AMTEST

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SOURCE
EMISSION
EVALUATION

OCTOBER 31, 1990

RECEIVED
NOV 9 - 1990
PUGET SOUND AIR POLLUTION
CONTROL AGENCY

Prepared For:

WOODWORTH & COMPANY, INC.
CEDARAPIDS DRUM MIX ASPHALT PLANT
VENTURI WET SCRUBBER SYSTEM
TACOMA, WASHINGTON
SEPTEMBER 6, 1990

Submitted by:

KRIS A. HANSEN
DIRECTOR, AIR QUALITY DIVISION

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JAMES A. GUENTHOER
SR. PROJECT ENGINEER

AM TEST, INC.
AIR QUALITY DIVISION
REDMOND, WASHINGTON

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

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INTRODUCTION

The purpose of this source emission evaluation performed at Woodworth & Company, Inc.'s Cedarapids drum mix asphalt plant located in Tacoma, Washington was to quantify the particulate matter emission concentration at the scrubber outlet. This drum mix asphalt plant was manufactured by Cedarapids and is equipped with a Cedarapids venturi wet scrubber system for controlling particulate matter emissions. According to plant personnel, the plant was producing approximately 290 tons per hour of mix on the test day. Three (3) particulate matter emission tests were performed on September 6, 1990. These tests were performed utilizing Environmental Protection Agency (EPA) procedures specified in the July 1, 1989 Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A, Methods 1, 2, 3A, 4 and 5. Methods 1 and 2 were performed to determine the stack gas velocity, temperature and volumetric flow rate. Method 3A was performed to determine the stack gas molecular weight and composition of the stack gas (carbon monoxide, carbon dioxide, and oxygen content). Method 4 was performed to determine the moisture content of the stack gas. Method 5 was performed to determine the particulate matter emission concentration of the stack gas. Condensable matter present in the gas stream was quantified by performing an extraction of the Method 5 impinger liquid as specified in Regulation I of the Puget Sound Air Pollution Control Agency (PSAPCA) regulations.

Mr. James A. Guenthoer, Sr. Project Engineer with Am Test, Inc.'s Air Quality Division based in Redmond, Washington performed the field sampling. Laboratory analysis, data reduction and final report preparation was performed by Mr. Kris A. Hansen, Ms. Angela F. Blaisdell, and Ms. Jan M. Widmeyer of Am Test. This project was coordinated by Mr. John Greco of Woodworth & Company, Inc. Mr. R. A. Suver was the plant operator for Woodworth & Company on the test day.

SUMMARY OF RESULTS

The results of the three (3) Method 1-5 compliance tests for determining particulate matter emission concentration, collected at Woodworth & Company, Inc.'s drum mix asphalt plant located in Tacoma, Washington on September 6, 1990 are summarized in Table 1 below, and on page 4 on a computer printout titled "Methods 1-5 Summary of Results".

Table 1. Summary of particulate matter emission concentration results from samples collected September 6, 1990 at Woodworth and Company, Inc.'s drum mix asphalt plant located in Tacoma, Washington.

SAMPLE RUN #	AM TEST LAB #	TOTAL PARTIC. CONC. gr/dscf	TOTAL PARTIC. CONC. mg/dscm	MASS EMISSION RATE lb/hr	AIR FLOW dscf/min
1	00399	0.118	270.9	37.4	36900
2	00400	0.036	83.3	11.4	36467
3	00401	0.049	111.0	15.7	37716
AVERAGE RUNS 2 & 3		0.043	97.2	13.6	37092

The total particulate emission concentration is presented in units of grains per dry standard cubic foot (gr/dscf) and milligrams per dry standard cubic meter (mg/dscm). The particulate matter mass emission rate is presented in units of pounds per hour (lb/hr). Airflow is also presented in units of dry standard cubic feet per minute (dscf/min). A process upset occured during run 1, therefore an average concentration for runs 2 and 3 is included in Table 1. Computer printouts which detail the complete results of runs 1-3 and may be found following the "Calculation of Results" section of this report on pages 19-21. Field data sheets and example calculations of results are included in the Appendix of this report.

METHODS 1-5 SUMMARY OF RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	72\WOODSUM
CLIENT:	WOODWORTH & CO., INC.
LOCATION:	TACOMA, WA
SAMPLE SITE:	SCRUBBER EXIT STACK
OPERATORS:	J. GUENTHOER

	RUN #1	RUN #2	RUN #3	AVERAGE
LAB #:	00399	00400	00401	
DATE:	9/6/90	9/6/90	9/6/90	
START TIME:	06:34	09:36	12:32	
STOP TIME:	07:40	10:43	13:37	
SAMPLE TIME (minutes):	60.0	60.0	60.0	
VOLUME SAMPLED (cubic feet):	38.091	39.549	40.218	39.286
VOLUME SAMPLED (dry std. cubic feet):	38.093	39.446	39.375	38.971
VOLUME SAMPLED (dry std. cubic meters):	1.079	1.117	1.115	1.104
STACK GAS MOISTURE (percent):	22.50	25.79	22.61	23.63
BAROMETRIC PRESSURE (inches of Hg):	30.00	30.04	30.04	30.03
STATIC PRESSURE (inches of H2O):	0.02	0.02	0.02	0.02
STACK PRESSURE (inches of Hg):	30.00	30.04	30.04	30.03
STACK TEMPERATURE (degrees F.):	147.4	147.5	147.5	147.5
STACK TEMPERATURE (degrees R.):	607.4	607.5	607.5	607.5
CARBON DIOXIDE (percent):	6.0	6.0	5.9	6.0
OXYGEN (percent):	12.8	12.8	12.9	12.8
CARBON MONOXIDE (ppm):	209	209	207	208
MOLECULAR WEIGHT (dry, g/g-mole):	29.47	29.47	29.46	29.47
MOLECULAR WEIGHT (wet, g/g-mole):	26.89	26.51	26.87	26.76
AVERAGE VELOCITY HEAD (inches of H2O):	0.035	0.036	0.036	0.036
PITOT TUBE Cp:	0.838	0.838	0.838	
VELOCITY (feet/second):	11.59	11.95	11.85	11.80
STACK DIAMETER (inches):	120	120	120	
STACK AREA (square feet):	78.540	78.540	78.540	
AIRFLOW (dry std. cubic feet per min.):	36900.4	36467.3	37715.5	37027.7
AIRFLOW (actual cubic feet per min.):	54625.2	56305.4	55846.5	55592.4
NOZZLE DIAMETER (inches):	0.501	0.501	0.501	
ISOKINETICS (percent):	99	103	100	101
FRONT-HALF PARTIC. EMISS. CONC. (gr/dscf):	0.053	0.032	0.034	0.040
BACK-HALF PARTIC. EMISS. CONC. (gr/dscf):	0.065	0.004	0.014	0.028
TOTAL PARTIC. EMISS. CONC. (gr/dscf):	0.118	0.036	0.049	0.068
PARTICULATE EMISSION CONC. (mg/dscm):	270.9	83.3	111.0	155.1
PARTIC. MASS EMISSION RATE (lb/hr):	37.4	11.4	15.7	21.5

SOURCE OPERATION

Woodworth & Company, Inc.'s drum mix asphalt plant located in Tacoma, Washington was manufactured by Cedarapids. This plant (Model 10044ADM, identification #39084), constructed and installed in 1984, is equipped with a Cedarapids venturi wet scrubber system (Model 10044ADM) to control particulate matter emissions. The scrubber system was operated with a water pressure of 105 psi and 100% recycled scrubber water. The water inlet temperature was 70° F, and the outlet water temperature was 140° F. The pressure drop across the venturi was approximately 21 inches of water on the test day. According to plant personnel, the plant operated at an average production rate of 290 tons/hour with an asphalt discharge temperature of 290° F. Process and production conditions were considered to be representative during runs 2 and 3, according to Woodworth & Company, Inc.'s personnel. A process upset occured during run 1. A process information sheet, completed by Mr. R. A. Suver is included in the Appendix of this report.

METHODOLOGY REFERENCES

Sampling procedures specified in the July 1, 1989 Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A, Methods 1, 2, 3A, 4 and 5 were followed throughout this project. Sampling and analysis procedures specified in the Puget Sound Air Pollution Control Agency (PSAPCA) "Particulate Source Test Procedures" adopted by the PSAPCA Board of Directors, August 11, 1983, in accordance with section 9.09 of Regulation I, PSAPCA, were utilized in conjunction with the EPA Method 5 procedures for "backhalf" analysis for extracting condensable matter. Methodology suggested in the EPA's Air Pollution Training Institute "Course 450 - Source Sampling For Particulate Pollutants" and quality assurance procedures outlined in the EPA's reference manual titled Quality Assurance Handbook for Air Pollution Measurement Systems, Volume 3, EPA-600/4-77-027b, along with current updates, were used with respect to quality assurance and testing protocol.

SAMPLING PROCEDURES

The 120 inch circular duct has four (4) sampling ports located at 90 degrees. The sample ports are located 10 feet upstream and 30 feet downstream from the nearest flow disturbance. Two (2) velocity and temperature traverses of twelve (12) points were performed during each Method 5 test. Figure 1 located in the Appendix of this report is a schematic of the stack and the point locations selected. Each point was sampled for 2.5 minutes, for a total sampling time for each Method 5 run of 60 minutes. The sample probe was marked with felt pen and heat resistant tape to indicate the proper point location.

Stack condition measurements were performed prior to testing, including measurements of pressure, temperature, velocity and a check for cyclonic flow. 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 all 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 plant was operating at the desired production rate and the desired operating parameters. A final check was made of the sample box and probe heat temperatures. 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. Sampling proceeded isokinetically at each of the 4 traverse points in each port. 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.

Samples of the combustion gas were collected during each run to be analyzed in Am Test's laboratory. The integrated samples collected in multilayer bags were analyzed using an Infrared Industries Model 2200 oxygen (O_2) analyzer. An Infrared Industries non-dispersive infrared (NDIR) analyzer (Model 702D) was utilized to measure the percent carbon dioxide (CO_2). An Automated Custom Systems (ACS) Model 3300 non-dispersive infrared analyzer was used to measure the parts per million (ppm) carbon monoxide (CO). Oxygen was also measured in the field using an Infrared Industries Model 2200 oxygen (O_2) analyzer. These analyzers meet 40 CFR 60, Appendix B, Performance Specification 3 and 4 criteria. Appropriate calibration gases were utilized to check the calibration of the automatic analyzers. The measurements during each test period were used to calculate the molecular weight of the stack gas. The results of the gas analysis are presented on the computer printouts in the "Calculation of Results" section of this report.

SAMPLE TRAIN

The sample train used for collecting particulate matter samples was an EPA Method 5 design with modifications as shown in Figure 2 which is located in the Appendix of this report. The stainless steel button hook nozzle used during each test was measured on-site with inside calipers. A stainless steel probe with a heated stainless steel liner was used for these tests. The probe was equipped with "S" type pitot tubes and a thermocouple sensor. A thermocouple indicator was used to measure the stack gas temperature at each sample point. The Fluke digital thermocouple indicator has been re-certified by the manufacturer to be accurate within ±1 degree Fahrenheit. A field check with 32 degree icewater was performed. A glass filter assembly containing a 125 millimeter Whatman 934-AH glass fiber filter was enclosed in a temperature-controlled heated sample box. The average box temperature was maintained at 248° F ± 25° F. The nozzle, probe liner, prefilter connective glassware and filter is often referred to as the "fronthalf" of the sample train. Following the filter is a condenser section which, by convention, is referred to as the "backhalf". The condenser section consisted of a modified Greenburg-Smith bubbler containing 100 milliliters (ml) of deionized water, an impinger also containing 100 ml of deionized water, an empty bubbler, and a bubbler containing indicating silica gel desiccant. The backhalf was maintained at a temperature below 68° F by adding ice to the condenser section throughout sampling.

The sample train was connected to a control box by means of an umbilical cord which contains 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 consists of a diaphragm pump which is used to pull the stack gas through the sample train, fine and coarse metering valves to control the sampling rate, a vacuum gauge which measures the pressure drop from the sampling nozzle to the metering valves, and a dry gas meter. The dry gas meter was calibrated using a spirometer at the Washington State Department of Ecology laboratory in Redmond, Washington. At the outlet of the dry gas meter is a calibrated orifice which is used to isokinetically control the flow of gas through the metering system. The pressure drop across the orifice was monitored with both low and high range magnehelic gauges. The pitot tubes utilized to measure stack gas velocity are connected to the control box via the umbilical cord. The control box contains low and high range magnehelic gauges which are used for the velocity measurement.

SAMPLE CLEAN-UP AND ANALYSIS

Following sample collection, the Method 5 sample box was transferred to a room free from air disturbances and airborne particulate matter. The filter was transferred to a petri dish labeled with the sample date, client name and run number. This filter portion of the particulate catch is referred to as the "A" section. Care was taken to assure that any loose particulate matter and filter mat were quantitatively transferred to the petri dish. The filters were then placed in an oven and baked at 103° C for 2 hours, then they were transferred to a desiccator containing indicating silica gel desiccant for at least 24 hours of desiccation prior to obtaining weights. The same baking and weighing procedure was followed to obtain the tare weights for the filters. The tare and final weights were made using a Mettler AE163 electronic balance set to a time integrating mode with a readability of 0.1 milligrams. The filters containing particulate matter were weighed to a constant weight of ±0.5 milligrams. The interval between weighings was at least 6 hours. These weights were recorded in a bound laboratory notebook.

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 following each run. Several rinses of acetone, with simultaneous loosening of particulate matter using a clean nylon brush, were used for the fronthalf 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. The contents of this "B" section acetone rinse was transferred to a tared, graduated 150 milliliter beaker. The volume of acetone was recorded and the beakers were placed in an evaporation chamber at slightly elevated ambient temperature and pressure. The acetone was evaporated at a temperature lower than the boiling point of acetone. A tared beaker with 100 milliliters of acetone from the same lot was handled in an identical fashion to the "B" section samples as a control. The tare and final weights of the beakers were obtained following at least 24 hours of desiccation. The samples and acetone blanks were weighed to a constant weight of ±0.5 milligrams at 6 hour or greater intervals.

The bubblers and impingers utilized for the condenser section, or "backhalf" of the sample train were weighed with a readability of ±0.1 grams before and after sampling on a Mettler 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 percent moisture was calculated and did not exceed the theoretical psychrometric chart value. The contents of the bubblers and impingers were then 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. This liquid was then 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 "Cx" section and this beaker's contents were allowed to evaporate at laboratory temperature and pressure until dry. The water layer was transferred to a tared 150 ml beaker labeled the "C" section and this beaker's contents were heated to 103° C until dry. The bubblers and impingers were given a final rinse with acetone into another tared, graduated beaker ("D" section) and it's contents were allowed to evaporate at laboratory temperature and pressure until dry. 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 ±0.5 milligrams after their contents had evaporated. 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, deionized water, and dichloromethane blank concentrations. The particulate weights are included on the "Methods 1, 2, 3A, 4 and 5 - Particulate Matter Emissions" computer printouts which immediately follow the "Calculation of Results" section of this report.

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 were utilized are included in the Environmental Protection Agency's (EPA's) reference manual titled Quality Assurance Handbook for Air Pollution Measurements Systems, Volume 3, EPA-600/4-77-027b. Procedures are followed throughout equipment preparation, field sampling, sample recovery, analysis, and data reduction. Am Test, Inc.'s Air Quality Division quality assurance procedures are discussed below.

CALIBRATION PROCEDURES AND FREQUENCY

Field equipment utilized for on-site measurements is calibrated at a frequency as recommended by the equipment manufacturer or industry practice. Prior to field use, each instrument is calibrated and the calibration value is reported in a calibration log. 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 were calibrated on-site before sampling using digital inside calipers readable to 0.001 inch. The dry gas meters used to accurately measure sample volumes have been calibrated using a wet test meter or a spirometer. The S-type pitot tubes utilized for velocity determination have been calibrated using a wind tunnel and standard P-type pitot tube, and are inspected regularly for wear. The Fluke^R digital thermocouple indicators used for temperature measurement have a readability of 1 degree Fahrenheit and have been certified by the manufacturer for their accuracy. Each thermocouple probe used to monitor temperature is checked quarterly at three (3) temperature settings. The Wallace and Tiernan absolute pressure gauge used to obtain pressure readings has a readability of 1 millimeter of mercury.

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

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

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

SAMPLE RECOVERY AND FIELD DOCUMENTATION

Data relative to samples, 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 are returned to the Air Quality Division laboratory. Sample recovery was carried out in a suitable area free from particulate matter contamination.

In the laboratory acetone, deionized water, dichloromethane and filter blanks were carried through the gravimetric analysis procedures. The samples were weighed to constant weights of ±0.5 milligrams following desiccation in a Labconco "Autodry 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 ±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 was set to a time integrating mode (100,000 readings per minute) with a readability of 0.01 milligrams. The balance was calibrated prior to every weighing session. The calibration of Am Test's Mettler balances is checked by the manufacturer on a yearly basis.

DATA REDUCTION, VALIDATION AND REPORTING

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

CALCULATION OF RESULTS

The Method 1-5 test results were calculated in accordance with current EPA 40 CFR 60 Method 1-5 and Puget Sound Air Pollution Control Agency (PSAPCA) Regulation I criteria. Copies of the pertinent equations are included in the Appendix of this report. Final result calculations were performed using custom-written spreadsheet programs run on Hewlett-Packard Vectra computer systems. A sample "by-hand" calculation was completed for run 3 using a Hewlett-Packard 11C calculator, and may be found in the Appendix of this report.

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                    METHODS 1, 2, 3A, 4 AND 5 - PARTICULATE MATTER EMISSIONS
                               AM TEST, INC. - AIR QUALITY DIVISION
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FILE NAME:      72\WOODM5R1              LAB #:                 00399
CLIENT:         WOODWORTH & CO., INC.    START TIME:            06:34 o'clock
LOCATION:       TACOMA, WA               STOP TIME:             07:40 o'clock
SAMPLE SITE:    SCRUBBER EXIT STACK      SAMPLE TIME:            60.0 minutes
SAMPLE DATE:    SEPTEMBER 6, 1990
RUN #:          1-METHOD 5
OPERATORS:      J. GUENTHOER

      IMPINGER WEIGHTS
   FINAL   INITIAL    NET            PITOT TUBE Cp:          0.838
   grams    grams    grams           NOZZLE DIAMETER:        0.501 inches
   -----    -----    -----           NOZZLE AREA:           0.0014 sq. feet
   774.6    587.6    187.0           STACK DIAMETER:           120 inches
   625.1    591.2     33.9           STACK AREA:            78.540 sq. feet
   463.6    460.7      2.9           METER TEMPERATURE:       66.5 degrees F
   778.0    767.2     10.8           BAROMETRIC PRES.:       30.00 inches Hg
TOTAL H2O GAIN:      234.6           STATIC PRESSURE:         0.02 inches H20
TOTAL VOLUME (SCF):  11.06           STACK PRESSURE:         30.00 inches Hg
PERCENT MOISTURE:    22.50           ORIFICE PRESSURE:       0.636 inches H20
Bws:                0.2250           METER PRESSURE:         30.05 inches Hg

INIT. METER VOLUME: 847.651
FINAL METER VOLUME: 885.742          AVERAGE CONC. CO2:        6.0 percent
VOLUME SAMPLED:      38.091          AVERAGE CONC. O2:        12.8 percent
STD VOLUME (DSCF):   38.093          AVERAGE CONC. CO:         209 ppm
STD VOLUME (DSCM):    1.079          MOLECULAR WEIGHT:       29.47 g/g-mole-dry
Y FACTOR:             0.993          MOLECULAR WEIGHT:       26.89 g/g-mole-wet

-----------------------------------------------------------------------------
SAMPLE     VELOCITY   TEMPERATURE      SAMPLE   VELOCITY   TEMPERATURE
POINT      " OF H20   DEGREES F.       POINT    " OF H20   DEGREES F.

W   1       0.020        144           S   1      0.050        147
    2       0.025        145               2      0.050        146
    3       0.030        145               3      0.060        146
    4       0.035        146               4      0.060        146
    5       0.040        146               5      0.050        147
    6       0.040        146               6      0.040        147
    7       0.030        146               7      0.030        149
    8       0.040        148               8      0.030        149
    9       0.040        147               9      0.030        149
   10       0.030        148              10      0.025        150
   11       0.030        148              11      0.025        152
   12       0.020        149              12      0.025        151
-----------------------------------------------------------------------------

PERCENT ISOKINETICS:                     99 %
STACK TEMPERATURE:                    147.4 degrees F         607.4 degrees R
AVERAGE VELOCITY HEAD:                0.035 " of H20
STACK GAS VELOCITY:                                           11.59 ft/second
STACK GAS AIR FLOW:                 54625.2 acf/min         36900.4 dscf/min
PARTICULATE EMISSION CONCENTRATION (FRONT-HALF):              0.053 gr/dscf
PARTICULATE EMISSION CONCENTRATION (BACK-HALF):               0.065 gr/dscf
TOTAL PARTICULATE EMISSION CONC. (FRONT & BACK-HALF):         0.118 gr/dscf
TOTAL PARTICULATE EMISSION CONCENTRATION:                     270.9 mg/dscm
PARTICULATE MATTER MASS EMISSION RATE:                         37.4 lb/hr
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FRONTHALF PARTICULATE MATTER MASS LOADING
---------------------------------------------------------
FILTER NUMBER:                                    #125-117
TARE WEIGHT OF FILTER (grams):                      1.0553
FINAL WEIGHT OF FILTER (grams):                     1.1216
NET WEIGHT OF PARTICULATE MATTER (grams):           0.0663

BEAKER NUMBER:                                    #150-880
TARE WEIGHT OF BEAKER (grams):                     68.1249
FINAL WEIGHT OF BEAKER (grams):                    68.1897
NET WEIGHT OF PARTICULATE MATTER (grams):           0.0648
VOLUME OF ACETONE (milliliters):                     245.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):           0.002
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):       0.0005

TOTAL FRONTHALF PARTICULATE MATTER (grams):         0.1306

BACKHALF PARTICULATE MATTER MASS LOADING
---------------------------------------------------------
"C" SECTION - CONDENSER PARTICULATE               #150-838
TARE WEIGHT OF BEAKER (grams):                     80.0729
FINAL WEIGHT OF BEAKER (grams):                    80.2222
NET WEIGHT OF PARTIC. MATTER (grams):               0.1493
TOTAL VOLUME OF WATER (milliliters):                 420.0
VOLUME OF WATER CONDENSED (milliliters):             223.8
NET VOLUME OF WATER FOR BLANK (milliliters):         196.2
WT./VOL. OF WATER BLANK (milligrams/ml):             0.002
NET WEIGHT OF PARTIC. DUE TO WATER (grams):         0.0004

"Cx" SECTION - HYDROCARBON EXTRACTION             #150-917
TARE WEIGHT OF BEAKER (grams):                     67.1785
FINAL WEIGHT OF BEAKER (grams):                    67.1824
NET WEIGHT OF PARTIC. MATTER (grams):               0.0039
TOTAL VOLUME OF CH2Cl2 (milliliters):                150.0
WT./VOL. OF CH2Cl2 BLANK (milligrams):               0.000
NET WEIGHT OF PARTIC. DUE TO CH2Cl2 (grams):        0.0000

"D" SECTION - ACETONE RINSE OF CONDENSER          #150-883
TARE WEIGHT OF BEAKER (grams):                     71.3813
FINAL WEIGHT OF BEAKER (grams):                    71.3903
NET WEIGHT OF PARTIC. MATTER (grams):               0.0090
TOTAL VOLUME OF ACETONE (milliliters):                60.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):           0.002
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):       0.0001

TOTAL BACKHALF PARTICULATE MATTER (grams):          0.1617
TOTAL WEIGHT OF PARTICULATE MATTER (grams):         0.2923
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METHODS 1, 2, 3A, 4 AND 5 - PARTICULATE MATTER EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

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FILE NAME:      72\WOODM5R2             LAB #:              00400
CLIENT:         WOODWORTH & CO., INC.   START TIME:         09:36 o'clock
LOCATION:       TACOMA, WA              STOP TIME:          10:43 o'clock
SAMPLE SITE:    SCRUBBER EXIT STACK     SAMPLE TIME:         60.0 minutes
SAMPLE DATE:    SEPTEMBER 6, 1990
RUN #:          2-METHOD 5
OPERATORS:      J. GUENTHOER

     IMPINGER WEIGHTS
   FINAL   INITIAL    NET               PITOT TUBE Cp:      0.838
   grams    grams    grams              NOZZLE DIAMETER:    0.501 inches
   -----    -----    -----              NOZZLE AREA:       0.0014 sq. feet
   821.2    625.0    196.2              STACK DIAMETER:       120 inches
   670.5    589.1     81.4              STACK AREA:        78.540 sq. feet
   493.0    490.6      2.4              METER TEMPERATURE:   68.7 degrees F
   776.2    765.5     10.7              BAROMETRIC PRES.:   30.04 inches Hg
TOTAL H2O GAIN:      290.7              STATIC PRESSURE:     0.02 inches H2O
TOTAL VOLUME (SCF):  13.71              STACK PRESSURE:     30.04 inches Hg
PERCENT MOISTURE:    25.79              ORIFICE PRESSURE:   0.709 inches H2O
Bws:                0.2579              METER PRESSURE:     30.09 inches Hg

INIT. METER VOLUME: 886.558
FINAL METER VOLUME: 926.107             AVERAGE CONC. CO2:    6.0 percent
VOLUME SAMPLED:      39.549             AVERAGE CONC. O2:    12.8 percent
STD VOLUME (DSCF):   39.446             AVERAGE CONC. CO:     209 ppm
STD VOLUME (DSCM):    1.117             MOLECULAR WEIGHT:   29.47 g/g-mole-dry
Y FACTOR:             0.993             MOLECULAR WEIGHT:   26.51 g/g-mole-wet

------------------------------------------------------------------------------
SAMPLE   VELOCITY   TEMPERATURE         SAMPLE   VELOCITY   TEMPERATURE
POINT    " OF H20   DEGREES F.          POINT    " OF H20   DEGREES F.

S  1       0.060       144              W  1       0.025       145
   2       0.060       144                 2       0.025       146
   3       0.075       142                 3       0.030       147
   4       0.075       145                 4       0.030       148
   5       0.060       147                 5       0.030       147
   6       0.040       148                 6       0.030       147
   7       0.040       148                 7       0.040       149
   8       0.030       148                 8       0.040       149
   9       0.025       148                 9       0.040       150
  10       0.025       149                10       0.030       151
  11       0.020       149                11       0.030       150
  12       0.020       148                12       0.030       150
------------------------------------------------------------------------------

PERCENT ISOKINETICS:                 103 %
STACK TEMPERATURE:                 147.5 degrees F        607.5 degrees R
AVERAGE VELOCITY HEAD:             0.036 " of H20
STACK GAS VELOCITY:                                       11.95 ft/second
STACK GAS AIR FLOW:              56305.4 acf/min        36467.3 dscf/min
PARTICULATE EMISSION CONCENTRATION (FRONT-HALF):          0.032 gr/dscf
PARTICULATE EMISSION CONCENTRATION (BACK-HALF):           0.004 gr/dscf
TOTAL PARTICULATE EMISSION CONC. (FRONT & BACK-HALF):     0.036 gr/dscf
TOTAL PARTICULATE EMISSION CONCENTRATION:                  83.3 mg/dscm
PARTICULATE MATTER MASS EMISSION RATE:                     11.4 lb/hr
```

```
FRONTHALF PARTICULATE MATTER MASS LOADING
-------------------------------------------------------------
FILTER NUMBER:                                      #125-115
TARE WEIGHT OF FILTER (grams):                        1.0475
FINAL WEIGHT OF FILTER (grams):                       1.0988
NET WEIGHT OF PARTICULATE MATTER (grams):             0.0513

BEAKER NUMBER:                                      #150-881
TARE WEIGHT OF BEAKER (grams):                       68.4059
FINAL WEIGHT OF BEAKER (grams):                      68.4375
NET WEIGHT OF PARTICULATE MATTER (grams):             0.0316
VOLUME OF ACETONE (milliliters):                       195.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):             0.002
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):         0.0004

TOTAL FRONTHALF PARTICULATE MATTER (grams):           0.0825

BACKHALF PARTICULATE MATTER MASS LOADING
-------------------------------------------------------------
"C" SECTION - CONDENSER PARTICULATE                 #150-839
TARE WEIGHT OF BEAKER (grams):                       82.0321
FINAL WEIGHT OF BEAKER (grams):                      82.0335
NET WEIGHT OF PARTIC. MATTER (grams):                 0.0014
TOTAL VOLUME OF WATER (milliliters):                   420.0
VOLUME OF WATER CONDENSED (milliliters):               280.0
NET VOLUME OF WATER FOR BLANK (milliliters):           140.0
WT./VOL. OF WATER BLANK (milligrams/ml):               0.002
NET WEIGHT OF PARTIC. DUE TO WATER (grams):           0.0003

"Cx" SECTION - HYDROCARBON EXTRACTION               #150-918
TARE WEIGHT OF BEAKER (grams):                       69.2757
FINAL WEIGHT OF BEAKER (grams):                      69.2818
NET WEIGHT OF PARTIC. MATTER (grams):                 0.0061
TOTAL VOLUME OF CH2Cl2 (milliliters):                  150.0
WT./VOL. OF CH2Cl2 BLANK (milligrams):                 0.000
NET WEIGHT OF PARTIC. DUE TO CH2Cl2 (grams):          0.0000

"D" SECTION - ACETONE RINSE OF CONDENSER            #150-884
TARE WEIGHT OF BEAKER (grams):                       67.4143
FINAL WEIGHT OF BEAKER (grams):                      67.4178
NET WEIGHT OF PARTIC. MATTER (grams):                 0.0035
TOTAL VOLUME OF ACETONE (milliliters):                  60.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):             0.002
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):         0.0001

TOTAL BACKHALF PARTICULATE MATTER (grams):            0.0106
TOTAL WEIGHT OF PARTICULATE MATTER (grams):           0.0931
```

```
                 METHODS 1, 2, 3A, 4 AND 5 - PARTICULATE MATTER EMISSIONS
                          AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:      72\WOODM5R3            LAB #:               00401
CLIENT:         WOODWORTH & CO., INC.  START TIME:          12:32 o'clock
LOCATION:       TACOMA, WA             STOP TIME:           13:37 o'clock
SAMPLE SITE:    SCRUBBER EXIT STACK    SAMPLE TIME:          60.0 minutes
SAMPLE DATE:    SEPTEMBER 6, 1990
RUN #:          3-METHOD 5
OPERATORS:      J. GUENTHOER

      IMPINGER WEIGHTS
   FINAL   INITIAL    NET          PITOT TUBE Cp:       0.838
   grams    grams    grams         NOZZLE DIAMETER:     0.501 inches
   -----    -----    -----         NOZZLE AREA:        0.0014 sq. feet
   794.2    593.5    200.7         STACK DIAMETER:        120 inches
   650.1    620.7     29.4         STACK AREA:         78.540 sq. feet
   526.8    523.6      3.2         METER TEMPERATURE:    78.6 degrees F
   870.6    859.9     10.7         BAROMETRIC PRES.:    30.04 inches Hg
TOTAL H20 GAIN:      244.0         STATIC PRESSURE:      0.02 inches H20
TOTAL VOLUME (SCF):  11.50         STACK PRESSURE:      30.04 inches Hg
PERCENT MOISTURE:    22.61         ORIFICE PRESSURE:    0.707 inches H20
Bws:                0.2261         METER PRESSURE:      30.09 inches Hg

INIT. METER VOLUME: 926.803
FINAL METER VOLUME: 967.021        AVERAGE CONC. CO2:     5.9 percent
VOLUME SAMPLED:      40.218        AVERAGE CONC. O2:     12.9 percent
STD VOLUME (DSCF):   39.375        AVERAGE CONC. CO:      207 ppm
STD VOLUME (DSCM):    1.115        MOLECULAR WEIGHT:    29.46 g/g-mole-dry
Y FACTOR:             0.993        MOLECULAR WEIGHT:    26.87 g/g-mole-wet

-------------------------------------------------------------------------------
SAMPLE    VELOCITY   TEMPERATURE     SAMPLE    VELOCITY   TEMPERATURE
POINT     " OF H20   DEGREES F.      POINT     " OF H20   DEGREES F.

W   1       0.030       142          S   1       0.060       145
    2       0.030       144              2       0.060       145
    3       0.030       146              3       0.060       146
    4       0.030       147              4       0.060       146
    5       0.030       147              5       0.060       147
    6       0.030       146              6       0.040       147
    7       0.035       148              7       0.030       147
    8       0.040       149              8       0.030       148
    9       0.040       150              9       0.025       149
   10       0.040       151             10       0.025       150
   11       0.030       151             11       0.025       150
   12       0.030       150             12       0.025       149
-------------------------------------------------------------------------------

PERCENT ISOKINETICS:                  100 %
STACK TEMPERATURE:                  147.5 degrees F         607.5 degrees R
AVERAGE VELOCITY HEAD:              0.036 " of H20
STACK GAS VELOCITY:                                         11.85 ft/second
STACK GAS AIR FLOW:             55846.5 acf/min           37715.5 dscf/min
PARTICULATE EMISSION CONCENTRATION (FRONT-HALF):            0.034 gr/dscf
PARTICULATE EMISSION CONCENTRATION (BACK-HALF):             0.014 gr/dscf
TOTAL PARTICULATE EMISSION CONC. (FRONT & BACK-HALF):       0.049 gr/dscf
TOTAL PARTICULATE EMISSION CONCENTRATION:                   111.0 mg/dscm
PARTICULATE MATTER MASS EMISSION RATE:                       15.7 lb/hr
```

```
FRONTHALF PARTICULATE MATTER MASS LOADING
----------------------------------------------------
FILTER NUMBER:                                  #125-116
TARE WEIGHT OF FILTER (grams):                    1.0472
FINAL WEIGHT OF FILTER (grams):                   1.1040
NET WEIGHT OF PARTICULATE MATTER (grams):         0.0568

BEAKER NUMBER:                                  #150-882
TARE WEIGHT OF BEAKER (grams):                   68.4811
FINAL WEIGHT OF BEAKER (grams):                  68.5118
NET WEIGHT OF PARTICULATE MATTER (grams):         0.0307
VOLUME OF ACETONE (milliliters):                   170.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):         0.002
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):     0.0003

TOTAL FRONTHALF PARTICULATE MATTER (grams):       0.0872

BACKHALF PARTICULATE MATTER MASS LOADING
----------------------------------------------------
"C" SECTION - CONDENSER PARTICULATE             #150-840
TARE WEIGHT OF BEAKER (grams):                   79.9742
FINAL WEIGHT OF BEAKER (grams):                  79.9965
NET WEIGHT OF PARTIC. MATTER (grams):             0.0223
TOTAL VOLUME OF WATER (milliliters):               410.0
VOLUME OF WATER CONDENSED (milliliters):           233.3
NET VOLUME OF WATER FOR BLANK (milliliters):       176.7
WT./VOL. OF WATER BLANK (milligrams/ml):           0.002
NET WEIGHT OF PARTIC. DUE TO WATER (grams):       0.0004

"Cx" SECTION - HYDROCARBON EXTRACTION           #150-919
TARE WEIGHT OF BEAKER (grams):                   68.2464
FINAL WEIGHT OF BEAKER (grams):                  68.2532
NET WEIGHT OF PARTIC. MATTER (grams):             0.0068
TOTAL VOLUME OF CH2Cl2 (milliliters):              150.0
WT./VOL. OF CH2Cl2 BLANK (milligrams):             0.000
NET WEIGHT OF PARTIC. DUE TO CH2Cl2 (grams):      0.0000

"D" SECTION - ACETONE RINSE OF CONDENSER        #150-885
TARE WEIGHT OF BEAKER (grams):                   68.0342
FINAL WEIGHT OF BEAKER (grams):                  68.0422
NET WEIGHT OF PARTIC. MATTER (grams):             0.0080
TOTAL VOLUME OF ACETONE (milliliters):              65.0
WT./VOL. OF ACETONE BLANK (milligrams/ml):         0.002
NET WEIGHT OF PARTIC. DUE TO ACETONE (grams):     0.0001

TOTAL BACKHALF PARTICULATE MATTER (grams):        0.0366
TOTAL WEIGHT OF PARTICULATE MATTER (grams):       0.1238
```

APPENDIX

SOURCE TEST OBSERVATION CHECKLIST
ASPHALT PLANTS WITH WET SCRUBBERS

Client Woodworth & Co. Date 9/5/90

Location Tacoma, WA

Process Information

Type of Plant Cedarapids Drum Mix

Manufacturer Cedarapids

Model 10044ADM Constructed/Installed 5-1-84

Identification No. 39084 Date Last Tested 7-2-87

Operation Personnel R. A. [illegible]

Process Rate 290 10% RAP (recycle) Tons/Hr Discharge Temp 290 °F

Type of Fuel # 2 Diesel Firing Rate 1.45 Gal/TON

A/C Injection Location 2/3's from burner.

Fines In Gravel (-200 mesh) ≈ 5%

Gravel Moisture ≈4.5% % Asphalt Type AR4000

Density #/Gal Flash Point — °F

Control Equipment

Manufacturer Cedarapids Model 10044ADM

Water Press 105 PSI Rate — Gal/Min

% Recycled Water 100 Saturated Stack No.

Venturi Press ΔP = 21 "H_2O Influent Pond Temp 70 °F

Static Pressure = — "H_2O Effluent Pond Temp 140 °F

Venturi Damper Position # Ponds

Size of Ponds Type Liner

Additional Information Sketch of Pond System

Authorized Signature

CROSS SECTIONAL AREA

Traverse Point	Distance (inches)
1	2.52
2	8.04
3	14.16
4	21.24
5	30.00
6	42.72
7	77.28
8	90.00
9	98.76
10	105.84
11	111.96
12	117.48

STACK DIMENSIONS

120 inch diameter circular stack

2 ports at 90 degrees

A = 10 feet

B = 30 feet

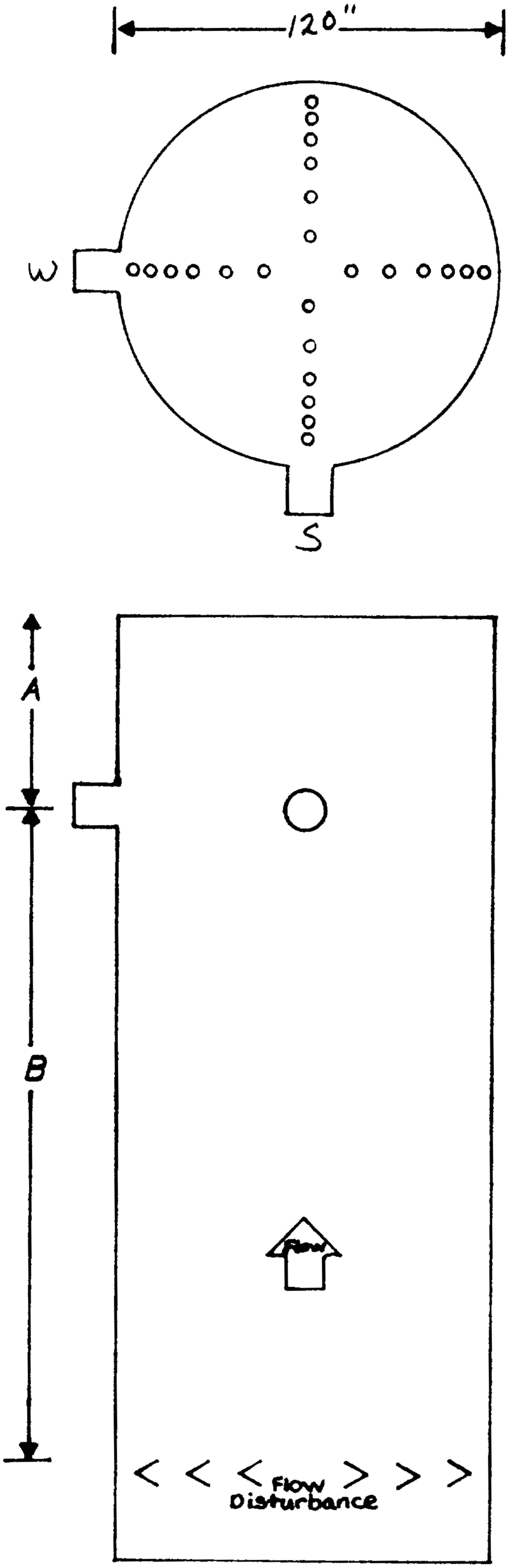

Figure 1. Location of sampling ports and traverse points at the outlet stack.

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

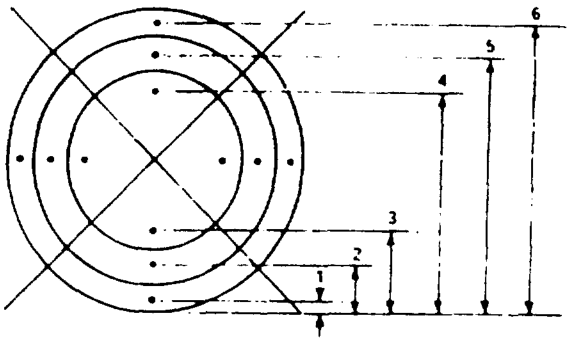

Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

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	65.4	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.

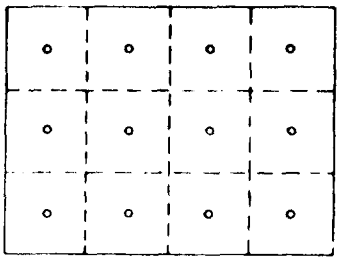

Figure 1 4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

METHOD 1 - MINIMUM NUMBER OF TRAVERSE POINTS

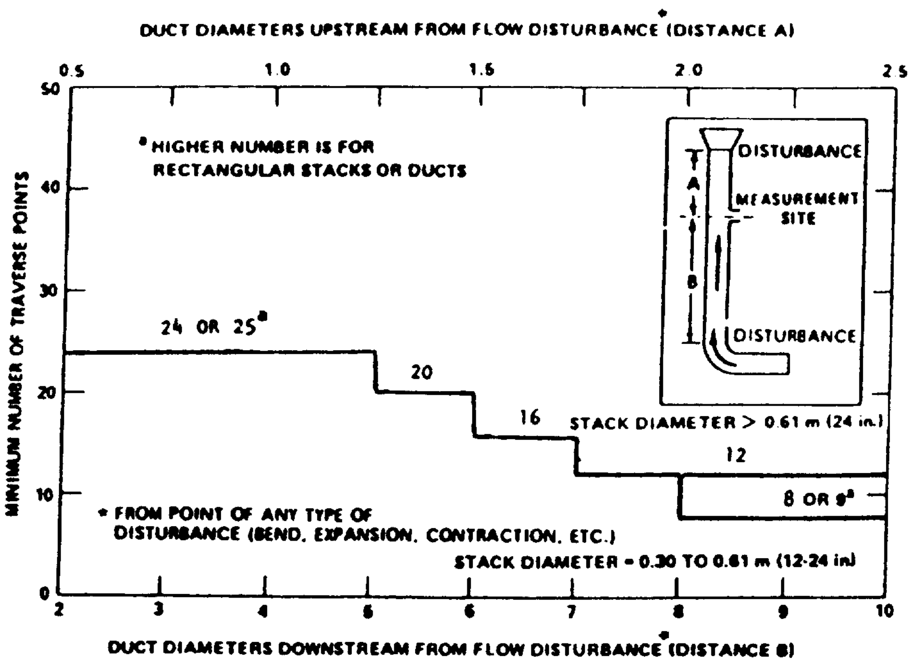

Figure 1-1. Minimum number of traverse points for particulate traverses.

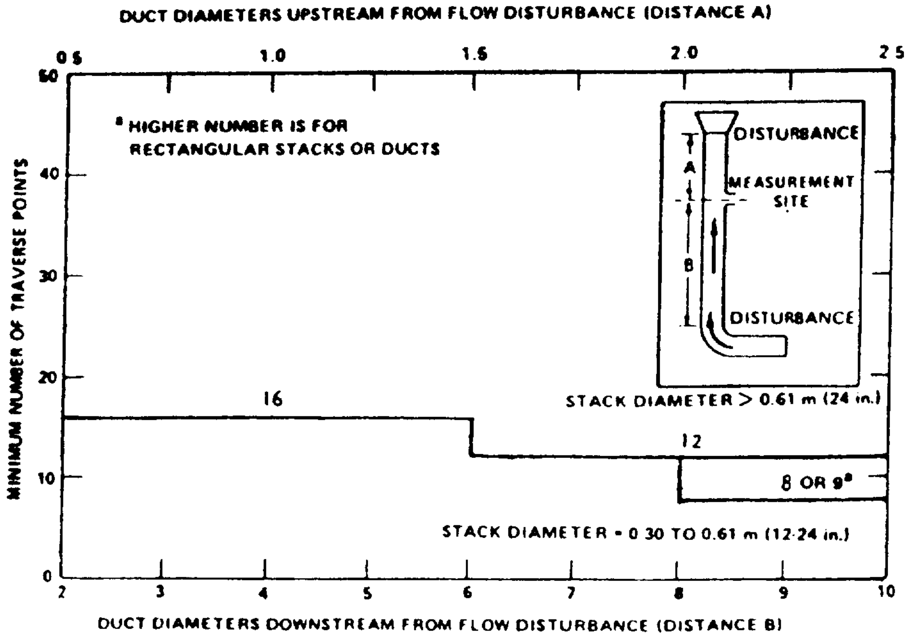

Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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).

$= M_d(1 - B_{ws}) + 18.0\ B_{ws}$

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).

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

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).

$= 273 + t_s$ for metric.

Eq. 2-7

$= 460 + t_s$ for English.

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.

$$v_s = K_p C_p(\sqrt{\Delta p})_{avg}\sqrt{\frac{T_{s(avg)}}{P_s M_s}}$$

Equation 2-9

5.3 Average Stack Gas Dry Volumetric Flow Rate.

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

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.

$$\%\ EA = \frac{\%O_2 - 0.5\%\ CO}{0.264\%\ N_2 - (\%O_2 - 0.5\%\ CO)} \times 100$$

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.

$$M_d = 0.440(\%CO_2) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO)$$

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, m² (ft²).

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 m³/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....n), m³/min (cfm).

L_p = Leakage rate observed during the post-test leak check, m³/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-m³/°K-g-mole (21.85 in. Hg-ft³/°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 H₂O (in. H₂O).

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

$$V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_1 V_{lc}$$

Where:

K_1 = 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_w 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.

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

6.7 Acetone Wash Blank.

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

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, ° K (° 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

Δp = 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)

SAMPLE CALCULATION SHEET
METHODS 1-5

CLIENT: Woodworth & Co. DATE OF TEST: 9/6/90

LOCATION: Tacoma, WA RUN #: 3

Particulate Matter Emission Concentration - Equation 5-1

Vm_{std} =
17.647°R/"Hg*40.218 ft³* .993*(30.04"Hg + (.707"H_2O/13.6))/(460 + 78.6 °F)

= 39.375 dscf

dscm = 39.375 dscf/35.31 ft³/m³

= 1.115 dscm

Substitution of Equation 5-4 into 5-5

W_a = .2 mg * 170 ml / 100 ml

= .34 mg

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

= 123.8 mg = 56.8 mg + 30.7 mg - 0.34 mg + 36.6 mg

C_s= (0.001 g/mg) * (15.43 grains/gram) * 123.8 mg / 39.375 dscf

= .049 gr/dscf (Equation 5-6)

gr/dscf @7% O_2 = ______ gr/dscf * (20.9% - 7%O_2)/(20.9% - ______ %O_2)

= ______ gr/dscf @ 7% O_2

gr/dscf @ 12% CO_2 = ______ gr/dscf * 12% / ______ %CO_2

= ______ gr/dscf @ 12% CO_2

mg/dscm = 123.8 mg/1.115 dscm

= 111.0 mg/dscm

Particulate Matter Emission Rate

pounds/hour = .049 gr/dscf *37155 dscf/min * 60 min/hr * 1 lb/7000 grains

= 15.7 lb/hr

Moisture - Equation 5-2 and 5-3

Vw_{std} = 0.04715 ft³/g * 244.0 grams of H_2O collected in impingers

= 11.50 scf

SAMPLE CALCULATION SHEET (continued)
METHODS 1-5

B_{ws} = (11.5 scf)/(11.5 scf + 39.375 dscf)

= 0.2261

%Moisture = 0.2261 * 100

= 22.61 %

<u>Molecular weight - Equation 3-2</u>

M_d = 0.440 * (5.9 %CO_2) + 0.320 * (12.9 %O_2) + 0.280 * (81.2 % CO + %N_2)

M_d = 29.46 g/g-mole (dry)

M_s = 29.46 g/g-mole * (1 - .2261) + 18.0 * .2261

M_s = 26.87 g/g-mole (wet)

<u>Stack gas velocity and volumetric flow rate - Equation 2-9 and 2-10</u>

V_s = 85.49 * .838 * .1907 * $\sqrt{607.5° R / 26.87 g/g-mole / 30.04 "Hg}$

V_s = 11.85 ft/sec (std)

Q_{sd} = 3600 * (1 - .2261) * 11.85 ft/sec * 78.54 ft² * (528 ° R/607.5° R) * (30.04 "Hg/29.92 "Hg)

= 2262935 dscf/hr / 60 min/hr

= 37715.5 dscf/min (dry standard cubic feet per minute)

acfm = 11.85 ft/sec * 78.54 ft² * 60 sec/min

= 55846.5 acfm (actual cubic feet per minute)

<u>Isokinetic variation - Equation 5-8</u>

I = 0.09450 * 39.375 dscf * 607.5° R/(30.04 "Hg * 11.85 ft/sec * 60 min * .0013690 ft² * (1 - .2261))

I = 100 %

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

SAMPLE CALCULATION SHEET (2)

Backhalf particulate

"C" Section

22.3 mg particulate in "C" Section beaker

410.0 ml of water in condensers, including rinses

233.3 ml of condensation in 1st, 2nd and 3rd bubblers (final weight - initial weight, assumes 1g/1ml water density)

176.7 ml of deionized, distilled water used in bubblers including rinses

.002 mg/ml blank partic. = (.2 mg H2O blank / 100 ml H2O)

.35 mg of blank particulate

= 21.9 mg of "C" partic. = 22.3 mg of partic. in "C" - .35 mg of blank

"Cx" Section

6.8 mg of particulate in "Cx" Section beaker

0.0 mg/ml of blank partic. = (00 mg CH2Cl2 blank / 100 ml CH2Cl2)

0.0 mg of blank particulate = (150 ml * 0.0 mg/ml)

= 6.8 mg of "Cx" partic = 6.8 mg of partic in "Cx" - 0.0 mg of blank

"D" Section

8.0 mg of particulate in "D" Section beaker

.002 mg/ml of blank particulate (same as "B" Section)

0.13 mg of blank particulate = (65 ml * .002 mg/ml)

= 7.87 mg of "D" partic. = 8.0 mg of partic. in "D" - .13 mg of blank

Total Backhalf Particulate

\+ 21.9 mg of "C" Section particulate

\+ 6.8 mg of "Cx" Section particulate

\+ 7.9 mg of "D" Section particulate

\+ NA mg of Backhalf filter (if applicable)

= 36.6 mg of Backhalf particulate

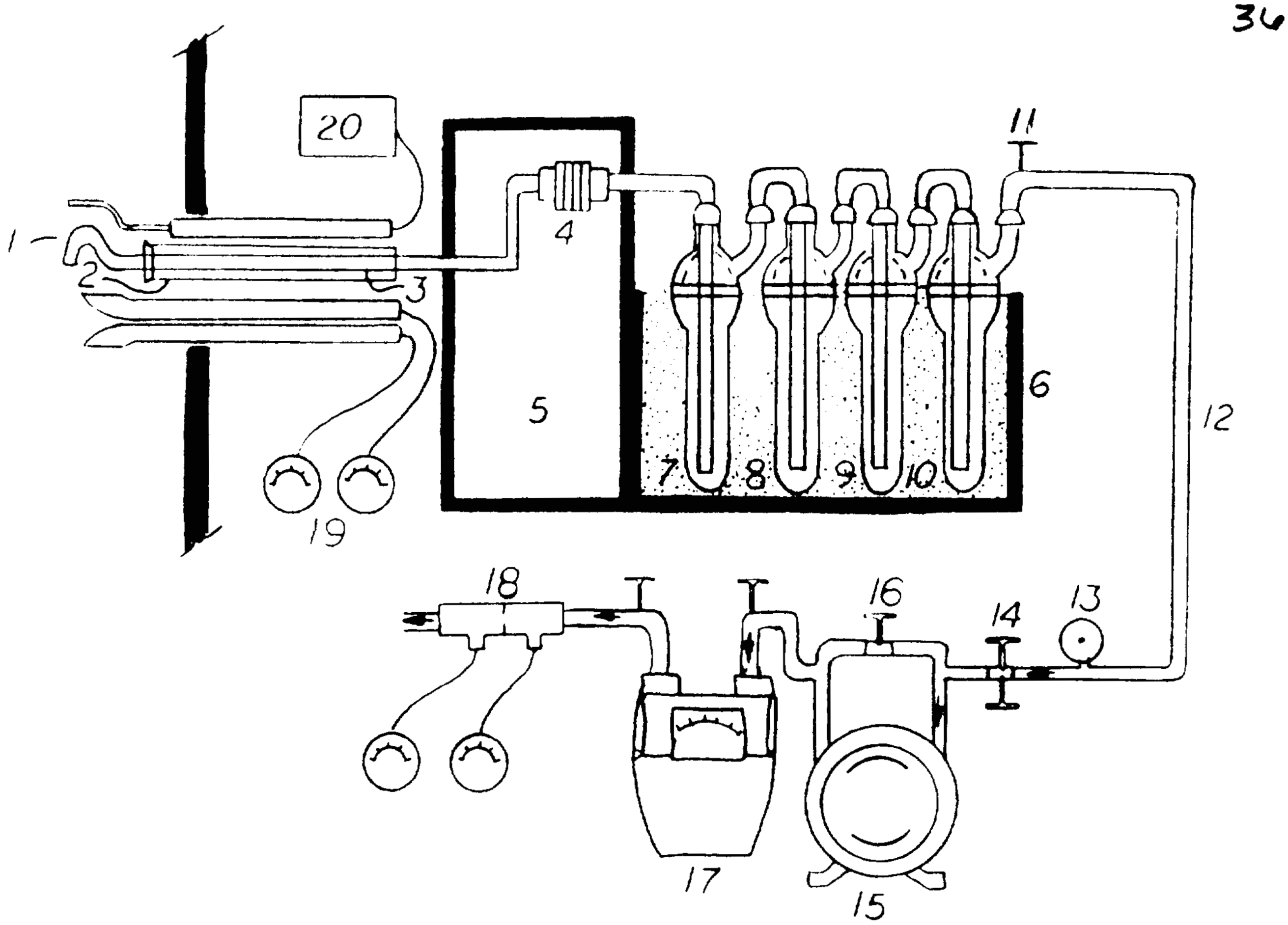

Figure 2. Method 5 Sample Train.

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

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

METER BOX #:	JAG RED #1
CALIBRATION DATE:	FEBRUARY 23, 1989
LOCATION:	STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
METHOD OF CALIB.:	SPIROMETER

TOTAL TIME min	DELTA H "H2O	METER VOL V1 cf	METER VOL V2 cf	TEMP OUT deg F	TEMP IN deg F	BARO. PRES. "Hg	VOLUME METER dscf	SPIRO H1 cm	SPIRO H2 cm	SPIRO TEMP deg C	VOLUME SPIRO dscf	Y FACTOR	KM^2	DELTA H@
4.0	1.0	408.200	411.341	80.0	76.0	29.84	3.090	80.0	13.5	22	3.111	0.993	0.99	0.927
4.0	1.0	412.300	415.425	81.5	76.5	29.84	3.069	80.0	14.0	22	3.088	0.994	0.98	0.938
5.0	0.5	415.800	418.552	80.5	77.0	29.84	2.700	80.0	21.8	22	2.723	0.992	0.97	0.946
3.5	1.5	419.200	422.505	79.5	77.0	29.84	3.254	80.0	10.1	22	3.270	0.995	0.96	0.961
AVERAGE												0.993	0.98	0.943

AT

Lab # 00399

TRAVERSE SAMPLING DATA

Page 1 of ______

Client Woodworth - Tacoma
Date 9-6-90
Sample Location Scrubber
Grit Stack
Operators JMG
Sample Box # Red-1
Run# 1-WS W/B1

EQUIPMENT CHECKS

Initial/Final
Leak Rate Cfm ∠.02/.008
Leak Test Vac 20/20
✓ Pitots, Pretest
✓ Pitots, Postest
✓ Orsat Sampling System
✓ Tedlar Bag
Thermocouple @ ______ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter 120"
Distance Upstream 30'
Distance Downstream 10'

Filter #125-117 tare ______ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler	774.6	587.6	
#2 Impinger	625.1	591.2	
#3 Bubbler	463.6	460.7	
#4 Silica Gel	778.0	767.2	

TOTAL WATER VOLUME 234.6 ✓

Start Time 0634
Stop Time 0740
Barometric Pressure "Hg 30.00" 762 mm
Static Pres"H_2O +.02
Production Rate ______

NOMOGRAPH SETUP

% Moisture ______
Meter Temp. ______
Stack Temp. ______
ΔH@ .943 Y .973
Pitot# 11' Side# A
Cp .838
Nozzle Diameter .501
K Factor ______
Reference ΔP ______

CO_2 = 6.0, CO = 218ppm

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp°F In	Gas Meter Temp°F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	O2
W 1	0	847.651	.02	.34	.34	61	61	2	266	55	144	
2			.025	.45	.45	61	61	2	257	49	145	
3	5		.03	.53	.53	62	61	2½	251	48	145	
4			.035	.62	.62	63	61	2½	246	48	146	
5	10		.04	.71	.71	64	62	3	257	47	146	
6			.04	.71	.71	66	62	3	251	48	146	
7	15		.03	.53	.53	67	62	2½	268	50	146	
8			.04	.71	.71	67	62	3	270	51	148	
9	20		.04	.71	.71	69	62	3	263	50	147	
10			.03	.53	.53	69	63	2½	267	5[illegible]	148	
11	25		.03	.53	.53	70	64	2½	270	52	148	
12			.02	.34	.34	70	64	2	268	52	149	
S 1	30		.05	.90	.90	67	65	3	257	58	147	
2			.05	.90	.90	67	65	3	264	56	146	
3	35		.06	1.08	1.08	70	65	3½	250	55	146	
4			.06	1.08	1.08	71	66	3½	245	54	146	
5	40		.05	.90	.90	72	66	3½	256	54	147	
6			.04	.72	.72	72	66	3	261	55	147	
7	45		.03	.54	.54	73	67	[illegible]	271	55	14[illegible]	
8			.03	.54	.54	73	67		262	56	149	
9	50		.03	.54	.54	72	67		266	53	149	
10			.025	.45	.45	72	65	2½	269	56	150	
11	55		.025	.45	.45	72	68	2½	270	55	152	
12			.025	.45	.45	74	69	2½	269	54	151	
	60	885.742										

38.091 V_m ✓
______ $\overline{(\sqrt{\Delta P})^2}$
0.636 $\overline{\Delta H}$ ✓
66.5 $\overline{T_m}$ ✓
147.4 $\overline{T_s}$ ✓
12.8%

DB

AT

Lab # 00400

TRAVERSE SAMPLING DATA

Page 1 of ______

Client Woodworth
Date 9-6-90
Sample Location Scrubber Exit Stack
Operators TAG
Sample Box # Red-2
Run# 2-MS

EQUIPMENT CHECKS

Initial/Final
Leak Rate Cfm <.01 / .007
Leak Test Vac 20 / 20
✓ Pitots, Pretest
✓ Pitots, Postest
✓ Orsat Sampling System
✓ Tedlar Bag
✓ Thermocouple @ ______ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter ______
Distance Upstream ______
Distance Downstream ______

Filter # 125-115 tare ______ mgs

	Final Wt.		Initial Wt.		Net Wt.
#1 Bubbler	821.2	-	625.0	=	
#2 Impinger	620.5	-	589.1	=	
#3 Bubbler	493.0	-	490.6	=	
#4 Silica Gel	776.2	-	765.5	=	

TOTAL WATER VOLUME 290.7

Start Time 0936
Stop Time 1043
Barometric Pressure "Hg 30.04 76[illegible]
Static Pres"H_2O [illegible]
Production Rate ______

NOMOGRAPH SETUP

% Moisture ______
Meter Temp. ______
Stack Temp. ______
ΔH@ .943 Y .993
Pitot# ______ Side# ______
Cp .838
Nozzle Diameter .501
K Factor ______
Reference ΔP ______

CO_2 = 6.0%; CO = 218 ppm

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O		Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp°F In	Gas Meter Temp°F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	O_2
S 1	0	886.558	.06		1.12	1.12	62	62	3	263	58	144	
2			.06		1.12	1.12	63	63	3	270	53	144	13.0
3	5		.075		1.40	1.40	65	63	4	245	50	142	13.0
4			.075		1.40	1.40	67	63	4	247	51	146	12.8
5	10		.06		1.12	1.12	69	63	3½	241	54	147	12.8
6			.04		.75	.75	70	64	3	239	56	148	12.7
7	15		.04		.75	.75	70	64	3	246	58	148	12.7
8			.03		.56	.56	71	65	2½	244	57	148	12.7
9	20		.025		.47	.47	71	65	2½	253	58	148	12.8
10			.025		.47	.47	71	65	2½	260	57	149	12.8
11	25		.02		.37	.37	71	66	2	263	55	149	12.9
12			.02		.37	.37	71	66	2	265	55	148	12.9
W 1	30		.025		.47	.47	68	68	2½	266	58	145	
2			.025		.47	.47	69	68	2½	263	51	146	12.9
3	35		.03		.56	.56	71	68	2½	262	49	147	12.9
4			.03		.56	.56	72	68	2½	261	50	148	12.8
5	40		.03		.56	.56	72	68	2½	260	50	147	12.7
6			.03		.56	.56	73	69	2½	259	50	147	12.7
7	45		.04		.75	.75	74	69	3	260	49	149	12.7
8			.04		.75	.75	75	70	3	257	49	149	12.7
9	50		.04		.75	.75	76	70	3	247	50	150	12.8
10			.03		.56	.56	76	70	2½	264	51	151	12.8
11	55		.03		.56	.56	76	70	2½	260	51	150	12.8
12			.03		.56	.56	77	71	2½	258	52	150	12.7
	60	926.107											

39.549 V_m

$(\sqrt{\Delta P})^2$

0.709 ΔH ✓

68.7 T_m ✓

147.5 T_s

12.8

AT

lab# 00401

TRAVERSE SAMPLING DATA

Page 1 of ______

Client Woodworth - Tacoma
Date 9-6-90
Sample Location Scrubber Exit Stack
Operators JAB
Sample Box # Tvd-3
Run# 3MS w/ BIT

EQUIPMENT CHECKS

Initial/Final
Leak Rate Cfm <.01 / .005
Leak Test Vac 20 / 19
✓ Pitots, Pretest
✓ Pitots, Postest
✓ Orsat Sampling System
Tedlar Bag
✓ Thermocouple @ ______ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter ______
Distance Upstream ______
Distance Downstream ______

Filter # 125-116 tare ______ mgs

	Final Wt.		Initial Wt.		Net Wt.
#1 Bubbler	794.2	-	593.5	=	
#2 Impinger	650.1	-	620.7	=	
#3 Bubbler	526.8	-	523.6	=	
#4 Silica Gel	870.6	-	859.9	=	

TOTAL WATER VOLUME 244.0 ✓

Start Time 1232
Stop Time 1337
Barometric Pressure "Hg 30.04 763
Static Pres"H_2O + .02
Production Rate ______

NOMOGRAPH SETUP

% Moisture ______
Meter Temp. ______
Stack Temp. ______
ΔH@ .943 Y .993
Pitot# ______ Side# ______
Cp .838
Nozzle Diameter .301
K Factor ______
Reference ΔP ______

CO_2 = 5.9% ; CO = 218 ppm

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O		Orifice Setting (ΔH), In H_2O Ideal	Actual	Gas Meter Temp°F In	Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	O_2
1	0	926.803	.03		.56	.56	74	73	2½	251	67	142	
2			.03		.57	.57	74	73	2½	264	66	144	13.1
3	5		.03		.57	.57	75	73	2½	261	62	146	12.9
4			.03		.57	.57	76	74	2½	252	58	147	12.8
5	10		.03		.57	.57	76	74	2½	255	57	147	12.8
6			.03		.57	.57	77	75	2½	245	60	146	12.7
7	15		.035		.66	.66	78	75	3	266	60	148	12.7
8			.04		.76	.76	79	75	3½	256	60	149	12.7
9	20		.04		.76	.76	80	75	3½	251	60	150	12.6
10			.04		.76	.76	81	75	3½	260	59	151	12.6
11	25		.03		.57	.57	81	76	3	263	55	151	12.7
12			.03		.57	.57	81	76	3	261	54	150	12.7
S 1	30		.06		1.13	1.13	79	77	4½	246	62	145	
2			.06		1.13	1.13	81	77	4½	250	56	145	13.2
3	35		.06		1.13	1.13	83	77	4½	244	56	146	13.0
4			.06		1.13	1.13	84	78	4½	241	57	146	13.0
5	40		.06		1.13	1.13	85	78	4½	246	58	147	13.1
6			.04		.76	.76	85	79	3½	254	59	147	12.9
7	45		.03		.57	.57	84	79	3	253	58	147	12.9
8			.03		.57	.57	84	79	3	260	59	148	13.0
9	50		.025		.48	.48	84	79	3	256	59	149	12.9
10			.025		.48	.48	84	80	3	250	59	150	13.0
11	55		.025		.48	.48	85	80	3	251	60	150	13.0
12			.025		.48	.98	85	81	3	253	60	149	12.9
	60	967.021											

40.218 / V_m ✓
$(\sqrt{\Delta P})^2$
0.707 / ΔH ✓
78.6 / T_m ✓
147.5 / T_s
12.9 ✓
DB