULATE EMISSION CALCULATIONS - (1)

6.1 Nomenclature.

A_n = Cross-sectional area of nozzle, m^2 (ft^2).

B_{ws} = Water vapor in the gas stream, proportion by volume.

C_a = Acetone blank residue concentration, mg/g.

c_s = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).

I = Percent of isokinetic sampling.

L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.0057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less.

L_i = Individual leakage rate observed during the leak check conducted prior to the "i^{th}" component change ($i = 1, 2, 3 \ldots n$), m^3/min (cfm).

L_p = Leakage rate observed during the post-test leak check, m^3/min (cfm).

m_a = Mass of residue of acetone after evaporation, mg.

m_n = Total amount of particulate matter collected, mg.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0lb/lb-mole).

P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).

P_s = Absolute stack gas pressure, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 mm Hg-m^3/°K-g-mole (21.85 in. Hg-ft^3/°R-lb-mole).

T_m = Absolute average dry gas meter temperature (see Figure 5-2), °K (°R).

T_s = Absolute average stack gas temperature (see Figure 5-2), °K (°R).

T_{std} = Standard absolute temperature, 293° K (528° R).

V_a = Volume of acetone blank, ml.

V_{aw} = Volume of acetone used in wash, ml.

V_{lc} = Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml.

V_m = Volume of gas sample as measured by dry gas meter, dcm (dscf).

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf).

v_s = Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec).

W_a = Weight of residue in acetone wash, mg.

Y = Dry gas meter calibration factor.

ΔH = Average pressure differential across the orifice meter (see Figure 5-2), mm H_2O (in. H_2O).

ρ_a = Density of acetone, mg/ml (see label on bottle).

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

θ = Total sampling time, min.

θ_1 = Sampling time interval, from the beginning of a run until the first component change, min.

θ_i = Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min.

θ_p = Sampling time interval, from the final (n^{th}) component change until the end of the sampling run, min.

13.6 = Specific gravity of mercury.

60 = Sec/min.

100 = Conversion to percent.

6.2 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop. See data sheet (Figure 5-2).

6.3 Dry Gas Volume. Correct the sample volume measured by the dry gas meter to standard conditions (20° C, 760 mm Hg or 68° F, 29.92 in. Hg) by using Equation 5-1.

$$V_{m(std)} = V_m Y \left(\frac{T_{std}}{T_m}\right)\left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{P_{std}}\right] = K_1 V_m Y \frac{P_{bar} + (\Delta H/13.6)}{T_m}$$

Equation 5-1

Where;

K_1 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

NOTE: Equation 5-1 can be used as written unless the leakage rate observed during any of the mandatory leak checks (i.e., the post-test leak check or leak checks conducted prior to component changes) exceeds L_a. If L_p or L_i exceeds L_a, Equation 5-1 must be modified as follows:

(a) Case I. No component changes made during sampling run. In this case, replace V_m in Equation 5-1 with the expression:

$$[V_m - (L_p - L_a)\theta]$$

(b) Case II. One or more component changes made during the sampling run. In this case, replace V_m in Equation 5-1 by the expression:

$$\left[V_m - (L_1 - L_a)\theta_1 - \sum_{i=2}^{n} (L_i - L_a)\theta_i - (L_p - L_a)\theta_p\right]$$

and substitute only for those leakage rates (L_i or L_p) which exceed L_a.

6.4 Volume of Water Vapor.

METHOD 5 - PARTICULATE EMISSION CALCULATIONS - (2)

Equation 5-2

$$V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_2 V_{lc}$$

Where:

$K_2 = 0.001333$ m³/ml for metric units
$= 0.04707$ ft³/ml for English units.

6.5 Moisture Content.

$$B_{ws} = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$$

Eq. 5-3

NOTE: In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one from the impinger analysis (Equation 5-3), and a second from the assumption of saturated conditions. The lower of the two values of B_{ws} shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in the Note of Section 1.2 of Method 4. For the purposes of this method, the average stack gas temperature from Figure 5-2 may be used to make this determination, provided that the accuracy of the in-stack temperature sensor is ±1° C (2° F).

6.6 Acetone Blank Concentration.

$$C_a = \frac{m_a}{V_a \rho_a}$$ Eq. 5-4

6.7 Acetone Wash Blank.

$$W_a = C_a V_{aw} \rho_a$$ Eq. 5-5

6.8 Total Particulate Weight. Determine the total particulate catch from the sum of the weights obtained from Containers 1 and 2 less the acetone blank (see Figure 5-3).

NOTE: Refer to Section 4.1.5 to assist in calculation of results involving two or more filter assemblies or two or more sampling trains.

6.9 Particulate Concentration.

$$c_s = (0.001\ g/mg)(m_n / V_{m(std)})$$

Eq. 5-6

6.10 Conversion Factors:

From	To	Multiply by
scf	m³	0.02832
g/ft³	gr/ft³	15.43
g/ft³	lb/ft³	2.205×10^{-3}
g/ft³	g/m³	35.31

6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data.

$$I = \frac{100\ T_s[K_3 V_{lc} + (P_m / T_m)(P_{bar} + \Delta H/13.6)]}{60\theta v_s P_s A_n}$$

Eq. 5-7

Where:

$K_3 = 0.003454$ mm Hg – m³/ml – °K for metric units.
$= 0.002669$ in. Hg – ft³/ml – °R for English units.

6.11.2 Calculation From Intermediate Values.

$$I = \frac{T_s V_{m(std)} P_{std} 100}{T_{std} v_s \theta A_n P_s 60(1 - B_{ws})}$$

$$= K_4 \frac{T_s V_{m(std)}}{P_s v_s A_n \theta (1 - B_{ws})}$$

Equation 5-8

where:

$K_4 = 4.320$ for metric units
$= 0.09450$ for English units.

6.12 Acceptable Results. If 90 percent ≤ I ≤ 110 percent, the results are acceptable. If the particulate results are low in comparison to the standard, and I is over 110 percent or less than 90 percent, the Administrator may accept the results.

NOMENCLATURE
METHOD 5 CALCULATIONS

Vm_{std} = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

Y = Dry gas meter calibration factor

P_b = Barometric pressure at the sampling site, mm Hg (in. Hg)

H = Average pressure differential across the orifice meter, mm H_2O (in. H_2O)

T_m = Absolute average dry gas meter temperature, $^\circ$ K ($^\circ$ R)

dscm = Dry standard cubic meters

dscf = Dry standard cubic feet

W_a = Weight of residue in acetone wash

M_a = Mass of residue of acetone after evaporation, mg

C_a = Acetone blank residue concentration, mg/g

V_a = Volume of acetone blank

V_{aw} = Volume of acetone used in wash, ml

M_n = Total amount of particulate matter collected, mg

C_s = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, mg/dscm (gr/dscf)

gr/dscf = grains per dry standard cubic foot

Vw_{std} = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf)

B_{ws} = Water vapor in the gas stream, proportion by volume

M_d = Molecular weight of stack gas, g/g-mole on dry basis

M_s = Molecular weight of stack gas, g/g-mole on wet basis

V_s = Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec)

C_p = Pitot tube coefficient, dimensionless

Δ_p = Velocity head of stack gas, mm H_2O (in. H_2O)

P_s = Absolute stack gas pressure, mm Hg (in. Hg)

NOMENCLATURE (continued)
METHOD 5 CALCULATIONS

Q_{std} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr)

dscf/min = dry standard cubic feet per minute (also identified as dcfm or scfm)

acfm = actual cubic feet per minute

I = Percent of isokinetic sampling

A_n = Cross-sectional area of nozzle, m^2 (ft^2)

AMTEST
AIR QUALITY, INC.

DRY GAS METER CALIBRATION
AM TEST - AIR QUALITY, INC.

FILE NAME: AK-4-94
METER BOX #: AK RED MAG
CALIBRATION DATE: 4-27-94
METHOD OF CALIB.: STANDARD DRY GAS METER (Method 5 Section 7.1)

TOTAL TIME min	DELTA H "H2O	METER VOL V1 cf	METER VOL V2 cf	TEMP IN deg F	TEMP OUT deg F	BARO. PRES. "Hg	STD DGM V1	STD DGM V2	ST.DGM TEMP IN deg F	ST.DGM TEMP OUT deg F	ST.DGM Yds FACTOR	Y FACTOR	DELTA H@
18.0	0.5	114.502	121.205	67.0	67.0	29.74	841.160	847.798	66.0	65.0	1.001	0.9929	2.049
15.5	1.0	121.613	129.749	66.0	65.0	29.72	848.203	856.307	64.0	64.0	1.001	0.9974	2.037
15.0	1.5	130.232	139.683	66.0	66.0	29.71	856.792	866.356	65.0	65.0	1.001	1.0111	2.059
15.5	2.0	139.883	151.313	69.0	67.0	29.68	866.438	877.863	65.0	64.0	1.001	1.0023	2.048
20.0	2.5	151.687	167.895	70.0	68.0	29.71	878.239	894.452	66.0	65.0	1.001	1.0018	2.119
25.0	3.0	168.375	190.588	74.0	69.0	29.71	894.923	917.009	65.0	65.0	1.001	1.0002	2.133
AVERAGE												1.001	2.074

AMTEST
AIR QUALITY, INC.

STANDARD DRY GAS METER CALIBRATION DATA SUMMARY
AMTEST AIR QUALITY, INC.

PERFROMED BY HOMER R. DULIN CO.

Cal. DGM Ind, SCFH	Primary Standard SCFH	Yds
13.5	13.8	1.022
25.7	25.8	1.004
35.9	35.7	0.994
46.5	46.2	0.994
55.9	55.9	1.000
66.8	66.6	0.997
85.5	84.8	0.992
88.8	88.5	0.997
99.9	100.1	1.002
108.6	108.9	1.003
113.3	113.5	1.002
	AVG. Yds =	1.001

52

HOMER R. DULIN CO.

729 EAST WILLOW STREET
LONG BEACH, CALIFORNIA 90806
(310) 424-8533 (213) 636-4096 FAX (310) 426-7707

CERT. NO. 4-304-4

CALIBRATION CERTIFICATION

SUBMITTED BY: KRIS A. HANSEN CO.

FLOWMETER SERIAL No. 0302

MANUFACTURER EQUIMETER MFG. SERIAL No. 27688

TUBE No. FLOAT No.
MODEL NO.: T-110

REMARKS: CALIBRATED IN CFH AIR @ 14.7 PSIA & 70 DEG F.

ACCURACY: SEE DATA

INDICATED		ACTUAL	
CFH		CFH	
113.3		113.5	
108.6		108.9	
99.9		100.1	
88.8		88.5	
85.5		84.8	
66.8		66.6	
55.9		55.9	
46.5		46.2	
35.9		35.7	
25.7		25.8	
13.5		13.8	

Flowmeter Certified with HOMER R. DULIN CO.

Equipment No. 12400 Accuracy 0.2% Calib. Due 5-28-94
Procedure No. 101G
NIST Cert. No. 821/249576-92

Our standards are certified by or are traceable to the National Institute of Standards and Technology and comply with MIL-STD-45662A

P.O. No. 06330 Shipper No.

4-18-94
CALIBRATION DATE

4-18-95
RECALIBRATION DATE

B. Richardson
CALIBRATION TECHNICIAN
B. RICHARDSON

TYPE S PITOT TUBE INSPECTION DATA FORM

Date 3/23/94 Pitot Tube # P2A

Client Looker & Assoc.

Location Puyallup, WA

Site(s) Baghouse Stack

Test Date(s) 9/8/94

Pitot tube assembly level? ✓ yes _____ no

Pitot tube openings damaged? ____ yes (explain below) ✓ no

α_1 = 1.5 ° (<10°), α_2 = 1.5 ° (<10°), β_1 = .5 ° (<5°),

β_2 = 1 ° (<5°)

γ = 1.5 °, θ = 1.5 °, A = .8656 cm (in.)

z = A sin γ = .023 cm (in.); <0.32 cm (<1/8 in.),

w = A sin θ = .023 cm (in.); <.08 cm (<1/32 in.)

P_A .4328 cm (in.) P_b .4328 cm (in.)

D_t = 5/16 cm (in.)

Comments:

_____

_____

_____

Calibration required? ____ yes* ✓ no

*If yes, tag and take out of service until repaired.

EH

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 12-29-30 Thermocouple Indicator # Red 4/F

Ambient Temperature 71 °F Barometric Pressure 29.85 in Hg

THERMOCOUPLE # OR REFERENCE	REFERENCE THERMOMETER TEMPERATURE °F	THERMOCOUPLE TEMPERATURE °F	TEMPERATURE DIFFERENCE °F	TEMPERATURE DIFFERENCE %
T2D				
	33	34	1	0.20%
	211	215	4	0.60%
	394	397	3	0.35%

$$\frac{(\text{ref temp, °F} + 460) - (\text{test therm. temp, °F} + 460)}{(\text{ref temp, °F} + 460)} \cdot 100 \leq 1.5\%$$

VP