TEST REPORT

FORMALDEHYDE EMISSIONS TESTING FROM ASPHALT HEATERS

Prepared for:

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1.0 INTRODUCTION

The National Asphalt Pavement Association (NAPA) initiated a project to develop emission factors for formaldehyde emissions from hot oil systems (HOS) at hot mix asphalt (HMA) plants. NAPA contracted the testing services to Pacific Environmental Services, Inc. (PES) who subsequently changed its corporate name to MACTEC Federal Programs, Inc. (MACTEC). The primary objective of the testing effort was to accurately determine formaldehyde concentrations and mass emission rates from HOS burners. Because carbon monoxide (CO) is also a product of incomplete combustion, determinations of CO concentrations and mass emissions were also made. The results will be used by NAPA to develop emission factors for formaldehyde and CO.

The United States Environmental Protection Agency (EPA) recommended to NAPA that at least four different HOS burners be tested in order to obtain sufficient data to constitute a statistically significant data base. In order to satisfy this recommendation, NAPA selected four HMA plants, all located in North Carolina, to serve as host facilities for the planned testing program. Three of the HOS burners were fired using No. 2 fuel oil and one HOS burner was fired using natural gas. The testing program included preparation of a Quality Assurance Project Plan/Site-Specific Test Plan (QAPP/SSTP), field testing and sample analyses, and report documentation. The QAPP/SSTP was approved by the EPA.

Table 1-1 summarizes the emissions test log for the four facilities. Presented in Figure 1.1 is the project organization and major lines of communication. Section 2.0 contains the results of the testing; Section 3.0 provides the problem definition and background; Section 4.0 contains descriptions of the measurement sites; Section 5.0 contains descriptions of the sampling and analysis procedures; and Section 6.0 contains the Quality Assurance/Quality Control procedures that were employed during the testing program and the results of calibrations and analytical QA data. Copies of all process data, field data generated during the testing, the subcontracting laboratory analytical report, computer calculations and example calculations, calibration data and compressed gas certifications of analysis, project participants, and reprints of the EPA Test Methods are contained in the appendices to this document.

TABLE 1.1

EMISSIONS TEST LOG

Run No.	Date	Pollutant	Run Time	Duration, Minutes
S.T. Wooten, Franklinton				
WF-F-1	3/25/03	Formaldehyde Carbon Monoxide	1030-1151	72.0
WF-F-2	3/25/03	Formaldehyde Carbon Monoxide	1255-1411	72.0
WF-F-3	3/25/03	Formaldehyde Carbon Monoxide	1511-1626	72.0
S.T. Wooten, Clayton				
WC-F-1	3/27/03	Formaldehyde Carbon Monoxide	0934-1109	72.0
WC-F-2	3/27/03	Formaldehyde Carbon Monoxide	1136-1250	72.0
WC-F-3	3/27/03	Formaldehyde Carbon Monoxide	1400-1503	72.0
REA - Mallard Creek				
MC-F-1	4/1/03	Formaldehyde Carbon Monoxide	0915-1040	72.0
MC-F-2	4/1/03	Formaldehyde Carbon Monoxide	1129-1245	72.0
MC-F-3	4/1/03	Formaldehyde Carbon Monoxide	1339-1501	72.0
REA - North Mecklenburg				
NM-F-1	4/2/03	Formaldehyde Carbon Monoxide	1435-1554	72.0
NM-F-2	4/3/03	Formaldehyde Carbon Monoxide	0830-0945	72.0
NM-F-3	4/3/03	Formaldehyde Carbon Monoxide	1026-1143	72.0

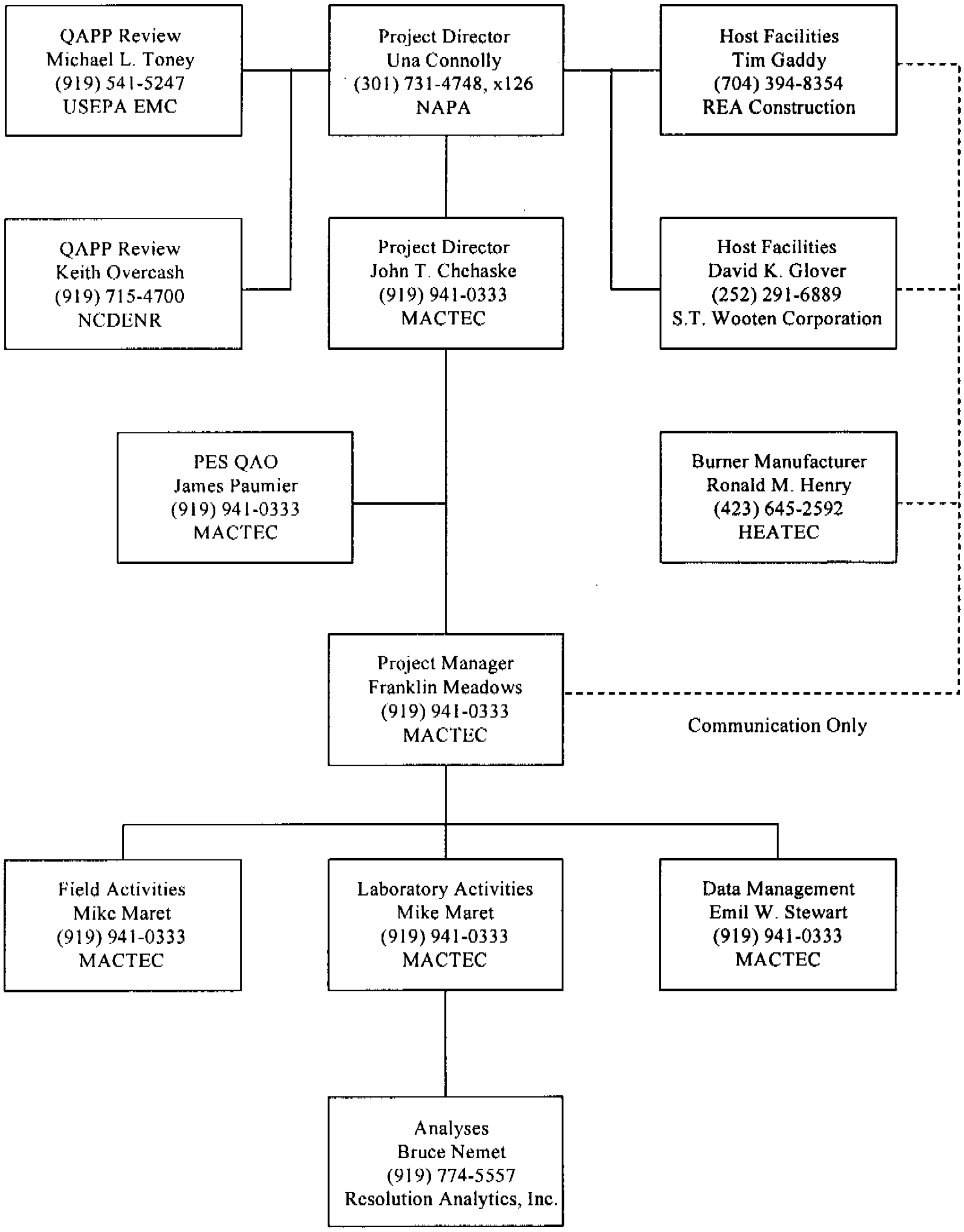

Figure 1.1 Project Organization

2.0 SUMMARY OF RESULTS

Summarized in this section are the results of the testing that was conducted at the four asphalt plants. Exhaust gas parameters, pollutant concentrations, and pollutant mass emission rates are summarized in Tables 2.1 through 2.8.

2.1 TEST OBJECTIVES AND TEST MATRIX

The following criteria for measurement data were established in the QAPP/SSTP:

- The representativeness of the formaldehyde and CO data will be ensured by testing four separate HOS burners.
- The HOS burners will be operated at high-fire, constant load conditions.
- Triplicate samples for formaldehyde and CO, each 60 minutes in duration, will be collected over a several hour work day to account for fluctuations over time. If any test runs need to be aborted, a replacement test run will be performed to ensure three data points for each parameter. The EPA has established three test runs as the minimum number for statistical purposes.
- The sample duration and volume must be sufficient to detect formaldehyde in the samples.
- Data completeness goal is 100%.

All of these criteria were met with the exception of two test runs at the S.T. Wooten-Clayton facility where no formaldehyde was detected in Run Nos. WC-F-2 and WC-F-3.

2.2 QUALITY ASSURANCE PROJECT PLAN AND SITE-SPECIFIC TEST PLAN CHANGES

The following field changes were made to the Quality Assurance Project Plan/Site-Specific Test Plan.

- The test times at each facility were increased from 60 minutes to 72 minutes.

- The measurement site at the S.T. Wooten-Franklinton facility was changed because a roof had been erected over the existing stack that prevented the installation of the stack extension. Alternative procedures in Method 1A were used.
- The S.T. Wooten-Wilson facility was changed to the S.T. Wooten-Clayton facility. Also at this location, a roof over the stack had been installed that prevented use of the stack extension.

2.3 FORMALDEHYDE AND CARBON MONOXIDE EMISSIONS

This section presents the results of the formaldehyde and CO testing. CO results were corrected for observed calibration and bias errors.

2.3.1 S.T. Wooten, Franklinton

Table 2.1 summarizes the stack gas conditions for the HOS burner at S. T. Wooten's Franklinton facility. The average stack gas velocity was 9.4 feet per second (fps) at 737 °F. The stack gas was comprised of 11.7 percent (%) CO_2, 6.3 % O_2 and 10.7 % moisture. The average stack gas volumetric flow rate was 197 actual cubic feet per minute (acfm) or 78 dry standard cubic feet per minute (dcsfm). During Run No. WF-F-1, the pre-test flow rate was 12.6% greater than the post-test flow rate. This may have introduced a positive bias of up to 12.6% on the formaldehyde and CO emissions reported for Run No. WF-F-1.

Table 2.2 summarizes the formaldehyde and CO emissions from the HOS burner stack at S.T. Wooten's Franklinton facility. The average heat input was 0.42 million Btu per hour (mmBtu/hr). The average formaldehyde concentration was 63.8 parts per billion, by volume (ppbv). The average formaldehyde mass emission rate was 2.38E-05 pounds per hour (lb/hr) or 5.66E-05 pounds per million Btu (lb/mmBtu). The average CO concentration was 30.1 parts per million, by volume (ppmv). The average CO mass emission rate was 1.09E-02 lb/hr or 2.59E-02 lb/mmBtu.

2.3.2 S.T. Wooten, Clayton

Table 2.3 summarizes the HOS burner stack gas conditions at S.T. Wooten's Clayton facility. The average stack gas velocity was 13.9 fps at 623 °F. The stack gas was comprised of 11.0 % CO_2, 8.0 % O_2 and 8.5 % moisture. The average stack gas volumetric flow rate was 708 acfm or 318 dscfm.

Table 2.4 summarizes the formaldehyde and CO emissions from the HOS burner stack at S.T. Wooten's Clayton facility. The average heat input was 0.91 mmBtu/hr. The average formaldehyde concentration was <2.05 ppbv. During runs WC-F-2 and WC-F-3 the formaldehyde concentrations were below the method detection limits of 1.55 and 1.39 ppbv, respectively. The average formaldehyde mass emission rate was <3.03E-06 lb/hr or <3.33E-06 lb/mmBtu. The average CO concentration was 1.8 ppmv. The average CO mass emission rate was 2.53E-03 lb/hr or 2.78E-03 lb/mmBtu.

TABLE 2.1

SUMMARY OF EXHAUST GAS PARAMETERS
HOS BURNER STACK
S.T. WOOTEN - FRANKLINTON

Run No.	WF-F-1	WF-F-2	WF-F-3	Average
Date	3/25/03	3/25/03	3/25/03	
Velocity, fps[a]	10.4	9.3	8.6	9.4
Temperature, °F	717	750	744	737
CO_2, % by volume	11.0	12.0	12.0	11.7
O_2, % by volume	6.5	6.5	6.0	6.3
Moisture, % by volume	10.9	10.9	10.3	10.7
Exhaust Gas Volumetric Flow Rate				
acfm[b]	218	193	180	197
dscfm[c]	87	75	71	78

[a] Feet per second at stack conditions

[b] Actual cubic feet per minute

[c] Dry standard cubic feet per minute at 68°F and 29.92" Hg

TABLE 2.2

SUMMARY OF FORMALDEHYDE AND CARBON MONOXIDE EMISSIONS
S.T. WOOTEN - FRANKLINTON

Run No.	WF-F-1	WF-F-2	WF-F-3	Average
Date	3/25/03	3/25/03	3/25/03	
Clock Time, 24-hr clock	1030-1151	1255-1411	1511-1626	
Heat input, mmBtu/hr[a]	0.42	0.42	0.42	
Formaldehyde				
Concentration, ppbv[b]	86.6	51.0	53.9	63.8
Emission Rate, lb/hr[c]	3.54E-05	1.80E-05	1.80E-05	2.38E-05
Emission Rate, lb/mmBtu[d]	8.43E-05	4.29E-05	4.28E-05	5.66E-05
	WF-CO-1	**WF-CO-2**	**WF-CO-3**	
Carbon Monoxide				
Concentration, ppmv[e]	58.6	25.1	6.7	30.1
Emission Rate, lb/hr[c]	2.23E-02	8.26E-03	2.08E-03	1.09E-02
Emission Rate, lb/mmBtu[d]	5.32E-02	1.97E-02	4.96E-03	2.59E-02

[a] Million Btu per hour
[b] Parts per billion by volume, dry basis
[c] Pounds per hour
[d] Pounds per million Btu
[e] Parts per million by volume, dry basis.

TABLE 2.3

SUMMARY OF EXHAUST GAS PARAMETERS
HOS BURNER STACK
S.T. WOOTEN - CLAYTON

Run No.	WC-F-1	WC-F-2	WC-F-3	Average
Date	3/27/03	3/27/03	3/27/03	
Velocity, fps[a]	13.6	13.8	14.3	13.9
Temperature, °F	629	615	625	623
CO_2, % by volume	11.0	11.0	11.0	11.0
O_2, % by volume	8.0	8.0	8.0	8.0
Moisture, % by volume	8.3	8.5	8.8	8.5
Exhaust Gas Volumetric Flow Rate				
acfm[b]	695	702	728	708
dscfm[c]	311	318	325	318

[a] Feet per second at stack conditions
[b] Actual cubic feet per minute
[c] Dry standard cubic feet per minute at 68°F and 29.92" Hg

TABLE 2.4

SUMMARY OF FORMALDEHYDE AND CARBON MONOXIDE EMISSIONS
S.T. WOOTEN - CLAYTON

Run No.	WC-F-1	WF-C-2	WF-C-3	Average
Date	3/27/03	3/27/03	3/27/03	
Clock Time, 24-hr clock	0934-1109	1136-1250	1400-1503	
Heat Input, mmBtu/hr[a]	0.91	0.91	0.91	
Formaldehyde				
Concentration, ppbv[b]	3.22	<1.55	<1.39	<2.05
Emission Rate, lb/hr[c]	4.68E-06	<2.30E-06	<2.11E-06	<3.03E-06
Emission Rate, lb/mmBtu[d]	5.15E-06	<2.53E-06	<2.32E-06	<3.33E-06
	WC-CO-1	**WC-CO-2**	**WC-CO-3**	
Carbon Monoxide				
Concentration, ppmv[c]	2.8	1.6	1.1	1.8
Emission Rate, lb/hr[c]	3.80E-03	2.22E-03	1.56E-03	2.53E-03
Emission Rate, lb/mmBtu[d]	4.18E-06	2.44E-03	1.72E-03	2.78E-03

[a] Million Btu per hour
[b] Parts per billion by volume, dry basis
[c] Pounds per hour
[d] Pounds per million Btu
[e] Parts per million by volume, dry basis.

2.3.3 REA Construction, Mallard Creek

Table 2.5 summarizes the HOS burner stack gas conditions at REA Construction's Mallard Creek facility. The average stack gas velocity was 20.0 fps at 692 °F. The stack gas was comprised of 9.2 % CO_2, 8.0 %O_2 and 15.9 % moisture. The average stack gas flow rate was 1,193 acfm or 464 dscfm.

Table 2.6 summarizes the formaldehyde and CO emissions from the HOS burner stack at REA Construction's Mallard Creek facility. The average heat input was 1.79 mmBtu/hr. The average formaldehyde concentration was 12.5 ppbv. The average formaldehyde mass emission rate was 2.69E-05 lb/hr or 1.51E-05 lb/mmBtu. The CO concentration was below the detection limit of 0.2 ppmv. The average CO mass emission rate was <4.05E-04 lb/hr or <2.27E-04 lb/mmBtu.

2.3.4 REA Construction, North Mecklenburg

Table 2.7 summarizes the HOS burner stack gas conditions at REA Construction's North Mecklenburg facility. The average stack gas velocity was 10.2 fps at 557 °F. The stack gas was comprised of 12.2 % CO_2, 4.5 % O_2 and 11.4 % moisture. The average stack gas volumetric flow rate was 514 acfm or 238 dscfm.

Table 2.8 summarizes the formaldehyde and CO emissions from the HOS burner stack at REA Construction's North Mecklenburg facility. The average heat input was 0.98 mmBtu/hr. The average formaldehyde concentration was 22.1 ppbv. The average formaldehyde mass emission rate was 2.40E-05 lb/hr or 2.45E-05 lb/mmBtu. The average CO concentration was 5.7 ppmv. The average CO mass emission rate was 5.82E-03 lb/hr or 5.94E-03 lb/mmBtu.

2.4 FUEL RATES

Summarized below are the fuel usage rates at each facility. During each measurement run at each facility, the fuel usage rates were held constant.

S.T. Wooten - Franklinton	No. 2 Fuel Oil	3.0 gph[a]
S.T. Wooten - Clayton	No. 2 Fuel Oil	6.5 gph[a]
REA Construction - Mallard Creek	Natural Gas	1700 cfh[b]
REA Construction - N. Mecklenburg	No. 2 Fuel Oil	7 gph[a]

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[a] Gallons per hour

[b] Cubic feet per hour

TABLE 2.5

SUMMARY OF EXHAUST GAS PARAMETERS
HOS BURNER STACK
REA CONSTRUCTION - MALLARD CREEK

Run No.	MC-F-1	MC-F-2	MC-F-3	Average
Date	4/01/03	4/01/03	4/01/03	
Velocity, fps[a]	19.0	20.6	20.4	20.0
Temperature, °F	667	707	700	692
CO_2, % by volume	9.5	9.0	9.2	9.2
O_2, % by volume	7.5	8.5	8.0	8.0
Moisture, % by volume	15.5	16.0	16.3	15.9
Exhaust Gas Volumetric Flow Rate				
acfm[b]	1,135	1,229	1,216	1,193
dscfm[c]	453	471	467	464

[a] Feet per second at stack conditions
[b] Actual cubic feet per minute
[c] Dry standard cubic feet per minute at 68°F and 29.92" Hg

TABLE 2.6

SUMMARY OF FORMALDEHYDE AND CARBON MONOXIDE EMISSIONS REA CONSTRUCTION - MALLARD CREEK

Run No.	MC-F-1	MC-F-2	MC-F-3	Average
Date	4/1/03	4/1/03	4/1/03	
Clock Time, 24-hr clock	0915-1040	1129-1245	1339-1501	
Heat Input, mmBtu/hr[a]	1.79	1.79	1.79	
Formaldehyde				
Concentration, ppbv[b]	17.8	4.73	14.8	12.5
Emission Rate, lb/hr[c]	3.78E-05	1.04E-05	3.24E-05	2.69E-05
Emission Rate, lb/mmBtu[d]	2.12E-05	5.83E-06	1.82E-05	1.51E-05
	MC-CO-1	**MC-CO-2**	**MC-CO-3**	
Carbon Monoxide				
Concentration, ppmv[e]	<0.2	<0.2	<0.2	<0.2
Emission Rate, lb/hr[c]	<3.96E-04	<4.11E-04	<4.08E-04	<4.05E-04
Emission Rate, lb/mmBtu[d]	<2.22E-04	<2.30E-04	<2.28E-04	<2.27E-04

[a] Million Btu per hour
[b] Parts per billion by volume, dry basis
[c] Pounds per hour
[b] Pounds per million Btu
[c] Parts per million by volume, dry basis - detection limit 0.2 ppmv

TABLE 2.7

SUMMARY OF EXHAUST GAS PARAMETERS
HOS BURNER STACK
REA CONSTRUCTION - NORTH MECKLENBURG

Run No.	**NM-F-1**	**NM-F-2**	**NM-F-3**	**Average**
Date	4/02/03	4/03/03	4/03/03	
Velocity, fps[a]	9.63	10.5	10.4	10.2
Temperature, °F	552	562	558	557
CO_2, % by volume	13.5	11	12	12.2
O_2, % by volume	4.0	5	4.5	4.5
Moisture, % by volume	10.9	11.1	12.0	11.4
Exhaust Gas Volumetric Flow Rate				
acfm[b]	494	533	523	514
dscfm[c]	227	246	240	238

[a] Feet per second at stack conditions

[b] Actual cubic feet per minute

[c] Dry standard cubic feet per minute at 68°F and 29.92" Hg

TABLE 2.8

SUMMARY OF FORMALDEHYDE AND CARBON MONOXIDE EMISSIONS REA CONSTRUCTION - NORTH MECKLENBURG

Run No.	**NM-F-1**	**NM-F-2**	**NF-F-3**	**Average**
Date	4/2/03	4/3/03	4/3/03	
Clock Time, 24-hr clock	1435-1554	0830-0945	1026-1143	
Heat Input, mmBtu/hr[a]	0.98	0.98	0.98	
Formaldehyde				
Concentration, ppbv[b]	44.4	12.8	9.0	22.1
Emission Rate, lb/hr[c]	4.71E-05	1.47E-05	1.01E-05	2.40E-05
Emission Rate, lb/mmBtu[d]	4.81E-05	1.51E-05	1.03E-05	2.45E-05
	NM-CO-1	**NM-CO-2**	**NM-CO-3**	
Carbon Monoxide				
Concentration, ppmv[e]	7.4	3.4	6.2	5.7
Emission Rate, lb/hr[c]	7.32E-03	3.65E-03	6.49E-03	5.82E-03
Emission Rate, lb/mmBtu[d]	7.47E-03	3.72E-03	6.63E-03	5.94E-03

[a] Million Btu per hour
[b] Parts per billion by volume, dry basis
[c] Pounds per hour
[d] Pounds per million Btu
[e] Parts per million by volume, dry basis.

3.0 PROBLEM DEFINITION AND BACKGROUND

In 2000, the U.S. Environmental Protection Agency's (EPA) Office of Air Quality Planning and Standards (OAQPS) published Section 11.1 in their "Compilation of Air Pollutant Emission Factors, 5th Edition, Volume 1: Stationary Point and Area Sources", more commonly know as AP-42. Section 11.1 provides emission factors for Hot Mix Asphalt (HMA) manufacturing facilities and ancillary operations. Ancillary operations include the heating system for the asphalt cement storage facilities. There are three types of heating systems that are used to maintain requisite asphalt cement temperatures in the storage tanks: hot oil heat transfer, direct-fired, and electric probes. The hot oil heat transfer system is the most common system in use today and the direct-fired system is phasing out.

The hot oil heat transfer system involves heating a specially designed heat transfer oil to specified temperatures and pumping the hot oil through a piping system that passes through the asphalt cement storage tank. The heat is provided by burning a fossil fuel. The flue gas generated from the combustion of the fossil fuel is emitted into the environment. The flue gas consists of typical products of combustion and incomplete combustion.

The heat input capacity of the burners in hot oil systems (HOS) generally range in size from less than 1 million Btu's per hour to 1.5 million Btu's per hour. The burners are operated to heat oil on an as-needed basis, which is based on the desired asphalt cement storage temperature. Once the asphalt cement reaches the specified temperature, the burner will shut down and remain inactive until the asphalt cement cools and its temperature drops below the temperature setting, just like any household heating system. The asphalt cement storage tanks are insulated to slow down the cooling process. The result is that the burners do not run continuously around the clock. HEATEC installed heat sinks on each burner so that the burners could operate continuously for the duration of the testing.

The list of emission factors for a HOS published by the EPA in AP-42 Section 11.1 includes only hazardous air pollutants, including formaldehyde, for a HOS burning No. 2 fuel oil. They were derived from a single stack test conducted in the 1980s. Because of the small size of the burners in terms of heat input capacity, HOS emissions have been considered insignificant when estimating emissions from a HMA facility, or they have been exempted by state regulations because the heat input rating falls below state regulatory thresholds. However, in 2002, several states have insisted that emissions be calculated for HOS at HMA facilities, and concerns have been raised by the states and the HMA industry regarding the reliability of the HOS emission factor for formaldehyde.

When the formaldehyde emission factor for asphalt HOS was compared to the formaldehyde emission factor published for combustion of fuel oil in an industrial furnace or boiler in AP-42 Section 1.3, the HOS emission factor was found to be three orders of magnitude higher. While it is accepted that small combustion units are not as efficient as industrial sized combustion units, the EPA agreed with NAPA that the combustion efficiency of a small combustion burner is unlikely to be three orders of magnitude lower.

On May 1, 2002, HMA industry representatives met with representatives from the EPA and the North Carolina Department of Environment and Natural Resources (NCDENR) in Raleigh, North Carolina, to discuss the situation regarding the formaldehyde emission factor for HOS as listed in Section 11.1, Table 11.1-13. This emission factor was based on data from a single stack test. The EPA recognizes that a single stack test does not constitute a statistically significant database. However, if that is all they have, they will use a single stack test to determine and publish emission factors. They account for the small quantity of data by assigning the lowest condfidence rating from the confidence rating scale established by the OAQPS. The EPA representative at the meeting stated that he believed at least four separate HOSs needed to be stack tested to establish an emission factor that would be assigned a higher confidence rating.

The EPA representative discussed his review of the original stack test from which the original formaldehyde emission factor was derived. He found that there were probably some deficiencies in the report and insufficient information to verify the derivation of the emission factor. He was able to verify that Method SW846/0011 was used. After considerable discussion among the participants of the meeting, it was determined that stack testing should be conducted to establish a more reliable emission factor for formaldehyde from asphalt cement HOS. It was also determined that Reference Method 316 would be used for this stack testing project.

4.0 MEASUREMENT SITES

The measurement sites at the four facilities were schematically similar, although different in size. Dimensional data on the measurement sites follow. In some cases the sites were modified to meet the requirements of EPA Methods 1 or 1A. The measurement sites and any modifications are discussed in this section.

4.1 S.T. WOOTEN, FRANKLINTON

Depicted in Figure 4.1 is a simplified schematic of the HOS burner exhaust stack at S. T. Wooten's Franklinton facility. The measurement site was located in an 8-inch inner diameter (ID) round, vertical stack 17.5 inches (2.2 stack diameters) downstream of the nearest flow disturbance (burner exhaust) and 16 inches (2.0 stack diameters) upstream of the atmosphere. The stack diameter was less than 12 inches and, therefore was subject to the requirements of EPA Method 1A, ***"Sample and Velocity Traverses for Stationary Sources With Small Stack or Ducts."*** According to EPA Method 1A criteria, this site required 24 pollutant sample traverse points, 12 along each of two perpendicular traverse axes.

Prior to testing, the stack was checked to verify the absence of cyclonic flow. The average rotation angle from 0° reference to obtain a null manometer reading was 10°. Therefore, the measurement site was suitable for testing without modifications.

4.2 S.T. WOOTEN, CLAYTON

Depicted in Figure 4.2 is a simplified schematic of the HOS burner exhaust stack at S.T. Wooten's Clayton facility. The measurement site was located in a 12.5-inch ID round, vertical stack 26 inches (2.1 stack diameters) downstream of the nearest flow disturbance (burner exhaust) and 25.5 inches (2.0 stack diameters) upstream of the atmosphere. This stack was greater than 12 inches in diameter and, therefore, was subject to the requirements of EPA Method 1, ***"Sample and Velocity Traverses for Stationary Sources."*** According to EPA Method 1 criteria, this site required 24 pollutant sample traverse points, 12 along each of two perpendicular traverse axes.

Prior to testing, the stack was checked to verify the absence of cyclonic flow. The average rotation angle from 0° reference to obtain a null manometer reading was 5.1°. Therefore, the measurement site was suitable for testing without modification.

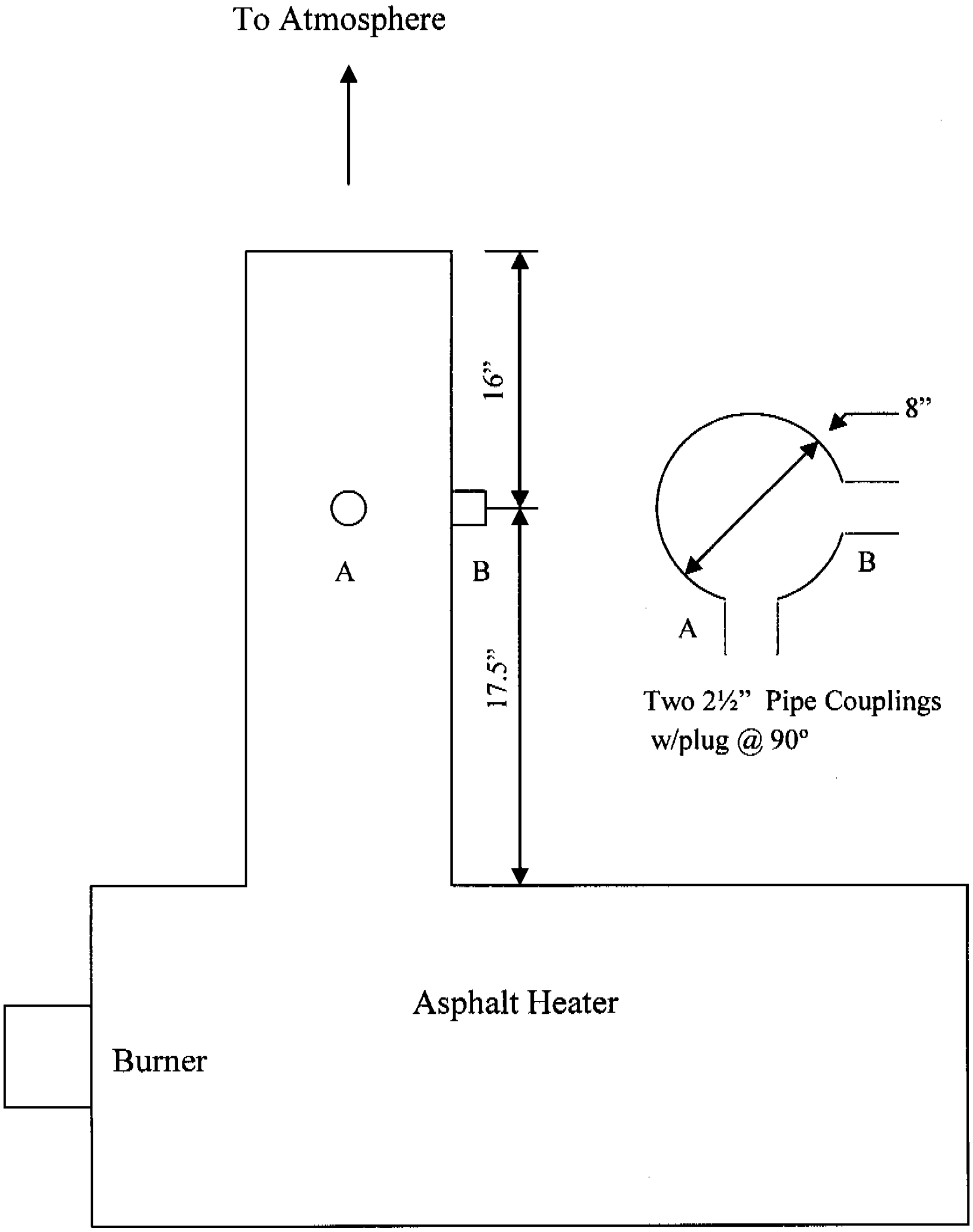

Figure 4.1 Simplified Schematic of HOS Burner Stack
S.T. Wooten - Franklinton Facility

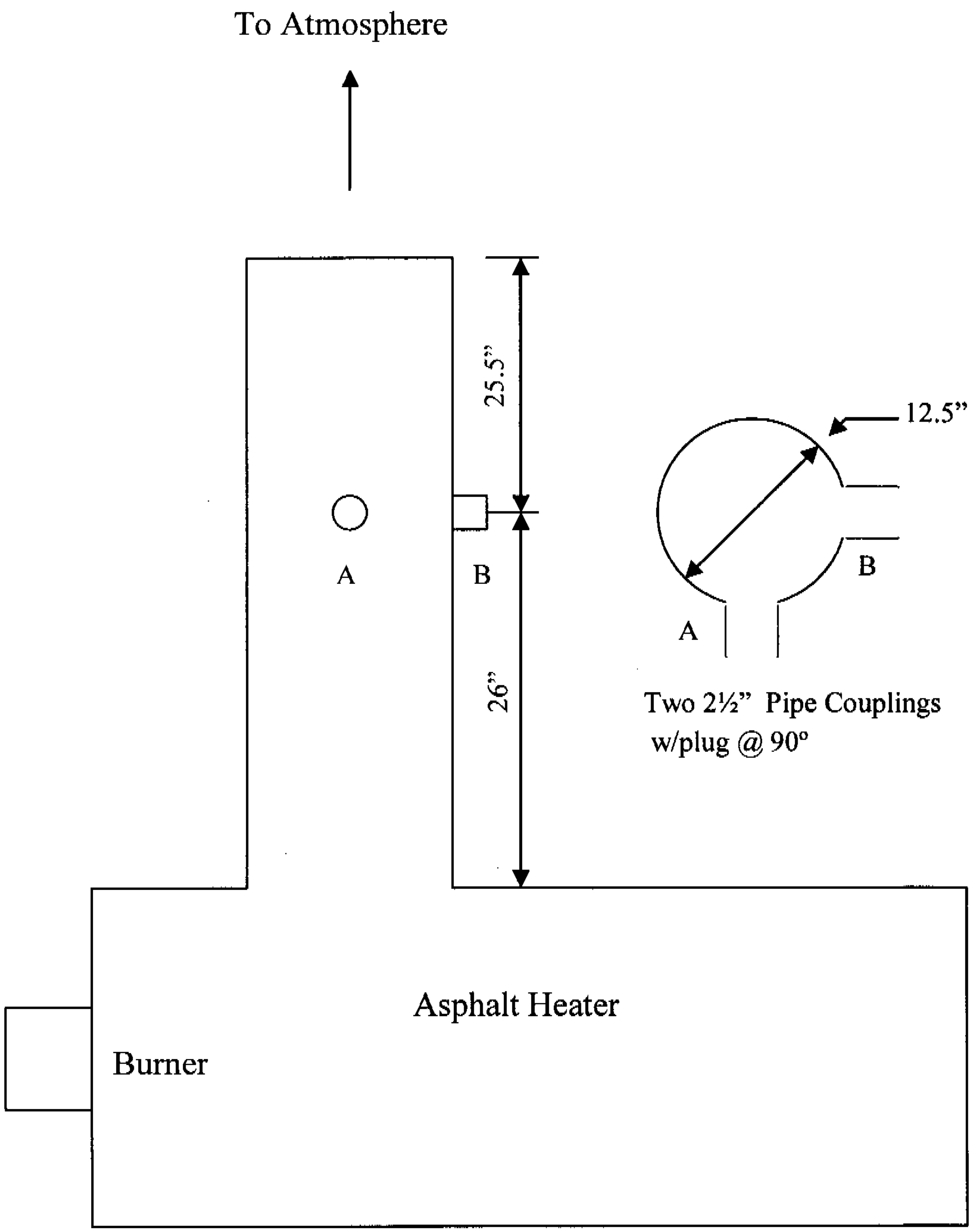

Figure 4.2 Simplified Schematic of HOS Burner Stack
S.T. Wooten - Clayton Facility

4.3 REA CONSTRUCTION, MALLARD CREEK

Depicted in Figure 4.3 is a simplified schematic of the HOS burner exhaust at REA Construction's Mallard Creek facility. At this facility, a stack extension was added. The measurement site was located in a 13.5-inch ID round, vertical stack 60.5 inches (4.5 stack diameters) downstream of the nearest flow disturbance (burner exhaust) and 28.0 inches (2.1 stack diameters) upstream of the atmosphere. The stack was greater than 12 inches in diameter and, therefore, was subject to the requirements of EPA Method 1, ***"Sample and Velocity Traverses for Stationary Sources."*** According to EPA Method 1 criteria, this site required 24 pollutant sample traverse points, 12 along each of two perpendicular traverse axes.

Prior to testing, the stack was checked to verify the absence of cyclonic flow. The average rotation angle from 0° reference to obtain a null manometer reading was 3.4°. Therefore, this site was suitable for testing without further modification.

4.4 REA CONSTRUCTION, NORTH MECKLENBURG

Depicted in Figure 4.4 is a simplified schematic of the HOS burner exhaust stack at REA Construction's North Mecklenburg facility. At this facility, the outlet stack has an outer jacket that serves as a heat exchanger. In order not to disturb the heat exchanger, a stack extension was added to the existing stack. The measurement site was located in a 13.5 inch ID round, vertical stack 60.5 inches (4.5 stack diameters) downstream of the neartest flow disturbance (burner exhaust) and 28.0 inches (2.1 stack diameters) upstream of the atmosphere. The stack was greater than 12 inches in diameter and, therefore, was subject to the requirements of EPA Method 1, ***"Sample and Velocity Traverses for Stationary Sources."*** According to EPA Method 1 criteria, this site required 24 pollutant sample traverse points, 12 along each of two perpendicular traverse axes.

Prior to testing, the stack was checked to verify the absence of cyclonic flow. The average rotation angle from 0° reference to obtain a null manometer reading was 0.4°. Therefore, the measurement site was suitable for testing without modifications.

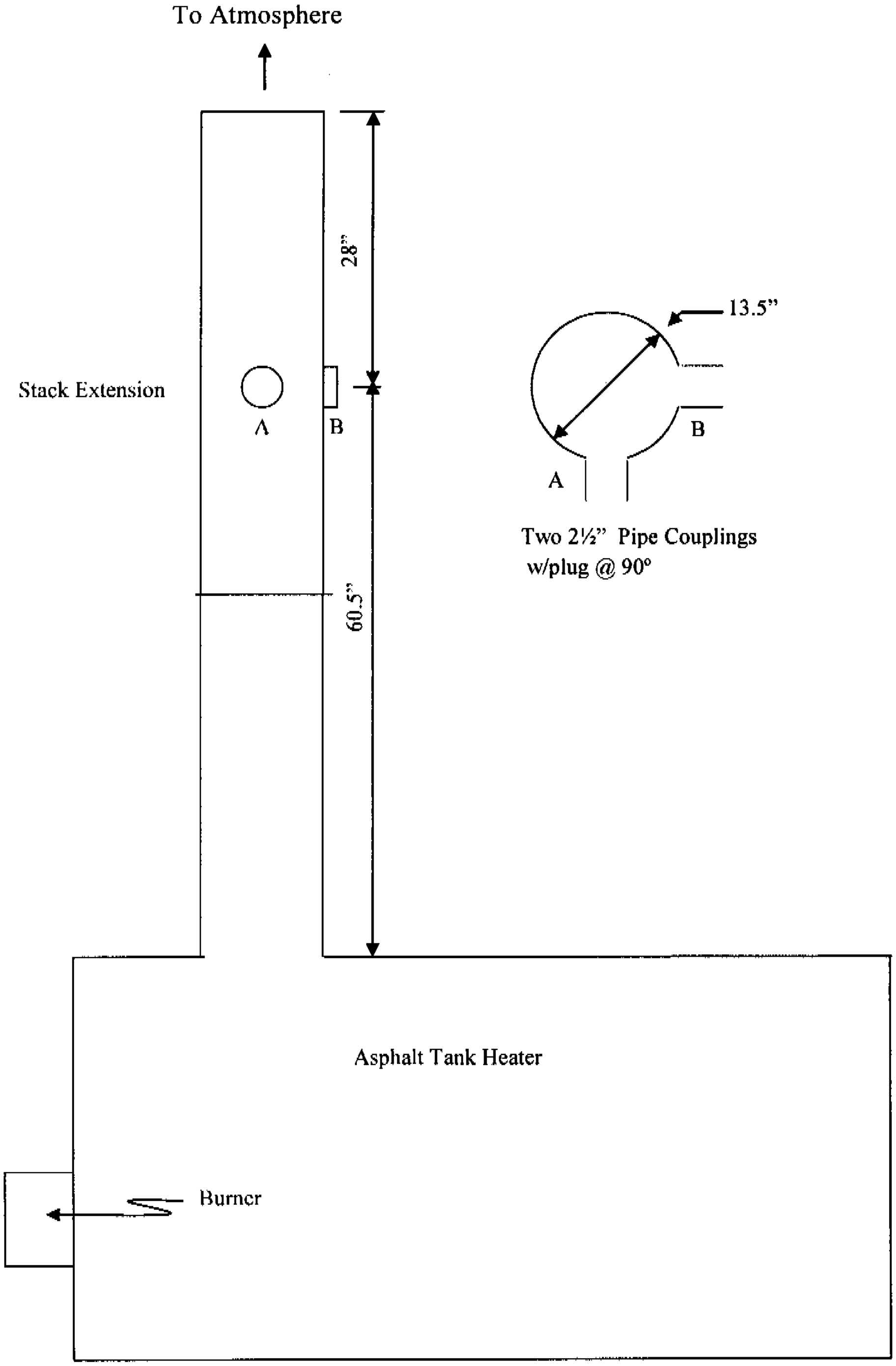

Figure 4.3 Simplified Schematic of HOS Burner Stack REA Construction - Mallard Creek Facility

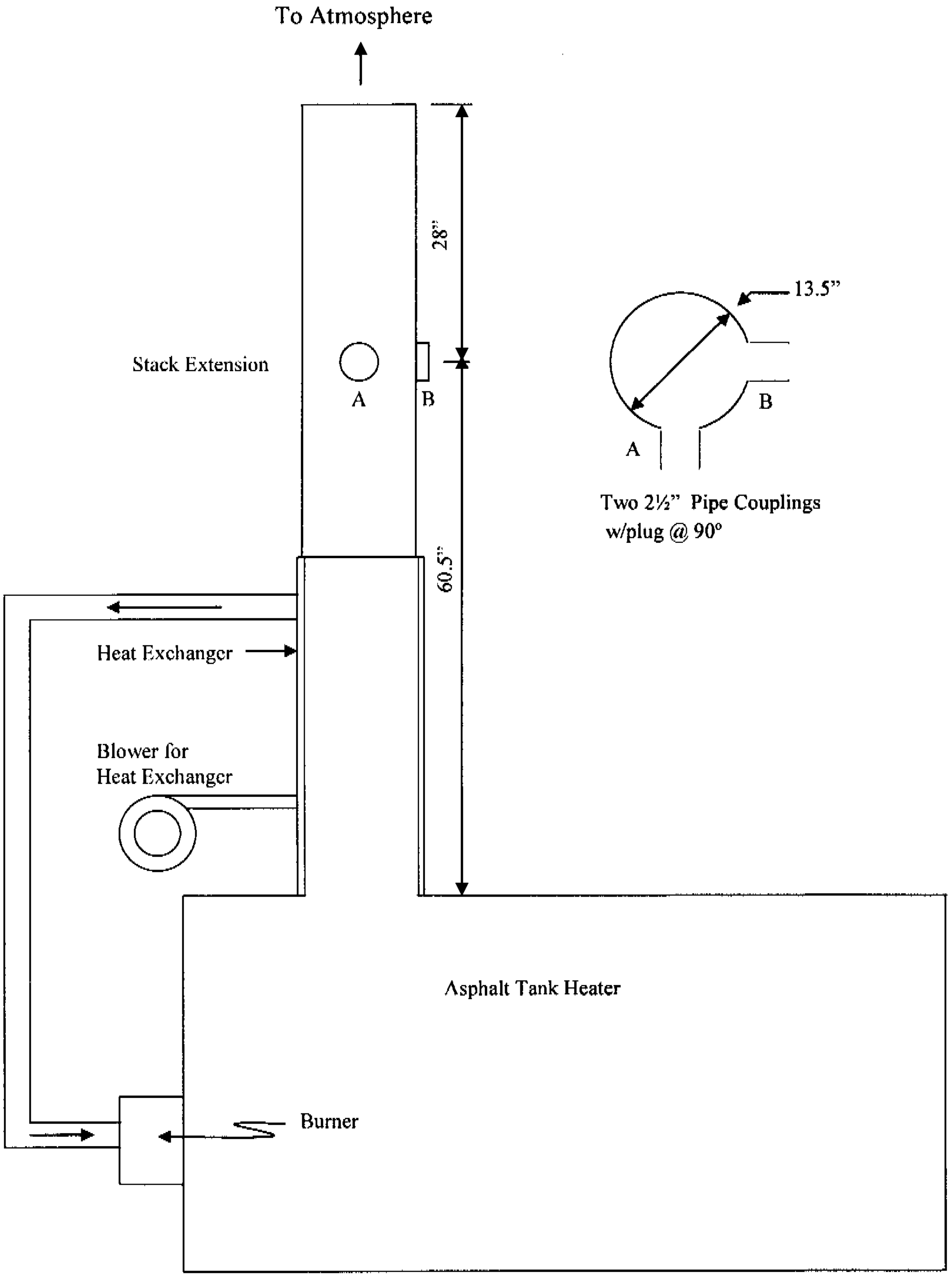

Figure 4.4 Simplified Schematic of HOS Burner Stack
REA Construction - N. Mecklinburg Facility

5.0 SAMPLING AND ANALYSIS PROCEDURES

Source sampling was performed at the outlet of each HOS burner stack to determine the concentrations and mass emission rates of formaldehyde and carbon monoxide. Three test runs were performed at each facility, with each measurement run having a net sampling time of 72 minutes. The sampling and analytical methods that were used are summarized in Table 5.1. In Table 5.2, the parameters measured, the sampling methods, the number of tests performed, and the duration of each test are summarized. Brief descriptions of the sampling and analysis procedures used are presented below. Copies of all the methods that were used are presented in Appendix E.

5.1 LOCATION OF MEASUREMENT SITES AND SAMPLE/VELOCITY TRAVERSE POINTS

EPA Method 1, ***"Sample and Velocity Traverses for Stationary Sources,"*** or Method 1A, ***"Sample and Velocity Traverses for Stationary Sources With Small Stacks or Ducts"*** was used to establish velocity and sample traverse point locations. The HOS burner stacks, and the locations of measurement sites and traverse points were discussed in Section 4.0 of this document.

5.2 DETERMINATION OF EXHAUST GAS VOLUMETRIC FLOW RATE

EPA Method 2, ***"Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube),"*** to determine exhaust gas velocity. A Type S Pitot tube, constructed according to Method 2 criteria and having an assigned coefficient of 0.84, was connected to an inclined-vertical manometer. The pitot tube was inserted into the duct and the velocity pressure (Δp) was recorded at each traverse point. The effluent gas temperature was also recorded at each traverse point using a Type K thermocouple. The average exhaust gas velocity was calculated from the average square roots of the velocity pressure, average exhaust gas temperature, exhaust gas molecular weight, and absolute stack pressure. The volumetric flow rate is the product of velocity and the stack cross-sectional area of the duct at the sampling location.

5.3 DETERMINATION OF EXHAUST GAS DRY MOLECULAR WEIGHT

EPA Method 3, ***"Gas Analysis for the Determination of Dry Molecular Weight"*** was used to determine exhaust gas dry molecular weight. During each formaldehyde measurement run, an integrated gas bag sample was collected, then analyzed using Fyrite® combustion gas analyzers to determine the carbon dioxide (CO_2) and oxygen (O_2) content. The stack gas dry molecular weight was calculated using the CO_2 and O_2 results.

TABLE 5.1

SUMMARY OF SAMPLING AND ANALYSIS METHODS

Sampling Method	Parameter or Target	Measurement Principle
EPA Method 1 or 1A	Traverse Point Locations	Linear Measurement
EPA Method 2	Velocity and Flow Rate	Differential Pressure, Thermocouple
EPA Method 3	Carbon Dioxide and Oxygen Content	Grab Sample/Fyrite® analysis
EPA Method 4	Moisture Content	Gravimetric
EPA Method 10	Carbon Monoxide	Non-dispersive infrared/Gas filter correlation
EPA Method 316	Formaldehyde	Colorimetric

TABLE 5.2

SUMMARY OF SAMPLING LOCATIONS, TEST PARAMETERS, SAMPLING METHODS, AND NUMBER AND DURATION OF TESTS

Sampling Location	Test Parameter	Sampling Methods	Number of Tests	Duration, (minutes)
S.T. Wooten Franklinton HOS Burner Stack	Exhaust Gas Flow Rate	EPA Method 2	3	72.0
	CO_2 & O_2 Content	EPA Method 3	3	72.0
	Moisture Content	EPA Method 4	3	72.0
	Carbon Monoxide	EPA Method 10	3	72.0
	Formaldehyde	EPA Method 316	3	72.0
S.T. Wooten Clayton HOS Burner Stack	Exhaust Gas Flow Rate	EPA Method 2	3	72.0
	CO_2 & O_2 Content	EPA Method 3	3	72.0
	Moisture Content	EPA Method 4	3	72.0
	Carbon Monoxide	EPA Method 10	3	72.0
	Formaldehyde	EPA Method 316	3	72.0
REA Construction Mallard Creek HOS Burner Stack	Exhaust Gas Flow Rate	EPA Method 2	3	72.0
	CO_2 & O_2 Content	EPA Method 3	3	72.0
	Moisture Content	EPA Method 4	3	72.0
	Carbon Monoxide	EPA Method 10	3	72.0
	Formaldehyde	EPA Method 316	3	72.0
REA Construction N. Mecklenburg HOS Burner Stack	Exhaust Gas Flow Rate	EPA Method 2	3	72.0
	CO_2 & O_2 Content	EPA Method 3	3	72.0
	Moisture Content	EPA Method 4	3	72.0
	Carbon Monoxide	EPA Method 10	3	72.0
	Formaldehyde	EPA Method 316	3	72.0

5.4 DETERMINATION OF EXHAUST GAS MOISTURE CONTENT

EPA Method 4, ***"Determination of Moisture Content in Stack Gases"***, was used to determine the exhaust gas moisture content. EPA Method 4 was performed in conjunction with each EPA Method 316 test run. Integrated, multi-point, isokinetic sampling was performed. Condensed moisture was determined by recording pre-test and post-test weights of the impingers and silica gel. All weighings were performed using an electronic top-loading platform balance with 0.1 gram sensitivity.

5.5 DETERMINATION OF CARBON MONOXIDE EMISSIONS

EPA Method 10, ***"Determination of Carbon Monoxide Emissions From Stationary Sources"*** was used to continuously measure CO concentrations in the stack gas. During each formaldehyde measurement run, a stack gas sample was extracted continuously from the sampling point and analyzed using a non-dispersive infrared analyzer (NDIR) with gas filter correlation (GFC). The NDIR/GFC analyzer was operated on a range of 0-100 parts per million by volume (ppmv). The output signal from the NDIR was monitored using a data logger and chart recorder.

5.6 DETERMINATION OF FORMALDEHYDE EMISSIONS

EPA Method 316, ***"Sampling and Analysis for Formaldehyde Emissions From Stationary Sources in the Mineral Wool and Fiberglass Industries"*** was used to determine formaldehyde concentrations. This method is applicable to the determination of formaldehyde concentrations from stationary sources. Gaseous and particulate pollutants are withdrawn isokinetically from the stack and are collected in high purity water. Formaldehyde present in the emissions is highly soluble in high purity water. The high purity water sample containing formaldehyde is then analyzed using the modified pararosaniline method. Formaldehyde in the sample reacts with acidic pararosanilin and sodium sulfite forming a purple chromophore. The intensity of the purple color, measured spectrophotometrically, provides an accurate and precise measure of the formaldehyde concentration in the sample. Using this method, formaldehyde can be detected as low as 11.3 parts per billion by volume (ppbv) or as high as 23,000,000 ppbv, based on a 1-hour sampling period and a sample volume of 30 cubic feet. The analytical laboratory was able to detect as low as 3.22 ppmv.

At the S.T. Wooten-Franklinton facility the testing was conducted as specified in Section 11.1.2 of EPA Method 1A. The volumetric flow rate and formaldehyde sampling was performed at the same location. To demonstrate that the flow rate was constant (within 10%) when the formaldehyde measurements were made, complete velocity traverses were performed before and after each run. The deviation were then calculated. Method 1A requires the deviation to not exceed 10%. Summarized in Table 5.3 are the measured initial and post-test flow rates and the deviations. The deviations were within the allowable 10% criteria, except for Run No. WF-F-1 where the deviation was 12.6%. Although, the deviation was >10% for this run, we feel

TABLE 5.3

SUMMARY OF VOLUMETRIC FLOW RATE DEVIATIONS HOS BURNER STACK, S.T. WOOTEN - FRANKLINTON

Run No.	WF-F-1	WF-F-2	WF-F-3
Pretest Flow Rate, dscfm[a]	87	76	71
Posttest Flow Rate, dscfm[a]	76	71	75
Deviation	12.6%	6.6%	5.6%
Method 1A Criteria	10%	10%	10%
Acceptable Yes/No	No	Yes	Yes

[a] Dry standard cubic feet per minute at 68°F and 29.92" Hg.

that steady state conditions were demonstrated because these values are within measurement errors at these very low flow rates.

5.7 DETERMINATION OF FUEL USAGE RATES

5.7.1 No. 2 Fuel Oil

The HOS burners at S.T. Wooten's Franklinton and Clayton facilities, and at REA Construction's North Mecklenburg facility were all fired using No. 2 fuel oil. The fuel usage at each plant was determined by HEATEC personnel. During each test run, the fuel pressure was recorded and the type and size of fuel nozzle was documented. Using calibration curves provided by the manufacturer, the fuel oil usage rate was determined.

5.7.2 Natural Gas

The HOS burner at REA Construction's Mallard Creek facility was fired using natural gas. The natural gas usage rate was determined by HEATEC personnel. During each test run, the fuel pressure was recorded and the type and size fuel nozzle was documented. Using calibration curves provided by the manufacturer, the natural gas usage rate was determined.

6.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PROCEDURES AND RESULTS

For any environmental measurement, a degree of uncertainty exists in the data generated due to the inherent limitations of the measurement system employed. The goals of a QA/QC program are to ensure, to the highest degree possible, the accuracy of the data collected. This section summarizes the QA/QC procedures that were employed by MACTEC in the performance of this test program. The procedures contained in the reference test methods and in the "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods," EPA/600/R-94/038c, served as the basis for performance for all testing and related work activities in this project.

6.1 CALIBRATION AND PREPARATION OF APPARATUS

The preparation and calibration of source sampling equipment is essential in maintaining data quality. Brief descriptions of the calibration procedures used by MACTEC are presented below. The results of equipment and sensor calibrations may be found in Appendix D. Detailed procedures, as presented in the EPA test methods, are contained in Appendix E.

6.1.1 Barometers

MACTEC used aneroid barometers which were calibrated against a barometric pressure reported by a nearby National Weather Service station.

6.1.2 Temperature Sensors

Bimetallic dial thermometers and Type K thermocouples were calibrated using the procedure described in Calibration Procedure 2e of EPA/600/R-94/038c. Each temperature sensor was calibrated over the expected range of use against an ASTM 3C or 3F thermometer. Table 6.1 summarizes the type of calibrations performed, the acceptable levels of variance, and the results. Digital thermocouple displays were calibrated using a thermocouple simulator having a range of 0-2400°F.

6.1.3 Pitot Tubes

MACTEC used Type S pitot tubes constructed according to EPA Method 2 specifications. Each pitot tube was inspected for conformance to the geometric specifications by the application of Calibration Procedure 2 of EPA/600/R-94/038c. Pitot tubes that meet these requirements are

TABLE 6.1

SUMMARY OF TEMPERATURE SENSOR CALIBRATION DATA

Temp. Sensor I.D.	Usage	Temperature, °R		Temperature Difference	Tolerances
		Reference	Sensor		
104-3A	Stack Gas	492 520 672	494 520 670	0.4% 0.0% 0.3%	<±1.5% <±1.5% <±1.5%
RT-14	Stack Gas	492 532 670	493 532 671	0.2% 0.0% 0.15%	<±1.5% <±1.5% <±1.5%
RMB-15	Meter Box Inlet	492 534 668	493 536 670	0.2% 0.37% 0.30%	<±1.0% <±1.0% <±1.0%
	Outlet	492 536 669	492 536 670	0.00% 0.00% 0.15%	<±1.0% <±1.0% <±1.0%
SH-1	Impinger Exit	492 536 668	492 536 668	0.00% 0.00% 0.00%	<±1.0% <±1.0% <±1.0%
SH-4	Impinger Exit	497 532 670	496 535 669	0.2% 0.56% 0.15%	<±1.0% <±1.0% <±1.0%
SH-5	Impinger Exit	492 531 667	493 531 667	0.20% 0.00% 0.00%	<±1.0% <±1.0% <±1.0%

assigned a pitot coefficient, C_p , of 0.84. The dimensional criteria and results for each pitot tube used are presented in Table 6.2.

6.1.4 Differential Pressure Gauges

MACTEC used Dwyer inclined/vertical manometers to measure differential pressures. The differential pressure measurements included velocity pressure, static pressure, and meter orifice pressure. Manometers were selected with sufficient sensitivity to accurately measure pressures over the entire range of expected values. Manometers are primary standards and require no calibration.

6.1.5 EPA Method 316 Dry Gas Meter and Orifice

The EPA Method 316 dry gas meter and orifice were calibrated in accordance with Sections 5.3.1 and 5.3.2 of EPA Method 5. This procedure involves direct comparison of the metered volume passed through the dry gas meter to a reference dry test meter. The reference dry test meter is calibrated annually using a wet test meter. Before its initial use in the field and annually thereafter, the metering system is calibrated over the entire range of operation as specified in EPA Method 5.

Acceptable tolerances for the individual dry gas meter correction factor (γ) and orifice calibration factor ($\Delta H_{@}$) during initial or annual calibrations are ± 0.02 and ± 0.20 from the average, respectively. After field use, a calibration check of the metering system was performed at a single intermediate setting based on the previous field test. The post-test calibration check of the dry gas meter correction factor must agree within 5% of the correction factor generated during the initial or annual calibration. The calibration results for the gas meter and orifice used in this test program is summarized in Table 6.3. All calibration check results were within allowable tolerances.

6.2 ON-SITE SAMPLING

The on-site QA/QC activities included:

6.2.1 Measurement Sites

Prior to sampling, each stack was checked dimensionally to determine measurement site locations, location of velocity and sample test ports, inside stack dimensions, and sample traverse point locations. Inside stack dimensions were checked through both traverse axes to confirm uniformity of the stack inside diameter. The inside stack dimensions, wall thickness, and sample port depths were measured to the nearest 0.1 inch.

TABLE 6.2

SUMMARY OF PITOT TUBE DIMENSIONAL DATA

Measurement	Criteria	Results Pitot Tube Identification RP-10	 104-3A
α_1	<10°	0	0
α_2	<10°	0	1
β_1	<5°	0	0
β_2	<5°	2	0
Υ	-	0	1
θ	-	0	0
A	-	1.031	.945
z	$\leq 0.125''$	0.000	0.017
w	$\leq 0.0313''$	0.000	0.000
D_t	$0.1875'' \leq D_t \leq 0.375''$	0.375	0.374
$(A/2)/D_t$	$1.05 \leq (A/2)/D_t \leq 1.50$	1.37	1.26
	Acceptable	Yes	Yes
	Assigned Coefficient	0.84	0.84

TABLE 6.3

SUMMARY OF DRY GAS METER AND ORIFICE CALIBRATION DATA

Meter No.	Dry Gas Meter Correction Factor, γ				Orifice Coefficient, $\Delta H_@$		
	Pre-test	Post-test	% Diff.	EPA Criteria	Average	Range	EPA Criteria
RMB-15	0.991	0.992	-0.001	± 5%	1.83	1.73 - 1.86	1.63 - 2.06

6.2.2 Velocity Measurements

All velocity measurement apparatus were assembled, leveled, zeroed, and leak-checked prior to use and at the end of each determination. The static pressure was determined at a single point near the center of the stack or duct cross-section.

6.2.3 Moisture

The Method 316 trains were used to determine stack gas moisture. During sampling, the exit gas of the last impinger was maintained below 68°F to ensure adequate condensation of the exhaust gas water vapor. The total condensate collected was determined on-site gravimetrically using an electronic platform balance with 0.1 gram sensitivity.

6.2.4 EPA Method 316

The sample trains were leak checked before and after each test run. All leak checks were within allowable limits. Sampling was conducted within the isokinetic sampling criteria of 100 ± 10%. Table 6.4 summarizes the EPA Method 316 sample team leak checks and Table 6.5 summarizes the EPA Method 316 isokinetic sampling ratios.

In addition to the samples, one field blank sample was collected at each of the four facilities. A Method 316 sampling train was assembled and transported to the sampling location, and leak-checked two times. The sample train was then recovered using the same procedures employed during the recovery of the sample trains used during actual sample runs. The collected fractions were transferred to labeled, pre-cleaned sample bottles, transported to the subcontract laboratory, and analyzed in the same manner as the collected samples.

MACTEC also collected samples of the water that was used during the program as blanks. These water blank samples were transported to the subcontract laboratory and analyzed for formaldehyde using the same procedures used for the samples.

6.2.5 EPA Method 10

EPA Method 10 does not provide measurement system performance criteria. Therefore, for Method 10, MACTEC used the measurement system performance criteria specified in EPA Method 6C. Table 6.6 summarizes the Protocol calibration gases used. Tables 6.7 through 6.9 summarize the measurement system performance criteria and the results, specifically calibration error tests (Table 6.7), bias checks (Table 6.8), and calibration drift (Table 6.9). All criteria were met.

TABLE 6.4

SUMMARY OF METHOD 316 SAMPLE TRAIN LEAK CHECKS

	Run No.	Leak Check		EPA Criteria @max. vac	Pass/Fail
		Pretest	Post-Test		
S.T. Wooten Franklinton	WF-F-1	0.00@15" Hg	0.00@4" Hg	0.02@4" Hg	Pass
	WF-F-2	0.00@15" Hg	0.00@4" Hg	0.02@4" Hg	Pass
	WF-F-3	0.003@15" Hg	0.00@4" Hg	0.02@4" Hg	Pass
	WF-F-FB	0.000@15" Hg	0.000@15" Hg	0.02@15" Hg	Pass
S.T. Wooten Clayton	WC-F-1	0.002@15" Hg	0.002@7" Hg	0.02@2" Hg	Pass
	WC-F-2	0.000@15" Hg	0.000@8" Hg	0.02@2" Hg	Pass
	WC-F-3	0.000@15" Hg	0.000@7" Hg	0.02@2" Hg	Pass
	WC-F-FB	0.002@15" Hg	0.000@15" Hg	0.02@15" Hg	Pass
REA Mallard Creek	MC-F-1	0.005@15" Hg	0.002@10" Hg	0.02@2" Hg	Pass
	MC-F-2	0.005@15" Hg	0.005@12" Hg	0.02@2" Hg	Pass
	MC-F-3	0.002@15" Hg	0.000@9" Hg	0.02@1" Hg	Pass
	MC-F-FB	0.02@15" Hg	0.015@15" Hg	0.02@15" Hg	Pass
REA N. Mecklenburg	NM-F-1	0.002@15" Hg	0.002@5" Hg	0.02@5" Hg	Pass
	NM-F-2	0.001@15" Hg	0.001@5" Hg	0.02@5" Hg	Pass
	NM-F-3	0.001@15" Hg	0.002@5" Hg	0.02@5" Hg	Pass
	NM-F-FB	0.000@15" Hg	0.001@5" Hg	0.02@5" Hg	Pass

TABLE 6.5

SUMMARY OF METHOD 316 ISOKINETIC SAMPLING RATIOS

Facility	Run No.	% Isokinetic		Pass/Fail
		Actual	EPA Criteria	
S.T. Wooten Franklinton	WF-F-1	103.8	90-110	Pass
	WF-F-2	105.7	90-110	Pass
	WF-F-3	106.2	90-110	Pass
S.T. Wooten Clayton	WC-F-1	98.4	90-110	Pass
	WC-F-2	95.2	90-110	Pass
	WC-F-3	101.5	90-110	Pass
REA Mallard Creek	MC-F-1	104.1	90-110	Pass
	MC-F-2	102.5	90-110	Pass
	MC-F-3	103.1	90-110	Pass
REA N. Mecklenburg	NM-F-1	103.1	90-110	Pass
	NM-F-2	100.2	90-110	Pass
	NM-F-3	100.5	90-110	Pass

TABLE 6.6

SUMMARY OF METHOD 10 CARBON MONOXIDE CALIBRATION GAS CYLINDERS

Cylinder Number	Contents	Expiration Date
CC87402	30.08 ppm CO in nitrogen	9/20/04
CC87521	59.39 ppm CO in nitrogen	11/17/05
CC17861	88.8 ppm CO in nitrogen	11/17/05

TABLE 6.7

SUMMARY OF EPA METHOD 10 CALIBRATION ERROR TESTS

Calibration Error, %							
Facility	**Date 2003**	**Zero**	**Low**	**Mid**	**High**	**EPA Criteria**	**Pass/Fail**
S.T. Wooten - Franklinton	3/25	0.00	-0.78	-1.39	0.00	± 2	Pass
S.T. Wooten - Clayton	3/27	0.10	-0.78	-1.29	-0.50	± 2	Pass
REA - Mallard Creek	4/1	0.00	-0.78	-1.39	-0.20	± 2	Pass
REA - North Mecklenburg	4/2	0.00	-1.18	-1.89	0.00	± 2	Pass
	4/3	0.00	-0.88	-1.49	0.10	± 2	Pass

TABLE 6.8

SUMMARY OF EPA METHOD 10 BIAS CHECKS

Bias Checks, %					
Facility	**Date 2003**	**Zero**	**Low**	**EPA Criteria**	**Pass/Fail**
S.T. Wooten - Franklinton	3/25	0.00	-0.40	± 5	Pass
S.T. Wooten - Clayton	3/27	-0.10	-1.30	± 5	Pass
REA - Mallard Creek	4/1	0.00	-1.40	± 5	Pass
REA - North Mecklenburg	4/2	0.00	-0.20	± 5	Pass
	4/3	0.20	-0.20	± 5	Pass

TABLE 6.9

SUMMARY OF EPA METHOD 10 CALIBRATION DRIFT TESTS

Calibration Drift, %						
Facility	**Date**	**Run No.**	**Zero**	**Span**	**EPA Criteria**	**Pass/Fail**
S.T. Wooten - Franklinton	3/25	1	0.10	1.10	± 3	Pass
		2	0.50	0.40	± 3	Pass
		3	0.00	0.00	± 3	Pass
S.T. Wooten - Clayton	3/27	1	0.10	0.10	± 3	Pass
		2	0.10	0.30	± 3	Pass
		3	0.00	0.00	± 3	Pass
REA - Mallard Creek	4/1	1	0.20	1.80	± 3	Pass
		2	0.70	0.30	± 3	Pass
		3	0.10	0.40	± 3	Pass
REA - North Mecklenburg	4/2	1	0.50	1.00	± 3	Pass
	4/3	2	0.30	0.40	± 3	Pass
	4/3	3	0.20	1.10	± 3	Pass

6.3 LABORATORY ANALYSES

6.3.1 Analysis of Blank Samples

The reagent blank was analyzed and found to contain < 0.546 micrograms (µg) of formaldehyde. Based on the lowest sample volume obtained (0.950 dscm), the reagent blank concentration was < 0.41 ppbv. This value is very low.

6.3.2 Method 316 Field Blank

One Method 316 field blank was collected at each facility. One complete sampling train was assembled in the field staging area, taken to the sampling site, and leak-checked for the same total number of times as the actual sampling train. No gaseous sample was passed through the field blank sampling trains. The results of the field blank analyses are shown in Table 6.10.

TABLE 6.10

SUMMARY OF METHOD 316 FIELD BLANK ANALYSES

Location	Run No.	µg Formaldehyde
S.T. Wooten - Franklinton	WF-F-FB(A) WF-F-FB(B)	< 0.929 < 1.15
S.T. Wooten - Clayton	WC-F-FB(A) WC-F-FB(B)	< 2.02 < 0.302
REA - Mallard Creek	MC-F-FB(A) MC-F-FB(B)	< 1.37 < 1.37
REA - North Mecklenburg	NM-F-FB(A) NM-F-FB(B)	2.09 1.24

6.3.3 Laboratory Spikes

Two laboratory spikes were performed, one for the S.T. Wooten-Franklinton and Clayton facilities, and one for the REA Construction-Mallard Creek and North Mecklenburg facilities. The results are shown below:

S.T. Wooten	91.8% Recovery
REA Construction	89.9% Recovery

These values are well within the ± 30% limits specified in Method 316.

APPENDIX A

PROCESS DATA

HEATEC
AN ASTEC CO.

P.O. BOX 72760
CHATTANOOGA, TN 37407

TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 7-30-83
PAGE 1 OF 9
COMPANY: MAc Tec
FAX NO.: 919-941-0234
ATTENTION: FRANK Meadows
FROM: Ron Henry
SUBJECT: BAck-up information for Emissions Test

Power Flame MANUAL
Pages - C30, C31, C32

Honeywell MANUAL - V5055
GAS Valves
Page 3

HEATEC
AN ASTEC CO.

P.O. BOX 72760
CHATTANOOGA, TN 37407

TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 3- -03

PAGE ___ OF ___

COMPANY: S.T. Wooten

FAX NO.: ___

ATTENTION: ___

FROM: ___

SUBJECT: NAPA Test - Clayton, NC

HC-120
H00-130

Nozzle - 6.5 gph 80° BPS HAGO

Pump pressure - 285#
Return Pressure - 170#

APPROX.
GPH - 8.5

Burner - Power Flame - C2-GO-15
Serial Number - 050094409
Invoice Number - 204106

~~7:50 Am~~	Hi Temp	Mod. Cont.	WATER Temp	Oil inlet	Oil outlet	Burn Out
7:50 Am	355	345	76°			0%
8:15 Am	348	325	85			100%
8:30 Am	348	325	93	291	243	
8:50 Am	348	325	104	293	244	
9:30 Am	349	326	119	291	246	
10:00 Am	352	329	132	296	251	
10:40 Am	356	333	146	296	253	
11:05 Am	357	334	155	298	258	
1:30 pm	369	347	195	308	270	
2:05 pm	370	348	203	301	267	
3:18 pm	370	348	207	309	271	
335 pm	367	345	206	304	269	

7. High turn down ratios are a distinct advantage of internal bypass systems. It is possible, however, to adjust for a low fire so small that the flame is being *chilled*. The fire will look excellent and appear bright and uniform, but a combustion efficiency test will reveal high smoke content and low CO_2. To correct this situation, increase the oil flow or decrease the air, or both. Be sure to test with proper instruments to ensure good, clean efficient combustion throughout the firing range.

Figure 29

Internal Bypass Oil Nozzle Components

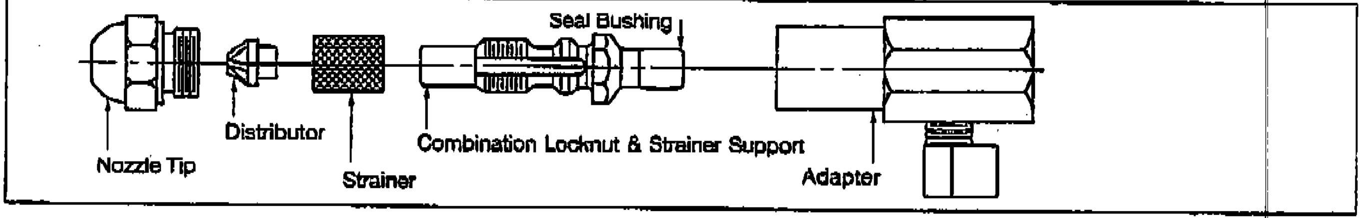

Table 8

Internal Bypass (Return Flow) Nozzle Data

HAGO

Nozzle Size 100 PSIG Nominal Rating GPH #2 Fuel Oil By-Pass (Return) Closed	Supply Pressure to Nozzle 300 PSIG at All Rates*							
	[redacted]	Approx. High Fire By-Pass (Return) Pressure PSIG By-Pass (Return) Closed	Reduced Firing Rates					
			[redacted]	Approx. Firing Rate GPH	[redacted]	Approx. Firing Rate GPH	[redacted]	Approx. Firing Rate GPH
4.5	[redacted]	207	[redacted]	5.5	[redacted]	4.4	[redacted]	3.1
5.0	[redacted]	196	[redacted]	5.9	[redacted]	4.4	[redacted]	2.8
5.5	[redacted]	209	[redacted]	7.0	[redacted]	5.2	[redacted]	3.6
6.0	[redacted]	190	[redacted]	7.0	[redacted]	5.1	[redacted]	3.1
6.5	[redacted]	195	[redacted]	7.6	[redacted]	5.2	[redacted]	3.4
7.0	[redacted]	202	[redacted]	7.1	[redacted]	5.1	[redacted]	3.5
7.5	[redacted]	181	[redacted]	10.0	[redacted]	7.1	[redacted]	4.8
8.0	[redacted]	197	[redacted]	11.6	[redacted]	8.2	[redacted]	5.5
9.0	[redacted]	200	[redacted]	12.5	[redacted]	8.9	[redacted]	6.0
9.5	[redacted]	178	[redacted]	12.0	[redacted]	8.0	[redacted]	5.1
10.0	[redacted]	202	[redacted]	13.8	[redacted]	9.6	[redacted]	6.3
10.5	[redacted]	202	[redacted]	11.4	[redacted]	8.0	[redacted]	5.4
11.0	[redacted]	203	[redacted]	11.4	[redacted]	11.4	[redacted]	7.9
11.5	[redacted]	192	[redacted]	17.6	[redacted]	12.8	[redacted]	8.5
12.0	[redacted]	194	[redacted]	18.1	[redacted]	13.0	[redacted]	9.1
12.5	[redacted]	196	[redacted]	18.6	[redacted]	13.4	[redacted]	8.9
13.0	[redacted]	205	[redacted]	17.8	[redacted]	12.9	[redacted]	8.8
13.5	[redacted]	192	[redacted]	21.0	[redacted]	14.8	[redacted]	10.5
14.0	[redacted]	208	[redacted]	18.9	[redacted]	13.3	[redacted]	8.5
14.5	[redacted]	207	[redacted]	18.6	[redacted]	14.1	[redacted]	9.2
15.0	[redacted]	199	[redacted]	21.8	[redacted]	15.6	[redacted]	10.4
16.0	[redacted]	190	[redacted]	24.9	[redacted]	18.2	[redacted]	11.9
17.0	[redacted]	206	[redacted]	23.4	[redacted]	16.9	[redacted]	11.5
17.5	[redacted]	204	[redacted]	24.4	[redacted]	18.1	[redacted]	12.2
18.0	[redacted]	206	[redacted]	20.0	[redacted]	15.3	[redacted]	11.1
19.0	[redacted]	202	[redacted]	27.8	[redacted]	20.2	[redacted]	14.1
19.5	[redacted]	185	[redacted]	24.3	[redacted]	17.1	[redacted]	11.3
20.0	[redacted]	185	[redacted]	26.5	[redacted]	18.3	[redacted]	12.1
21.0	[redacted]	190	[redacted]	26.2	[redacted]	18.8	[redacted]	13.1
21.5	[redacted]	192	[redacted]	26.8	[redacted]	18.4	[redacted]	12.8
22.0	[redacted]	192	[redacted]	26.0	[redacted]	19.6	[redacted]	13.6
24.0	[redacted]	190	[redacted]	29.7	[redacted]	21.7	[redacted]	15.1
26.0	[redacted]	198	[redacted]	29.5	[redacted]	22.1	[redacted]	15.8
28.0	[redacted]	198	[redacted]	31.6	[redacted]	23.8	[redacted]	17.9
30.0	[redacted]	196	[redacted]	35.9	[redacted]	28.3	[redacted]	21.6
32.0	[redacted]	192	[redacted]	40.3	[redacted]	31.2	[redacted]	23.9
35.0	[redacted]	205	[redacted]	40.1	[redacted]	26.1	[redacted]	22.5
40.0	[redacted]	196	[redacted]	49.3	[redacted]	31.9	[redacted]	27.8
45.0	[redacted]	188	[redacted]	61.9	[redacted]	43.8	[redacted]	39.7
50.0	[redacted]	175	[redacted]	73.7	[redacted]	51.2	[redacted]	46.1

T. T. Wate
Clayton, NC

HEATEC
AN ASTEC CO.

P.O. BOX 72760
CHATTANOOGA, TN 37407

TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 3-25-03
PAGE ___ OF ___
COMPANY: S. T. Wooten
FAX NO.: ___
ATTENTION: ___
FROM: R. Henry
SUBJECT: NAPA Test

S. T. Wooten - Franklinton - 500,000 BTU
booster heater. Job #
Nozzle - 300 gph 45° PLP - Monarch
PCA - Memory 0 - before Adjustment
Memory 1 - After Adjustment
PF-1 burner Pump pressure - 100#

DELAVAN VARI-FLO 30630 and 30637

Nozzle Data	Supply Pressure to Nozzle 300 PSIG at All Rates Except Alternate Firing*	Alternate Firing		
Nozzle Size 300 PSIG Nominal Rating GPH #2 Fuel Oil By-Pass (Return) Closed	Approx. High Fire Rate GPH 300 PSIG By-Pass (Return) Closed	Approx. Alternate Nozzle Pressure PSIG	Approx. By-Pass (Return) Pressure PSIG	Approx. By-Pass (Return) Pressure PSIG
35.0	35.0	-	140	100
37.5	37.5	-	140	100
40.0	40.0	-	140	100
45.0	45.0	-	140	100
50.0	50.0	-	-	86
55.0	55.0	-	91	-
60.0	60.0	-	94	-
65.0	65.0	-	85	-
70.0	70.0	-	88	-
80.0	-	265	78	-
80.0	-	260	85	-
80.0	-	280	90	-
80.0	80.0	-	65	-
90.0	-	260	90	-
90.0	-	280	85	-
90.0	90.0	-	80	-
100.0	-	260	90	-
100.0	-	280	90	-
100.0	100.0	-	90	-
125.0	-	260	90	-
125.0	-	280	90	-
125.0	125.0	-	90	-
150.0	-	260	90	-
150.0	-	280	90	-
150.0	150.0	-	90	-

* When Supply Pressure to Nozzle is Lower Than 300 PSIG the By-Pass(Return) and Firing Rates Will be Reduced Somewhat. Consult Factory for Further Information.

Table 9

OIL NOZZLE FLOW RATES

Simplex Nozzle System (Monarch PLP or Equivalent Solid or Semi Solid)
Flow Rate vs Pressure

Capacity in GPH #2 Oil

Wooten
anklinton, NC

100# Nominal Rating	140#	180#	220#	260#	300#
2	2.3	2.6	2.9	3.1	3.3
2.5	2.8	3.2	3.6	3.8	4.1
3	3.4	3.8	4.2	4.7	5.0
3.5	3.9	4.6	4.9	5.4	5.9
4	4.5	5.1	5.6	6.2	6.7
4.5	5.0	5.7	6.3	7.0	7.4
5	5.6	6.4	7.1	7.7	8.2
5.5	6.1	7.0	7.7	8.4	9.1
6	6.7	7.7	8.5	9.2	9.9
6.5	7.2	8.3	9.2	10.0	10.7
7	7.9	9.0	9.9	10.7	11.4
7.5	8.5	9.6	10.5	11.5	12.2
8	9.1	10.3	11.3	12.3	13.0
9	10.1	11.5	12.8	13.9	14.8
10	11.2	12.8	14.2	15.4	16.6
11	12.5	14.2	15.6	17.0	18.2
12	13.6	15.3	17.0	18.5	19.8

Oil Nozzle Servicing

1. Nozzles used on Power Flame Type C burners are of two types: simplex and internal bypass. The simplex nozzle is normally used on smaller burners in the three to eight gallons per hour range. The bypass nozzle is used for larger inputs requiring higher turndown or more sophisticated air/fuel control. Both types of nozzles have GPH ratings stamped on the side. Stamped ratings are based on 100 psig except

TYPICAL PARAMETERS OF VARIOUS FUELS[a]

Type of Fuel	Heating Value		Sulfur	Ash
	kcal	BTU	% (by weight)	% (by weight)
Solid Fuels				
Bituminous Coal	7,200/kg	13,000/lb	0.6-5.4	4-20
Anthracite Coal	6,810/kg	12,300/lb	0.5-1.0	7.0-16.0
Lignite (@ 35% moisture)	3,990/kg	7,200/lb	0.7	6.2
Wood (@ 40% moisture)	2,880/kg	5,200/lb	N	1-3
Bagasse (@ 50% moisture)	2,220/kg	4,000/lb	N	1-2
Bark (@ 50% moisture)	2,492/kg	4,500/lb	N	1-3[b]
Coke, Byproduct	7,380/kg	13,300/lb	0.5-1.0	0.5-5.0
Liquid Fuels				
Residual Oil	$9.98 \times 10^6/m^3$	150,000/gal	0.5-4.0	0.05-0.1
Distillate Oil	$9.30 \times 10^6/m^3$	140,000/gal	0.2-1.0	N
Diesel	$9.12 \times 10^6/m^3$	137,000/gal	0.4	N
Gasoline	$8.62 \times 10^6/m^3$	130,000/gal	0.03-0.04	N
Kerosene	$8.32 \times 10^6/m^3$	135,000/gal	0.02-0.05	N
Liquid Petroleum Gas	$6.25 \times 10^6/m^3$	94,000/gal	N	N
Gaseous Fuels				
Natural Gas	$9{,}341/nm^3$	1,050/SCF	N	N
Coke Oven Gas	$5{,}249/nm^3$	590/SCF	0.5-2.0	N
Blast Furnace Gas	$890/nm^3$	100/SCF	N	N

[a] N = negligible.

[b] Ash content may be considerably higher when sand, dirt, etc. are present.

Source: AP-42, Appendix A

HEATEC
AN ASTEC CO.

P.O. BOX 72760
CHATTANOOGA, TN 37407

TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 7-30-83
PAGE 1 OF 9
COMPANY: MAC Tec
FAX NO.: 919-941-0234
ATTENTION: FRANK Meadows
FROM: Ron Henry
SUBJECT: BACK-up information for Emissions Test

Power Flame MANUAL
Pages - C30, C31, C32

Honeywell MANUAL - V5055 GAS Valves
Page 3

HEATEC
AN ASTEC CO.

P.O. BOX 72760
CHATTANOOGA, TN 37407

TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 3- -03
PAGE ___ OF ___
COMPANY: S.T. Wooten
FAX NO.:
ATTENTION:
FROM:
SUBJECT: NAPA Test - Clayton, NC

HC-120
H00-130

Nozzle - 6.5 gph 80° BPS HAGO

Pump pressure - 285#
Return Pressure - 170#

Approx.
GPH - 8.5

Burner - Power Flame - C2-GO-15
Serial Number - 050094409
Invoice Number - 204106

~~7:50 Am~~	Hi Temp	Mod. Cont.	Water Temp	Oil inlet	oil outlet	Bur Out
7:50 Am	355	345	76°			0%
8:15 Am	348	325	85			100%
8:30 Am	348	325	93	291	243	
8:50 Am	348	325	104	293	244	
9:30 Am	349	326	119	291	246	
10:00 Am	352	329	132	296	251	
10:40 Am	356	333	146	296	253	
11:05 Am	357	334	155	298	258	
1:30 pm	369	347	195	308	270	
2:05 pm	370	348	203	301	267	
3:18 pm	370	348	207	309	271	
335 pm	367	345	206	304	269	

7. High turn down ratios are a distinct advantage of internal bypass systems. It is possible, however, to adjust for a low fire so small that the flame is being *chilled*. The fire will look excellent and appear bright and uniform, but a combustion efficiency test will reveal high smoke content and low CO_2. To correct this situation, increase the oil flow or decrease the air, or both. Be sure to test with proper instruments to ensure good, clean efficient combustion throughout the firing range.

Figure 29

Internal Bypass Oil Nozzle Components

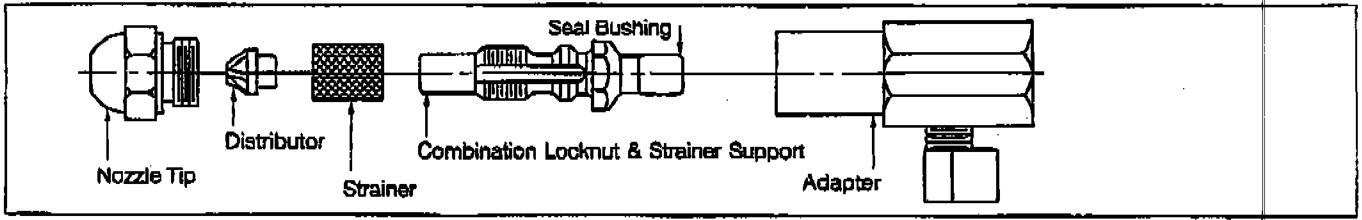

Table 8

Internal Bypass (Return Flow) Nozzle Data

HAGO

T. Wooten
Clayton, NC

Nozzle Size 100 PSIG Nominal Rating GPH #2 Fuel Oil By-Pass (Return) Closed	Supply Pressure to Nozzle 300 PSIG at All Rates*							
	[redacted]	Approx. High Fire By-Pass (Return) Pressure PSIG By-Pass (Return) Closed	Reduced Firing Rates					
			[redacted]	Approx. Firing Rate GPH	[redacted]	Approx. Firing Rate GPH	[redacted]	Approx. Firing Rate GPH
4.5	[redacted]	207	[redacted]	5.5	[redacted]	4.4	[redacted]	3.1
5.0	[redacted]	196	[redacted]	5.9	[redacted]	4.4	[redacted]	2.8
5.5	[redacted]	209	[redacted]	7.0	[redacted]	5.2	[redacted]	3.6
6.0	[redacted]	190	[redacted]	7.0	[redacted]	5.1	[redacted]	3.1
6.5	[redacted]	195	[redacted]	7.6	[redacted]	5.2	[redacted]	3.4
7.0	[redacted]	202	[redacted]	7.1	[redacted]	5.1	[redacted]	3.5
7.5	[redacted]	181	[redacted]	10.0	[redacted]	7.1	[redacted]	4.8
8.0	[redacted]	197	[redacted]	11.6	[redacted]	8.2	[redacted]	5.5
9.0	[redacted]	200	[redacted]	12.5	[redacted]	8.9	[redacted]	6.0
9.5	[redacted]	178	[redacted]	12.0	[redacted]	8.0	[redacted]	5.1
10.0	[redacted]	202	[redacted]	13.8	[redacted]	9.6	[redacted]	6.3
10.5	[redacted]	202	[redacted]	11.4	[redacted]	8.0	[redacted]	5.4
11.0	[redacted]	203	[redacted]	11.4	[redacted]	11.4	[redacted]	7.9
11.5	[redacted]	192	[redacted]	17.8	[redacted]	12.8	[redacted]	8.5
12.0	[redacted]	194	[redacted]	18.1	[redacted]	13.0	[redacted]	9.1
12.5	[redacted]	196	[redacted]	18.6	[redacted]	13.4	[redacted]	8.9
13.0	[redacted]	205	[redacted]	17.8	[redacted]	12.9	[redacted]	8.8
13.5	[redacted]	192	[redacted]	21.0	[redacted]	14.8	[redacted]	10.5
14.0	[redacted]	208	[redacted]	18.9	[redacted]	13.3	[redacted]	8.5
14.5	[redacted]	207	[redacted]	18.6	[redacted]	14.1	[redacted]	9.2
15.0	[redacted]	199	[redacted]	21.8	[redacted]	15.6	[redacted]	10.4
16.0	[redacted]	190	[redacted]	24.9	[redacted]	18.2	[redacted]	11.9
17.0	[redacted]	206	[redacted]	23.4	[redacted]	16.9	[redacted]	11.5
17.5	[redacted]	204	[redacted]	24.4	[redacted]	18.1	[redacted]	12.2
18.0	[redacted]	206	[redacted]	20.0	[redacted]	15.3	[redacted]	11.1
19.0	[redacted]	202	[redacted]	27.8	[redacted]	20.2	[redacted]	14.1
19.5	[redacted]	185	[redacted]	24.3	[redacted]	17.1	[redacted]	11.3
20.0	[redacted]	185	[redacted]	26.5	[redacted]	18.3	[redacted]	12.1
21.0	[redacted]	190	[redacted]	26.2	[redacted]	18.8	[redacted]	13.1
21.5	[redacted]	192	[redacted]	26.8	[redacted]	18.4	[redacted]	12.8
22.0	[redacted]	192	[redacted]	26.0	[redacted]	19.6	[redacted]	13.6
24.0	[redacted]	190	[redacted]	29.7	[redacted]	21.7	[redacted]	15.1
26.0	[redacted]	198	[redacted]	29.5	[redacted]	22.1	[redacted]	15.8
28.0	[redacted]	198	[redacted]	31.6	[redacted]	23.8	[redacted]	17.9
30.0	[redacted]	196	[redacted]	35.9	[redacted]	28.3	[redacted]	21.6
32.0	[redacted]	192	[redacted]	40.3	[redacted]	31.2	[redacted]	23.9
35.0	[redacted]	205	[redacted]	40.1	[redacted]	26.1	[redacted]	22.5
40.0	[redacted]	198	[redacted]	49.3	[redacted]	31.9	[redacted]	27.8
45.0	[redacted]	188	[redacted]	61.9	[redacted]	43.8	[redacted]	39.7
50.0	[redacted]	175	[redacted]	73.7	[redacted]	51.2	[redacted]	46.1

HEATEC
AN ASTEC CO.
P.O. BOX 72760
CHATTANOOGA, TN 37407
TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 3-25-03
COMPANY: S.T. Wooten
ATTENTION:
SUBJECT: NAPA Test
PAGE ___ OF ___
FAX NO.:
FROM: R. Henry

S.T. Wooten - Franklinton - 500,000 BTU
booster heater. Job #
Nozzle - 300 gph 45° PLP - Monarch
PCA - Memory 0 - before Adjustment
Memory 1 - After Adjustment
PF-1 burner Pump pressure - 100 #

DELAVAN VARI-FLO 30630 and 30637

Nozzle Data	Supply Pressure to Nozzle 300 PSIG at All Rates Except Alternate Firing*	Alternate Firing		
Nozzle Size 300 PSIG Nominal Rating GPH #2 Fuel Oil By-Pass (Return) Closed	Approx. High Fire Rate GPH 300 PSIG By-Pass (Return) Closed	Approx. Alternate Nozzle Pressure PSIG	Approx. By-Pass (Return) Pressure PSIG	Approx. By-Pass (Return) Pressure PSIG
35.0	35.0	-	140	100
37.5	37.5	-	140	100
40.0	40.0	-	140	100
45.0	45.0	-	140	100
50.0	50.0	-	-	86
55.0	55.0	-	91	-
60.0	60.0	-	94	-
65.0	65.0	-	85	-
70.0	70.0	-	88	-
80.0	-	265	78	-
80.0	-	260	85	-
80.0	-	280	90	-
80.0	80.0	-	65	-
90.0	-	260	90	-
90.0	-	280	85	-
90.0	90.0	-	80	-
100.0	-	260	90	-
100.0	-	280	90	-
100.0	100.0	-	90	-
125.0	-	260	90	-
125.0	-	280	90	-
125.0	125.0	-	90	-
150.0	-	260	90	-
150.0	-	280	90	-
150.0	150.0	-	90	-

* When Supply Pressure to Nozzle is Lower Then 300 PSIG the By-Pass(Return) and Firing Rates Will be Reduced Somewhat. Consult Factory for Further Information.

Table 9

OIL NOZZLE FLOW RATES

Simplex Nozzle System (Monarch PLP or Equivalent Solid or Semi Solid)

Flow Rate vs Pressure

Capacity in GPH #2 Oil

Wooten

anklinton, NC

100# Nominal Rating	140#	180#	220#	260#	300#
2	2.3	2.6	2.9	3.1	3.3
2.5	2.8	3.2	3.6	3.9	4.1
3	3.4	3.8	4.2	4.7	5.0
3.5	3.9	4.5	4.9	5.4	5.9
4	4.5	5.1	5.6	6.2	6.7
4.5	5.0	5.7	6.3	7.0	7.4
5	5.6	6.4	7.1	7.7	8.2
5.5	6.1	7.0	7.7	8.4	9.1
6	6.7	7.7	8.5	9.2	9.9
6.5	7.2	8.3	9.2	10.0	10.7
7	7.9	9.0	9.9	10.7	11.4
7.5	8.5	9.6	10.5	11.5	12.2
8	9.1	10.3	11.3	12.3	13.0
9	10.1	11.5	12.8	13.9	14.8
10	11.2	12.8	14.2	15.4	16.6
11	12.5	14.2	15.6	17.0	18.2
12	13.6	15.3	17.0	18.5	19.8

Oil Nozzle Servicing

1. Nozzles used on Power Flame Type C burners are of two types: simplex and internal bypass. The simplex nozzle is normally used on smaller burners in the three to eight gallons per hour range. The bypass nozzle is used for larger inputs requiring higher turndown or more sophisticated air/fuel control. Both types of nozzles have GPH ratings stamped on the side. Stamped ratings are based on 100 psig except

HEATEC
AN ASTEC CO.

P.O. BOX 72760
CHATTANOOGA, TN 37407

TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 4-1-03
PAGE ____ OF ____
COMPANY: RAE Const.
FAX NO.: 704-548-0181
ATTENTION: Tim Gaddy
FROM:
SUBJECT: NAPA/EPA Test - Mallard Creek Plant

Heater - H90-046 HC-200-C

Burner - Power Flame C2-GO-20A
Serial # - 039048607
Invoice # - 77895

Tee pressure - 2.5" wc
Combustion Chamber - 1" wc
> Steve Groves @ P.F. Says 2500 CF,
(I think more like 1900 CFH.)

Burner on @ 8:53 am

	Hi Temp	Burn. Cont.	Water	Water Tank Inlet Temp	Water Tank outlet temp
8:53 am -	180°	160°	~~77°~~		
9:30 Am -	370°	285	79	272	227
10:AM -	400°	315	89	297	242
10:30 Am -	410°	330	106	302	256
Heater off @ 10:40					
Heater on @ 11:22					
11:22 Am	260°	230	104	204	151
12:00 NOON	410	330	116	316	262
1:30 pm	420	335	136	318	259
2:00 pm	425	340	148	322	264
3:00 pm	430	350	159	322	264
Test over @ 3:00 pm					

Pressure drop Across V-5055 gas valve - .125" wc

Using the chart in the Honeywell manual, we were using ~~1,700,000~~ 1,350,000 BTU hr.

Ambient Operating Temperature Rating:
-40°F to 150°F (-40°C to 66°C); -40°F to 125°F (-40°C to 52°C) when used with V9055.

Table 2. Valve Rated Capacity.

Valve Size (in.)	I.A.S.[a] Rated Capacity	
	cf/h	cu m/hr
3/4	665	18.8
1	960	27.2
1-1/4	1406	39.8
1-1/2	1717	48.6
2	3620	102.5
2-1/2	4250	120.3
3	5230	148.1
4 (V5055A)	10200	288.8
4 (V5055B,C)	9180	259.9

[a] A joint venture of CGA Approvals Inc. and AGA Laboratories.

Material: Die-cast aluminum.

Mounting: Mounts directly in the gas supply line.

Dimensions: See Fig. 2 and 3.

Weight:
3/4, 1, 1-1/4, 1-1/2, in. valve: 4 lb. (1.8 kg).
2 in. valve: 8 lb. (3.6 kg).
2-1/2, 3 in. valve: 11 lb. (5.0 kg).
4 in. valve: 28 lb. (12.7 kg).

CAE Const
Mallard Creek
Pressure Drop
.125" wc

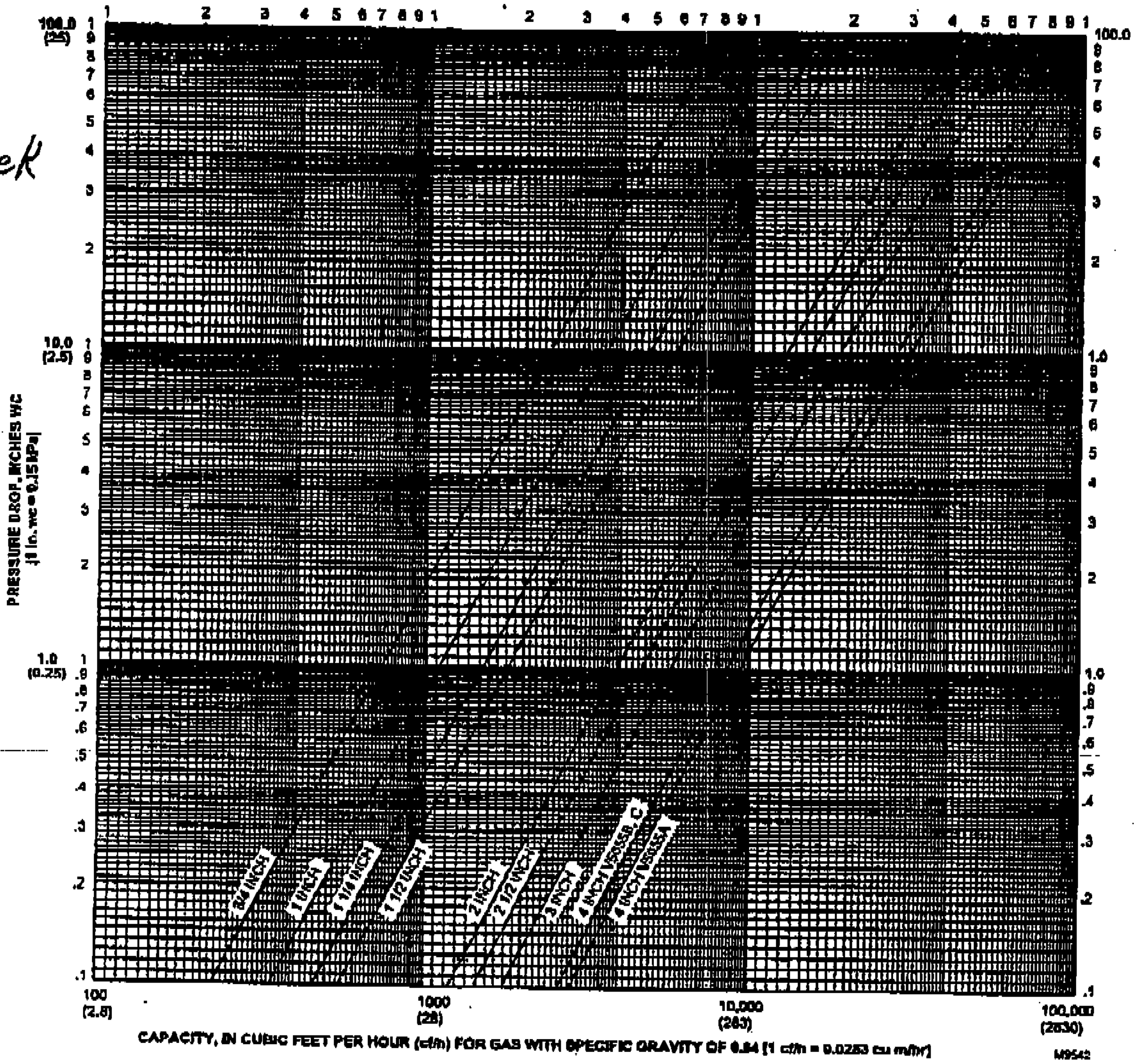

Fig. 1. Flow curves for V5055 Valves.

HEATEC
AN ASTEC CO.

P.O. BOX 72760
CHATTANOOGA, TN 37407

TELEPHONE: 423-821-5200
TELEFAX: 423-821-7673

DATE: 4-3-03
PAGE ____ OF ____
COMPANY: REA Const.
FAX NO.:
ATTENTION:
FROM:
SUBJECT: NAPA Test - North Mecklinburg

Power Flame Burner Model # C2-GO-15
Serial # 100101336
Inv. # 223593

HC-120
HOl-297
7.0 GPH 45° Delavan Nozzle
Pump Press. - 300#
Return Press - 140#

	Hi Temp	Mod. Temp	Water	Oil inlet	Oil outlet
8:20 -	257	202	119	209	193
8:30 -	292	239	120	237	217
9:00 -	345	293	130	295	262
9:30 -	364	313	150	320	285
10:00 -	371	322	158	323	287
10:40 -	378	329	169	324	289
11:05 -	382	334	182	340	302
11:30 -	387	339	191	343	307
11:45 -	390	342	201	348	312

Heater - off @ 11:45

MONARCH

Nozzle Size 100 PSIG Nominal Rating GPH #2 Fuel Oil By-Pass (Return) Closed	Supply Pressure to Nozzle 300 PSIG at All Rates*							
			Reduced Firing Rates					
		Approx. High Fire By-Pass (Return) Pressure PSIG By-Pass (Return) Closed		Approx. Firing Rate GPH		Approx. Firing Rate GPH		Approx. Firing Rate GPH
4.5		205		7.7		3.4		-
5.0		195		7.6		4.9		3.6
5.5		180		4.6		3.5		-
6.0		215		5.9		4.4		3.1
6.5		225		6.3		4.8		3.6
7.0		220		7.9		5.4		3.6
7.5		205		7.6		5.4		4.1
8.0		200		7.7		5.0		3.5
9.0		200		9.1		5.9		3.9
9.5		210		9.4		6.2		4.3
10.5		220		9.8		6.5		4.3
12.0		210		12.5		8.1		4.9
13.5		210		18.5		10.8		6.6
15.5		220		13.9		9.0		6.8
17.5		225		22.4		17.0		10.9
19.5		235		23.6		17.4		10.3
21.5		240		26.4		19.4		11.9
24.0		230		33.4		24.3		14.4
28.0		215		40.2		21.1		11.1
30.0		225		50.6		38.0		23.2
35.0		200		38.0		32.6		15.7
40.0		190		54.3		40.5		22.2
45.0		180		66.0		49.6		29.4
50.0		165		61.9		-		-

DELAVAN VARI-FLO 33769

Nozzle Size 100 PSIG Nominal Rating GPH #2 Fuel Oil By-Pass (Return) Closed	Supply Pressure to Nozzle 300 PSIG at All Rates*							
			Reduced Firing Rates					
		Approx. High Fire By-Pass (Return) Pressure PSIG By-Pass (Return) Closed		Approx. Firing Rate GPH		Approx. Firing Rate GPH		Approx. Firing Rate GPH
4.5		162		5.0		4.0		3.0
5.0		136		7.0		6.0		4.0
5.5		150		8.0		7.0		4.0
6.0		-		-		-		-
6.5		160		9.0		7.0		4.0
7.0		141		10.0		8.0		4.0
8.0		158		10.0		8.0		5.0
9.0		132		10.0		7.5		5.0
9.5		158		10.0		7.5		5.0
10.0		150		-		-		-
12.0		154		16.0		12.0		8.0
14.0		160		17.0		11.0		8.0
16.0		144		17.0		15.0		10.0
18.0		165		22.0		15.0		10.0
20.0		160		24.0		18.0		14.0
22.0		155		27.0		20.0		15.0
24.0		144		30.0		25.0		15.0
26.0		150		35.0		27.0		15.0
28.0		148		40.0		30.0		16.0
30.0		138		40.0		30.0		17.0
35.0		175		40.0		30.0		20.0
40.0		115		45.0		35.0		23.0
45.0		166		60.0		40.0		25.0
50.0		-		-		-		-

EA Const.
ecklinburg
→ 7.0

* When Supply Pressure to Nozzle is Lower Than 300 PSIG the By-Pass (Return) and Firing Rates Will be Reduced Somewhat. Consult Factory for Further Information.

TOTAL P.09

TYPICAL PARAMETERS OF VARIOUS FUELS[a]

Type of Fuel	Heating Value		Sulfur	Ash
	kcal	BTU	% (by weight)	% (by weight)
Solid Fuels				
Bituminous Coal	7,200/kg	13,000/lb	0.6-5.4	4-20
Anthracite Coal	6,810/kg	12,300/lb	0.5-1.0	7.0-16.0
Lignite (@ 35% moisture)	3,990/kg	7,200/lb	0.7	6.2
Wood (@ 40% moisture)	2,880/kg	5,200/lb	N	1-3
Bagasse (@ 50% moisture)	2,220/kg	4,000/lb	N	1-2
Bark (@ 50% moisture)	2,492/kg	4,500/lb	N	1-3[b]
Coke, Byproduct	7,380/kg	13,300/lb	0.5-1.0	0.5-5.0
Liquid Fuels				
Residual Oil	$9.98 \times 10^6/m^3$	150,000/gal	0.5-4.0	0.05-0.1
Distillate Oil	$9.30 \times 10^6/m^3$	140,000/gal	0.2-1.0	N
Diesel	$9.12 \times 10^6/m^3$	137,000/gal	0.4	N
Gasoline	$8.62 \times 10^6/m^3$	130,000/gal	0.03-0.04	N
Kerosene	$8.32 \times 10^6/m^3$	135,000/gal	0.02-0.05	N
Liquid Petroleum Gas	$6.25 \times 10^6/m^3$	94,000/gal	N	N
Gaseous Fuels				
Natural Gas	$9,341/nm^3$	1,050/SCF	N	N
Coke Oven Gas	$5,249/nm^3$	590/SCF	0.5-2.0	N
Blast Furnace Gas	$890/nm^3$	100/SCF	N	N

[a] N = negligible.

[b] Ash content may be considerably higher when sand, dirt, etc. are present.

Source: AP-42, Appendix A

APPENDIX B

RAW FIELD DATA

Appendix B.1

Raw Field Data

S.T. Wooten
Franklinton

PACIFIC ENVIRONMENTAL SERVICES, INC.

Central Park West
5001 South Miami Boulevard, P.O. Box 12077
Research Triangle Park, North Carolina 27709
(919) 941-0333 FAX: (919) 941-0284

EPA METHOD 1 FIELD DATA SHEET
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Facility: ST Wooten - Franklinton, NC
Project No.: 5940.000
Sampling Location: HOS Burner Stack
Date: 3/24/03
Inside of Far Wall to Outside of Nipple, in.: 12 1/4
Inside of Near Wall to Outside of Nipple, in.: 4 1/4
Stack Inside Diameter, in.: 8"
Points Calculated by: MDM
Distance Downstream from Flow Disturbance (Distance B), in.: 17 1/2 / Stack ID = 2.2 duct diameters
Distance Upstream from Flow Disturbance (Distance A), in.: 16 / Stack ID = 2.0 duct diameters

Traverse Point Number	Fraction of Length	Length (inches)	Product of Cols. 2 & 3 (to nearest 1/8 inch)	Nipple Length (inches)	Traverse Point Location (Sum of Col 4 & 5)
1	0.021	8	** 0.168 (1/2)	4 1/4	4.418 (4 3/4)
2	0.067	8	0.536	4 1/4	4.786 (4 3/4)
3	0.118	8	0.944	4 1/4	~~4.012~~ 5.194 ~~5.144~~ 5 1/4
4	0.177	8	1.416	4 1/4	5.666 5 5/8
5	0.250	8	2	4 1/4	6.25 6 1/4
6	0.356	8	2.848	4 1/4	7.098 7 1/8
7	0.644	8	5.152	4 1/4	9.402 9 3/8
8	0.750	8	6	4 1/4	10.25 10 1/4
9	0.823	8	6.584	4 1/4	10.834 10 7/8
10	0.882	8	7.056	4 1/4	11.306 11 3/8
11	0.933	8	7.464	4 1/4	11.714 (11 3/4)
12	0.979	8	** 7.832 (7.5)	4 1/4	12.08 (11 3/4)

SCHEMATIC OF SAMPLING LOCATION:

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EPA METHOD 2 FIELD DATA SHEET

Facility: ST WOOTEN - FRANKLINTON, NC
Sampling Location: HOT Stack
Run # PRELIM M-2
Barometric Pressure, (in. Hg): 29.92
Moisture, (%): ~10
Stack Gas Dry Molecular weight, (g/g-mol): 30.0
Stack Diameter or Side 1 Dimension, (in.): 8"
Wet Bulb Temperature (°F): N/A

Project No.: 5940.000
Date: 3/24/03
Clock Time: 1530
Operators: MDM & NP
Stack Static Pressure, in H_2O: ~ + 0.01
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): -
Dry Bulb Temperature (°F): N/A

Prelim VT
&
Yaw Check

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.03	720	8.4
2	-2	0.03	720	8.4
3	-3	0.04	725	8.6
4	-4	0.04	729	8.5
5	-5	0.03	734	9.1
6	-6	0.02	734	9.1
7	-7	0.02	726	9.2
8	-8	0.02	714	11.0
9	-9	0.015	706	13.2
10	-10	0.015	682	13.4
11	-11	0.015	~670	7.3
12	-12	0.015	~670	5.9
13	B-1	0.02	701	10.1
14	-2	0.02	700	10.1
15	-3	0.02	713	10.1
16	-4	0.02	710	11.3
17	-5	0.02	710	9.1
18	-6	0.01	711	8.4
19	-7	0.01	708	7.3
20	-8	0.01	711	8.1
21	-9	0.02	720	9.2
22	-10	0.03	745	12.0
23	-11	0.04	729	15.1
24	-12	0.04	732	15.9
25				

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EPA METHOD 2 FIELD DATA SHEET

Facility: ST WOOTEN FRANKLINTON, NC
Sampling Location: HOS STACK
Run # WF - F - M2 - 1
Barometric Pressure, (in. Hg): ~~24.5~~ 30.09
Moisture, (%): ~70
Stack Gas Dry Molecular weight, (g/g-mol): 30.0
Stack Diameter or Side 1 Dimension, (in.): 8"
Wet Bulb Temperature (°F): N/A

Project No.: 5940.00
Date: 3/25/03
Clock Time: 0955
Operators: MDM, NP, FM
Stack Static Pressure, in H_2O: + 0.01
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): -
Dry Bulb Temperature (°F): -

Pre-Run 1

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.005	704	
2	-2	0.005	699	
3	-3	0.005	698	
4	-4	0.005	699	
5	-5	0.005	704	
6	-6	0.005	712	
7	-7	0.005	727	
8	-8	0.010	749	
9	-9	0.020	756	
10	-10	0.045	759	
11	-11	0.035	746	
12	-12	0.035	747	
13	B-1	0.030	685	
14	-2	0.030	680	
15	-3	0.040	654	
16	-4	0.030	680	
17	-5	0.020	720	
18	-6	0.015	729	
19	-7	0.010	726	
20	-8	0.010	727	
21	-9	0.010	726	
22	-10	0.015	727	
23	-11	0.015	726	
24	-12	0.015	726	
25				

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Sample Train Recovery Data

N-1

S.T. Wooten
Facility: ~~Franklinton~~
Project No.: 5940.000
Date: 3/25/03
Run No.: WF - F - 1
Clean-up person: FM
Sampling Location: HOS Burner Stack
Field Team Leader: Mike Maret
Samplers: MDM, NP, FM
Comments:

Front-Half Data

Filter No.: N/A
Filter Media:
Tare Wt (mg):
Filter No.: N/A
Filter Media:
Tate Wt (mg):

Back-Half Data

Contents:	100 ml H_2O	100 ml H_2O	EMPTY
Final mass (g):	785.5	768.8	630.2
Initial mass (g):	734.7	739.1	620.6
Net Mass (g)	50.8	29.7	9.6

Contents:	Silica Gel		
Final mass (g):	755.7		
Initial mass (g):	741.8		
Net Mass (g)	13.9		

Total Moisture Collected: (g): 104.0

Description of Impinger Catch:

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Research Triangle Park, North Carolina 27709
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EPA METHOD 2 FIELD DATA SHEET

Facility: ST WOOTEN - FLANLINTON
Sampling Location: HOS STACK
Run # WF-F-M2-2
Barometric Pressure, (in. Hg): ~~29.50~~ 30.09
Moisture, (%): 11.1
Stack Gas Dry Molecular weight, (g/g-mol): 30.18
Stack Diameter or Side 1 Dimension, (in.): 8"
Wet Bulb Temperature (°F): –

Project No.: 5940.000
Date: 3/25/03
Clock Time: ~1220
Operators: MDM
Stack Static Pressure, in H_2O: 0.01
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): –
Dry Bulb Temperature (°F): –

POST 1
PRE 2

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.005	670	
2	-2	0.005	670	
3	-3	0.005	696	
4	-4	0.005	719	
5	-5	0.005	725	
6	-6	0.005	732	
7	-7	0.005	746	
8	-8	0.010	757	
9	-9	0.015	773	
10	-10	0.020	785	
11	-11	0.030	784	
12	-12	0.030	784	
13	B-1	0.005	762	
14	-2	0.005	762	
15	-3	0.005	761	
16	-4	0.040	761	
17	-5	0.045	762	
18	-6	0.025	761	
19	-7	0.015	763	
20	-8	0.010	763	
21	-9	0.010	761	
22	-10	0.010	761	
23	-11	0.010	770	
24	-12	0.010	775	
25				

PACIFIC ENVIRONMENTAL SERVICES, INC.

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Central Park West
5001 South Miami Boulevard, P.O. Box 12077
Research Triangle Park, North Carolina 27709
(919) 941-0333 FAX: (919) 941-0234

ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: SI WOOTEN
Sampling Location: HOS OUTLET
Assumed B_{ws}: 11 Filter No.: –
Probe Length/Type: 4' glass Pitot #: PP-10
Stack Diameter: 8" A_s: 0.349

Sample Type: M316 Operator(s): WWM/NP
P_{bar}: ~~29.5~~ 30.09 in Hg CO_2: 17 % O_2: 6 %
P_g: 0.01 inH_2O Thermocouple ID.: CT-14
Pretest Leak Check: Pitot: ✓ Orsat: ✓
Posttest Leak Check: Pitot: ✓ Orsat: ✓

Date: 3/25/03 Run Number: WF-F-3
Nozzle ID: NEW Nozzle Diameter: 0.627
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: 0.003 cfm @ 15 in. Hg
Posttest Leak Rate: 0.000 cfm @ 4 in. Hg
K = 68.66

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0	1511	250.813											
1	A-1	3	1514	251.8	0.005	0.34	0.34	754	~~N/A~~ 209	N/A	66		74	73	<1
2	-2	6	1517	252.8	0.005	0.34	0.34	754	209	N/A	55		74	74	<1
3	-3	9	1520	253.9	0.005	0.34	0.34	756	217	N/A	55		74	74	<1
4	-4	12	1523	254.9	0.005	0.34	0.34	750	222	N/A	55		75	75	<1
5	-5	15	1526	255.8	0.005	0.34	0.34	744	229	N/A	55		75	74	<1
6	-6	18	1529	256.8	0.005	0.34	0.34	761	228	N/A	55		75	75	<1
7	-7	21	1532	257.8	0.005	0.34	0.34	731	228	N/A	55		74	74	<1
8	-8	24	1535	259.2	0.005	0.34	0.34	748	251	N/A	49		75	74	<1
9	-9	27	1538	260.6	0.010	0.69	0.69	727	254	N/A	49		75	74	<1
10	-10	30	1541	262.4	0.020	1.37	1.37	745	247	N/A	50		75	74	<1
11	-11	33	1544	264.4	0.025	1.72	1.72	745	251	N/A	49		76	74	<1
12	-12	36	1547	266.937	0.030	2.06	2.06	743	260	N/A	49		77	74	<1
13		36	1550	266.937	STOP FOR	PORT CHANGE									
14	B-1	39	1553	269.2	0.030	2.06	2.06	744	250	N/A	54		76	75	<1
15	-2	42	1556	271.6	0.030	2.06	2.06	744	270	N/A	50		77	74	<1
16	-3	45	1559	273.8	0.030	2.06	2.06	745	275	N/A	60		77	74	<1
17	-4	48	1602	275.7	0.020	1.37	1.37	742	266	N/A	53		77	74	<1
18	-5	51	1605	277.4	0.015	1.03	1.03	740	254	N/A	54		77	75	<1
19	-6	54	1608	278.9	0.010	0.69	0.69	740	247	N/A	54		76	74	<1
20	-7	57	1611	279.9	0.005	0.34	0.34	743	241	N/A	56		76	75	<1
21	-8	60	1614	280.9	0.005	0.34	0.34	741	231	N/A	58		75	74	<1
22	-9	63	1617	281.9	0.005	0.34	0.34	740	234	N/A	58		75	78	<1

ΔV_m:______ Δp:______ ΔH:______ t_s:______ t_m:______

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PACIFIC ENVIRONMENTAL SERVICES, INC.

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Central Park West
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Research Triangle Park, North Carolina 27709
(919) 941-0333 FAX: (919) 941-0234

ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: ST WOOTEN FRANKLINTON, NC
Sampling Location: HOS STACK
Assumed B_{ws}: ~11 Filter No.: N/A
Probe Length/Type: 4' glass Pitot #: RP-6
Stack Diameter: 8" A_s: 0.349

Sample Type: M316 Operator(s): MJ/MW/NP
P_{bar}: ~~29.50~~ 30.04 in Hg O_2: ~11 % CO_2: ~6.5 %
P_g: 0.01 inH_2O Thermocouple ID.:
Pretest Leak Check: Pitot: - Orsat:
Posttest Leak Check: Pitot: Orsat:

Date: 3/25/03 Run Number: WF-F-3
Nozzle ID: - Nozzle Diameter: 0.627
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: cfm @ in. Hg
Posttest Leak Rate: cfm @ in. Hg

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0													
1	-10	66	1620	282.9	0.005	0.34	0.34	741	238	N/A	59		75	74	<1
2	-11	69	1623	283.9	0.005	0.34	0.34	741	247	N/A	58		75	74	<1
3	-12	72	1626	284.870	0.005	0.34	0.34	740	255	N/A	58		75	74	<1
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															

ΔV_m: Δp: ΔH: t_s: t_m:

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Research Triangle Park, North Carolina 27709
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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: ST WOOTEN - FRANKLINTON
Sampling Location: HOS OUTLET
Assumed B_{ws}: 11 Filter No.: N/A
Probe Length/Type: 4'-glass Pitot #: Pf-10
Stack Diameter: 8" A_s: ______

Sample Type: M316 Operator(s): MDM / NP
P_{bar}: 30.04 29.50 in Hg O_2: 11.5 % CO_2: 6 %
P_g: 0.01 inH_2O Thermocouple ID.: ______
Pretest Leak Check: Pitot: N/A Orsat: N/A
Posttest Leak Check: Pitot: N/A Orsat: N/A

Date: 3/25/03 Run Number: ~~FB~~ WF-F-FB
Nozzle ID: — Nozzle Diameter: 0.627
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: 0.000 cfm @ 15 in. Hg
Posttest Leak Rate: 0.000 cfm @ 15 in. Hg

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0													
1															
2					FIELD BLANK										
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															

ΔV_m: ______ Δp: ______ ΔH: ______ t_s: ______ t_m: ______

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Sample Train Recovery Data

BOX N-5

S.T. Wooten

Facility: Franklinton

Date: 3/25/03

Clean-up person: FM

Field Team Leader: Mike Maret

Comments:

Project No.: 5940.000

Run No.: Field Blank

Sampling Location: HOS Burner Stack

Samplers: MDM / NP

Front-Half Data

Filter No.: N/A Filter Media: Tare Wt (mg):

Filter No.: N/A Filter Media: Tate Wt (mg):

Back-Half Data

Contents:	100 ml H_2O	100 ml H_2O	Empty
Final mass (g):	N/A	N/A	N/A
Initial mass (g):	701.3	619.3	617.6
Net Mass (g)			

Contents:	Silica Gel		
Final mass (g):	N/A		
Initial mass (g):	844.4		
Net Mass (g)			

Total Moisture Collected: (g):

Description of Impinger Catch:

Appendix B.2

Raw Field Data

S.T. Wooten
Clayton

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EPA METHOD 1 FIELD DATA SHEET
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Facility: S. WOOTEN - CLAYTON
Project No.: 5940.000
Sampling Location: HOS STACK
Date: 3/26/03
Inside of Far Wall to Outside of Nipple, in.: ~~16 1/4~~ 16 3/8
Inside of Near Wall to Outside of Nipple, in.: 4 1/8
Stack Inside Diameter, in.: 12 1/2
Points Calculated by: MDM
Distance Downstream from Flow Disturbance (Distance B), in.: 26" / Stack ID = 2.08 duct diameters
Distance Upstream from Flow Disturbance (Distance A), in.: 25 1/2 / Stack ID = 2.04 duct diameters

~~CO2 10.5~~
~~O2 7.5~~

Traverse Point Number	Fraction of Length	Length (inches)	Product of Cols. 2 & 3 (to nearest 1/8 inch)	Nipple Length (inches)	Traverse Point Location (Sum of Col 4 & 5)	
1	0.021	12 1/2	0.263 (0.5)	4 1/4	4.51	4 3/4 **
2	0.067	12 1/2	0.838	4 1/4	5.09	5 1/8
3	0.118	12 1/2	~~0~~ 1.375	4 1/4	5.63	5 5/8
4	~~0.25~~ 0.177	12 1/2	2.213	4 1/4	6.46	6 1/2
5	~~0.356~~ 0.250	12 1/2	3.125	4 1/4	7.38	7 3/8
6	~~0.644~~ 0.356	12 1/2	4.450	4 1/4	8.70	8 3/4
7	~~0.780~~ 0.644	12 1/2	8.050	4 1/4	12.30	12 1/4
8	~~0.823~~ 0.750	12 1/2	9.375	4 1/4	13.63	13 5/8
9	~~0.882~~ 0.823	12 1/2	10.288	4 1/4	14.54	14 1/2
10	~~0.93~~ 0.882	12 1/2	11.025	4 1/4	15.28	15 3/8
11	0.933	12 1/2	11.663	4 1/4	15.91	15 7/8
12	0.979	12 1/2	12.238 (12)	4 1/4	16.49	16 1/4 **

SCHEMATIC OF SAMPLING LOCATION: 16 1/2 / 4 1/4 ** - Adjusted.

10.5
9.0

~~CO2 11.0~~
~~O2 6.0~~

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EPA METHOD 2 FIELD DATA SHEET

Facility: ST WOOREN CYATUN
Sampling Location: HOS STACK
Run #: Prelim
Barometric Pressure, (in. Hg): ~~29.92~~ 30.09
Moisture, (%): 11
Stack Gas Dry Molecular weight, (g/g-mol): 30.00
Stack Diameter or Side 1 Dimension, (in.): 12 1/2
Wet Bulb Temperature (°F): -

Project No.: ~~8A~~ 5940.00
Date: 3/26/03
Clock Time: ~ 1200
Operators: WDM & WP
Stack Static Pressure, in H_2O: - 0.003
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): -
Dry Bulb Temperature (°F): -

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.050	599	-13.8
2	-2	0.055	599	-9.5
3	-3	0.060	600	-10
4	-4	0.065	600	-5.1
5	-5	0.050	600	-5
6	-6	0.045	602	-5
7	-7	0.020	603	-5
8	-8	0.015	603	-5
9	-9	0.010	602	-6
10	-10	0.010	603	-5
11	-11	0.010	604	0
12	-12	0.010	604	+5.1
13	B-1	0.015	593	0
14	-2	0.015	596	0
15	-3	0.015	602	1
16	-4	0.020	603	0
17	-5	0.020	604	0
18	-6	0.020	607	0
19	-7	0.040	609	0
20	-8	0.040	609	+10
21	-9	0.050	610	+10
22	-10	0.050	612	+9
23	-11	0.045	611	+10
24	-12	0.050	610	+9
25				

Δp : 0.0325
T_s = 603

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EPA METHOD 2 FIELD DATA SHEET

Facility: S.T. Wooten - Clayton, N.C.

Sampling Location: HOS STACK

Run # 1

Barometric Pressure, (in. Hg): 30.09

Moisture, (%): 11

Stack Gas Dry Molecular weight, (g/g-mol): 30.0

Stack Diameter or Side 1 Dimension, (in.): 12 1/2

Wet Bulb Temperature (°F): -

Project No.: 5940.000

Date: 3-27-03

Clock Time: 0900

Operators: Hanke / MARET

Stack Static Pressure, in H_20: + 0.03

Pitot Tube Coefficient, C_p: 0.84

Stack Diameter or Side 1 Dimension, (in.): -

Dry Bulb Temperature (°F): -

Pre Run #1

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.065	641	—
2	-2	0.075	640	—
3	-3	0.075	639	—
4	-4	0.07	640	—
5	-5	0.06	638	—
6	-6	0.025	637	—
7	-7	0.02	636	—
8	-8	0.015	633	—
9	-9	0.015	633	—
10	-10	0.012	632	—
11	-11	0.01	631	—
12	-12	0.01	632	—
13	B-1	0.015	629	—
14	-2	0.015	632	—
15	-3	0.0156	635	—
16	-4	0.0159	635	—
17	-5	0.02	625	—
18	-6	0.02	615	—
19	-7	0.03	614	—
20	-8	0.035	615	—
21	-9	0.035	615	—
22	-10	0.035	616	—
23	-11	0.0358	616	—
24	-12	0.043	615	—
25				

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: S.T. Wooten, Clayton- NC
Sampling Location: Hos Stack
Assumed B_{ws}: 10 %
Filter No.: N/A
Probe Length/Type: 4' glass
Pitot #: RP-10
Stack Diameter: 12.5"
A_s: 0.852

Sample Type: M316
Operator(s): BA MM NP
P_{bar}: ~~29.92~~ 766 in Hg
CO_2: 14.0 %
O_2: 8 %
P_g: 0.003 inH2O
Thermocouple ID: ET-14
Pretest Leak Check: Pitot: ✓ Orsat: ✓
Posttest Leak Check: Pitot: ✓ Orsat: –

Date: 3-27-03
Run Number: WC-F-1
Nozzle ID: –
Nozzle Diameter: 0.627
Meter Box No.: 15
γ: 0.991
ΔH@: 1.83
Pretest Leak Rate: 0.002 cfm @ 15 in. Hg
Posttest Leak Rate: 0.002 cfm @ 7 in. Hg

Read: Record Data every 3 mins
K= 68.00

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H₂O)	Orifice Pressure Differential (ΔH, in H₂O) Desired	Orifice Pressure Differential (ΔH, in H₂O) Actual	Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F) Inlet	Dry Gas Meter Temperature (°F) Outlet	Pump Vacuum (in. Hg)
0		0	~~1034~~ 0934	285.~~004~~ 393											
1	A-1	3	0937	~~285.004~~ 288.7	0.065	4.42	4.42	613	247	N/A	47		58	56	2
2	-2	6	0940	292.2	0.075	5.1	5.1	613	249	N/A	43		62	57	2
3	-3	9	0943	295.8	0.075	5.1	5.1	610	247	N/A	45		63	57	2
4	-4	12	0946	299.3	0.07	4.76	4.76	613	245	N/A	52		66	58	2
5	-5	15	0949	302.5	0.06	4.08	4.08	613	243	N/A	60		67	58	2
6	-6	18	0952	304.7	0.025	1.7	1.7	613	249	N/A	68		66	59	0.5
7	-7	21	0955	306.6	0.02	1.36	1.36	614	246	N/A	64		65	59	0.5
8	-8	24	0958	308.3	0.015	1.02	1.02	612	245	N/A	61		64	59	<1
9	-9	27	1001	309.9	0.015	1.02	1.02	611	250	N/A	57		64	59	<1
10	-10	30	1004	311.4	0.012	0.8160	0.860	615	242	N/A	55		63	59	<1
11	-11	33	1007	312.8	0.01	0.68	0.68	614	244	N/A	53		63	59	<1
12	-12	36	1010	314.203	0.01	0.68	0.68	613	248	N/A	52		64	59	<1
13	B-1	36	~~1015~~	314.203	~~0.015~~	~~1.02~~	~~1.02~~	STOP FOR PORT CHANGE							
14	B-1	39	1016	315.9	0.015	1.02	1.02	613	250	N/A	50		63	60	<1
15	-2	42	1019	317.6	0.015	1.02	1.02	612	245	N/A	47		64	60	<1
16	-3	45	1022	319.2	0.015	1.02	1.02	611	244	N/A	46		65	61	<1
17	-4	48	1025	320.9	0.016	1.09	1.09	614	244	N/A	47		65	61	<1
18	-5	51	1028	323.3	0.02	1.36	1.36	612	241	N/A	46		65	61	<1
19	-6	54	1031	325.3	0.02	1.36	1.36	613	248	N/A	45		67	62	<1
20	-7	57	1034	327.6	0.03	2.04	2.04	613	245	N/A	46		67	62	1
21	-8	60	1037	330.1	0.035	2.38	2.38	614	241	N/A	46		68	62	1
22	-9	63	~~1100~~ 1040	332.5	0.035	2.38	2.38	613	251	N/A	46		68	62	

ΔV_m:______ Δp:______ ΔH:______ t_s:______ t_m:______

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: S.T. Wooten- Clayton, NC Sample Type: M316 Operator(s): BH MD JP Date: 3-27-03 Run Number: WC-F-1

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	-10	66	~~1103~~ 1043	335.0	0035	2.38	2.38	613	243	NA	47		68	63	1
24	-11	69	~~1106~~ 1046	337.5	0.0358	2.43	2.43	613	240	NA	47		68	63	1
25	-12	72	~~1109~~ 1049	340.201	0.043	2.92	2.92	615	246	NA	47		68	63	2
26															
27															
28															
29															
30															
31															
32															
33															
34															
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43															
44															
45															
46															
47															
48															
49															
50															

ΔV_m:_____ Δp:_____ ΔH:_____ t_s:_____ t_m:_____

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Sample Train Recovery Data

N-1

S.T. Wooten

Facility: CLAYTON

Project No.: 5940.000

Date: 3/27/03

Run No.: WC-F-1

Clean-up person: MDW

Sampling Location: HOS Burner Stack

Field Team Leader: MDW

Samplers: BH/NP

Comments:

Front-Half Data

Filter No.: N/A Filter Media: Tare Wt (mg):

Filter No.: Filter Media: Tate Wt (mg):

Back-Half Data

Contents:	100 ml D.I H2O	100 ml DI H2O	EMPTY
Final mass (g):	792.2	777.9	633.1
Initial mass (g):	741.0	745.4	623.4
Net Mass (g)			

Contents:	Silica Gel		
Final mass (g):	775.0		
Initial mass (g):	762.1		
Net Mass (g)			

Total Moisture Collected: (g):

Description of Impinger Catch:

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EPA METHOD 2 FIELD DATA SHEET

Facility: S.T. Wooten - Clayton, N.C
Sampling Location: HOS - STACK
Run # 1 M2-2
Barometric Pressure, (in. Hg): 30.09
Moisture, (%): 11
Stack Gas Dry Molecular weight, (g/g-mol): 30.0
Stack Diameter or Side 1 Dimension, (in.): 12 1/2
Wet Bulb Temperature (°F): -

Project No.: 5840.000
Date: 3-27-03
Clock Time: 1115
Operators: HD BH SP
Stack Static Pressure, in H_2O: 0.003
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): -
Dry Bulb Temperature (°F): -

Post Run #1
Pre-run #2

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.07	616	
2	-2	0.07	616	
3	-3	0.08	614	
4	-4	0.075	613	
5	-5	0.07	614	
6	-6	0.04	614	
7	-7	0.02	615	
8	-8	0.02	6 5	
9	-9	0.015	614	
10	-10	0.01	613	
11	-11	0.01	615	
12	-12	0.01	614	
13	B-1	0.01	616	
14	-2	0.015	615	
15	-3	0.02	616	
16	-4	0.02	615	
17	-5	0.02	615	
18	-6	0.025	616	
19	-7	0.03	613	
20	-8	0.03	616	
21	-9	0.03	615	
22	-10	0.035	617	
23	-11	0.035	615	
24	-12	0.035	615	
25				

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: S.T. Wooten - Clayton, NC
Sampling Location: HAS STACK
Assumed B_{ws}: 10% Filter No.: N/A
Probe Length/Type: 4' glass Pitot #: R-P-10
Stack Diameter: 12.5" A_s: 0.852

3 MINUTE READINGS

Sample Type: M316 Operator(s): BH NP MD
P_{bar}: 76 mm in Hg CO_2: 11 % O_2: 8 %
P_g: 0.003 inH$_2$O Thermocouple ID.: RT-14
Pretest Leak Check: Pitot: — Orsat: —
Posttest Leak Check: Pitot: — Orsat: —

Date: 3-27-03 Run Number: WC-F-2
Nozzle ID: NEW Nozzle Diameter: 0.677
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: 0.000 cfm @ 15 in. Hg
Posttest Leak Rate: 0.000 cfm @ 8 in. Hg

K = 68.00

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H$_2$O)	Orifice Pressure Differential (ΔH, in H$_2$O) Desired	Actual	Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F) Inlet	Outlet	Pump Vacuum (in. Hg)
0		0	1136	340,326											
1	A-1	3	1139	343.7	0.07	4.76	4.76	617	216	N/A	45		67	65	2
2	-2	6	1142	347.1	0.07	4.76	4.76	616	253	N/A	38		70	65	2
3	-3	9	1145	350.7	0.08	5.44	5.44	619	244	N/A	40		73	65	2
4	-4	12	1148	354.3	0.075	5.1	5.1	616	249	N/A	43		75	66	2
5	-5	15	1151	357.8	0.07	4.76	4.76	619	242	N/A	45		77	67	2
6	-6	18	1154	360.5	0.04	2.72	2.72	618	252	N/A	47		78	68	<1
7	-7	21	1157	362.5	0.02	1.36	1.36	618	243	N/A	47		77	68	<1
8	-8	24	1200	364.4	0.02	1.36	1.36	618	257	N/A	47		76	68	<1
9	-9	27	1203	366.1	0.015	1.02	1.02	618	237	N/A	45		75	69	<1
10	-10	30	1206	367.5	0.01	0.68	0.68	622	251	N/A	45		74	69	<1
11	-11	33	1209	368.9	0.01	0.68	0.68	618	249	N/A	45		74	69	<1
12	-12	36	1211	370.306	0.01	0.68	0.68	622	242	N/A	46		73	69	<1
13	B-1	36	1214	370.306		STOP FOR PORT CHANGE									
14	B-1	39	1217	371.8	0.01	0.68	0.68	621	250	N/A	42		72	69	<1
15	-2	42	1220	373.4	0.015	1.02	1.02	619	240	N/A	41		73	70	<1
16	-3	45	1223	375.3	0.02	1.36	1.36	622	246	N/A	40		74	70	<1
17	-4	48	1226	377.2	0.02	1.36	1.36	619	246	N/A	40		74	70	4
18	-5	51	1229	379.1	0.02	1.36	1.36	621	245	N/A	40		75	70	<1
19	-6	54	1232	381.2	0.025	1.70	1.70	620	243	N/A	40		75	70	<1
20	-7	57	1235	383.5	0.03	2.04	2.04	621	248	N/A	40		76	71	<1
21	-8	60	1238	385.8	0.03	2.04	2.04	618	241	N/A	40		77	71	<1
22	-9	63	1241	388.1	0.03	2.04	2.04	615	256	N/A	41		77	71	<1

ΔV_m:____ Δp:____ ΔH:____ t_s:____ t_m:____

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: S.T. Wiofen-Clayton, NC Sample Type: M316 Operator(s): BH MP MD Date: 3-27-03 Run Number: WC-F-2

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	-10	66	1244	390.6	0.035	2.38	2.38	618	243	N/A	42		77	72	<1
24	-11	69	1247	393.1	0.035	2.38	2.38	618	245	N/A	42		78	72	<1
25	-12	72	1250	395.548	0.035	2.38	2.38	623	243	N/A	43		77	72	<1
26															
27															
28															
29															
30															
31															
32															
33															
34															
35															
36															
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42															
43															
44															
45															
46															
47															
48															
49															
50															

ΔV_m:_____ Δp:_____ ΔH:_____ t_s:_____ t_m:_____

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Sample Train Recovery Data

RN-2

S.T. Wooten

Facility: Clayton

Date: 3/27/03

Clean-up person: MDM

Field Team Leader: MDM

Comments:

Project No.: 5940,000

Run No.: INC-F-2

Sampling Location: H05 Burner Stack

Samplers: BH/NP

Front-Half Data

Filter No.: N/A Filter Media: Tare Wt (mg):

Filter No.: Filter Media: Tate Wt (mg):

Back-Half Data

Contents:	100 ml H2O	100 ml H2O	Empty
Final mass (g):	~~792.2~~ 701.6	~~777.9~~ 769.7	533.0
Initial mass (g):	628.2	747.7	530.0
Net Mass (g)			

Contents:	Silica Gel		
Final mass (g):	869.3		
Initial mass (g):	860.0		
Net Mass (g)			

Total Moisture Collected: (g):

Description of Impinger Catch:

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EPA METHOD 2 FIELD DATA SHEET

Facility: S.T. Wooten - Clayton, NC
Sampling Location: HOS Stack
Run # 2
Barometric Pressure, (in. Hg): 30.09
Moisture, (%): 11
Stack Gas Dry Molecular weight, (g/g-mol): 30.0
Stack Diameter or Side 1 Dimension, (in.): 12 1/2
Wet Bulb Temperature (°F): –

Project No.: 5940.000
Date: 3-27-03
Clock Time: 1316
Operators: MD BH NP
Stack Static Pressure, in H_2O: 0.03
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): –
Dry Bulb Temperature (°F): –

Post - #2
Pre - run #3

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.06	627	
2	-2	0.07	623	
3	-3	0.075	625	
4	-4	0.075	624	
5	-5	0.07	625	
6	-6	0.06	623	
7	-7	0.03	624	
8	-8	0.02	625	
9	-9	0.015	626	
10	-10	0.015	626	
11	-11	0.015	625	
12	-12	0.01	625	
13	B-1	0.01	624	
14	-2	0.015	624	
15	-3	0.015	625	
16	-4	0.015	626	
17	-5	0.02	626	
18	-6	0.02	625	
19	-7	0.03	626	
20	-8	0.035	623	
21	-9	0.04	626	
22	-10	0.04	623	
23	-11	0.04	625	
24	-12	0.045	624	
25				

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: S.T. Wooten, Clayton, N.C. Sample Type: M316 Operator(s): BH MD NP Date: 3-27-03 Run Number: WC-F-3

Sampling Location: HOS STACK P_{bar}: 766mm in Hg CO$_2$: 11 % ~~C~~O$_2$: 8 % Nozzle ID: New Nozzle Diameter: 0.627

Assumed B_{ws}: 10% Filter No.: ~~RP-10~~ N/A P_g: 0.003 inH$_2$O Thermocouple ID.: RT-14 Meter Box No.: 15 γ: 0.991 ΔH@: 1.93

Probe Length/Type: 4' glass Pitot #: RP10 Pretest Leak Check: Pitot: ✓ Orsat: ✓ Pretest Leak Rate: 0.000 cfm @ 15 in. Hg

Stack Diameter: 12.5" A_s: – 0.852 Posttest Leak Check: Pitot: ✓ Orsat: ✓ Posttest Leak Rate: 0.000 cfm @ 7 in. Hg

K = 71.4

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H$_2$O)	Orifice Pressure Differential (ΔH, in H$_2$O) Desired	Orifice Pressure Differential (ΔH, in H$_2$O) Actual	Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F) Inlet	Dry Gas Meter Temperature (°F) Outlet	Pump Vacuum (in. Hg)
0		0	1400	396.206											
1	A-1	3	1403	399.7	0.06	4.28	4.28	625	167	NA	39		72	69	2
2	-2	6	1406	403.2	0.07	4.99	4.99	626	240	N/A	36		75	70	2
3	-3	9	1409	406.9	0.075	5.35	5.35	627	248	N/A	38		79	70	2
4	-4	12	1412	410.6	0.075	5.35	5.35	623	258	NA	40		82	72	2.2
5	-5	15	1415	414.2	0.07	4.99	4.99	625	248	NA	42		83	72	2
6	-6	18	1418	417.7	0.06	4.28	4.28	625	245	NA	43		83	73	2
7	-7	21	1421	421.3	0.03	2.14	2.14	625	245	NA	44		82	73	2
8	-8	24	1424	423.7	0.02	1.43	1.43	625	253	NA	44		83	73	2
9	-9	27	1427	425.4	0.015	1.07	1.07	624	247	NA	41		79	73	<1
10	-10	30	1430	427.2	0.015	1.07	1.07	625	244	NA	40		79	73	<1
11	-11	33	1433	428.9	0.01	0.71	0.71	624	248	NA	39		78	73	<1
12	-12	36	1436	430.263	0.01	0.71	0.71	624	242	NA	38		77	73	<1
13	B-1	36	1437	430.263	STOP	for	CHANGE								
14	B-1	39	1440	431.8	0.01	0.71	0.71	626	244	NA	40		74	72	<1
15	-2	42	1443	433.4	0.015	1.07	1.07	626	248	NA	39		74	72	<1
16	-3	45	1446	435.1	0.015	1.07	1.07	626	242	NA	38		75	72	<1
17	-4	48	1449	436.9	0.015	1.07	1.07	627	244	NA	39		75	72	<1
18	-5	51	1452	438.8	0.02	1.43	1.43	624	249	NA	38		75	72	<1
19	-6	54	1455	440.7	0.02	1.43	1.43	626	242	NA	39		75	72	<1
20	-7	57	1458	443.1	0.03	2.14	2.14	626	253	NA	39		76	72	1
21	-8	60	1501	445.6	0.035	2.5	2.5	623	244	NA	40		77	72	1
22	-9	63	1504	448.3	0.04	2.86	2.86	623	248	NA	41		78	72	1

ΔV$_m$: ______ Δp: ______ ΔH: ______ t$_s$: ______ t$_m$: ______

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: S.T. Wooten, Clayton, P.C. Sample Type: M316 Operator(s): AH PR MDM Date: 3-27-03 Run Number: WE-F-3

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	-10	66	1507	451.1	0.04	2.86	2.86	625	245	NA	42		77	72	1
24	-11	69	1500	453.9	0.04	2.86	2.86	626	246	NA	43		77	73	1.5
25	-12	72	1503	456.757	0.045	3.21	3.21	625	269	NA	43		77	73	1
26															
27															
28															
29															
30															
31															
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45															
46															
47															
48															
49															
50															

ΔV_m:____ Δp:____ ΔH:____ t_s:____ t_m:____

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Sample Train Recovery Data

N-5

Facility: S.T. Wooten Clayton
Project No.: 5940.000
Date: 3/27/03
Run No.: WF-F-3
Clean-up person: MDM
Sampling Location: HOS Burner Stack
Field Team Leader: MDM
Samplers: BH / NP
Comments:

Front-Half Data

Filter No.: N/A Filter Media: Tare Wt (mg):
Filter No.: N/A Filter Media: Tate Wt (mg):

Back-Half Data

Contents:	100 ml DI H2O	100 ml DI H2O	EMPTY
Final mass (g):	788.6	663.3	609.5
Initial mass (g):	722.2	622.5	605.7
Net Mass (g)			

Contents:	Silica Gel		
Final mass (g):	858.0		
Initial mass (g):	846.0		
Net Mass (g)			

Total Moisture Collected: (g):

Description of Impinger Catch:

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EPA METHOD 2 FIELD DATA SHEET

Facility: S.T. Wooten Clayton, NC
Sampling Location: HOS STACK
Run # 3
Barometric Pressure, (in. Hg): 30.09
Moisture, (%): 11
Stack Gas Dry Molecular weight, (g/g-mol): 30.0
Stack Diameter or Side 1 Dimension, (in.): 12 1/2
Wet Bulb Temperature (°F): –

Project No.: 5940.000
Date: 3-27-03
Clock Time: 1530
Operators: RH MDM PP
Stack Static Pressure, in H_2O: 0.003
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): –
Dry Bulb Temperature (°F): –

Port #3

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.06	622	
2	-2	0.07	620	
3	-3	0.075	622	
4	-4	0.08	622	
5	-5	0.075	629	
6	-6	0.06	620	
7	-7	0.025	619	
8	-8	0.02	620	
9	-9	0.015	618	
10	-10	0.01	617	
11	-11	0.01	618	
12	-12	0.01	618	
13	B-1	0.01	619	
14	-2	0.01	620	
15	-3	0.015	622	
16	-4	0.02	622	
17	-5	0.02	623	
18	-6	0.025	622	
19	-7	0.035	623	
20	-8	0.035	620	
21	-9	0.035	620	
22	-10	0.04	623	
23	-11	0.04	621	
24	-12	0.045	620	
25				

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: S.T. Wooten, Clayton, NC
Sampling Location: Hos Stack
Assumed B_{ws}: 10% Filter No.: N/A
Probe Length/Type: 4' glass Pitot #: RP-10
Stack Diameter: 12.5" A_s: ______

Sample Type: M3 %l Operator(s): BA/P MDM
P_{bar}: 766 mm in Hg O_2: ____ % CO_2: ____ %
P_g: ______ inH_2O Thermocouple ID.: ______
~~Pretest Leak Check: Pitot: N/A Orsat: N/A~~
~~Posttest Leak Check: Pitot: N/A Orsat: N/A~~

Date: 3-27-03 Run Number: F-B.
Nozzle ID: ______ Nozzle Diameter: ______
Meter Box No.: 15 γ: ______ ΔH@: ______
Pretest Leak Rate: 0.002 cfm @ 15 in. Hg
Posttest Leak Rate: 0.000 cfm @ 15 in. Hg

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0	1320												
1															
2							Field Blank								
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															

ΔV_m: ______ Δp: ______ ΔH: ______ t_s: ______ t_m: ______

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Sample Train Recovery Data

Facility: SA WOOTEN - CLAYTON
Project No.: 5540-aw
Date: 3/27/03
Run No.: WC-F-FB
Clean-up person: MVM
Sampling Location: HOS Outlet
Field Team Leader: MVM
Samplers: BH / NP
Comments:

Front-Half Data

Filter No.: N/A
Filter Media:
Tare Wt (mg):
Filter No.: N/A
Filter Media:
Tate Wt (mg):

Back-Half Data

Contents:	DI H_2O	DI H_2O	MT
Final mass (g):	741.9	738.7	624.0
Initial mass (g):	741.7	738.3	624.0
Net Mass (g)			

Contents:	Si Gel.		
Final mass (g):	775.0		
Initial mass (g):	775.1		
Net Mass (g)			

Total Moisture Collected: (g):

Description of Impinger Catch:

Appendix B.3

Raw Field Data

REA Construction
Mallard Creek

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EPA METHOD 1 FIELD DATA SHEET
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Facility: Rea Mallard Creek
Project No.: 5940.000
Sampling Location: HOS
Date: 3-31-03
Inside of Far Wall to Outside of Nipple, in.: 16.25"
Inside of Near Wall to Outside of Nipple, in.: ~~3 1/4~~ 3 3/8
Stack Inside Diameter, in.: ~~12 7/8~~ 13 1/2
Points Calculated by: MDM
Distance Downstream from Flow Disturbance (Distance B), in.: 60.5 / Stack ID = ~~13~~ 4.64 duct diameters
Distance Upstream from Flow Disturbance (Distance A), in.: 28 1/4 / Stack ID = 2.19 13 duct diameters

Traverse Point Number	Fraction of Length	Length (inches)	Product of Cols. 2 & 3 (to nearest 1/8 inch)	Nipple Length (inches)	Traverse Point Location (Sum of Col 4 & 5)	
						y x
1	0.021	~~3.375~~ 12 7/8	0.270 1/2	3.375	3.65 3 7/8	
2	0.067	~~3.375~~	0.863		4.24 4 1/4	
3	0.110	~~3.375~~	1.416		4.79 4 3/4	
4	0.177	~~3.375~~	2.279		5.65 5 5/8	
5	0.250	~~3.375~~	3.219		6.59 6 5/8	
6	0.356	~~3.375~~	4.584		7.96 8	
7	0.644	~~3.37~~	8.292		11.67 11 5/8	
8	0.750		9.656		13.03 13.	
9	0.823		10.596		13.97 14.	
10	0.882		11.356		14.73 14 3/4	
11	0.933		12.012		15.39 15 3/8	
12	0.979		12.605 12 3/4		15.49 15 3/4	x x

SCHEMATIC OF SAMPLING LOCATION:

12 7/8 Adjusted

Nipple A = 3 3/4
B 3 3/4

16.25 A
16.25 B

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EPA METHOD 2 FIELD DATA SHEET

Facility: ECA Construction
Sampling Location: HOS Stack
Run # Prelim VT 1
Barometric Pressure, (in. Hg): 29.92
Moisture, (%): 15
Stack Gas Dry Molecular weight, (g/g-mol): 30.00
Stack Diameter or Side 1 Dimension, (in.): 12 7/8
Wet Bulb Temperature (°F): -

Project No.: 5940.U00
Date: 3/31/03
Clock Time: 1723
Operators: MDM / NP
Stack Static Pressure, in H_2O: -0.020
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): -
Dry Bulb Temperature (°F): -

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	B ~~A~~-1	0.035 ~~0.060~~	~~726~~ 695	-22.9
2	-2	0.035	660	-15.2
3	-3	0.030	657	-0.4
4	-4	0.030	659	-8.6
5	-5	0.035	699	-0.1
6	-6	0.040	716	-2.2
7	-7	0.045	741	+10
8	-8	0.055	753	+5
9	-9	0.055	757	+0.5
10	-10	0.060	759	+0.3
11	-11	0.060	751	+3.0
12	-12	0.085	739	+0.6
13	A ~~B~~-1	0.060	620	+1.1
14	-2	0.070	620	+1.8
15	-3	0.070	650	+1.6
16	-4	0.075	673	+1.2
17	-5	0.070	684	+1.4
18	-6	0.060	696	+0.4
19	-7	0.050	702	+2.0
20	-8	0.045	703	+0.1
21	-9	0.045	700	+0.3
22	-10	0.045	697	+0.1
23	-11	0.045	692	+1.1
24	-12	0.045	689	+1.2
25				

Δp : 0.0504
T_s : 665

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GAS PRESSURE = 2.5" w.c.   1.25" ~~1.5"~~ w c
gas press = 1700 cfh

ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: REA CONSTRUCTION - MALLARD CREEK
Sampling Location: HUS STACK
Assumed B_{ws}: 10   Filter No.: N/A
Probe Length/Type: 4' glass   Pitot #: EP-4 104-3A
Stack Diameter: ~~12 7/8~~ 13 1/2 A_s: 0.994

Sample Type: M316   Operator(s): MPM/NP
P_{bar}: 30.20 29.62 in Hg O_2: 7.5 % CO_2: 9.5 %
P_g: -0.020 inH_2O Thermocouple ID.: 104-3A
Pretest Leak Check: Pitot: ✓   Orsat: –
Posttest Leak Check: Pitot: ✓   Orsat: –

Date: 4/1/03   Run Number: MC · F · 1
Nozzle ID: Van   Nozzle Diameter: 0.495
Meter Box No.: 15   γ: 0.991   ΔH@: 1.83
Pretest Leak Rate: 0.005 cfm @ 15 in. Hg
Posttest Leak Rate: 0.002 cfm @ 10 in. Hg
Y : 25.51   ** Leak check @ probe liner tip **

READ AND RECORD ALL DATA EVERY 3 MINUTES

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O) Desired	Actual	Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F) Inlet	Outlet	Pump Vacuum (in. Hg)
0		0	0915	456.935											
1	A-1	3	0918	459.0	0.070	1.79	1.79	530	244	N/A	49		60	56	<1
2	A-2	6	0921	461.4	0.080	2.04	2.04	594	244	N/A	44		63	57	<1
3	A-3	9	0924	463.7	0.080	2.04	2.04	625	241	N/A	43		65	58	<1
4	A-4	12	0927	466.1	0.080	2.04	2.04	658	245	N/A	44		68	59	<1
5	A-5	15	0930	468.1	0.075	1.91	1.91	685	241	N/A	45		69	60	<1
6	A-6	18	0933	470.3	0.070	1.79	1.79	707	245	N/A	48		69	60	<1
7	A-7	21	0936	472.4	0.060	1.53	1.53	727	246	N/A	50		70	61	<1
8	A-8	24	0939	474.3	0.055	1.40	1.40	731	242	N/A	53		70	62	<1
9	A-9	27	0942	476.2	0.055	1.40	1.40	728	247	N/A	55		70	62	<1
10	A-10	30	0945	478.1	0.050	1.28	1.28	775	243	N/A	57		71	63	<1
11	A-11	33	0948	480.0	0.055	1.40	1.40	718	245	N/A	59		71	63	<1
12	A-12	36	0951	481.986	0.050	1.28	1.28	707	243	N/A	61		71	64	<1
13	B-1	36	1004	481.986	STOP FOR	PORT CHANGE									
14	B-1	39	1007	483.1	0.020	0.51	0.51	563	243	N/A	60		67	68	<1
15	B-2	42	1010	484.5	0.025	0.64	0.64	568	239	N/A	57		69	65	<1
16	B-3	45	1013	485.9	0.025	0.64	0.64	576	245	N/A	54		69	65	<1
17	B-4	48	1016	487.4	0.030	0.77	0.77	559	245	N/A	53		70	66	<1
18	B-5	51	1019	488.8	0.030	0.77	0.77	612	238	N/A	52		70	66	<1
19	B-6	54	1022	490.4	0.040	1.02	1.02	688	244	N/A	52		71	66	<1
20	B-7	57	1025	492.1	0.040	1.02	1.02	700	248	N/A	52		71	67	<1
21	B-8	60	1028	494.1	0.060	1.53	1.53	738	242	N/A	52		72	67	<1
22	B-9	63	1031	496.3	0.060	1.53	1.53	739	245	N/A	53		73	67	<1

ΔV_m:______   Δp:______   ΔH:______ t_s:______ t_m:______

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: REA Construction - Maryland Greek Sample Type: M316 Operator(s): MDM/NP Date: 4/1/03 Run Number: MC-F-1

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	B-10	66	1034	498.2	0.065	1.66	1.66	736	246	N/A	54		73	68	2
24	B-11	69	1037	500.2	0.065	1.66	1.66	725	245	N/A	55		74	68	2
25	B-12	72	1040	502.338	0.065	1.66	1.66	723	245	N/A	58		74	74	2
26															
27															
28															
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48															
49															
50															

ΔV_m: 45.403 $\sqrt{\Delta p}$: 0.2294 ΔH: 1.39 t_s: 667 t_m: 65.46

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Sample Train Recovery Data

N.1

Facility: REA Mallard Creek
Project No.: 5940.020
Date: 3-31-03
Run No.: ~~#1~~ MC-F-1
Clean-up person: FM
Sampling Location: HOS Stack
Field Team Leader: MM
Samplers: MP, MM
Comments:

Front-Half Data

Filter No.: N/A
Filter Media: N/A
Tare Wt (mg):
Filter No.: N/A
Filter Media: N/A
Tate Wt (mg):

Back-Half Data

	100ml	100ml	
Contents:	DI H2O	DI H2O	MT
Final mass (g):	829.6	796.1	635.4
Initial mass (g):	734.3	745.0	622.4
Net Mass (g)	95.3	51.1	13.0

Contents:	S Gel		
Final mass (g):	862.7		
Initial mass (g):	844.8		
Net Mass (g)	17.9		

Total Moisture Collected: (g): 177.3

Description of Impinger Catch:

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: REA Construction - Mallard Creek
Sampling Location: HOS Stack
Assumed B$_{ws}$: 15 Filter No.: N/A
Probe Length/Type: 4' glass Pitot #: RP-4
Stack Diameter: 13½ ~~12 7/8~~ A$_s$: 0.994

Sample Type: M316 Operator(s): MDM/NP
P$_{bar}$: 30.20 ~~29.92~~ in Hg O$_2$: ~~[illegible]~~ 8.5 % CO$_2$: 9.0 %
P$_g$: 0.020 inH$_2$O Thermocouple ID.: 104-3A
Pretest Leak Check: Pitot: ✓ Orsat: ✓
Posttest Leak Check: Pitot: ✓ Orsat: ✓

Date: 4/1/03 Run Number: MC-F-2
Nozzle ID: - Nozzle Diameter: 0.495
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: 0.005 cfm @ 15 in. Hg
Posttest Leak Rate: 0.005 cfm @ 12 in. Hg

READ AND RECORD ALL DATA EVERY 3 MINUTES

K = 24.5

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H$_2$O)	Orifice Pressure Differential (ΔH, in H$_2$O) Desired	Actual	Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F) Inlet	Outlet	Pump Vacuum (in. Hg)
0		0	1129	502.634											
1	B-1	3	1132	503.9	0.025	0.61	0.61	525	227	N/A	60		72	70	<1
2	-2	6	1135	-	0.030	0.74	0.74	587	239	N/A	53		73	70	<1
3	-3	9	1138	506.9	0.035	0.86	0.86	663	245	N/A	52		75	71	<1
4	-4	12	1142	508.6	0.040	0.98	0.99	689	248	N/A	51		76	71	<1
5	-5	15	1145	510.2	0.040	0.98	0.98	701	242	N/A	50		77	72	<1
6	-6	18	1148	511.9	0.050	1.23	1.23	718	257	N/A	49		78	72	<1
7	-7	21	1151	513.9	0.050	1.23	1.23	729	241	N/A	49		78	73	<1
8	-8	24	1154	515.9	0.060	1.47	1.47	741	248	N/A	49		79	73	<1
9	-9	27	1157	518.0	0.075	1.84	1.84	750	246	N/A	49		79	73	<1
10	-10	30	1200	520.3	0.080	1.96	1.96	747	242	N/A	48		80	74	<1
11	-11	33	1203	522.6	0.080	1.96	1.96	742	249	N/A	48		80	74	2
12	-12	36	1206	525.024	0.085	2.08	2.08	739	243	N/A	48		80	74	2
13	A-1	36	1209	525.024	STOP FOR PORT CHANGE										
14	A-1	~~36~~ 39	1212	527.3	0.075	1.84	1.84	656	242	N/A	56		77	74	2
15	-2	~~39~~ 42	1215	-	0.075	1.84	1.84	667	238	N/A	52		78	74	2
16	-3	~~42~~ 45	1218	-	0.085	2.10	2.10	718	244	N/A	52		79	74	2
17	-4	~~45~~ 48	1221	531.6	0.080	1.96	1.96	724	243	N/A	52		79	74	2
18	-5	~~48~~ 51	1224	533.8	0.075	1.84	1.84	736	242	N/A	52		79	74	2
19	-6	54	1227	538.1	0.070	1.72	1.72	743	247	N/A	52		80	74	2
20	-7	57	1230	540.0	0.055	1.35	1.35	743	244	N/A	54		80	74	<1
21	-8	60	1233	542.0	0.055	1.35	1.35	742	246	N/A	54		80	74	1
22	-9	63	1236	543.9	0.060	1.47	1.47	735	244	N/A	54		80	75	1

ΔV$_m$:______ Δp:______ ΔH:______ t$_s$:______ t$_m$:______

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: LEA CONSTRUCTION - MALLARD CREEK Sample Type: M316 Operator(s): MDM/NP Date: 4/1/03 Run Number: MC-F-2

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	-10	66	1239	~~543.9~~ 545.9	0.060	1.47	1.47	726	244	N/A	55		81	75	<1
24	-11	69	1242	547.9	0.060	1.47	1.47	726	244	N/A	54		81	75	<1
25	-12	72	1245	549.918	0.060	1.47	1.47	726	247	N/A	54		81	81	<1
26															
27															
28															
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ΔV_m:______ Δp:______ ΔH:______ t_s:______ t_m:______

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RN-2

Sample Train Recovery Data

Facility: REA Mallard Creek

Date: 4/1/03

Clean-up person: FM

Field Team Leader: MDM

Comments:

Project No.: 5940.000

Run No.: MC-F-~~1~~2~~A~~

Sampling Location: HOS Stack

Samplers: MP MM

Front-Half Data

Filter No.: N/A

Filter Media: N/A

Tare Wt (mg):

Filter No.: N/A

Filter Media: N/A

Tate Wt (mg):

Back-Half Data

	100ml	100ml	
Contents:	DI Water	DI Water	MT
Final mass (g):	762.9	776.2	533.2
Initial mass (g):	620.8	748.00	528.3
Net Mass (g)	142.1	28.2	4.9

Contents:	S. Gel		
Final mass (g):	975.8		
Initial mass (g):	961.4		
Net Mass (g)	14.4		

Total Moisture Collected: (g): 189.6

Description of Impinger Catch:

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: RCA Construction · Mallard Creek
Sampling Location: HOS Stack
Assumed B_{ws}: 15 Filter No.: N/A
Probe Length/Type: 4' glass Pitot #: RP-4
Stack Diameter: ~~12 7/8~~ 13 1/2 A_s: 0.994

Sample Type: M316 Operator(s): MWM/NP
P_{bar}: 29.92 in Hg O_2: ~~4.5~~ 8.0a % CO_2: 9.2 %
P_g: 0.02 inH_2O Thermocouple ID.: 164-3A
Pretest Leak Check: Pitot: ✓ Orsat: ✓
Posttest Leak Check: Pitot: ✓ Orsat: ✓

Date: 4/1/03 Run Number: MC-F-3
Nozzle ID: - Nozzle Diameter: 0.495
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: 0.002 cfm @ 15 in. Hg
Posttest Leak Rate: 0.000 cfm @ 9 in. Hg
K = 24.5

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0	1339	550.427											
1	A-1	3	1342	552.7	0.085	~~0.085~~	~~0.085~~	672	236	N/A	52		75	74	1
2	-2	6	1345	555.0	0.080	1.96	1.96	692	250	N/A	45		78	74	1
3	-3	9	1348	557.2	0.070	1.72	1.72	715	246	N/A	44		80	74	1
4	-4	12	1351	559.3	0.070	1.72	1.72	720	247	N/A	43		80	75	1
5	-5	15	1354	561.5	0.070	1.72	1.72	715	247	N/A	43		81	75	1
6	-6	18	1357	563.6	0.070	1.72	1.72	735	234	N/A	43		82	75	1
7	-7	21	1400	565.6	0.055	1.35	1.35	750	244	N/A	44		82	76	1
8	-8	24	1403	567.6	0.055	1.35	1.35	752	242	N/A	45		82	76	1
9	-9	27	1406	569.6	0.060	1.47	1.47	747	246	N/A	45		83	77	1
10	-10	30	1409	571.5	0.060	1.47	1.47	743	240	N/A	46		83	77	1
11	-11	33	1412	573.5	0.060	1.47	1.47	731	246	N/A	46		83	77	1
12	-12	36	1415	575.527	0.060	1.47	1.47	730	245	N/A	47		83	77	1
13	B-1	36	1425	575.527	STOP FOR PORT CHANGE										
14	-1	39	1428	577.9	0.025	0.61	0.61	588	244	N/A	54		78	77	1
15	-2	42	1431	578.4	0.035	0.86	0.86	656	244	N/A	46		79	77	1
16	-3	45	1434	580.0	0.035	0.86	0.86	715	250	N/A	45		79	77	1
17	-4	48	1437	581.7	0.040	0.98	0.98	725	240	N/A	44		79	77	1
18	-5	51	1440	583.5	0.045	1.1	1.1	733	247	N/A	45		79	77	1
19	-6	54	1443	585.3	0.045	1.1	1.1	736	246	N/A	45		80	77	1
20	-7	57	1446	587.2	0.060	1.47	1.47	752	242	N/A	45		80	77	1
21	-8	60	1449	589.4	0.065	1.6	1.6	756	247	N/A	45		81	77	1
22	-9	63	1452	591.3	0.070	1.72	1.72	751	243	N/A	45		82	77	1

ΔV_m:______ Δp:______ ΔH:______ t_s:______ t_m:______

a Estimated based on ratio of CO2/O2 for NG fuel

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: REA Construction - Mallard Creek Sample Type: M316 Operator(s): MDM/NP Date: 4/1/03 Run Number: MC-F-FB

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	-10	66	1455	~~591.3~~ 593.5	0.065	1.6	1.6	750	250	N/A	46		82	77	1
24	-11	69	1458	595.7	0.075	1.84	1.84	742	245	N/A	47		83	77	1
25	-12	72	1501	597.897	0.075	1.84	1.84	743	244	N/A	48		83	77	1
26															
27															
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50															

ΔV_m:_____ Δp:_____ ΔH:_____ t_s:_____ t_m:_____

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Sample Train Recovery Data

N-5

Facility: Rea Mallard Creek
Project No.: 5940.000
Date: 4/1/03
Run No.: MC-F-3
Clean-up person: FM
Sampling Location: HOS Stack
Field Team Leader: MM
Samplers: MP, MM
Comments:

Front-Half Data

Filter No.: N/A Filter Media: N/A Tare Wt (mg):
Filter No.: N/A Filter Media: N/A Tate Wt (mg):

Back-Half Data

Contents:	100ml DI Water	100ml DI Water	MT
Final mass (g):	865.0	648.7	607.5
Initial mass (g):	716.2	621.7	603.6
Net Mass (g)	148.8	27.0	3.9

Contents:	Si Gel		
Final mass (g):	981.5		
Initial mass (g):	967.6		
Net Mass (g)	13.9		

Total Moisture Collected: (g): 193.6

Description of Impinger Catch:

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: REA Construction · Mallard Creek
Sampling Location: HOS Stack Outlet
Assumed B_{ws}: 15 Filter No.: N/A
Probe Length/Type: 4' glass Pitot #: RP-4
Stack Diameter: 12 7/8 A_s: ______

Sample Type: M316 Operator(s): MDM/NP
P_{bar}: 29.92 in Hg O_2: 8.5 % CO_2: 9.0 %
P_g: -0.02 inH_2O Thermocouple ID.: ______
~~Pretest Leak Check: Pitot:~~ ______ Orsat: ______
~~Posttest Leak Check: Pitot:~~ ______ Orsat: ______

Date: 4/1/03 Run Number: MC-F-FB
Nozzle ID: - Nozzle Diameter: 0.495
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: 0.070 cfm @ 15 in. Hg
Posttest Leak Rate: 0.015 cfm @ 15 in. Hg

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0													
1															
2					FIELD BLANK.										
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
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15															
16															
17															
18															
19															
20															
21															
22															

ΔV_m: ______ Δp: ______ ΔH: ______ t_s: ______ t_m: ______

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Sample Train Recovery Data

N-1

Facility: REA Construction Mallard Creek
Project No.: 5940,000
Date: 4-1-03
Run No.: MC-F-FB (Field Blank)
Clean-up person: F. Meadows
Sampling Location: HOS Burner Stack
Field Team Leader: M. Maret
Samplers: MDM / NP
Comments:

Front-Half Data

Filter No.: N/A
Filter Media:
Tare Wt (mg):
Filter No.:
Filter Media:
Tate Wt (mg):

Back-Half Data

Contents:	100 ml H2O	100 ml H2O	EMPTY
Final mass (g):			
Initial mass (g):	740.6	745.3	623.6
Net Mass (g)			

	4		
Contents:	Silica Gel		
Final mass (g):			
Initial mass (g):	862.3		
Net Mass (g)			

Total Moisture Collected: (g):

Description of Impinger Catch:

Appendix B.4

Raw Field Data

REA Construction
North Mecklenburg

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EPA METHOD 1 FIELD DATA SHEET
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Facility: REA Construction - N. Mecklenburg
Project No.: 5940.06
Sampling Location: HDS Stack
Date: 4/2/03
Inside of Far Wall to Outside of Nipple, in.:
Inside of Near Wall to Outside of Nipple, in.: 3 3/8
Stack Inside Diameter, in.: 13 1/2
Points Calculated by: MDM
Distance Downstream from Flow Disturbance (Distance B), in.: 60.5 / Stack ID = 4.48 duct diameters
Distance Upstream from Flow Disturbance (Distance A), in.: 28.0 / Stack ID = 2.07 duct diameters

Traverse Point Number	Fraction of Length	Length (inches)	Product of Cols. 2 & 3 (to nearest 1/8 inch)	Nipple Length (inches)	Traverse Point Location (Sum of Col 4 & 5)
1	0.021	13 1/2	0.284 (1/2)	3 3/8	3 7/8
2	0.067		0.905		4.28 4 1/4
3	0.110		1.485		4.86 4 7/8
4	0.177		2.39		5.76 5 3/4
5	0.250		3.378		6.75 6 3/4
6	0.356		4.806		8.19 8 1/8
7	0.644		8.694		12.07 12 1/8
8	0.750		10.125		13.50 13 1/2
9	0.823		11.111		14.49 14 1/2
10	0.882		11.907		15.28 15 1/4
11	0.933		12.596		15.97 16
12	0.979	↓	13.217 (13)	↓	16 3/8

SCHEMATIC OF SAMPLING LOCATION:

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EPA METHOD 1 FIELD DATA SHEET
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Facility: Rea North Mecklenburg
Project No.: 5940.000
Sampling Location: ROS Stack Outlet
Date: 4-2-03
Inside of Far Wall to Outside of Nipple, in.: 16.0"
Inside of Near Wall to Outside of Nipple, in.: 3.5" 3 3/8
Stack Inside Diameter, in.: 13.5"
Points Calculated by: NP
Distance Downstream from Flow Disturbance (Distance B), in.: Ⓐ 74.5 / Ⓑ 76.5 / Stack ID = Ⓐ 13.0 / Ⓑ 13.0 duct diameters 5.48
Distance Upstream from Flow Disturbance (Distance A), in.: 28.0" Ⓐ 28.0" Ⓑ / Stack ID = 13.0" Ⓐ 13.01" Ⓑ duct diameters 2.07

Traverse Point Number	Fraction of Length	Length (inches)	Product of Cols. 2 & 3 (to nearest 1/8 inch)	Nipple Length (inches)	Traverse Point Location (Sum of Col 4 & 5)	
1	0.026	13 1/2	0.351	3.375	3.73 3 7/8	***
2	0.082	↓	1.107	3.375	4.49 4 1/2	
3	0.146		1.971	3.375	5.35 5 3/8	
4	0.226		3.051	3.375	6.43 6 1/2	
5	0.342		4.617	3.375	7.99 8	
6	0.658		8.883	3.375	12.26 12 1/4	
7	0.774		10.449	3.375	13.82 13 3/4	
8	0.854		11.529	3.375	14.90 14 7/8	
9	0.918		12.393	3.375	15.77 15 3/4	
10	0.974		13.149	3.375	16.52 16 3/8	***
11						
12						

*** Adjusted.

SCHEMATIC OF SAMPLING LOCATION:

16 7/8
16 3/8

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EPA METHOD 2 FIELD DATA SHEET

Facility: REA Construction - N. Mecklenburg
Sampling Location: HDS Stack
Run # Helium
Barometric Pressure, (in. Hg): ~~29.92~~ 30.10
Moisture, (%): 10
Stack Gas Dry Molecular weight, (g/g-mol): 30.00
Stack Diameter or Side 1 Dimension, (in.): 13½
Wet Bulb Temperature (°F): -

Project No.: 5940.00
Date: 4/2/03
Clock Time: 1345
Operators: MDM / NP
Stack Static Pressure, in H_2O: -0.010
Pitot Tube Coefficient, C_p: 0.84
Stack Diameter or Side 1 Dimension, (in.): -
Dry Bulb Temperature (°F): -

LINE	Traverse Point Number	Velocity Head Δp (in. H_2O)	Stack Temperature T_s (°F)	Yaw Angle α (°)
1	A-1	0.010	501	0.2
2	-2	0.010	469	2.4
3	-3	0.010	469	0
4	-4	0.010	480	0.9
5	-5	0.010	498	0.4
6	-6	0.010	511	0.4
7	-7	0.010	528	0.5
8	-8	0.010	541	0.6
9	-9	0.010	552	0.3
10	-10	0.010	552	0.9
11	-11	0.010	556	0.2
12	-12	0.010	556	0.3
13	B-1	0.010	482	0.2
14	-2	0.040	459	0.1
15	-3	0.040	463	0.3
16	-4	0.035	499	0.1
17	-5	0.030	537	0.4
18	-6	0.025	550	0.4
19	-7	0.015	555	0.3
20	-8	0.010	558	0
21	-9	0.010	559	0.3
22	-10	0.010	558	0.6
23	-11	0.005	552	0.3
24	-12	0.005	546	0.2
25				

Δp = 0.0148
Ts = 522

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ISOKINETIC SAMPLING FIELD DATA SHEET

CO2 13.5 O2 4.0 %

Plant: RCA Construction - N. Mecklenburg
Sample Type: M316 / Operator(s): MM / NP
Date: 4/2/03
Run Number: NM-F-1
Sampling Location: HDS Stack
P_{bar}: ~~29.92~~ 30.10 in Hg
O_2: ~~4~~ 13.5 %
CO_2: ~~13.5~~ 4.0 %
Nozzle ID: NEW
Nozzle Diameter: 0.625
Assumed B_{ws}: 10
Filter No.: N/A
P_g: -0.010 inH2O
Thermocouple ID.: R 10431
Meter Box No.: 15
γ: 0.991
ΔH@: 1.83
Probe Length/Type: 4' glass
Pitot #: RP-4
Pretest Leak Check: Pitot: ✓ Orsat: ✓
Pretest Leak Rate: 0.002 cfm @ 15 in. Hg
Stack Diameter: 13½
A_s: 0.994
Posttest Leak Check: Pitot: ✓ Orsat: ✓
Posttest Leak Rate: 0.0002 cfm @ 5 in. Hg

READ AND RECORD ALL DATA EVERY 3 MINUTES

K: 78

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O) Desired	Actual	Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F) Inlet	Outlet	Pump Vacuum (in. Hg)
0		0	1435	598.027											
1	A-1	3	1438	599.5	0.010	0.78	0.78	505	247	N/A	69		78	78	<1
2	-2	6	1441	601.0	0.010	0.78	0.78	467	245	N/A	63		79	78	<1
3	-3	9	1444	602.4	0.010	0.78	0.78	469	247	N/A	59		79	78	<1
4	-4	12	1447	604.0	0.010	0.78	0.78	436	247	N/A	56		80	78	<1
5	-5	15	1450	605.4	0.010	0.78	0.78	514	245	N/A	54		81	79	<1
6	-6	18	1453	607.3	0.015	1.17	1.17	547	249	N/A	53		82	78	<1
7	-7	21	1456	608.8	0.010	0.78	0.78	532	243	N/A	52		83	79	<1
8	-8	24	1459	610.2	0.010	0.78	0.78	540	249	N/A	53		83	79	<1
9	-9	27	1502	611.7	0.010	0.78	0.78	587	243	N/A	53		83	79	<1
10	-10	30	1505	613.2	0.010	0.78	0.78	581	245	N/A	54		83	79	<1
11	-11	33	1508	614.7	0.010	0.78	0.78	578	246	N/A	55		84	79	<1
12	-12	36	1511	616.265	0.010	0.78	0.78	576	245	N/A	55		84	80	<1
13	B-1	36	1518	616.265	STOP FOR	PORT CHANGE									
14	B-1	39	1521	619.4	0.050	3.9	3.9	525	246	N/A	63		85	80	2
15	B-2	42	1524	622.3	0.035	2.73	2.73	525	247	N/A	51		87	81	1.5
16	B-3	45	1527	625.0	0.035	2.73	2.73	559	243	N/A	50		88	81	1.5
17	B-4	48	1530	627.8	0.04	3.12	3.12	577	246	N/A	45		89	81	1.0
18	B-5	51	1533	630.5	0.035	2.73	2.73	537	246	N/A	46		89	82	1.0
19	B-6	54	1536	632.8	0.025	1.95	1.95	602	245	N/A	48		88	82	1.0
20	B-7	57	1539	634.6	0.015	1.17	1.17	605	245	N/A	49		88	82	1.0
21	B-8	60	1542	636.1	0.01	0.78	0.78	600	243	N/A	50		87	82	<1
22	B-9	63	1545	637.7	0.01	0.78	0.78	597	246	N/A	51		87	82	<1

ΔV_m:____ Δp:____ ΔH:____ t_s:____ t_m:____

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: REA Const. N. Mecklenburg Sample Type: M316 Operator(s): BH MDH NP Date: 4/2/03 Run Number: 1

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	B-10	66	1548	639.1	0.01	0.78	0.78	581	244	N/A	51		86	82	<1
24	B-11	69	1551	640.7	0.01	0.78	0.78	572	243	N/A	52		86	82	<1
25	B-12	72	1554	642.150	0.01	0.78	0.78	570	244	N/A	51		86	82	<1
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ΔV_m:______ Δp:______ ΔH:______ t_s:______ t_m:______

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Sample Train Recovery Data

N-1

REA Construction

Facility: North Mecklenburg
Project No.: 5940.000
Date: 4/2/03
Run No.: NM ~~MC~~-F-1
Clean-up person: MDM
Sampling Location: HOS Burner Stack
Field Team Leader: M. Maret
Samplers: MDM / NP
Comments:

Front-Half Data

Filter No.: N/A Filter Media: Tare Wt (mg):
Filter No.: N/A Filter Media: Tate Wt (mg):

Back-Half Data

Contents:	100 ml H_2O	100 ml H_2O	Empty
Final mass (g):	824.4	759.5	627.2
Initial mass (g):	740.6	744.0	624.2
Net Mass (g)	83.8	15.5	3.0

Contents:	Silica Gel		
Final mass (g):	872.6		
Initial mass (g):	862.8		
Net Mass (g)	9.8		

Total Moisture Collected: (g): 112.1

Description of Impinger Catch:

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: LEA - North Mecklenburg
Sampling Location: HDS Stack
Assumed B_{ws}: 10 Filter No.: N/A
Probe Length/Type: 4' glass Pitot #: PP-4
Stack Diameter: 13.5" A_s: 0.994

Sample Type: M316 Operator(s): BH
P_{bar}: 30.1 in Hg O_2: - % CO_2: - %
P_g: -0.010 inH_2O Thermocouple ID.: 104-3A
Pretest Leak Check: Pitot: N/A Orsat: N/A
Posttest Leak Check: Pitot: N/A Orsat: N/A

Date: 4/2/03 Run Number: NM-F-FB
Nozzle ID: New Nozzle Diameter: 0.627
Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Pretest Leak Rate: 0.0000 cfm @ 15 in. Hg
Posttest Leak Rate: 0.0001 cfm @ 5 in. Hg

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0													
1															
2					Field Blank										
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ΔV_m:____ Δp:____ ΔH:____ t_s:____ t_m:____

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: REA COAST. N. MECKLENBURG Sample Type: M316 Operator(s): RA PP MDM Date: 4/2/03 Run Number: PM-F2

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, in H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	10	66	9:39	685.5	0.01	0.75	0.75	607	247	N/A	42		84	77	<1
24	11	69	9:42	687.0	0.01	0.75	0.75	604	241	N/A	41		84	78	<1
25	12	72	9:45	688.400	0.01	0.75	0.75	603	247	N/A	40		84	78	<1
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ΔV_m:______ Δp:______ ΔH:______ t_s:______ t_m:______

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Sample Train Recovery Data

N-5

REA Construction
Facility: North Mecklenburg
Project No.: 5940.000
Date: 4/2/03
Run No.: NM-F-2
Clean-up person: MDM
Sampling Location: HUS Burner Stack
Field Team Leader: M. Maret
Samplers: BH / NP
Comments:

Front-Half Data

Filter No.: N/A
Filter Media:
Tare Wt (mg):
Filter No.: N/A
Filter Media:
Tate Wt (mg):

Back-Half Data

Contents:	100 ml H_2O	100 ml H_2O	Empty
Final mass (g):	799.7	650.9	610.1
Initial mass (g):	722.2	622.8	606.1
Net Mass (g)	77.5	28.1	4.0

Contents:	Silica Gel		
Final mass (g):	992.2		
Initial mass (g):	981.5		
Net Mass (g)	10.7		

Total Moisture Collected: (g): 120.3

Description of Impinger Catch:

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ISOKINETIC SAMPLING FIELD DATA SHEET

Plant: REA Construction - N. Mecklenburg Sample Type: M316 Operator(s): RH JP MDM Date: 4/3/03 Run Number: NH-F-3
Sampling Location: Hos Stack P_{bar}: 29.92 in Hg CO_2: 12 % O_2: 4.5 % Nozzle ID: New Nozzle Diameter: ~~0.625~~ 0.627
Assumed B_{ws}: 10 Filter No.: NA P_g: 0.010 inH₂O Thermocouple ID.: 104-3A Meter Box No.: 15 γ: 0.991 ΔH@: 1.83
Probe Length/Type: 4' glass Pitot #: RP-4 Pretest Leak Check: Pitot: ✓ Orsat: ✓ Pretest Leak Rate: 0.0001 cfm @ 15 in. Hg
Stack Diameter: 13.5 A_s: 0.994 Posttest Leak Check: Pitot: ✓ Orsat: ✓ Posttest Leak Rate: 0.002 cfm @ 5 in. Hg
K= 75

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft³)	Velocity Head (ΔP, in H₂O)	Orifice Pressure Differential (ΔH, in H₂O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
0		0	1026	688.553											
1	B-1	3	1029	691.4	0.05	3.75	3.75	490	237	NA	54		83	80	1.5
2	-2	6	1032	694.6	0.055	4.13	4.13	490	251	NA	47		85	80	1.5
3	-3	9	1035	697.9	0.055	4.13	4.13	490	252	NA	42		87	80	2
4	-4	12	1038	701.1	0.05	3.75	3.75	490	252	NA	41		89	81	1.5
5	-5	15	1041	704.0	0.04	3.0	3.0	557	241	NA	42		90	81	1.0
6	-6	18	1044	706.3	0.025	1.8	1.88	594	248	NA	42		90	82	<1
7	-7	21	1047	708.1	0.015	1.13	1.13	606	241	NA	42		89	82	<1
8	-8	24	1050	709.6	0.01	0.75	0.75	603	249	NA	43		88	82	<1
9	-9	27	1053	711.3	0.015	1.13	1.13	600	280	NA	43		88	82	<1
10	-10	30	1056	713.1	0.015	1.13	1.13	557	250	NA	42		87	82	<1
11	-11	33	1059	714.9	0.015	1.13	1.13	596	242	NA	41		87	82	<1
12	-12	36	1102	716.634	0.015	1.13	1.13	585	295	NA	41		87	82	<1
13	A-1	36	1107	716.634	~~0.058~~	~~0.39~~	~~0.39~~	STOP FOR PORT Δ							
14	A-1	39	1110	717.7	0.005	0.39	0.39	496	243	NA	49		85	82	<1
15	-2	42	1113	718.8	0.005	0.39	0.39	496	248	NA	48		85	82	<1
16	-3	45	1116	720.3	0.01	0.75	0.75	496	264	NA	47		85	82	<1
17	-4	48	1119	721.4	0.005	0.39	0.39	495	244	NA	47		85	82	<1
18	-5	51	1122	722.8	0.01	0.75	0.75	521	245	NA	48		86	83	<1
19	-6	54	1125	724.3	0.01	0.75	0.75	570	247	NA	47		86	83	<1
20	-7	57	1128	725.8	0.01	0.75	0.75	594	249	NA	47		86	82	<1
21	-8	60	1131	727.2	0.01	0.75	0.75	608	~~246~~ 243	NA	48		87	83	<1
22	-9	63	1134	729.0	0.015	1.13	1.13	608	244	NA	46		87	83	<1

ΔV$_m$:____ Δp:____ ΔH:____ t_s:____ t_m:____

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ISOKINETIC SAMPLING FIELD DATA SHEET (continued)

Plant: REA Const. P. Mecklenburg Sample Type: M316 Operator(s): RA PP MDM Date: 4/3/03 Run Number: PM1 F-3

LINE	Traverse Point Number	Sampling Time (min)	Clock Time (24-hr)	Dry Gas Meter Reading (V_m, ft^3)	Velocity Head (ΔP, in H_2O)	Orifice Pressure Differential (ΔH, In H_2O)		Stack Temp (°F)	Probe Temp (°F)	Filter Temp (°F)	Impinger Temp (°F)		Dry Gas Meter Temperature (°F)		Pump Vacuum (in. Hg)
						Desired	Actual						Inlet	Outlet	
23	-10	66	1137	730.8	0.015	1.13	1.13	606	244	PA	45		87	83	4
24	-11	69	1140	732.5	0.015	1.13	1.13	601	246	PA	45		88	83	<1
25	-12	72	1143	734.274	0.015	1.13	1.13	598	245	PA	46		88	83	<1
26															
27															
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50															

ΔV_m:____ Δp:____ ΔH:____ t_s:____ t_m:____

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Sample Train Recovery Data

N-2

Facility: RCA Construction - N. Mecklenburg
Project No.: 5940.000
Date: 4/2/03
Run No.: NM-F-3
Clean-up person: MDM
Sampling Location: HOS Stack
Field Team Leader: MDM
Samplers: BH / NP
Comments:

Front-Half Data

Filter No.: N/A
Filter Media:
Tare Wt (mg):
Filter No.: N/A
Filter Media:
Tate Wt (mg):

Back-Half Data

Contents:	DI H2O 100 ml	100 ml DI H2O	MT
Final mass (g):	729.0	765.7	531.3
Initial mass (g):	633.1	748.7	~~633.1~~ 528.4
Net Mass (g)	95.9	17.0	2.9

Contents:	Si Gl		
Final mass (g):	984.8		
Initial mass (g):	972.2		
Net Mass (g)	12.6		

Total Moisture Collected: (g): 128.4

Description of Impinger Catch:

APPENDIX C

METHOD 316 LABORATORY ANALYTICAL DATA

RESOLUTION ANALYTICS, INC.

Specialists in Air Emission Analysis

ANALYTICAL REPORT

- FORMALDEHYDE
  (EPA METHOD 316)

CLIENT: MACTEC, INC.

RFA#: 5940

2733 Lee Avenue • Sanford, NC 27330 • Phone: 919-774-5557 • Fax: 919-776-6785

RESOLUTION ANALYTICS, INC.
Specialists in High Performance Liquid Chromatography

REPORT SUMMARY

RFA#: 5940

SAMPLE ID	*Formaldehyde*
H2O BLANK	< 0.546 µgs
WF-F-FB (A)	< 0.929 µgs
WF-F-FB (B)	< 1.15 µgs
WF-F-1 (A)	116 µgs
WF-F-1 (B)	6.55 µgs
WF-F-2 (A)	52.9 µgs
WF-F-2 (B)	10.9 µgs
WF-F-3 (A)	59.5 µgs
WF-F-3 (B)	4.41 µgs
WC-F-FB (A)	< 2.02 µgs
WC-F-FB (B)	< 0.382 µgs
WC-F-1 (A)	5.99 µgs
WC-F-1 (B)	0.328 µgs
WC-F-2 (A)	< 2.57 µgs
WC-F-2 (B)	< 0.437 µgs
WC-F-3 (A)	< 2.62 µgs
WC-F-3 (B)	< 0.328 µgs
FIELD SPIKE	91.8 %

PACIFIC ENVIRONMENTAL SERVICES, INC.

Central Park West
5001 South Miami Boulevard, P.O. Box 12077
Research Triangle Park, North Carolina 27709-2077
(919) 941-0333 FAX: (919) 941-0234

Chain of Custody Record

Project Numb 5940

Project Name NAPA-Formaldehyde Testing

Samplers: Maret, Meadows

Date	Time	Field Sample ID	Sample Description	Formaldehyde EPA Method 316	Analysis Requested						Remarks
3/25/2003	1151	WF-F-1(A)	Nozzle, Probe, 1st Impinger	√							
3/25/2003	1151	WF-F-1(B)	2nd & 3rd Impinger	√							
3/25/2003	1411	WF-F-2(A)	Nozzle, Probe, 1st Impinger	√							
3/25/2003	1411	WF-F-2(B)	2nd & 3rd Impinger	√							
3/25/2003	1626	WF-F-3(A)	Nozzle, Probe, 1st Impinger	√							
3/25/2003	1626	WF-F-3(B)	2nd & 3rd Impinger	√							
3/25/2003	1430	WF-F-FB(A)	Nozzle, Probe, 1st Impinger	√							
3/25/2003	1430	WF-F-FB(B)	2nd & 3rd Impinger	√							
3/27/2003	1109	WC-F-1(A)	Probe, 1st & 2nd Impinger	√							
3/27/2003	1109	WC-F-1(B)	3rd Impinger	√							
3/27/2003	1250	WC-F-2(A)	Probe, 1st & 2nd Impinger	√							
3/27/2003	1250	WC-F-2(B)	3rd Impinger	√							
3/27/2003	1503	WC-F-3(A)	Probe, 1st & 2nd Impinger	√							
3/27/2003	1503	WC-F-3(B)	3rd Impinger	√							
3/27/2003	1445	WC-F-FB(A)	Probe, 1st & 2nd Impinger	√							
3/27/2003	1445	WC-F-FB(B)	3rd Impinger	√							
3/27/2003	1445	WC-F-RB	Reagent Blank	√							

Relinquished by: (Signature)	Date/Time 1215 3/28/03	Received by: (Signature) J Bruce Maret	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for lab by: (Signature)	REMARKS		

Page:____ of ____

RESOLUTION ANALYTICS, INC.
Specialists in High Performance Liquid Chromatography

Wet Chemistry Bench Data Sheet

Client Name: PES-MACTEC

Analyst: GRE

RFA# 5940

Date: 3/31/03

Method: EPA 316 Analyte: Formaldehyde Matrix: H_2O

Unit of Measurement ☐ mls ☒ ABS ☐ mv ☐ ppm

******** Calibration Data *******

Concentration	Value
0.25 ppm	0.127
0.5 ppm	0.273
1.0 ppm	0.557
2.0 ppm	1.096
3.0 ppm	1.648

******** Pre-Analysis Data *******

Electrode Slope:

Conc. of Lot Std (ppm):

******** Audit Report *******

Calculated	Expected	% DEV
-N/A-		

******** Sample Data *******

Sample ID	1st Reading	2nd Reading	Dilution Factor	Sample Volume (mls)
RET BLK	ND	—	1x	
WF-F-FB(A)	ND			170
-FB(B)	ND			210
WC-F-FB(A)	ND			370
-FB(B)	ND			70
WF-F-1 (A)	0.212	—	1x	300
-1 (B)	0.085			240
WF-F-2 (A)	0.088			330
-2 (B)	0.026			230
WF-F-3 (A)	0.109			300
-3 (B)	0.011			220

RESOLUTION ANALYTICS, INC.
Specialists in High Performance Liquid Chromatography

Wet Chemistry Bench Data Sheet

Client Name: PES-MactEC
Analyst: GRE
RFA# 5940
Date: 3/31/03

Method: EPA 316 **Analyte:** ______ **Matrix:** ______

Unit of Measurement ☐ mls ☒ ABS ☐ mv ☐ ppm

******** **Calibration Data** *******

Concentration	Value
See	
Pg	

******** **Pre-Analysis Data** *******

Electrode Slope: ______
Conc. of Lot Std (ppm): ______

******** **Audit Report** *******

Calculated	Expected	% DEV
-N/A-		

******** **Sample Data** *******

Sample ID	1st Reading	2nd Reading	Dilution Factor	Sample Volume (mls)
WC-F-1(A)	0.007	—	1x	470
-1(B)	0.003			60
WC-F-2(A)	ND			470
-2(B)	ND			80
WC-F-3(A)	ND			480
-3(B)	ND			60
LAB SPIKE	0.756	—	1x	—

MACTEC

Central Park West
5001 South Miami Boulevard, P.O. Box 12077
Research Triangle Park, North Carolina 27709-2077
(919) 941-0333 FAX: (919) 941-0234

Chain of Custody Record

Project Numb 5940	Project Name NAPA-Formaldehyde Testing	Analysis Requested	Remarks
Samplers: Maret, Meadows, Pauley			

Date	Time	Field Sample ID		Sample Description	Formaldehyd							Remarks
4/1/2003	1050	MC-F-1(A)		Nozzle, Probe, 1st Impinger	√							
4/1/2003	1050	MC-F-1(B)		2nd Impinger	√							
4/1/2003	1300	MC-F-2(A)		Nozzle, Probe, 1st Impinger	√							
4/1/2003	1300	MC-F-2(B)		2nd Impinger	√							
4/1/2003	1515	MC-F-3(A)		Nozzle, Probe, 1st Impinger	√							
4/1/2003	1515	MC-F-3(B)		2nd Impinger	√							
4/1/2013	1600	MC-F-FB(A)		Nozzle, Probe, 1st Impinger	√							
4/1/2003	1600	MC-F-FB(B)		2nd Impinger	√							
4/2/2003	1610	NM-F-1(A)		Nozzle, Probe, 1st Impinger	√							
4/2/2003	1610	NM-F-1(B)		2nd Impinger	√							
4/2/2003	1640	NM-F-FB(A)		Nozzle, Probe, 1st Impinger	√							
4/2/2003	1640	NM-F-FB(B)		2nd Impinger	√							
4/3/2003	1000	NM-F-2(A)		Nozzle, Probe, 1st Impinger	√							
4/3/2003	1000	NM-F-2(B)		2nd Impinger	√							
4/3/2003	1200	NM-F-3(B)A		Nozzle, Probe, 1st Impinger	√							
4/3/2003	1200	NM-F(3(B)		2nd Impinger	√							

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time 4/05/03	Received for lab by: (Signature) Bruce	REMARKS		

Page:____ of ____

Analytical Narrative

RFA # 5940

Page 1 of 1

Client/Plant Name: MACTEC, Inc.

Date Rec'd in lab: 4/08/03

Analyst: GRE

Date of Analysis: 4/10/03

Analysis Method: EPA Method 316

Analyte(s): Formaldehyde

Sample Matrix & Components:

DI H_2O

Summary of Sample Prep:

Samples were derivitized using a solution of *p*-rosaniline per EPA Method 316 then analyzed by colorimetry at 570nm using a 5-point calibration curve.

Summary of Instrumentation:

ThermoSpectronic™ spectrophotometer model Genesys 20

Analytical Detection Limit(s): 5.46 ppb Formaldehyde

Summary of Sample Spike Analysis:

1.25 mls of sample NM-F-1 (B) was spiked with 1.25 mls of a 2.5 ppm formaldehyde standard then analyzed in the same manner as the samples. A 89.9% recovery was obtained.

Summary of QA Audit Sample Analysis:

See Analytical Data Sheets for results of internal QC audit results. (All internal QC results were within ±30% limits.)

Miscellaneous Comments Regarding Sample Analysis: (Note unusual catch weights, interferences, odd sample behavior, and steps taken to confirm unusual results. Also note any deviations from standard analytical procedures, together with justification and possible affect on results. Specify samples when applicable.)

None.

Confirmation of Data Review:

To the best of my knowledge this analytical data has been checked thoroughly for completeness and the results presented are accurate, error-free, legible, and have been performed and validated in accordance with the approved method(s).

Lab QA Officer Signature J. Bruce [illegible] Date 4/10/03

Method 316 (Formaldehyde) Analytical Data Sheet

Client Name: **MACTEC, Inc.**	RFA# **5940**
Analyst: **GRE**	Date: **04/10/2003**
Filename: C:\JOBS\PES\5940\M316-2.WB1	

Formaldehyde Standard Calibration Curve by Linear Regression

Formaldehyde Conc. (µgs/ml)	Standard ABS	Calculated Concentration (µgs/ml)	Percent Deviation from Actual
0.25	0.127	0.231	-7.51%
0.50	0.273	0.497	-0.59%
1.00	0.557	1.014	1.41%
2.00	1.096	1.995	-0.23%
3.00	1.648	3.000	0.01%

Slope 0.549 Intercept 0.0000 R2= 1.000

Deionized Water

Sample ID	ABS	Sample Dilution Factor	Sample Final Volume (mls)	**Formaldehyde Catch (µgs)**
MC-F-FB (A)	< 0.003	1	250	**< 1.37**
MC-F-FB (B)	< 0.003	1	250	**< 1.37**
NM-F-FB (A)	0.005	1	230	**2.09**
NM-F-FB (B)	0.004	1	170	**1.24**
MC-F-1 (A)	0.044	1	360	**28.8**
MC-F-1 (B)	< 0.003	1	320	**< 1.75**
MC-F-2 (A)	0.011	1	390	**7.81**
MC-F-2 (B)	< 0.003	1	300	**< 1.64**
MC-F-3 (A)	0.032	1	420	**24.5**
MC-F-3 (B)	< 0.003	1	290	**< 1.58**
NM-F-1 (A)	0.100	1	370	**67.4**
NM-F-1 (B)	< 0.003	1	180	**< 0.98**
NM-F-2 (A)	0.025	1	390	**17.8**
NM-F-2 (B)	0.007	1	210	**2.68**
NM-F-3 (A)	0.017	1	370	**11.5**
NM-F-3 (B)	0.008	1	180	**2.62**

SAMPLE ID	Spike Volume (mls)	Spike Conc. (ppm)	ABS	Original Catch (µgs)	Spike Catch (µgs)	Expected Catch (mgs)	% Recovery
NM-F-1 (B)	1.25	2.50	0.617	---	**1.12**	**1.25**	**89.9%**

***** IN-HOUSE AUDIT REPORT *****

	Dilution Factor	ABS	Calculated PPM	Expected PPM	% Recovery
IN-HOUSE	1	1.387	**2.53**	**2.50**	-1.00%

Printing Date Printing Time 03:08 PM

APPENDIX D

CALCULATIONS & COMPUTER SUMMARIES

Summary of Stack Gas Parameters and Test Results
EPA Method 316 - Formaldehyde Concentrations
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC
Page 1 of 2

	RUN NUMBER	**WF-F-1**	**WF-F-2**	**WF-F-3**	
	RUN DATE	**3/25/2003**	**3/25/2003**	**3/25/2003**	**Average**
	RUN TIME	**1030-1151**	**1255-1411**	**1511-1626**	
	MEASURED DATA				
γ	Meter Box Correction Factor	0.991	0.991	0.991	0.991
ΔH	Avg Meter Orifice Pressure, in. H_2O	1.20	0.94	0.83	0.99
P_{bar}	Barometric Pressure, inches Hg	30.09	30.09	30.09	30.09
V_m	Sample Volume, ft^3	40.697	35.998	34.057	36.917
T_m	Average Meter Temperature, °F	76	77	75	76
P_{static}	Stack Static Pressure, inches H_2O	0.01	0.01	0.01	0.0
T_s	Average Stack Temperature, °F	717	750	744	737
V_{lc}	Condensate Collected, ml	104.0	92.2	82.2	92.8
CO_2	Carbon Dioxide content, % by volume	11	12	12	11.7
O_2	Oxygen content, % by volume	6.5	6.5	6.0	6.3
N_2	Nitrogen content, % by volume	82.5	81.5	82.0	82.0
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84
$\Delta p^{1/2}$	Average Square Root Δp, (in. $H_2O)^{1/2}$	0.1239	0.1088	0.1019	0.1115
Θ	Sample Run Duration, minutes	72	72	72	72
D_n	Nozzle Diameter, inches	0.627	0.627	0.627	0.627
	CALCULATED DATA				
A_n	Nozzle Area, ft^2	0.002144	0.002144	0.002144	0.002144
$V_{m(std)}$	Standard Meter Volume, dscf	40.023	35.359	33.564	36.315
$V_{m(std)}$	Standard Meter Volume, dscm	1.133	1.001	0.950	1.028
P_s	Stack Pressure, inches Hg	30.09	30.09	30.09	30.09
B_{ws}	Moisture, % by volume	10.9	10.9	10.3	10.7
$B_{ws(sat)}$	Moisture (at saturation), % by volume	23683.7	28645.3	27752.4	26693.8
V_{wstd}	Standard Water Vapor Volume, ft^3	4.895	4.340	3.869	4.368
$1\text{-}B_{ws}$	Dry Mole Fraction	0.891	0.891	0.897	0.893
M_d	Molecular Weight (d.b.), lb/lb•mole	30.02	30.18	30.16	30.12
M_s	Molecular Weight (w.b.), lb/lb•mole	28.71	28.85	28.90	28.82
V_s	Stack Gas Velocity, ft/s	10.39	9.22	8.61	9.41
A	Stack Area, ft^2	0.349	0.349	0.349	0.349
Q_a	Stack Gas Volumetric flow, acfm	218	193	180	197
Q_s	Stack Gas Volumetric flow, dscfm	87	75	71	78
$Q_{s(cmm)}$	Stack Gas Volumetric flow, dscmm	2	2	2	2
I	Isokinetic Sampling Ratio, %	103.6	106.0	106.5	105.3

Summary of Stack Gas Parameters and Test Results
EPA Method 316 - Formaldehyde Concentrations
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC
Page 2 of 2

	RUN NUMBER	**WF-F-1**	**WF-F-2**	**WF-F-3**	
	RUN DATE	**3/25/2003**	**3/25/2003**	**3/25/2003**	**Average**
	RUN TIME	**1030-1151**	**1255-1411**	**1511-1626**	
	Fuel Usage Rate, gph	3.00	3.0	3.00	3.0
	Heat Content, Btu/gallon [a]	140,000	140,000	140,000	140,000
	Heat Input Rate, million Btu/hr	0.42	0.42	0.42	0.42
	EMISSIONS DATA				
	Formaldehyde				
	Formula Weight, lb/lb-mole	30.03	30.03	30.03	30.03
	Catch, µg	122.55	63.8	63.91	83.4
C_{PM}	Concentration, ppmvd	0.0866	0.0510	0.0539	0.0638
C_{PM}	Concentration, mg/dscm	0.1081	0.0637	0.0672	0.0797
E_{PM}	Emission Rate, lb/hr	3.54E-05	1.80E-05	1.80E-05	2.38E-05
E_{PM}	Emission Rate, lb/mmBtu	8.43E-05	4.29E-05	4.28E-05	5.66E-05
	Carbon Monoxide				
	Formula Weight, lb/lb-mole	28.01	28.01	28.01	28.01
C_{CO}	Concentration, ppmvd	58.6	25.1	6.7	30.1
E_{CO}	Emission Rate, lb/hr	2.23E-02	8.26E-03	2.08E-03	1.09E-02
E_{CO}	Emission Rate, lb/mmBtu	5.32E-02	1.97E-02	4.96E-03	2.59E-02

[a] From AP-42

Metered Sample Volume

	WF-F-1	WF-F-2	WF-F-3
Run Start	173.702	214.522	250.813
Run End	214.399	250.520	284.870
Leak Check 1 Start			
Leak Check 1 End			
Leak Check 2 Start			
Leak Check 2 End			
Volume Metered	40.697	35.998	34.057
Leak Check 3 Start	0	0	0
Leak Check 3 End	0	0	0

WF-F-1

Impinger/XAD H2O

Init Tare	Final	Net H2O Gain
734.7	785.5	50.8
739.1	768.8	29.7
620.6	630.2	9.6
741.8	755.7	13.9
0	0	0
0	0	0
Condensate Collected:		104
	H2O=	10.90

WF-F-2

Impinger/XAD H2O

Init Tare	Final	Net H2O Gain
623.7	677.9	54.2
742.1	763.6	21.5
525.7	530.9	5.2
848.7	860	11.3
0	0	0
		0
Condensate Collected:		92.2
	H2O=	10.93

WF-F-3

Impinger/XAD H2O

Init Tare	Final	Net H2O Gain
741.2	803.6	62.4
744.6	755.4	10.8
623.4	625.3	1.9
755.5	762.6	7.1
		0
		0
Condensate Collected:		82.2
	H2O=	10.34

Effluent Gas Velocity Head, (ΔP)

WF-F-1			WF-F-2			WF-F-3		
Pt	Δp	$\Delta p^{1/2}$	Pt	Δp	$\Delta p^{1/2}$	Pt	Δp	$\Delta p^{1/2}$
1	0.005	0.071	1	0.005	0.071	1	0.005	0.071
2	0.005	0.071	2	0.005	0.071	2	0.005	0.071
3	0.005	0.071	3	0.005	0.071	3	0.005	0.071
4	0.005	0.071	4	0.005	0.071	4	0.005	0.071
5	0.005	0.071	5	0.005	0.071	5	0.005	0.071
6	0.005	0.071	6	0.005	0.071	6	0.005	0.071
7	0.005	0.071	7	0.005	0.071	7	0.005	0.071
8	0.010	0.100	8	0.010	0.100	8	0.005	0.071
9	0.020	0.141	9	0.015	0.122	9	0.010	0.100
10	0.045	0.212	10	0.020	0.141	10	0.020	0.141
11	0.035	0.187	11	0.030	0.173	11	0.025	0.158
12	0.035	0.187	12	0.030	0.173	12	0.030	0.173
13	0.030	0.173	13	0.005	0.071	13	0.030	0.173
14	0.030	0.173	14	0.005	0.071	14	0.030	0.173
15	0.040	0.200	15	0.005	0.071	15	0.030	0.173
16	0.030	0.173	16	0.040	0.200	16	0.020	0.141
17	0.020	0.141	17	0.045	0.212	17	0.015	0.122
18	0.015	0.122	18	0.025	0.158	18	0.010	0.100
19	0.010	0.100	19	0.015	0.122	19	0.005	0.071
20	0.010	0.100	20	0.010	0.100	20	0.005	0.071
21	0.010	0.100	21	0.010	0.100	21	0.005	0.071
22	0.015	0.122	22	0.010	0.100	22	0.005	0.071
23	0.015	0.122	23	0.010	0.100	23	0.005	0.071
24	0.015	0.122	24	0.010	0.100	24	0.005	0.071
25		0.000	25		0.000	25		0.000
26		0.000	26		0.000	26		0.000
27		0.000	27		0.000	27		0.000
28		0.000	28		0.000	28		0.000
29		0.000	29		0.000	29		0.000
30		0.000	30		0.000	30		0.000
31		0.000	31		0.000	31		0.000
32		0.000	32		0.000	32		0.000
33		0.000	33		0.000	33		0.000
34		0.000	34		0.000	34		0.000
35		0.000	35		0.000	35		0.000
36		0.000	36		0.000	36		0.000
37		0.000	37		0.000	37		0.000
38		0.000	38		0.000	38		0.000
39		0.000	39		0.000	39		0.000
40		0.000	40		0.000	40		0.000
41		0.000	41		0.000	41		0.000
42		0.000	42		0.000	42		0.000
43		0.000	43		0.000	43		0.000
44		0.000	44		0.000	44		0.000
45		0.000	45		0.000	45		0.000
46		0.000	46		0.000	46		0.000
47		0.000	47		0.000	47		0.000
48		0.000	48		0.000	48		0.000
49		0.000	49		0.000	49		0.000
50		0.000	50		0.000	50		0.000
Average $\Delta P^{1/2}$		0.1239	Average $\Delta P^{1/2}$		0.1088	Average $\Delta P^{1/2}$		0.1019

Dry Gas Meter Orifice Differential, (ΔH)

WF-F-1		WF-F-2		WF-F-3	
Pt	ΔH	Pt	ΔH	Pt	ΔH
1	0.34	1	0.34	1	0.34
2	0.34	2	0.34	2	0.34
3	0.34	3	0.34	3	0.34
4	0.34	4	0.34	4	0.34
5	0.34	5	0.34	5	0.34
6	0.34	6	0.34	6	0.34
7	0.34	7	0.34	7	0.34
8	0.67	8	0.69	8	0.34
9	1.37	9	1.03	9	0.69
10	3.09	10	1.37	10	1.37
11	2.40	11	2.06	11	1.72
12	2.40	12	2.06	12	2.06
13	2.06	13	0.34	13	2.06
14	2.06	14	0.34	14	2.06
15	2.75	15	0.34	15	2.06
16	2.06	16	2.75	16	1.37
17	1.37	17	3.09	17	1.03
18	1.03	18	1.72	18	0.69
19	0.67	19	1.03	19	0.34
20	0.67	20	0.69	20	0.34
21	0.67	21	0.69	21	0.34
22	1.03	22	0.69	22	0.34
23	1.03	23	0.69	23	0.34
24	1.03	24	0.69	24	0.34
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg ΔH	1.20	Avg ΔH	0.94	Avg ΔH	0.828

Effluent Gas Temperature, (°F)

WF-F-1		WF-F-2		WF-F-3	
Pt	T_s	Pt	T_s	Pt	T_s
1	704	1	670	1	761
2	699	2	670	2	762
3	698	3	696	3	765
4	699	4	719	4	767
5	704	5	725	5	769
6	712	6	732	6	777
7	727	7	746	7	774
8	749	8	757	8	774
9	756	9	773	9	766
10	759	10	785	10	764
11	746	11	784	11	769
12	747	12	784	12	774
13	685	13	762	13	704
14	680	14	762	14	704
15	654	15	761	15	712
16	680	16	761	16	719
17	720	17	762	17	724
18	729	18	761	18	726
19	726	19	763	19	728
20	727	20	763	20	726
21	726	21	761	21	725
22	727	22	761	22	724
23	726	23	770	23	726
24	726	24	775	24	727
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg T_s	717	Avg T_s	750	Avg T_s	744

Dry Gas Meter Temperature, (°F)

WF-F-1			WF-F-2			WF-F-3		
Pt	Inlet	Outlet	Pt	Inlet	Outlet	Pt	Inlet	Outlet
1	69	65	1	74	75	1	74	73
2	72	97	2	74	75	2	74	74
3	72	68	3	74	74	3	74	74
4	73	68	4	74	74	4	75	75
5	75	70	5	75	74	5	75	74
6	75	70	6	76	75	6	75	75
7	77	73	7	76	75	7	74	74
8	75	72	8	77	76	8	75	74
9	77	73	9	77	76	9	75	74
10	78	72	10	78	78	10	75	74
11	79	73	11	80	76	11	76	74
12	81	75	12	80	77	12	77	74
13	78	75	13	78	77	13	76	75
14	79	75	14	77	76	14	77	74
15	79	74	15	78	77	15	77	74
16	81	75	16	78	77	16	77	74
17	81	75	17	80	77	17	77	75
18	81	76	18	80	77	18	76	74
19	81	75	19	80	76	19	76	75
20	82	76	20	79	77	20	75	74
21	83	77	21	78	77	21	75	75
22	83	78	22	78	76	22	75	74
23	84	79	23	79	77	23	75	74
24	84	79	24	78	77	24	75	74
25			25			25		
26			26			26		
27			27			27		
28			28			28		
29			29			29		
30			30			30		
31			31			31		
32			32			32		
33			33			33		
34			34			34		
35			35			35		
36			36			36		
37			37			37		
38			38			38		
39			39			39		
40			40			40		
41			41			41		
42			42			42		
43			43			43		
44			44			44		
45			45			45		
46			46			46		
47			47			47		
48			48			48		
49			49			49		
50			50			50		
Avg T_m		76.4	Avg T_m		76.8	Avg T_m		74.8

GAS FLOW CALCULATIONS

PLANT: S.T. Wooten Franklinton, NC SOURCE/RUN: WF-F-M2-4 DATE: 3-25-03

MOLECULAR WEIGHT OF DRY STACK GAS

$$M_d = 0.44\ (\%\ CO_2) + 0.32\ (\%\ O_2) + 0.28\ (\%N_2 + \%\ CO)$$

$$= (0.44 \times \underline{\qquad}) + (0.32 \times \underline{\qquad}) + (0.28 \times \underline{\qquad})$$

$$= \underline{\qquad}\ \text{lb/lb - mole}$$

MOLECULAR WEIGHT OF STACK GAS, STACK CONDITIONS

$$M_s = M_d\ (1 - B_{WS}) + 18(B_{WS})$$

$$= \underline{\qquad}\ (1 - \underline{\qquad}) + 18(\underline{\qquad})$$

$$= \underline{\qquad}\ \text{lb/lb - mole at stack conditions}$$

STACK GAS VELOCITY, FPS

$$V_S = 85.49 \times C_p\ (\sqrt{\Delta P})\sqrt{\frac{T_S}{P_S \times M_S}}$$

$$= 85.49 \times \underline{.84} \times \underline{.1061}\left(\sqrt{\frac{1176}{\underline{30.09} \times \underline{28.74}}}\right)$$

$$= \underline{8.885}\ \text{fps}$$

VOLUMETRIC FLOW RATE AT STACK CONDITIONS, acfm

$$Q_a(\text{circular}) = 60 \times V_S \left(\frac{\pi d^2}{4}\right) = 60 \times V_S\ (5.454 \times 10^{-3})\ (d^2)$$

$$= 60 \times \underline{8.885} \times 5.454 \times 10^{-3}\ (\underline{\quad 8 \quad})^2$$

$$Q_a(\text{rectangular}) = 60 \times V_S \left(\frac{L \times W}{144}\right) = 60 \times V_S\ (L + W)\ 6.944 \times 10^{-3}$$

$$= 60 \times \underline{\qquad}\ (\underline{\qquad} \times \underline{\qquad})\ 6.944 \times 10^{-3}$$

$$Q_a = \underline{186.1}\ \text{acfm}$$

VOLUMETRIC FLOW RATE AT STANDARD CONDITIONS, dscfm

$$Q_{std} = 17.64 \times Q_a \times \frac{P_S}{T_S}\ (1 - B_{WS})$$

$$= 17.647 \times \underline{186.1} \times \frac{(30.09)}{(1176)}\ (1 - \underline{.103})$$

$$= \underline{75.4}\ \text{dscfm}$$

Summary of Carbon Monoxide Concentrations

EPA Method 10 - Carbon Monoxide Concentration

HOS Outlet

S.T. Wooten Corporation - Franklinton, NC

RUN	Date	Time	CO ppmvd	
			Actual	Drift Corrected
1	3/25/2003	1030-1151	55.2	58.6
2	3/25/2003	1255-1411	23.0	25.1
3	3/25/2003	1511-1626	5.8	6.7
AVERAGE			28.0	30.1

Summary of Calibration and Drift Corrections
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC

25-Mar-03

	Cal Gas	Direct		Bias	
		Response	Cal Error	Response	Cal Error
Zero	0.00	0.00	0.00%	0.0	0.00%
Low	30.08	29.30	-0.78%	28.9	-0.40%
Mid	59.39	58.00	-1.39%		
High	88.80	88.80	0.00%		

Pre Cal	0.00 28.90		
Run 1	55.21	Corrected	58.6 ppm CO
Post Cal	0.10 27.80	Drift	0.10% 1.10%
Run 2	23.00	Corrected	25.1 ppm CO
Post Cal	-0.40 27.40	Drift	0.50% 0.40%
Run 3	5.76	Corrected	6.7 ppm CO
Post Cal	-0.40 27.40	Drift	0.00% 0.00%

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC

Run 1

Date	Time	CO (ppm)
3/25/103	10:30:00	72.136
3/25/103	10:31:00	70.032
3/25/103	10:32:00	70.72
3/25/103	10:33:00	67.477
3/25/103	10:34:00	70.988
3/25/103	10:35:00	64.77
3/25/103	10:36:00	74.794
3/25/103	10:37:00	72.795
3/25/103	10:38:00	64.874
3/25/103	10:39:00	66.661
3/25/103	10:40:00	70.596
3/25/103	10:41:00	65.353
3/25/103	10:42:00	58.114
3/25/103	10:43:00	64.627
3/25/103	10:44:00	65.904
3/25/103	10:45:00	68.214
3/25/103	10:46:00	62.697
3/25/103	10:47:00	57.548
3/25/103	10:48:00	65.378
3/25/103	10:49:00	62.443
3/25/103	10:50:00	60.344
3/25/103	10:51:00	59.005
3/25/103	10:52:00	60.2
3/25/103	10:53:00	59.562
3/25/103	10:54:00	61.691
3/25/103	10:55:00	60.328
3/25/103	10:56:00	61.342
3/25/103	10:57:00	57.971
3/25/103	10:58:00	61.61
3/25/103	10:59:00	58.318
3/25/103	11:00:00	58.71
3/25/103	11:01:00	57.511
3/25/103	11:02:00	62.334
3/25/103	11:03:00	66.019
3/25/103	11:04:00	62.354
3/25/103	11:05:00	60.588
3/25/103	11:06:00	57.4
3/25/103	11:07:00	62.746
3/25/103	11:08:00	60.202
3/25/103	11:09:00	59.218
3/25/103	11:10:00	57.876
3/25/103	11:11:00	52.412
3/25/103	11:12:00	55.583

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC

3/25/103	11:13:00	54.765
3/25/103	11:14:00	55.725
3/25/103	11:15:00	54.97
3/25/103	11:16:00	52.646
3/25/103	11:17:00	52.307
3/25/103	11:18:00	57.088
3/25/103	11:19:00	55.471
3/25/103	11:20:00	55.444
3/25/103	11:21:00	54.803
3/25/103	11:22:00	54.169
3/25/103	11:23:00	51.526
3/25/103	11:24:00	52.836
3/25/103	11:25:00	53.663
3/25/103	11:26:00	40.785
3/25/103	11:27:00	48.627
3/25/103	11:28:00	51.902
3/25/103	11:29:00	48.649
3/25/103	11:30:00	50.817
3/25/103	11:31:00	51.366
3/25/103	11:32:00	51.13
3/25/103	11:33:00	51.182
3/25/103	11:34:00	48.964
3/25/103	11:35:00	49.603
3/25/103	11:36:00	47.592
3/25/103	11:37:00	48.948
3/25/103	11:38:00	49.032
3/25/103	11:39:00	47.167
3/25/103	11:40:00	50.523
3/25/103	11:41:00	50.044
3/25/103	11:42:00	48.142
3/25/103	11:43:00	47.489
3/27/103	10:46:26	2.60
3/27/103	10:47:26	2.34
3/27/103	10:48:26	2.22
3/27/103	10:49:26	2.27
Average		55.21

Summary of Raw CEM Data

EPA Method 10 - Carbon Monoxide Concentration

HOS Outlet

S.T. Wooten Corporation - Franklinton, NC

Run 2

Date	Time	CO (ppm)
3/25/103	12:55:17	37.29
3/25/103	12:56:17	35.787
3/25/103	12:57:17	39.469
3/25/103	12:58:17	38.332
3/25/103	12:59:17	36.723
3/25/103	13:00:17	38.493
3/25/103	13:01:17	36.37
3/25/103	13:02:17	37.371
3/25/103	13:03:17	36.471
3/25/103	13:04:17	38.226
3/25/103	13:05:17	24.745
3/25/103	13:06:17	29.008
3/25/103	13:07:17	37.763
3/25/103	13:08:17	38.189
3/25/103	13:09:17	36.621
3/25/103	13:10:17	36.973
3/25/103	13:11:17	37.072
3/25/103	13:12:17	38.984
3/25/103	13:13:17	35.771
3/25/103	13:14:17	36.955
3/25/103	13:15:17	37.377
3/25/103	13:16:17	39.03
3/25/103	13:17:17	37.274
3/25/103	13:18:17	36.36
3/25/103	13:19:17	37.329
3/25/103	13:20:17	39.388
3/25/103	13:21:17	37.361
3/25/103	13:22:17	35.667
3/25/103	13:23:17	33.71
3/25/103	13:24:17	34.666
3/25/103	13:25:17	35.866
3/25/103	13:26:17	36.706
3/25/103	13:27:17	37.346
3/25/103	13:28:17	37.702
3/25/103	13:29:17	38.271
3/25/103	13:30:17	38.866
3/25/103	13:31:17	36.425
3/25/103	13:32:17	38.392
3/25/103	13:33:17	20.138
3/25/103	13:34:17	14.953
3/25/103	13:35:17	11.683
3/25/103	13:36:17	9.531
3/25/103	13:37:17	9.177

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC

3/25/103	13:38:17	8.542
3/25/103	13:39:17	7.622
3/25/103	13:40:17	7.037
3/25/103	13:41:17	7.978
3/25/103	13:42:17	7.715
3/25/103	13:43:17	6.872
3/25/103	13:44:17	9.049
3/25/103	13:45:17	10.147
3/25/103	13:46:17	11.764
3/25/103	13:47:17	9.732
3/25/103	13:48:17	9.112
3/25/103	13:49:17	9.57
3/25/103	13:50:17	9.783
3/25/103	13:51:17	10.397
3/25/103	13:52:17	7.739
3/25/103	13:53:17	7.785
3/25/103	13:54:17	8.959
3/25/103	13:55:17	11.713
3/25/103	13:56:17	10.976
3/25/103	13:57:17	8.159
3/25/103	13:58:17	9.932
3/25/103	13:59:17	11.287
3/25/103	14:00:17	8.034
3/25/103	14:01:17	8.52
3/25/103	14:02:17	7.187
3/25/103	14:03:17	7.932
3/25/103	14:04:17	7.978
3/25/103	14:05:17	10.682
3/25/103	14:06:17	10.957
3/25/103	14:07:17	12.627
3/25/103	14:08:17	9.071
3/25/103	14:09:17	8.63
3/25/103	14:10:17	8.771
3/25/103	14:11:17	8.913
Average		23.00004

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC

Run 3

Date	Time	CO (ppm)
3/25/103	15:11:17	3.464
3/25/103	15:12:17	3.381
3/25/103	15:13:17	4.054
3/25/103	15:14:17	3.56
3/25/103	15:15:17	4.381
3/25/103	15:16:17	5.111
3/25/103	15:17:17	8.379
3/25/103	15:18:17	7.212
3/25/103	15:19:17	5.479
3/25/103	15:20:17	6.924
3/25/103	15:21:17	3.872
3/25/103	15:22:17	3.552
3/25/103	15:23:17	5.601
3/25/103	15:24:17	5.252
3/25/103	15:25:17	2.541
3/25/103	15:26:17	2.141
3/25/103	15:27:17	8.334
3/25/103	15:28:17	12.832
3/25/103	15:29:17	7.512
3/25/103	15:30:17	4.918
3/25/103	15:31:17	4.456
3/25/103	15:32:17	3.914
3/25/103	15:33:17	3.703
3/25/103	15:34:17	5.357
3/25/103	15:35:17	5.626
3/25/103	15:36:17	6.186
3/25/103	15:37:17	8.008
3/25/103	15:38:17	5.229
3/25/103	15:39:17	5.266
3/25/103	15:40:17	6.29
3/25/103	15:41:17	6.296
3/25/103	15:42:17	4.588
3/25/103	15:43:17	5.912
3/25/103	15:44:17	5.399
3/25/103	15:45:17	5.096
3/25/103	15:46:17	4.907
3/25/103	15:47:17	5.357
3/25/103	15:48:17	6.003
3/25/103	15:49:17	5.418
3/25/103	15:50:17	6.846
3/25/103	15:51:17	5.375
3/25/103	15:52:17	6.392
3/25/103	15:53:17	6.189

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Franklinton, NC

3/25/103	15:54:17	5.639
3/25/103	15:55:17	5.372
3/25/103	15:56:17	4.807
3/25/103	15:57:17	6.021
3/25/103	15:58:17	7.88
3/25/103	15:59:17	7.659
3/25/103	16:00:17	7.389
3/25/103	16:01:17	7.432
3/25/103	16:02:17	4.305
3/25/103	16:03:17	5.121
3/25/103	16:04:17	5.884
3/25/103	16:05:17	5.663
3/25/103	16:06:17	2.865
3/25/103	16:07:17	1.58
3/25/103	16:08:17	5.974
3/25/103	16:09:17	5.384
3/25/103	16:10:17	4.808
3/25/103	16:11:17	6.921
3/25/103	16:12:17	8.615
3/25/103	16:13:17	7.533
3/25/103	16:14:17	8.057
3/25/103	16:15:17	8.518
3/25/103	16:16:17	7.573
3/25/103	16:17:17	6.294
3/25/103	16:18:17	5.728
3/25/103	16:19:17	6.62
3/25/103	16:20:17	6.174
3/25/103	16:21:17	5.772
3/25/103	16:22:17	5.096
3/25/103	16:23:17	5.254
3/25/103	16:24:17	6.923
3/25/103	16:25:17	6.371
3/25/103	16:26:17	6.396
Average		5.762

Summary of Stack Gas Parameters and Test Results
EPA Method 316 - Formaldehyde Concentrations
HOS Outlet
S.T. Wooten Corporation - Clayton, NC
Page 1 of 2

	RUN NUMBER	**WC-F-1**	**WC-F-2**	**WC-F-3**	
	RUN DATE	**3/27/2003**	**3/27/2003**	**3/27/2003**	**Average**
	RUN TIME	**0934-1109**	**1136-1250**	**1400-1503**	
	MEASURED DATA				
γ	Meter Box Correction Factor	0.991	0.991	0.991	0.991
ΔH	Avg Meter Orifice Pressure, in. H_2O	2.05	2.25	2.48	2.26
P_{bar}	Barometric Pressure, inches Hg	30.16	30.16	30.16	30.16
V_m	Sample Volume, ft^3	54.808	55.222	60.570	56.867
T_m	Average Meter Temperature, °F	63	72	75	70
P_{static}	Stack Static Pressure, inches H_2O	0.003	0.003	0.003	0.0
T_s	Average Stack Temperature, °F	629	615	625	623
V_{lc}	Condensate Collected, ml	106.3	107.7	123.0	112.3
CO_2	Carbon Dioxide content, % by volume	11	11	11	11.0
O_2	Oxygen content, % by volume	8.0	8	8	8.0
N_2	Nitrogen content, % by volume	81.0	81.0	81.0	81.0
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84
$\Delta p^{1/2}$	Average Square Root Δp, (in. H_2O)$^{1/2}$	0.1698	0.1726	0.1780	0.1735
Θ	Sample Run Duration, minutes	72	72	72	72
D_n	Nozzle Diameter, inches	0.627	0.627	0.627	0.627
	CALCULATED DATA				
A_n	Nozzle Area, ft^2	0.002144	0.002144	0.002144	0.002144
$V_{m(std)}$	Standard Meter Volume, dscf	55.581	55.041	60.073	56.898
$V_{m(std)}$	Standard Meter Volume, dscm	1.574	1.559	1.701	1.611
P_s	Stack Pressure, inches Hg	30.16	30.16	30.16	30.16
B_{ws}	Moisture, % by volume	8.3	8.4	8.8	8.5
$B_{ws(sat)}$	Moisture (at saturation), % by volume	13444.3	12175.7	13062.2	12894.1
V_{wstd}	Standard Water Vapor Volume, ft^3	5.004	5.069	5.790	5.288
$1-B_{ws}$	Dry Mole Fraction	0.917	0.916	0.912	0.915
M_d	Molecular Weight (d.b.), lb/lb•mole	30.08	30.08	30.08	30.08
M_s	Molecular Weight (w.b.), lb/lb•mole	29.08	29.06	29.02	29.05
V_s	Stack Gas Velocity, ft/s	13.59	13.72	14.23	13.85
A	Stack Area, ft^2	0.852	0.852	0.852	0.852
Q_a	Stack Gas Volumetric flow, acfm	695	702	728	708
Q_s	Stack Gas Volumetric flow, dscfm	311	318	325	318
$Q_{s(cmm)}$	Stack Gas Volumetric flow, dscmm	9	9	9	9
I	Isokinetic Sampling Ratio, %	98.5	95.6	101.9	98.7

Summary of Stack Gas Parameters and Test Results
EPA Method 316 - Formaldehyde Concentrations
HOS Outlet
S.T. Wooten Corporation - Clayton, NC
Page 2 of 2

	RUN NUMBER	WC-F-1	WC-F-2	WC-F-3	Average
	RUN DATE	3/27/2003	3/27/2003	3/27/2003	
	RUN TIME	0934-1109	1136-1250	1400-1503	
	Fuel Usage Rate, gph	6.50	6.5	6.50	6.5
	Heat Content, Btu/gallon [a]	140,000	140,000	140,000	140,000
	Heat Input Rate, million Btu/hr	0.91	0.91	0.91	0.91
	EMISSIONS DATA				
	Formaldehyde				
	Formula Weight, lb/lb-mole	30.03	30.03	30.03	30.03
	Catch, µg	6.318	< 3.007	< 2.948	< 4.091
C_{PM}	Concentration, ppmvd	0.00322	< 0.00155	< 0.00139	< 0.00205
C_{PM}	Concentration, mg/dscm	0.00401	< 0.00193	< 0.00173	< 0.00256
E_{PM}	Emission Rate, lb/hr	4.68E-06	< 2.30E-06	< 2.11E-06	< 3.03E-06
E_{PM}	Emission Rate, lb/mmBtu	5.15E-06	< 2.53E-06	< 2.32E-06	< 3.33E-06

Note: Formaldehyde was not detected during Run 2 or 3. Values shown are calculated based on the "<" reported catch and are used in calculating the 3-run average.

	Carbon Monoxide				
	Formula Weight, lb/lb-mole	28.01	28.01	28.01	28.01
C_{CO}	Concentration, ppmvd	2.8	1.6	1.1	1.8
E_{CO}	Emission Rate, lb/hr	3.80E-03	2.22E-03	1.56E-03	2.53E-03
E_{CO}	Emission Rate, lb/mmBtu	4.18E-03	2.44E-03	1.72E-03	2.78E-03

[a] From AP-42

Metered Sample Volume

	WC-F-1	WC-F-2	WC-F-3
Run Start	285.393	340.326	396.206
Run End	340.201	395.548	456.776
Leak Check 1 Start			
Leak Check 1 End			
Leak Check 2 Start			
Leak Check 2 End			
Volume Metered	54.808	55.222	60.570
Leak Check 3 Start	0	0	0
Leak Check 3 End	0	0	0

WC-F-1

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	741	792.2	51.2
	745.4	777.9	32.5
	623.4	633.1	9.7
	762.1	775	12.9
	0	0	0
	0	0	0
0	Condensate Collected:		106.3
67		H2O=	8.28

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WC-F-2

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	628.2	701.6	73.4
	747.7	769.7	22
	530	533	3
	860	869.3	9.3
	0	0	0
			0
	Condensate Collected:		107.7
		H2O=	8.45

WC-F-3

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	722.2	788.6	66.4
	622.5	663.3	40.8
	605.7	609.5	3.8
	846	858	12
			0
			0
	Condensate Collected:		123
		H2O=	8.81

Effluent Gas Velocity Head, (ΔP)

WC-F-1			WC-F-2			WC-F-3		
Pt	Δp	$\Delta p^{1/2}$	Pt	Δp	$\Delta p^{1/2}$	Pt	Δp	$\Delta p^{1/2}$
1	0.065	0.255	1	0.070	0.265	1	0.060	0.245
2	0.075	0.274	2	0.070	0.265	2	0.070	0.265
3	0.075	0.274	3	0.080	0.283	3	0.075	0.274
4	0.070	0.265	4	0.075	0.274	4	0.075	0.274
5	0.060	0.245	5	0.070	0.265	5	0.070	0.265
6	0.025	0.158	6	0.040	0.200	6	0.060	0.245
7	0.020	0.141	7	0.020	0.141	7	0.030	0.173
8	0.015	0.122	8	0.020	0.141	8	0.020	0.141
9	0.015	0.122	9	0.015	0.122	9	0.015	0.122
10	0.012	0.110	10	0.010	0.100	10	0.015	0.122
11	0.010	0.100	11	0.010	0.100	11	0.015	0.122
12	0.010	0.100	12	0.010	0.100	12	0.010	0.100
13	0.015	0.122	13	0.010	0.100	13	0.010	0.100
14	0.015	0.122	14	0.015	0.122	14	0.015	0.122
15	0.016	0.125	15	0.020	0.141	15	0.015	0.122
16	0.016	0.126	16	0.020	0.141	16	0.015	0.122
17	0.020	0.141	17	0.020	0.141	17	0.020	0.141
18	0.020	0.141	18	0.025	0.158	18	0.020	0.141
19	0.030	0.173	19	0.030	0.173	19	0.030	0.173
20	0.035	0.187	20	0.030	0.173	20	0.035	0.187
21	0.035	0.187	21	0.030	0.173	21	0.040	0.200
22	0.035	0.187	22	0.035	0.187	22	0.040	0.200
23	0.036	0.189	23	0.035	0.187	23	0.040	0.200
24	0.043	0.207	24	0.035	0.187	24	0.045	0.212
25		0.000	25		0.000	25		0.000
26		0.000	26		0.000	26		0.000
27		0.000	27		0.000	27		0.000
28		0.000	28		0.000	28		0.000
29		0.000	29		0.000	29		0.000
30		0.000	30		0.000	30		0.000
31		0.000	31		0.000	31		0.000
32		0.000	32		0.000	32		0.000
33		0.000	33		0.000	33		0.000
34		0.000	34		0.000	34		0.000
35		0.000	35		0.000	35		0.000
36		0.000	36		0.000	36		0.000
37		0.000	37		0.000	37		0.000
38		0.000	38		0.000	38		0.000
39		0.000	39		0.000	39		0.000
40		0.000	40		0.000	40		0.000
41		0.000	41		0.000	41		0.000
42		0.000	42		0.000	42		0.000
43		0.000	43		0.000	43		0.000
44		0.000	44		0.000	44		0.000
45		0.000	45		0.000	45		0.000
46		0.000	46		0.000	46		0.000
47		0.000	47		0.000	47		0.000
48		0.000	48		0.000	48		0.000
49		0.000	49		0.000	49		0.000
50		0.000	50		0.000	50		0.000
Average $\Delta P^{1/2}$		0.1698	Average $\Delta P^{1/2}$		0.1726	Average $\Delta P^{1/2}$		0.1780

Dry Gas Meter Orifice Differential, (ΔH)

WC-F-1		WC-F-2		WC-F-3	
Pt	ΔH	Pt	ΔH	Pt	ΔH
1	4.42	1	4.760	1	4.28
2	5.10	2	4.760	2	4.99
3	5.10	3	5.440	3	5.35
4	4.76	4	5.10	4	5.35
5	1.08	5	4.76	5	4.99
6	1.70	6	2.72	6	4.28
7	1.36	7	1.36	7	2.14
8	1.02	8	1.36	8	1.43
9	1.02	9	1.02	9	1.07
10	0.82	10	0.68	10	1.07
11	0.68	11	0.68	11	0.71
12	0.68	12	0.68	12	0.71
13	1.02	13	0.68	13	0.71
14	1.02	14	1.02	14	1.07
15	1.02	15	1.36	15	1.07
16	1.09	16	1.36	16	1.07
17	1.36	17	1.36	17	1.43
18	1.36	18	1.70	18	1.43
19	2.04	19	2.04	19	2.14
20	2.38	20	2.04	20	2.50
21	2.38	21	2.04	21	2.86
22	2.38	22	2.38	22	2.86
23	2.43	23	2.38	23	2.86
24	2.92	24	2.38	24	3.21
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg ΔH	2.05	Avg ΔH	2.25	Avg ΔH	2.483

Effluent Gas Temperature, (°F)

WC-F-1		WC-F-2		WC-F-3	
Pt	T_S	Pt	T_S	Pt	T_S
1	641	1	616	1	627
2	640	2	616	2	623
3	639	3	614	3	625
4	640	4	613	4	624
5	638	5	614	5	625
6	637	6	614	6	623
7	636	7	615	7	624
8	633	8	615	8	625
9	633	9	614	9	626
10	632	10	613	10	626
11	631	11	615	11	625
12	632	12	614	12	625
13	629	13	616	13	624
14	632	14	615	14	624
15	635	15	616	15	625
16	635	16	615	16	626
17	625	17	615	17	626
18	615	18	616	18	625
19	614	19	613	19	626
20	615	20	616	20	623
21	615	21	615	21	626
22	616	22	617	22	623
23	616	23	615	23	625
24	615	24	615	24	624
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg T_S	629	Avg T_S	615	Avg T_S	625

Dry Gas Meter Temperature, (°F)

WC-F-1			WC-F-2			WC-F-3		
Pt	Inlet	Outlet	Pt	Inlet	Outlet	Pt	Inlet	Outlet
1	58	56	1	67	65	1	72	69
2	62	57	2	70	65	2	75	70
3	63	57	3	73	65	3	79	70
4	66	58	4	75	66	4	82	71
5	67	58	5	77	67	5	83	72
6	66	59	6	78	68	6	83	73
7	65	59	7	77	68	7	82	73
8	64	59	8	76	68	8	83	73
9	64	59	9	75	69	9	79	73
10	63	59	10	74	69	10	79	73
11	63	59	11	74	69	11	78	73
12	64	59	12	73	69	12	77	73
13	63	60	13	72	69	13	74	72
14	64	60	14	73	70	14	74	72
15	65	61	15	74	70	15	75	72
16	65	61	16	74	70	16	75	72
17	65	61	17	75	70	17	75	72
18	67	62	18	75	70	18	75	72
19	67	62	19	76	71	19	76	72
20	68	62	20	77	71	20	77	72
21	68	62	21	77	71	21	78	72
22	68	63	22	77	72	22	77	72
23	68	63	23	78	72	23	77	73
24	68	63	24	77	72	24	77	73
25			25			25		
26			26			26		
27			27			27		
28			28			28		
29			29			29		
30			30			30		
31			31			31		
32			32			32		
33			33			33		
34			34			34		
35			35			35		
36			36			36		
37			37			37		
38			38			38		
39			39			39		
40			40			40		
41			41			41		
42			42			42		
43			43			43		
44			44			44		
45			45			45		
46			46			46		
47			47			47		
48			48			48		
49			49			49		
50			50			50		
Avg T_m		62.5	Avg T_m		71.9	Avg T_m		74.8

Summary of Carbon Monoxide Concentrations
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Clayton, NC

RUN	Date	Time	CO ppmvd	
			Actual	Drift Corrected
1	3/27/2003	0934-1109	2.5	2.8
2	3/27/2003	1136-1250	1.3	1.6
3	3/27/2003	1400-1513	0.8	1.1
AVERAGE			1.6	1.8

Summary of Calibration and Drift Corrections
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Clayton, NC

27-Mar-03

	Cal Gas	Direct		Bias	
		Response	Cal Error	Response	Cal Error
Zero	0.00	0.10	0.10%	0.0	-0.10%
Low	30.08	29.30	-0.78%	28.0	-1.30%
Mid	59.39	58.10	-1.29%		
High	88.80	88.30	-0.50%		

Pre Cal	0.00 28.00		
Run 1	2.54	Corrected	2.8 ppm CO
Post Cal	-0.10 27.90	Drift	0.10% 0.10%
Run 2	1.34	Corrected	1.6 ppm CO
Post Cal	-0.20 27.60	Drift	0.10% 0.30%
Run 3	0.82	Corrected	1.1 ppm CO
Post Cal	-0.20 27.60	Drift	0.00% 0.00%

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Clayton, NC

Run 1

Date	Time	CO (ppm)
	9:34	
	9:35	
3/27/103	9:37:26	3.20
3/27/103	9:38:26	3.26
3/27/103	9:39:26	3.29
3/27/103	9:40:26	3.13
3/27/103	9:41:26	2.90
3/27/103	9:42:26	3.06
3/27/103	9:43:26	3.19
3/27/103	9:44:26	3.14
3/27/103	9:45:26	2.79
3/27/103	9:46:26	3.26
3/27/103	9:47:26	2.72
3/27/103	9:48:26	2.69
3/27/103	9:49:26	2.50
3/27/103	9:50:26	2.71
3/27/103	9:51:26	2.70
3/27/103	9:52:26	2.67
3/27/103	9:53:26	2.77
3/27/103	9:54:26	2.55
3/27/103	9:55:26	2.72
3/27/103	9:56:26	3.29
3/27/103	9:57:26	3.12
3/27/103	9:58:26	2.65
3/27/103	9:59:26	2.64
3/27/103	10:00:26	2.51
3/27/103	10:01:26	2.71
3/27/103	10:02:26	2.46
3/27/103	10:03:26	2.44
3/27/103	10:04:26	2.56
3/27/103	10:05:26	2.48
3/27/103	10:06:26	2.72
3/27/103	10:07:26	2.46
3/27/103	10:08:26	2.47
3/27/103	10:09:26	2.68
3/27/103	10:10:26	2.36
3/27/103	10:11:26	2.57
3/27/103	10:12:26	2.52
3/27/103	10:13:26	2.28
3/27/103	10:14:26	2.21
3/27/103	10:15:26	2.37
3/27/103	10:16:26	2.16
3/27/103	10:17:26	2.34

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Clayton, NC

3/27/103	10:18:26	2.51
3/27/103	10:19:26	2.24
3/27/103	10:20:26	2.56
3/27/103	10:21:26	2.49
3/27/103	10:22:26	2.41
3/27/103	10:23:26	2.30
3/27/103	10:24:26	2.54
3/27/103	10:25:26	2.47
3/27/103	10:26:26	2.13
3/27/103	10:27:26	2.29
3/27/103	10:28:26	2.04
3/27/103	10:29:26	2.18
3/27/103	10:30:26	2.49
3/27/103	10:31:26	2.06
3/27/103	10:32:26	2.18
3/27/103	10:33:26	2.09
3/27/103	10:34:26	2.09
3/27/103	10:35:26	2.13
3/27/103	10:36:26	2.52
3/27/103	10:37:26	2.23
3/27/103	10:38:26	2.24
3/27/103	10:39:26	2.47
3/27/103	10:40:26	2.47
3/27/103	10:41:26	2.25
3/27/103	10:42:26	2.31
3/27/103	10:43:26	2.46
3/27/103	10:44:26	2.27
3/27/103	10:45:26	2.22
3/27/103	10:46:26	2.60
3/27/103	10:47:26	2.34
3/27/103	10:48:26	2.22
3/27/103	10:49:26	2.27
Average		2.54

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Clayton, NC

Run 2

Date	Time	CO (ppm)
3/27/103	11:36:26	1.52
3/27/103	11:37:26	1.61
3/27/103	11:38:26	1.63
3/27/103	11:39:26	1.61
3/27/103	11:40:26	1.50
3/27/103	11:41:26	1.87
3/27/103	11:42:26	1.80
3/27/103	11:43:26	1.74
3/27/103	11:44:26	1.47
3/27/103	11:45:26	1.19
3/27/103	11:46:26	1.51
3/27/103	11:47:26	1.31
3/27/103	11:48:26	1.38
3/27/103	11:49:26	1.17
3/27/103	11:50:26	1.16
3/27/103	11:51:26	1.28
3/27/103	11:52:26	1.15
3/27/103	11:53:26	1.27
3/27/103	11:54:26	1.35
3/27/103	11:55:26	1.52
3/27/103	11:56:26	1.64
3/27/103	11:57:26	1.44
3/27/103	11:58:26	1.73
3/27/103	11:59:26	1.36
3/27/103	12:00:26	1.52
3/27/103	12:01:26	1.78
3/27/103	12:02:26	1.43
3/27/103	12:03:26	1.24
3/27/103	12:04:26	1.30
3/27/103	12:05:26	1.42
3/27/103	12:06:26	1.45
3/27/103	12:07:26	1.40
3/27/103	12:08:26	1.46
3/27/103	12:09:26	1.67
3/27/103	12:10:26	1.33
3/27/103	12:11:26	1.30
3/27/103	12:12:26	1.32
3/27/103	12:13:26	1.42
3/27/103	12:15:38	1.30
3/27/103	12:16:38	1.34
3/27/103	12:17:38	1.11
3/27/103	12:18:38	1.12

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Clayton, NC

3/27/103	12:19:38	1.38
3/27/103	12:20:38	1.27
3/27/103	12:21:38	1.17
3/27/103	12:22:38	1.34
3/27/103	12:23:38	1.03
3/27/103	12:24:38	0.90
3/27/103	12:25:38	1.22
3/27/103	12:26:38	1.20
3/27/103	12:27:38	1.62
3/27/103	12:28:38	1.49
3/27/103	12:29:38	1.22
3/27/103	12:30:38	1.17
3/27/103	12:31:38	1.19
3/27/103	12:32:38	1.20
3/27/103	12:33:38	1.20
3/27/103	12:34:38	1.19
3/27/103	12:35:38	1.11
3/27/103	12:36:38	1.02
3/27/103	12:37:38	1.18
3/27/103	12:38:38	1.17
3/27/103	12:39:38	1.12
3/27/103	12:40:38	1.21
3/27/103	12:41:38	1.19
3/27/103	12:42:38	1.24
3/27/103	12:43:38	1.27
3/27/103	12:44:38	1.12
3/27/103	12:45:38	1.17
3/27/103	12:46:38	1.49
3/27/103	12:47:38	1.26
3/27/103	12:48:38	1.22
3/27/103	12:49:38	1.30
3/27/103	12:50:38	1.22
Average		1.34

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
S.T. Wooten Corporation - Clayton, NC

Run 3

Date	Time	CO (ppm)
3/27/103	14:00:38	1.456
3/27/103	14:01:38	1.742
3/27/103	14:02:38	1.786
3/27/103	14:03:38	1.693
3/27/103	14:04:38	1.733
3/27/103	14:05:38	1.543
3/27/103	14:06:38	1.340
3/27/103	14:07:38	1.480
3/27/103	14:08:38	1.382
3/27/103	14:09:38	1.451
3/27/103	14:10:38	1.208
3/27/103	14:11:38	1.305
3/27/103	14:12:38	1.422
3/27/103	14:13:38	1.131
3/27/103	14:14:38	1.100
3/27/103	14:15:38	0.881
3/27/103	14:16:38	0.968
3/27/103	14:17:38	0.888
3/27/103	14:18:38	1.117
3/27/103	14:19:38	1.081
3/27/103	14:20:38	1.060
3/27/103	14:21:38	1.078
3/27/103	14:22:38	1.150
3/27/103	14:23:38	1.058
3/27/103	14:24:38	0.961
3/27/103	14:25:38	0.979
3/27/103	14:26:38	1.292
3/27/103	14:27:38	0.919
3/27/103	14:28:38	0.994
3/27/103	14:29:38	0.793
3/27/103	14:30:38	0.829
3/27/103	14:31:38	0.897
3/27/103	14:32:38	0.805
3/27/103	14:33:38	0.825
3/27/103	14:34:38	0.916
3/27/103	14:35:38	0.730
3/27/103	14:36:38	0.725
3/27/103	14:37:38	0.731
3/27/103	14:38:38	0.908
3/27/103	14:39:38	0.961
3/27/103	14:40:38	0.731
3/27/103	14:41:38	0.679
3/27/103	14:42:38	0.526

Summary of Stack Gas Parameters and Test Results
EPA Method 316 - Formaldehyde Concentrations
HOS Outlet
REA Asphalt - Mallard Creek Plant - Charlotte, NC
Page 2 of 2

	RUN NUMBER	**MC-F-1**	**MC-F-2**	**MC-F-3**	
	RUN DATE	**4/1/2003**	**4/1/2003**	**4/1/2003**	**Average**
	RUN TIME	**0915-1040**	**1129-1245**	**1339-1501**	
	Fuel Usage Rate, cf/h	1,700	1,700	1,700	1,700
	Heat Content, Btu/cf [a]	1,050	1,050	1,050	1,050
	Heat Input Rate, million Btu/hr	1.79	1.79	1.79	1.79
	EMISSIONS DATA				
	Formaldehyde				
	Formula Weight, lb/lb-mole	30.03	30.03	30.03	30.03
	Catch, µg	28.8	7.81	24.5	20.4
C_{PM}	Concentration, ppmvd	0.0178	0.00473	0.0148	0.0125
C_{PM}	Concentration, mg/dscm	0.0223	0.00590	0.0185	0.0156
E_{PM}	Emission Rate, lb/hr	3.78E-05	1.04E-05	3.24E-05	2.69E-05
E_{PM}	Emission Rate, lb/mmBtu	2.12E-05	5.83E-06	1.82E-05	1.51E-05
	Carbon Monoxide				
	Formula Weight, lb/lb-mole	28.01	28.01	28.01	28.01
C_{CO}	Concentration, ppmvd	< 0.2	< 0.2	< 0.2	< 0.2
E_{CO}	Emission Rate, lb/hr	< 3.96E-04	< 4.11E-04	< 4.08E-04	< 4.05E-04
E_{CO}	Emission Rate, lb/mmBtu	< 2.22E-04	< 2.30E-04	< 2.28E-04	< 2.27E-04

[a] From AP-42

ISOKINETIC CALCULATION

SITE REA Mallard Creek TEST NO. MC-F-1

		RUN 1	RUN 2	RUN 3
1. Volume of dry gas sampled corrected to standard conditions. Note: V_m must be corrected for leakage if any leakage rates exceed L_a). $V_{m_{std}} = 17.65 \times V_m \times Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] =$	V_m, ft^3	45.403		
	Y	0.991		
	P_{bar}, in.Hg	30.20		
	$\overline{\Delta H}$, in.H_2O	1.39		
	$\overline{T}_m$, °R	526		
	$V_{m_{std}}$, dscf	45.785		
2. Volume of water vapor at standard conditions, ft^3. $V_{w_{std}} = 0.04707 V_{1c} =$	V_{1c}, g	177.3		
	$V_{w_{std}}$, ft^3	8.346		
3. Moisture content in stack gas. $B_{ws} = \frac{V_{w_{std}}}{(V_{m_{std}} + V_{w_{std}})} =$	B_{ws}	0.1542		
	$1-B_{ws}$	0.8458		
4. Dry molecular weight of stack gas, lb/lb-mole. $M_d = 0.440\ (\%\ CO_2) + 0.320\ (\%\ O_2) + 0.280\ (\%\ N_2 + \%\ CO) =$	% CO_2	9.5		
	% O_2	7.5		
	% N_2 + % CO	83.0		
	M_d, lb/lb-mole	29.82		
5. Molecular weight of stack gas. $M_s = M_d\ (1-B_{ws}) + 18\ B_{ws} =$	M_s, lb/lb-mole	28.00		
6. Stack velocity at stack conditions, fps. $V_s = 85.49\ Cp\ (\text{avg.} \sqrt{\Delta P}) \sqrt{\frac{T_s}{P_s M_s}} =$	P_{static}, in.H_2O	-0.02		
	P_s, in.Hg	30.20		
	$\overline{T}_s$, °R	1127		
	$\overline{\sqrt{\Delta P}}$	0.2294		
NOTE: $P_s = P_{bar} + \left(\frac{P_{static}}{13.6}\right)$	Cp	0.84		
	V_s, fps	19.018		
7. Isokinetic variation $\% I = \frac{V_{m_{std}} \times T_s \times 17.32}{V_s \times D_n^2 \times \theta \times P_s \times (1-B_{ws})}$	Dn, in.	0.495		
	θ, min.	72.0		
	% I			

Isokinetic Sampling Data Reduction Spreadsheet
HOS Outlet

Metered Sample Volume

	MC-F-1	MC-F-2	MC-F-3
Run Start	456.935	502.634	550.427
Run End	502.338	549.918	597.897
Leak Check 1 Start			
Leak Check 1 End			
Leak Check 2 Start			
Leak Check 2 End			
Volume Metered	45.403	47.284	47.470
Leak Check 3 Start	0	0	0
Leak Check 3 End	0	0	0

MC-F-1

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	734.3	829.6	95.3
	745	796.1	51.1
	622.4	635.4	13
	844.8	862.7	17.9
	0	0	0
	0	0	0
	Condensate Collected:		177.3
		H2O=	15.45

MC-F-2

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	620.8	762.9	142.1
	748	776.2	28.2
	528.3	533.2	4.9
	961.4	975.8	14.4
	0	0	0
			0
	Condensate Collected:		189.6
		H2O=	16.03

MC-F-3

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	716.2	865	148.8
	621.7	648.7	27
	603.6	607.5	3.9
	967.6	981.5	13.9
			0
			0
	Condensate Collected:		193.6
		H2O=	16.33

Effluent Gas Velocity Head,

MC-F-1			MC-F-2		
Pt	Δp	$\Delta p^{1/2}$	Pt	Δp	$\Delta p^{1/2}$
1	0.070	0.265	1	0.025	0.158
2	0.080	0.283	2	0.030	0.173
3	0.080	0.283	3	0.035	0.187
4	0.080	0.283	4	0.040	0.200
5	0.075	0.274	5	0.040	0.200
6	0.070	0.265	6	0.050	0.224
7	0.060	0.245	7	0.050	0.224
8	0.055	0.235	8	0.060	0.245
9	0.055	0.235	9	0.075	0.274
10	0.050	0.224	10	0.080	0.283
11	0.055	0.235	11	0.080	0.283
12	0.050	0.224	12	0.085	0.292
13	0.020	0.141	13	0.075	0.274
14	0.025	0.158	14	0.075	0.274
15	0.025	0.158	15	0.085	0.292
16	0.030	0.173	16	0.080	0.283
17	0.030	0.173	17	0.075	0.274
18	0.040	0.200	18	0.070	0.265
19	0.040	0.200	19	0.055	0.235
20	0.060	0.245	20	0.055	0.235
21	0.060	0.245	21	0.060	0.245
22	0.065	0.255	22	0.060	0.245
23	0.065	0.255	23	0.060	0.245
24	0.065	0.255	24	0.060	0.245
25		0.000	25		0.000
26		0.000	26		0.000
27		0.000	27		0.000
28		0.000	28		0.000
29		0.000	29		0.000
30		0.000	30		0.000
31		0.000	31		0.000
32		0.000	32		0.000
33		0.000	33		0.000
34		0.000	34		0.000
35		0.000	35		0.000
36		0.000	36		0.000
37		0.000	37		0.000
38		0.000	38		0.000
39		0.000	39		0.000
40		0.000	40		0.000
41		0.000	41		0.000
42		0.000	42		0.000
43		0.000	43		0.000
44		0.000	44		0.000
45		0.000	45		0.000
46		0.000	46		0.000
47		0.000	47		0.000
48		0.000	48		0.000
49		0.000	49		0.000
50		0.000	50		0.000
Average $\Delta P^{1/}$		0.2294	Average $\Delta P^{1/}$		0.2438

Dry Gas Meter Orifice Differential, (ΔH)

MC-F-1		MC-F-2		MC-F-3	
Pt	ΔH	Pt	ΔH	Pt	ΔH
1	1.79	1	0.61	1	2.08
2	2.04	2	0.74	2	1.96
3	2.04	3	0.86	3	1.72
4	2.04	4	0.98	4	1.72
5	1.91	5	0.98	5	1.72
6	1.79	6	1.23	6	1.72
7	1.53	7	1.23	7	1.35
8	1.40	8	1.47	8	1.35
9	1.40	9	1.84	9	1.47
10	1.28	10	1.96	10	1.47
11	1.40	11	1.96	11	1.47
12	1.28	12	2.08	12	1.47
13	0.51	13	1.84	13	0.61
14	0.64	14	1.84	14	0.86
15	0.64	15	2.10	15	0.86
16	0.77	16	1.96	16	0.98
17	0.77	17	1.84	17	1.10
18	1.02	18	1.72	18	1.10
19	1.02	19	1.35	19	1.47
20	1.53	20	1.35	20	1.60
21	1.53	21	1.47	21	1.72
22	1.66	22	1.47	22	1.60
23	1.66	23	1.47	23	1.84
24	1.66	24	1.47	24	1.84
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg ΔH	1.39	Avg ΔH	1.49	Avg ΔH	1.462

Effluent Gas Temperature, (°F)

MC-F-1		MC-F-2		MC-F-3	
Pt	T_s	Pt	T_s	Pt	T_s
1	530	1	525	1	672
2	594	2	587	2	692
3	625	3	663	3	715
4	658	4	689	4	720
5	685	5	701	5	715
6	707	6	718	6	735
7	727	7	729	7	750
8	731	8	741	8	752
9	728	9	750	9	747
10	725	10	747	10	743
11	718	11	742	11	731
12	707	12	739	12	730
13	563	13	656	13	588
14	565	14	667	14	656
15	526	15	718	15	175
16	559	16	724	16	725
17	612	17	736	17	733
18	688	18	743	18	736
19	700	19	743	19	752
20	738	20	742	20	756
21	739	21	735	21	751
22	736	22	726	22	750
23	725	23	726	23	742
24	723	24	726	24	743
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg T_s	667	Avg T_s	707	Avg T_s	700

Dry Gas Meter Temperature, (°F)

MC-F-1			MC-F-2			MC-F-3		
Pt	Inlet	Outlet	Pt	Inlet	Outlet	Pt	Inlet	Outlet
1	60	56	1	72	70	1	75	74
2	63	57	2	73	70	2	78	74
3	65	58	3	75	71	3	80	74
4	68	59	4	76	71	4	80	75
5	69	60	5	77	72	5	81	75
6	69	60	6	78	72	6	82	75
7	70	61	7	78	73	7	82	76
8	70	62	8	79	73	8	82	76
9	70	62	9	79	73	9	83	77
10	71	63	10	80	74	10	83	77
11	71	63	11	80	74	11	83	77
12	71	64	12	80	74	12	83	77
13	67	68	13	77	74	13	78	77
14	69	65	14	78	74	14	79	77
15	69	65	15	79	74	15	79	77
16	70	66	16	79	74	16	79	77
17	70	66	17	79	74	17	79	77
18	71	66	18	80	74	18	80	77
19	71	67	19	80	74	19	80	77
20	72	67	20	80	74	20	81	77
21	73	67	21	80	75	21	82	77
22	73	68	22	81	75	22	82	77
23	74	68	23	81	75	23	83	77
24	74	74	24	81	81	24	83	77
25			25			25		
26			26			26		
27			27			27		
28			28			28		
29			29			29		
30			30			30		
31			31			31		
32			32			32		
33			33			33		
34			34			34		
35			35			35		
36			36			36		
37			37			37		
38			38			38		
39			39			39		
40			40			40		
41			41			41		
42			42			42		
43			43			43		
44			44			44		
45			45			45		
46			46			46		
47			47			47		
48			48			48		
49			49			49		
50			50			50		
Avg T_m		66.7	Avg T_m		76.0	Avg T_m		78.5

Summary of Carbon Monoxide Concentrations
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - Mallard Creek Plant

RUN	Date	Time	CO ppmvd	
			Actual	Drift Corrected
1	4/1/2003	0915-1040	-0.2	-0.4
2	4/1/2003	1129-1245	-0.5	-0.5
3	4/1/2003	1339-1501	-0.5	-0.1
AVERAGE			-0.4	-0.3

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - Mallard Creek Plant

Run 1

Date	Time	CO (ppm)
4/ 1/103	9:15:16	-0.321
4/ 1/103	9:16:16	-0.34
4/ 1/103	9:17:16	-0.347
4/ 1/103	9:18:16	-0.337
4/ 1/103	9:19:16	-0.33
4/ 1/103	9:20:16	-0.309
4/ 1/103	9:21:16	-0.371
4/ 1/103	9:22:16	-0.357
4/ 1/103	9:23:16	-0.321
4/ 1/103	9:24:16	-0.348
4/ 1/103	9:25:16	-0.34
4/ 1/103	9:26:16	-0.371
4/ 1/103	9:27:16	-0.342
4/ 1/103	9:28:16	-0.281
4/ 1/103	9:29:16	-0.325
4/ 1/103	9:30:16	-0.348
4/ 1/103	9:31:16	-0.288
4/ 1/103	9:32:16	-0.323
4/ 1/103	9:33:16	-0.322
4/ 1/103	9:34:16	-0.281
4/ 1/103	9:35:16	-0.297
4/ 1/103	9:36:16	-0.299
4/ 1/103	9:37:16	-0.315
4/ 1/103	9:38:16	-0.283
4/ 1/103	9:39:16	-0.265
4/ 1/103	9:40:16	-0.249
4/ 1/103	9:41:16	-0.281
4/ 1/103	9:42:16	-0.282
4/ 1/103	9:43:16	-0.265
4/ 1/103	9:44:16	-0.266
4/ 1/103	9:45:16	-0.264
4/ 1/103	9:46:16	-0.249
4/ 1/103	9:47:16	-0.249
4/ 1/103	9:48:16	-0.282
4/ 1/103	9:49:16	-0.284
4/ 1/103	9:50:16	-0.223
4/ 1/103	9:51:16	-0.217
4/ 1/103	9:52:16	-0.198
4/ 1/103	9:53:16	-0.211
4/ 1/103	9:54:16	-0.265
4/ 1/103	9:55:16	-0.24
4/ 1/103	9:56:16	-0.165
4/ 1/103	9:57:16	-0.199

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - Mallard Creek Plant

4/ 1/103	9:58:16	-0.18
4/ 1/103	9:59:16	-0.209
4/ 1/103	10:00:16	-0.215
4/ 1/103	10:01:16	-0.21
4/ 1/103	10:02:16	-0.188
4/ 1/103	10:03:16	-0.184
4/ 1/103	10:04:16	-0.182
4/ 1/103	10:05:16	-0.181
4/ 1/103	10:06:16	-0.2
4/ 1/103	10:07:16	-0.192
4/ 1/103	10:08:16	-0.205
4/ 1/103	10:09:16	-0.165
4/ 1/103	10:10:16	-0.156
4/ 1/103	10:11:16	-0.142
4/ 1/103	10:12:16	-0.172
4/ 1/103	10:13:16	-0.145
4/ 1/103	10:14:16	-0.184
4/ 1/103	10:15:16	-0.182
4/ 1/103	10:16:16	-0.091
4/ 1/103	10:17:16	-0.097
4/ 1/103	10:18:16	-0.135
4/ 1/103	10:19:16	-0.104
4/ 1/103	10:20:16	-0.163
4/ 1/103	10:21:16	-0.169
4/ 1/103	10:22:16	-0.117
4/ 1/103	10:23:16	-0.178
4/ 1/103	10:24:16	-0.149
4/ 1/103	10:25:16	-0.172
4/ 1/103	10:26:16	-0.155
4/ 1/103	10:27:16	-0.104
4/ 1/103	10:28:16	-0.117
4/ 1/103	10:29:16	-0.13
4/ 1/103	10:30:16	-0.155
4/ 1/103	10:31:16	-0.164
4/ 1/103	10:32:16	-0.105
4/ 1/103	10:33:16	-0.148
4/ 1/103	10:34:16	-0.122
4/ 1/103	10:35:16	-0.077
4/ 1/103	10:36:16	-0.132
4/ 1/103	10:37:16	-0.166
4/ 1/103	10:38:16	-0.169
Average		-0.2245357

Summary of Raw CEM Data

EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - Mallard Creek Plant

Run 2

Date	Time	CO (ppm)
4/ 1/103	11:39:53	-0.752
4/ 1/103	11:40:53	-0.76
4/ 1/103	11:41:53	-0.746
4/ 1/103	11:42:53	-0.769
4/ 1/103	11:43:53	-0.736
4/ 1/103	11:44:53	-0.735
4/ 1/103	11:45:53	-0.71
4/ 1/103	11:46:53	-0.704
4/ 1/103	11:47:53	-0.721
4/ 1/103	11:48:53	-0.702
4/ 1/103	11:49:53	-0.687
4/ 1/103	11:50:53	-0.702
4/ 1/103	11:51:53	-0.688
4/ 1/103	11:52:53	-0.686
4/ 1/103	11:53:53	-0.664
4/ 1/103	11:54:53	-0.638
4/ 1/103	11:55:53	-0.687
4/ 1/103	11:56:53	-0.687
4/ 1/103	11:57:53	-0.658
4/ 1/103	11:58:53	-0.631
4/ 1/103	11:59:53	-0.687
4/ 1/103	12:00:53	-0.647
4/ 1/103	12:01:53	-0.654
4/ 1/103	12:02:53	-0.594
4/ 1/103	12:03:53	-0.604
4/ 1/103	12:04:53	-0.593
4/ 1/103	12:05:53	-0.58
4/ 1/103	12:06:53	-0.588
4/ 1/103	12:07:53	-0.577
4/ 1/103	12:08:53	-0.58
4/ 1/103	12:09:53	-0.586
4/ 1/103	12:10:53	-0.545
4/ 1/103	12:11:53	-0.528
4/ 1/103	12:12:53	-0.485
4/ 1/103	12:13:53	-0.486
4/ 1/103	12:14:53	-0.535
4/ 1/103	12:15:53	-0.537
4/ 1/103	12:16:53	-0.486
4/ 1/103	12:17:53	-0.456
4/ 1/103	12:18:53	-0.465
4/ 1/103	12:19:53	-0.408
4/ 1/103	12:20:53	-0.454
4/ 1/103	12:21:53	-0.418

Summary of Raw CEM Data

EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - Mallard Creek Plant

4/ 1/103	12:22:53	-0.441
4/ 1/103	12:23:53	-0.371
4/ 1/103	12:24:53	-0.371
4/ 1/103	12:25:53	-0.37
4/ 1/103	12:26:53	-0.354
4/ 1/103	12:27:53	-0.471
4/ 1/103	12:28:53	-0.389
4/ 1/103	12:29:53	-0.388
4/ 1/103	12:30:53	-0.422
4/ 1/103	12:31:53	-0.47
4/ 1/103	12:32:53	-0.452
4/ 1/103	12:33:53	-0.42
4/ 1/103	12:34:53	-0.468
4/ 1/103	12:35:53	-0.434
4/ 1/103	12:36:53	-0.404
4/ 1/103	12:37:53	-0.451
4/ 1/103	12:38:53	-0.439
4/ 1/103	12:39:53	-0.421
4/ 1/103	12:40:53	-0.386
4/ 1/103	12:41:53	-0.437
4/ 1/103	12:42:53	-0.388
4/ 1/103	12:43:53	-0.389
4/ 1/103	12:44:53	-0.389
4/ 1/103	12:45:53	-0.455
Average		-0.55

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - Mallard Creek Plant

Run 3

Date	Time	CO (ppm)
4/ 1/103	13:39:53	-0.521
4/ 1/103	13:40:53	-0.558
4/ 1/103	13:41:53	-0.516
4/ 1/103	13:42:53	-0.531
4/ 1/103	13:43:53	-0.573
4/ 1/103	13:44:53	-0.589
4/ 1/103	13:45:53	-0.589
4/ 1/103	13:46:53	-0.546
4/ 1/103	13:47:53	-0.575
4/ 1/103	13:48:53	-0.575
4/ 1/103	13:49:53	-0.573
4/ 1/103	14:29:19	-0.491
4/ 1/103	14:30:19	-0.528
4/ 1/103	14:31:19	-0.47
4/ 1/103	14:32:19	-0.473
4/ 1/103	14:33:19	-0.531
4/ 1/103	14:34:19	-0.509
4/ 1/103	14:35:19	-0.457
4/ 1/103	14:36:19	-0.572
4/ 1/103	14:37:19	-0.541
4/ 1/103	14:38:19	-0.592
4/ 1/103	14:39:19	-0.463
4/ 1/103	14:40:19	-0.438
4/ 1/103	14:41:19	-0.489
4/ 1/103	14:42:19	-0.475
4/ 1/103	14:43:19	-0.491
4/ 1/103	14:44:19	-0.537
4/ 1/103	14:45:19	-0.561
4/ 1/103	14:46:19	-0.554
4/ 1/103	14:47:19	-0.51
4/ 1/103	14:48:19	-0.492

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - Mallard Creek Plant

4/ 1/103	14:49:19	-0.535
4/ 1/103	14:50:19	-0.536
4/ 1/103	14:51:19	-0.496
4/ 1/103	14:52:19	-0.458
4/ 1/103	14:53:19	-0.538
4/ 1/103	14:54:19	-0.544
4/ 1/103	14:55:19	-0.521
4/ 1/103	14:56:19	-0.545
4/ 1/103	14:57:19	-0.555
4/ 1/103	14:58:19	-0.493
4/ 1/103	14:59:19	-0.491
4/ 1/103	15:00:19	-0.527
4/ 1/103	15:01:19	-0.555
Average		-0.525

Summary of Stack Gas Parameters and Test Results
EPA Method 316 - Formaldehyde Concentrations
HOS Outlet
REA Asphalt - North Mecklenburg Plant - Charlotte, NC
Page 2 of 2

	RUN NUMBER	NM-F-1	NM-F-2	NM-F-3	
	RUN DATE	**4/2/2003**	**4/3/2003**	**4/3/2003**	**Average**
	RUN TIME	**1435-1554**	**0830-0945**	**1026-1143**	
	Fuel Usage Rate, gph	7.00	7.0	7.00	7.0
	Heat Content, Btu/gallon [a]	140,000	140,000	140,000	140,000
	Heat Input Rate, million Btu/hr	0.98	0.98	0.98	0.98
	EMISSIONS DATA				
	Formaldehyde				
	Formula Weight, lb/lb-mole	30.03	30.03	30.03	30.03
	Catch, µg	67.4	20.48	14.12	34.0
C_{PM}	Concentration, ppmvd	0.0444	0.0128	0.0090	0.0221
C_{PM}	Concentration, mg/dscm	0.0554	0.0160	0.0112	0.0276
E_{PM}	Emission Rate, lb/hr	4.71E-05	1.47E-05	1.01E-05	2.40E-05
E_{PM}	Emission Rate, lb/mmBtu	4.81E-05	1.51E-05	1.03E-05	2.45E-05
	Carbon Monoxide				
	Formula Weight, lb/lb-mole	28.01	28.01	28.01	28.01
C_{CO}	Concentration, ppmvd	7.4	3.4	6.2	5.7
E_{CO}	Emission Rate, lb/hr	7.32E-03	3.65E-03	6.49E-03	5.82E-03
E_{CO}	Emission Rate, lb/mmBtu	7.47E-03	3.72E-03	6.63E-03	5.94E-03

[a] From AP-42

sokinetic Sampling Data Reduction Spreadsheet
HOS Outlet

Metered Sample Volume

	NM-F-1	NM-F-2	NM-F-3
Run Start	598.027	642.650	688.553
Run End	642.150	688.400	734.274
Leak Check 1 Start			
Leak Check 1 End			
Leak Check 2 Start			
Leak Check 2 End			
Volume Metered	44.123	45.750	45.721
Leak Check 3 Start	0	0	0
Leak Check 3 End	0	0	0

NM-F-1

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	740.6	824.4	83.8
	744	759.5	15.5
	624.2	627.2	3
	862.8	872.6	9.8
	0	0	0
	0	0	0
	Condensate Collected:		112.1
		H2O=	10.94

NM-F-2

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	722.2	799.7	77.5
	622.8	650.9	28.1
	606.1	610.1	4
	981.5	992.2	10.7
	0	0	0
			0
	Condensate Collected:		120.3
		H2O=	11.14

NM-F-3

	Init Tare	Final	Net H2O Gain
Impinger/XAD H2O	633.1	729	95.9
	748.7	765.7	17
	528.4	531.3	2.9
	972.2	984.8	12.6
			0
			0
	Condensate Collected:		128.4
		H2O=	12.00

Effluent Gas Velocity Head, (Δ P)

NM-F-1			NM-F-2			NM-F-3		
Pt	Δp	$\Delta p^{1/2}$	Pt	Δp	$\Delta p^{1/2}$	Pt	Δp	$\Delta p^{1/2}$
1	0.0100	0.100	1	0.010	0.100	1	0.050	0.224
2	0.0100	0.100	2	0.010	0.100	2	0.055	0.235
3	0.0100	0.100	3	0.015	0.122	3	0.055	0.235
4	0.0100	0.100	4	0.010	0.100	4	0.050	0.224
5	0.0100	0.100	5	0.010	0.100	5	0.040	0.200
6	0.0150	0.122	6	0.010	0.100	6	0.025	0.158
7	0.0100	0.100	7	0.015	0.122	7	0.016	0.126
8	0.0100	0.100	8	0.010	0.100	8	0.010	0.100
9	0.0100	0.100	9	0.010	0.100	9	0.015	0.122
10	0.0100	0.100	10	0.015	0.122	10	0.015	0.122
11	0.0100	0.100	11	0.015	0.122	11	0.015	0.122
12	0.0100	0.100	12	0.015	0.122	12	0.015	0.122
13	0.0500	0.224	13	0.060	0.245	13	0.005	0.071
14	0.0350	0.187	14	0.060	0.245	14	0.005	0.071
15	0.0350	0.187	15	0.054	0.232	15	0.010	0.100
16	0.0400	0.200	16	0.045	0.212	16	0.005	0.071
17	0.0350	0.187	17	0.040	0.200	17	0.010	0.100
18	0.0250	0.158	18	0.030	0.173	18	0.010	0.100
19	0.0150	0.122	19	0.015	0.122	19	0.010	0.100
20	0.0100	0.100	20	0.010	0.100	20	0.010	0.100
21	0.0100	0.100	21	0.010	0.100	21	0.015	0.122
22	0.0100	0.100	22	0.010	0.100	22	0.015	0.122
23	0.0100	0.100	23	0.010	0.100	23	0.015	0.122
24	0.0100	0.100	24	0.010	0.100	24	0.015	0.122
25		0.000	25		0.000	25		0.000
26		0.000	26		0.000	26		0.000
27		0.000	27		0.000	27		0.000
28		0.000	28		0.000	28		0.000
29		0.000	29		0.000	29		0.000
30		0.000	30		0.000	30		0.000
31		0.000	31		0.000	31		0.000
32		0.000	32		0.000	32		0.000
33		0.000	33		0.000	33		0.000
34		0.000	34		0.000	34		0.000
35		0.000	35		0.000	35		0.000
36		0.000	36		0.000	36		0.000
37		0.000	37		0.000	37		0.000
38		0.000	38		0.000	38		0.000
39		0.000	39		0.000	39		0.000
40		0.000	40		0.000	40		0.000
41		0.000	41		0.000	41		0.000
42		0.000	42		0.000	42		0.000
43		0.000	43		0.000	43		0.000
44		0.000	44		0.000	44		0.000
45		0.000	45		0.000	45		0.000
46		0.000	46		0.000	46		0.000
47		0.000	47		0.000	47		0.000
48		0.000	48		0.000	48		0.000
49		0.000	49		0.000	49		0.000
50		0.000	50		0.000	50		0.000
Average $\Delta P^{1/2}$		0.1245	Average $\Delta P^{1/2}$		0.1351	Average $\Delta P^{1/2}$		0.1330

Dry Gas Meter Orifice Differential, (Δ H)

NM-F-1		NM-F-2		NM-F-3	
Pt	ΔH	Pt	ΔH	Pt	ΔH
1	0.78	1	0.75	1	3.75
2	0.78	2	0.75	2	1.13
3	0.78	3	0.39	3	4.13
4	0.78	4	0.75	4	3.75
5	0.78	5	0.75	5	3.00
6	1.17	6	0.75	6	1.88
7	0.78	7	1.13	7	1.13
8	0.78	8	0.75	8	0.75
9	0.78	9	0.75	9	1.13
10	0.78	10	1.13	10	1.13
11	0.78	11	1.13	11	1.13
12	0.78	12	1.13	12	1.13
13	3.90	13	4.50	13	0.39
14	2.73	14	4.50	14	0.39
15	2.73	15	3.75	15	0.75
16	3.12	16	3.38	16	0.39
17	2.73	17	3.00	17	0.75
18	1.95	18	2.25	18	0.75
19	1.17	19	1.13	19	0.75
20	0.78	20	0.75	20	0.75
21	0.78	21	0.75	21	1.13
22	0.78	22	0.75	22	1.13
23	0.78	23	0.75	23	1.13
24	0.78	24	0.75	24	1.13
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg ΔH	1.33	Avg ΔH	1.52	Avg ΔH	1.395

Effluent Gas Temperature, (°F)

NM-F-1		NM-F-2		NM-F-3	
Pt	T_S	Pt	T_S	Pt	T_S
1	505	1	458	1	490
2	467	2	458	2	490
3	469	3	458	3	490
4	436	4	518	4	490
5	574	5	546	5	557
6	547	6	463	6	594
7	532	7	490	7	606
8	540	8	603	8	603
9	587	9	605	9	600
10	581	10	600	10	597
11	578	11	597	11	596
12	576	12	597	12	595
13	525	13	550	13	496
14	525	14	552	14	496
15	559	15	558	15	496
16	577	16	580	16	495
17	537	17	588	17	521
18	602	18	601	18	570
19	605	19	615	19	594
20	600	20	614	20	608
21	597	21	612	21	608
22	581	22	607	22	606
23	572	23	604	23	601
24	570	24	603	24	598
25		25		25	
26		26		26	
27		27		27	
28		28		28	
29		29		29	
30		30		30	
31		31		31	
32		32		32	
33		33		33	
34		34		34	
35		35		35	
36		36		36	
37		37		37	
38		38		38	
39		39		39	
40		40		40	
41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	
Avg T_S	552	Avg T_S	562	Avg T_S	558

Dry Gas Meter Temperature, (°F)

NM-F-1			NM-F-2			NM-F-3		
Pt	Inlet	Outlet	Pt	Inlet	Outlet	Pt	Inlet	Outlet
1	78	78	1	67	61	1	83	80
2	79	78	2	69	62	2	85	80
3	79	78	3	71	63	3	87	80
4	80	78	4	72	64	4	89	81
5	81	79	5	73	65	5	90	81
6	82	78	6	74	65	6	90	82
7	83	79	7	75	67	7	89	82
8	83	79	8	75	67	8	88	82
9	83	79	9	76	68	9	88	82
10	83	79	10	77	69	10	87	82
11	84	79	11	77	69	11	87	82
12	84	80	12	78	70	12	87	82
13	85	80	13	82	72	13	85	82
14	87	81	14	82	72	14	85	82
15	88	81	15	84	73	15	85	82
16	89	81	16	85	74	16	85	82
17	89	82	17	86	75	17	86	83
18	88	82	18	86	75	18	86	83
19	88	82	19	86	77	19	86	82
20	87	82	20	85	77	20	87	83
21	87	82	21	84	77	21	87	83
22	86	82	22	84	77	22	87	83
23	86	82	23	84	78	23	88	83
24	86	82	24	84	78	24	88	83
25			25			25		
26			26			26		
27			27			27		
28			28			28		
29			29			29		
30			30			30		
31			31			31		
32			32			32		
33			33			33		
34			34			34		
35			35			35		
36			36			36		
37			37			37		
38			38			38		
39			39			39		
40			40			40		
41			41			41		
42			42			42		
43			43			43		
44			44			44		
45			45			45		
46			46			46		
47			47			47		
48			48			48		
49			49			49		
50			50			50		
Avg T_m		82.3	Avg T_m		74.8	Avg T_m		84.4

Summary of Carbon Monoxide Concentrations
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - North Mecklenburg Plant

RUN	Date	Time	CO ppmvd	
			Actual	Drift Corrected
1	4/2/2003	1435-1554	6.8	7.4
2	4/3/2003	0830-0945	3.2	3.4
3	4/3/2003	1026-1143	5.6	6.2
AVERAGE			5.2	5.7

Summary of Raw CEM Data

EPA Method 10 - Carbon Monoxide Concentration

HOS Outlet

REA Construction - North Mecklenburg Plant

Run 1

Date	Time	CO (ppm)
4/ 2/103	14:35:18	10.572
4/ 2/103	14:36:18	10.327
4/ 2/103	14:37:18	10.029
4/ 2/103	14:38:18	9.614
4/ 2/103	14:39:18	9.133
4/ 2/103	14:40:18	8.7
4/ 2/103	14:41:18	8.685
4/ 2/103	14:42:18	8.781
4/ 2/103	14:43:18	8.85
4/ 2/103	14:44:18	8.369
4/ 2/103	14:45:18	8.421
4/ 2/103	14:46:18	8.354
4/ 2/103	14:47:18	8.319
4/ 2/103	14:48:18	8.152
4/ 2/103	14:49:18	8.171
4/ 2/103	14:50:18	8.237
4/ 2/103	14:51:18	7.934
4/ 2/103	14:52:18	7.684
4/ 2/103	14:53:18	7.854
4/ 2/103	14:54:18	7.92
4/ 2/103	14:55:18	7.919
4/ 2/103	14:56:18	7.819
4/ 2/103	14:57:18	7.82
4/ 2/103	14:58:18	7.202
4/ 2/103	14:59:18	7.122
4/ 2/103	15:00:18	7.054
4/ 2/103	15:01:18	6.988
4/ 2/103	15:02:18	6.792
4/ 2/103	15:03:18	6.94
4/ 2/103	15:04:18	6.806
4/ 2/103	15:05:18	6.737
4/ 2/103	15:06:18	6.806
4/ 2/103	15:07:18	6.806
4/ 2/103	15:08:18	7.04
4/ 2/103	15:09:18	6.922
4/ 2/103	15:10:18	6.77
4/ 2/103	15:11:18	7.004
4/ 2/103	15:12:18	7.187
4/ 2/103	15:13:18	6.682
4/ 2/103	15:14:18	6.922
4/ 2/103	15:15:18	6.623
4/ 2/103	15:16:18	6.72
4/ 2/103	15:17:18	6.421

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - North Mecklenburg Plant

4/ 2/103	15:18:18	6.275
4/ 2/103	15:19:18	6.392
4/ 2/103	15:20:18	6.438
4/ 2/103	15:21:18	6.421
4/ 2/103	15:22:18	6.175
4/ 2/103	15:23:18	6.171
4/ 2/103	15:24:18	6.178
4/ 2/103	15:25:18	6.14
4/ 2/103	15:26:18	6.097
4/ 2/103	15:27:18	5.945
4/ 2/103	15:28:18	6.021
4/ 2/103	15:29:18	5.849
4/ 2/103	15:30:18	5.826
4/ 2/103	15:31:18	5.916
4/ 2/103	15:32:18	5.678
4/ 2/103	15:33:18	5.821
4/ 2/103	15:34:18	5.467
4/ 2/103	15:35:18	5.437
4/ 2/103	15:36:18	5.328
4/ 2/103	15:37:18	5.474
4/ 2/103	15:38:18	5.389
4/ 2/103	15:39:18	5.407
4/ 2/103	15:40:18	5.746
4/ 2/103	15:41:18	5.438
4/ 2/103	15:42:18	5.104
4/ 2/103	15:43:18	5.407
4/ 2/103	15:44:18	5.45
4/ 2/103	15:45:18	5.249
4/ 2/103	15:46:18	5.026
4/ 2/103	15:47:18	5.065
4/ 2/103	15:48:18	5.086
4/ 2/103	15:49:18	4.944
4/ 2/103	15:50:18	4.991
4/ 2/103	15:51:18	5.115
4/ 2/103	15:52:18	5.257
4/ 2/103	15:53:18	5.128
4/ 2/103	15:54:18	5.38
Average		6.7929875

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - North Mecklenburg Plant

Run 2

Date	Time	CO (ppm)
4/ 3/103	8:30:19	1.825
4/ 3/103	8:31:19	1.841
4/ 3/103	8:32:19	1.889
4/ 3/103	8:33:19	1.94
4/ 3/103	8:34:19	1.925
4/ 3/103	8:35:19	2.023
4/ 3/103	8:36:19	2.004
4/ 3/103	8:37:19	2.037
4/ 3/103	8:38:19	2.163
4/ 3/103	8:39:19	2.185
4/ 3/103	8:40:19	2.153
4/ 3/103	8:41:19	2.235
4/ 3/103	8:42:19	2.333
4/ 3/103	8:43:19	2.282
4/ 3/103	8:44:19	2.335
4/ 3/103	8:45:19	2.397
4/ 3/103	8:46:19	2.581
4/ 3/103	8:47:19	2.696
4/ 3/103	8:48:19	2.712
4/ 3/103	8:49:19	2.512
4/ 3/103	8:50:19	2.876
4/ 3/103	8:51:19	2.596
4/ 3/103	8:52:19	2.731
4/ 3/103	8:53:19	2.78
4/ 3/103	8:54:19	2.878
4/ 3/103	8:55:19	2.912
4/ 3/103	8:56:19	2.926
4/ 3/103	8:57:19	3.125
4/ 3/103	8:58:19	2.844
4/ 3/103	8:59:19	3.027
4/ 3/103	9:00:19	3.375
4/ 3/103	9:01:19	3.245
4/ 3/103	9:02:19	3.291
4/ 3/103	9:03:19	3.407
4/ 3/103	9:04:19	3.317
4/ 3/103	9:05:19	3.128
4/ 3/103	9:06:19	3.423
4/ 3/103	9:07:19	3.558
4/ 3/103	9:08:19	3.588
4/ 3/103	9:09:19	3.431
4/ 3/103	9:10:19	3.619
4/ 3/103	9:11:19	3.24
4/ 3/103	9:12:19	3.168

Summary of Raw CEM Data
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - North Mecklenburg Plant

4/ 3/103	9:13:19	3.268
4/ 3/103	9:14:19	3.191
4/ 3/103	9:15:19	3.313
4/ 3/103	9:16:19	3.657
4/ 3/103	9:17:19	3.771
4/ 3/103	9:18:19	3.312
4/ 3/103	9:19:19	3.196
4/ 3/103	9:20:19	3.796
4/ 3/103	9:21:19	4.016
4/ 3/103	9:22:19	3.85
4/ 3/103	9:23:19	4.348
4/ 3/103	9:24:19	4.348
4/ 3/103	9:25:19	4.105
4/ 3/103	9:26:19	3.625
4/ 3/103	9:27:19	3.642
4/ 3/103	9:28:19	3.686
4/ 3/103	9:29:19	3.584
4/ 3/103	9:30:19	3.88
4/ 3/103	9:31:19	4.277
4/ 3/103	9:32:19	3.917
4/ 3/103	9:33:19	4.454
4/ 3/103	9:34:19	4.473
4/ 3/103	9:35:19	4.03
4/ 3/103	9:36:19	4.653
4/ 3/103	9:37:19	4.91
4/ 3/103	9:38:19	4.398
4/ 3/103	9:39:19	3.963
4/ 3/103	9:40:19	3.577
4/ 3/103	9:41:19	3.756
4/ 3/103	9:42:19	4.005
4/ 3/103	9:43:19	3.986
4/ 3/103	9:44:19	3.841
4/ 3/103	9:45:19	4.427
Average		3.234316

Summary of Raw CEM Data

EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - North Mecklenburg Plant

Run 3

Date	Time	CO (ppm)
4/ 3/103	10:26:19	5.255
4/ 3/103	10:27:19	5.584
4/ 3/103	10:28:19	5.187
4/ 3/103	10:29:19	5.292
4/ 3/103	10:30:19	5.509
4/ 3/103	10:31:19	5.217
4/ 3/103	10:32:19	4.838
4/ 3/103	10:33:19	4.757
4/ 3/103	10:34:19	5.096
4/ 3/103	10:35:19	5.102
4/ 3/103	10:36:19	4.186
4/ 3/103	10:37:19	3.743
4/ 3/103	10:38:19	4.146
4/ 3/103	10:39:19	4.997
4/ 3/103	10:40:19	5.429
4/ 3/103	10:41:19	5.609
4/ 3/103	10:42:19	5.246
4/ 3/103	10:43:19	5.275
4/ 3/103	10:44:19	5.216
4/ 3/103	10:45:19	4.786
4/ 3/103	10:46:19	4.611
4/ 3/103	10:47:19	4.541
4/ 3/103	10:48:19	4.663
4/ 3/103	10:49:19	4.528
4/ 3/103	10:50:19	4.121
4/ 3/103	10:51:19	4.8
4/ 3/103	10:52:19	4.958
4/ 3/103	10:53:19	5.123
4/ 3/103	10:54:19	4.763
4/ 3/103	10:55:19	3.921
4/ 3/103	10:56:19	3.745
4/ 3/103	10:57:19	3.969
4/ 3/103	10:58:19	3.552
4/ 3/103	10:59:19	3.598
4/ 3/103	11:00:19	3.846
4/ 3/103	11:01:19	4.134
4/ 3/103	11:02:19	4.849
4/ 3/103	11:03:19	5.086
4/ 3/103	11:04:19	5.151
4/ 3/103	11:05:19	4.061
4/ 3/103	11:06:19	4.201
4/ 3/103	11:07:19	4.404
4/ 3/103	11:08:19	4.945

Summary of Calibration and Drift Corrections
EPA Method 10 - Carbon Monoxide Concentration
HOS Outlet
REA Construction - North Mecklenburg Plant

2-Apr-03

	Cal Gas	Direct		Bias	
		Response	Cal Error	Response	Cal Error
Zero	0.00	0.00	0.00%	0.0	0.00%
Low	30.08	28.90	-1.18%	28.7	-0.20%
Mid	59.39	57.50	-1.89%		
High	88.80	88.80	0.00%		

Pre Cal	0.00 28.70		
Run 1	6.79	Corrected	7.4 ppm CO
Post Cal	-0.50 27.70	Drift	0.50% 1.00%

3-Apr-03

	Cal Gas	Direct		Bias	
		Response	Cal Error	Response	Cal Error
Zero	0.00	0.00	0.00%	0.2	0.20%
Low	30.08	29.20	-0.88%	29.0	-0.20%
Mid	59.39	57.90	-1.49%		
High	88.80	88.90	0.10%		

Pre Cal	0.20 29.00		
Run 2	3.23	Corrected	3.4 ppm CO
Post Cal	-0.20 28.10	Drift	0.30% 0.40%
Run 3	5.63	Corrected	6.2 ppm CO
Post Cal	0.00 27.00	Drift	0.20% 1.10%

APPENDIX E

QA/QC DATA

PACIFIC ENVIRONMENTAL SERVICES, INC.

S-TYPE PITOT CALIBRATION

Pitot Tube Number: 104-3-A

Date: 5/6/2002

Effective Length: 84

Calibrated By: MDM

Pitot Tube Openings Damaged? YES [✓ NO]

Pitot Tube Assembly Level? [✓ YES] NO

α_1 = 0 °(< 10°)

α_2 = 1 °(< 10°)

β_1 = 0 °(< 5°)

β_2 = 0 °(< 5°)

γ = 1

θ = 0

A = $\frac{0.945}{0.981}$ in.

z = A sin γ = 0.0165 cm (in.) 0.32 cm (< 1/8 in. (0.125))

w = A sin θ = 0.0000 cm (in.) 0.08 cm (< 1/32 in. (0.03125))

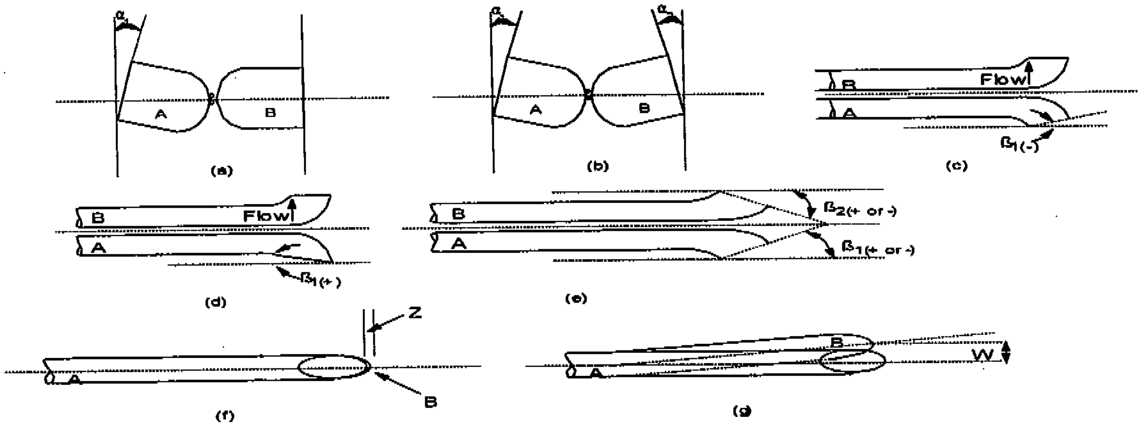
P_A = 0.49 in.

P_B = 0.49 in.

D_t = 0.374 in. (0.1875" ≤ D_t ≤ 0.375")

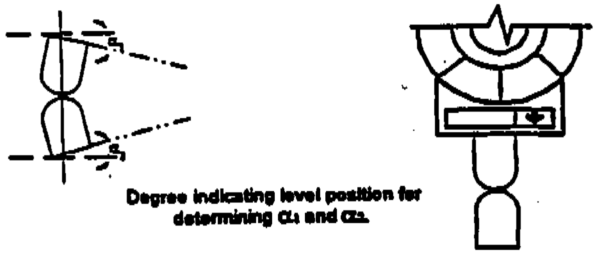
$A/2D_t$ = 1.2634 in. (1.05 ≤ $A/2D_t$ ≤ 1.50)

A/2 = 0.4725 in. (0.3927 < A/2 < 0.561)

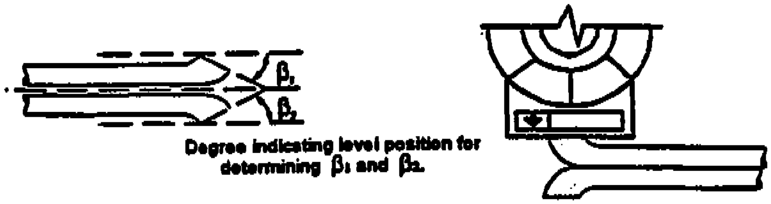


The types of face-opening misalignment shown above will not affect the baseline value of Cp(s) so long as α_1 and α_2 is less than or equal to 10°, β_1 and β_2 is less than or equal to 5°, z is less than or equal to 0.32 cm (1/8 in.), and w is less than or equal to 0.08 cm(1/32 in.) (reference 11.0 in Section 16.0).

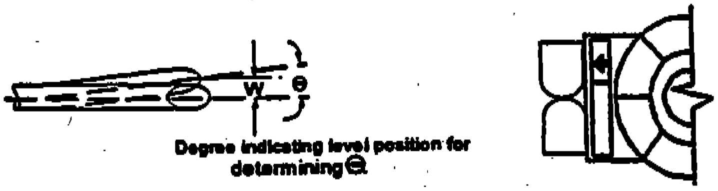
CALIBRATION DATA SHEET 2
Type S Pitot Tube Inspection



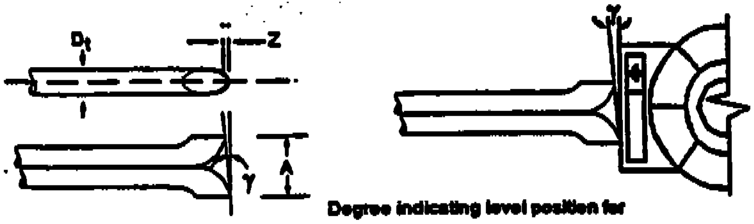
Degree indicating level position for determining α_1 and α_2.



Degree indicating level position for determining β_1 and β_2.



Degree indicating level position for determining Θ.



Degree indicating level position for determining γ then calculate Z.

Level and Perpendicular?	YES	
Obstruction?	NO	
Damaged?	NO	
α_1 $(-10° \le \alpha_1 \le +10°)$	0	✓
α_2 $(-10° \le \alpha_2 \le +10°)$	0	✓
β_1 $(-5° \le \beta_1 \le +5°)$	0	✓
β_2 $(-5° \le \beta_2 \le +5°)$	2	✓
γ	0	
Θ	0	
$z = A \tan \gamma$ (≤ 0.125")	0	✓
$w = A \tan \Theta$ (≤ 0.03125")	0	✓
D_t (3/16" ≤ D_t ≤ 3/8")	3/8"	
A	1 1/32"	✓
$A/2D_t$ $(1.05 \le P_A/D_t \le 1.5)$	1.37	✓

QA/QC Check
Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Certification
I certify that the Type S pitot tube/probe ID# RP-10 meets or exceeds all specifications, criteria and/or applicable design features and is hereby assigned a pitot tube calibration factor C_p of 0.84.

Certified by: JWB 1-20-98
Personnel (Signature/Date)

Team Leader (Signature/Date)

PES
A MACTEC COMPANY

Pacific Environmental Services, Inc.
5001 South Miami Boulevard, Suite 300
P.O. BOX 12077
Research Triangle Park, NC 27709

Office: 919/941-0333 Fax: 919/941-0234
Home Page: www.mactec.com

Temperature Read-out Check

Date: 7/22/2003
Channel: 1
Meter Box No.: RMB-15
Checked by: MDM

Simulated Temperature		Temperature Reading		Difference	
(°F)	(°R)	(°F)	(°R)	(°R)	(%)
0	460	-4	456	-4	-0.87%
100	560	96	556	-4	-0.71%
200	660	197	657	-3	-0.45%
300	760	297	757	-3	-0.39%
400	860	396	856	-4	-0.47%
500	960	497	957	-3	-0.31%
600	1060	598	1058	-2	-0.19%
700	1160	697	1157	-3	-0.26%
800	1260	799	1259	-1	-0.08%
900	1360	898	1358	-2	-0.15%
1000	1460	999	1459	-1	-0.07%
1100	1560	1098	1558	-2	-0.13%
1200	1660	1197	1657	-3	-0.18%
1300	1760	1299	1759	-1	-0.06%
1400	1860	1399	1859	-1	-0.05%
1500	1960	1499	1959	-1	-0.05%
1600	2060	1599	2059	-1	-0.05%
1700	2160	1699	2159	-1	-0.05%
1800	2260	1800	2260	0	0.00%
1900	2360	1899	2359	-1	-0.04%
2000	2460	2001	2461	1	0.04%
2001	2461	2002	2462	1	0.04%

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Home Page: www.mactec.com

Type-K Thermocouple Calibration Form

T/C No.: 104-3-A
Calibrator: MD Maret
Date: 5/6/2002

Calibration Medium	Sensor Temperature		Reference Temperature		Absolute Difference		EPA Criteria
	(°F)	(°R)	(°F)	(°R)	(°R)	(%)	%
Ice Water	34	494	32	492	2	0.40%	± 1.5
Ambient Air	60	520	60	520	0	0.00%	± 1.5
Boiling Water	210	670	212	672	2	0.30%	± 1.5

TEMPERATURE SENSOR CALIBRATION FORM

Temperature Sensor No. SH-1 **Sensor Type** K-TC **Length** 6"
Ambient Temp. °F 76 **Barometric Pressure, "Hg** 29.59
Reference Temp. Sensor: ASTM 3F

Date	Ref. Point No.	Temp. Source	Temp. °F		Temp. Diff. %	Within Limits Y/N	Calibrated By
			Ref. Sensor	Test Sensor			
11-2-98	1	ICE H2O	32	32	0	Y	DDH
11-2-98	2	AMB. Air	76	76	0	Y	DDH
11-2-98	3	Boil H2O	208	208	0	Y	DDH
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

$$\% \text{ Temp. Diff} = \frac{(\text{Ref. Temp} + 460) - (\text{Test Temp.} + 460)}{(\text{Ref. Temp.} + 460)} \times 100 \leq 1.5\,\%$$

TEMPERATURE SENSOR CALIBRATION FORM

Temperature Sensor No. SH-4 **Sensor Type** K - T/c **Length** 6" - Gooseneck
Ambient Temp. °F 72 **Barometric Pressure, "Hg** 29.98
Reference Temp. Sensor: ASTM 3F

Date	Ref. Point No.	Temp. Source	Temp. °F		Temp. Diff. %	Within Limits Y/N	Calibrated By
			Ref. Sensor	Test Sensor			
10/21/97	1	Ice water	(497) 37	(496) 36	0.20	Y	MDM
10/21/97	2	amb. air	(532) 72	(535) 75	-0.56	Y	MDM
10/21/97	3	B water.	(670) 210	(669) 209	0.15	Y	MDM
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

$$\%\ \text{Temp. Diff} = \frac{(\text{Ref. Temp} + 460) - (\text{Test Temp.} + 460)}{(\text{Ref. Temp.} + 460)} \times 100 \leq 1.5\ \%$$

TEMPERATURE SENSOR CALIBRATION FORM

Temperature Sensor No. SH-5 Sensor Type K-TC Length 6''
Ambient Temp. °F 71 Barometric Pressure, "Hg 29.55
Reference Temp. Sensor: ASTM 3F

Date	Ref. Point No.	Temp. Source	Temp. °F		Temp. Diff. %	Within Limits Y/N	Calibrated By
			Ref. Sensor	Test Sensor			
11-2-98	1	ICE H2O	32	33	.205	Y	DDH
11-2-98	2	Amb. Air	71	71	0	Y	DDH
11-2-98	3	Boil H2O	207	207	0	Y	DDH
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

$$\% \text{ Temp. Diff} = \frac{(\text{Ref. Temp} + 460) - (\text{Test Temp.} + 460)}{(\text{Ref. Temp.} + 460)} \times 100 \leq 1.5\ \%$$

TEMPERATURE SENSOR CALIBRATION FORM

Temperature Sensor No. RT-14 **Sensor Type** K-TC **Length** 3'

Ambient Temp. °F 72 **Barometric Pressure, "Hg** 29.58"

Reference Temp. Sensor:

Date	Ref. Point No.	Temp. Source	Temp. °F		Temp. Diff. %	Within Limits Y/N	Calibrated By
			Ref. Sensor	Test Sensor			
2-5-98	1	ICE H2O	32	33	.202	Y	JWB
"	2	AMB. AIR	72	72	0	Y	JWB
"	3	BOIL. H2O	210	211	.150	Y	JWB
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

$$\%\ \text{Temp. Diff} = \frac{(\text{Ref. Temp} + 460) - (\text{Test Temp.} + 460)}{(\text{Ref. Temp.} + 460)} \times 100 \le 1.5\ \%$$

TEMPERATURE SENSOR CALIBRATION FORM

Temperature Sensor No. RMB-15 DGM-IN **Sensor Type** K-Type **Length** 12"
Ambient Temp. °F 76 **Barometric Pressure, "Hg** 29.80
Reference Temp. Sensor: ____________

Date	Ref. Point No.	Temp. Source	Temp. °F		Temp. Diff. %	Within Limits Y/N	Calibrated By
			Ref. Sensor	Test Sensor			
03-18-99	1	ICE H2O	32	33	.203 ~~-.002~~	✓	DDH
03-18-99	2	AMB. AIR	75	76	-.186	✓	DDH
03-18-99	3	Boil H2O	208	210	.299	✓	DDH
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

$$\% \text{ Temp. Diff} = \frac{(\text{Ref. Temp} \overset{492\ \cancel{535}}{+ 460}) - (\text{Test Temp.} \overset{493\quad 536}{+ 460})}{(\text{Ref. Temp.} + 460)} \times 100 \le 1.5\ \%$$

536

TEMPERATURE SENSOR CALIBRATION FORM

Temperature Sensor No. DGM-Out RMB-15 Sensor Type K-Type Length 12"
Ambient Temp. °F 76 Barometric Pressure, "Hg 29.80
Reference Temp. Sensor:

Date	Ref. Point No.	Temp. Source	Temp. °F		Temp. Diff. %	Within Limits Y/N	Calibrated By
			Ref. Sensor	Test Sensor			
03/18/99	1	ICE H2O	32	32	0	Y	DDH
03/18/99	2	AMB. AIR	76	76	0	Y	DDH
03/18/99	3	Boil H2O	209	210	.149	Y	DDH
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

$$\%\ \text{Temp. Diff} = \frac{(\text{Ref. Temp} + 460) - (\text{Test Temp.} + 460)}{(\text{Ref. Temp.} + 460)} \times 100 \leq 1.5\ \%$$

PACIFIC ENVIRONMENTAL SERVICES, INC.

Central Park West
5001 South Miami Boulevard, P.O. Box 12077
Research Triangle Park, North Carolina 27709-2077
(919) 941-0333 FAX: (919) 941-0234

Inital Dry Gas Meter (DGM) Calibration Form (English Units)

Date Begin: 9/5/02 Calibrator: F. Meadows Meter Box (DGM) No.: **RMB-15**

P_{bar}, in Hg, initial: 30.09 Ref. Meter Correction Factor: 1.0077 (10/5/97 - Verified 7/03/02)

ΔH Setting	0.5	1.0	1.5	2.0	3.0	4.0	
Nominal Flow Rate, acfm	0.41	0.56	0.68	0.79	0.96	1.10	
Date	9/5/02	9/5/02	9/5/02	9/5/02	9/5/02	9/5/02	
Barometric Pressure, in Hg	30.09	30.09	30.09	30.09	30.09	30.09	
Trial Duration, minutes	14	10	10	9	8	6	
Meterbox RMB-15 Parameters							
Volume Reading, Initial	526.161	532.254	538.059	545.067	552.560	560.612	
Volume Reading, Final	531.862	537.890	544.856	552.143	560.252	567.232	
Net DGM Volume, ACF	5.701	5.636	6.797	7.076	7.692	6.620	
Meter Temperatures (°F)							
Inlet, Initial	65	67	71	75	78	81	
Inlet, Final	67	71	75	79	82	84	
Avg. Inlet	66	69	73	77	80	82.5	
Outlet, Initial	66	65	67	69	70	72	
Outlet, Final	65	67	68	70	72	73	
Average Outlet	65.5	66	67.5	69.5	71	72.5	
Reference DGM Parameters							
Volume Reading, Initial	702.032	707.966	713.642	720.456	727.755	735.557	
Volume Reading, Final	707.578	713.457	720.25	727.334	735.215	742.014	
Net DGM Volume, ACF	5.546	5.491	6.608	6.878	7.460	6.457	
Meter Temperatures (°F)							
Initial	62	63	63	64	64	64	
Final	62	63	64	64	64	64	
Average	62	63	63.5	64	64	64	**Average**
DGM Correction Factor, γ	0.986	0.988	0.989	0.992	0.991	0.998	**0.991**
Reference Orifice Press. ΔH	1.726	1.800	1.860	1.850	1.860	1.860	**1.83**
Gamma Criteria (Y > 0.02 from Y_avg?)	ok	ok	ok	ok	ok	ok	
Orifice Criteria (dH@ > 0.2 from dH@ avg?)	ok	ok	ok	ok	ok	ok	

PACIFIC ENVIRONMENTAL SERVICES, INC.

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(919) 941-0333 FAX: (919) 941-0234

Post Test Dry Gas Meter (DGM) Calibration Form (English Units)

Date Begin: 6/19/03 Calibrator: MD Maret Meter Box (DGM) No.: **RMB-15**
System Vacuum: 5 Pretest Meter Correction Factor: **0.991**
P_{bar}, in Hg, initial: 29.79 Ref. Meter Correction Factor: 1.0077 (10/5/97 - Verified 7/03/02)

ΔH Setting	1	1	1	
Nominal Flow Rate, acfm	0.56	0.56	0.56	
Date	6/19/03	6/19/03	6/19/03	
Barometric Pressure, in Hg	29.79	29.79	29.79	
Trial Duration, minutes	9	9	9	
Meterbox RMB-15 Parameter				
Volume Reading, Initial	875.640	880.709	885.773	
Volume Reading, Final	880.709	885.773	890.837	
Net DGM Volume, ACF	5.069	5.064	5.064	
Meter Temperatures (°F)				
Inlet, Initial	70	72	74	
Inlet, Final	72	74	77	
Avg. Inlet	71	73	75.5	
Outlet, Initial	69	69	71	
Outlet, Final	69	71	72	
Average Outlet	69	70	71.5	
Reference DGM Parameters				
Volume Reading, Initial	296.114	301.114	306.101	
Volume Reading, Final	301.114	306.101	311.068	
Net DGM Volume, ACF	5.000	4.987	4.967	
Meter Temperatures (°F)				
Initial	70	70	70	
Final	70	70	72	
Average	70	70	71	**Average**
DGM Correction Factor, γ	0.992	0.993	0.991	**0.992**
Reference Orifice Press. $\Delta H_{@}$	1.815	1.820	1.834	**1.82**

% Change From Original Gamma (Y): **0.1%**

Change < 5%? **PASSES**

BOC GASES

Assay Laboratory
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Riverton,NJ 08077
(609) 829 7878

CERTIFICATE OF ANALYSIS
EPA Protocol Gas

CUSTOMER
RTP Compressed Plant
11 TRIANGLE DRIVE
RESEARCH TRI PK, NC 277090000

CUSTOMER PO NO: GRACE CONSULTING

Previous Certification Date(s):

CYLINDER NO : CC87402
EXPIRATION DATE : 20-Sep-2004
CERTIFICATION DATE : 21-Sep-2001
CYLINDER PRESSURE : 2000 psig
PRODUCT ID NO : 02000838
LOT NUMBER : 460337

ANALYTICAL INFORMATION

This calibration standard has been certified per the 1997 EPA Traceability Protocol, Document EPA-600/97/121, Using Procedure G1. All Values certified to be +/-1% NIST Traceable.

Do Not Use This Cylinder below 150 psig. i.e. 1.0 Megapascal

Analytical Results

Components	Requested Mixture	Certified Concentration	Analytical Uncertainty	Assay Dates
CARBON MONOXIDE	30.00 ppm	30.08 ppm	+/-1.00% NIST Traceable	09/14/01 & 09/21/01
NITROGEN	BALANCE GAS			

CALIBRATION STANDARDS USED IN ASSAY

Type	LOT ID	Cylinder No	Concentration	Expiration
NTRM 81678	98060212	XC012001B	49.59 +/- 0.40 ppm C0/N2	02/01/02

ANALYTICAL INSTRUMENTS USED IN ASSAY

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Siemens 6E N1-L9-0191	NonDispersive Infrared	09/04/01

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CERTIFICATE OF ANALYSIS
EPA Protocol Gas

CUSTOMER
RTP Compressed Plant
11 TRIANGLE DRIVE
RESEARCH TRI PK, NC 277090000

CUSTOMER PO NO:

Previous Certification Date(s):

CYLINDER NO : CC87521
EXPIRATION DATE : 17-Nov-2005
CERTIFICATION DATE : 25-Nov-2002
CYLINDER PRESSURE : 2000 psig
PRODUCT ID NO : 24006032
LOT NUMBER : 532429

ANALYTICAL INFORMATION

is calibration standard has been certified per the 1997 EPA Traceability Protocol, Document EPA-600/97/121, Using Procedure G1. All Values certified be +/-1% NIST Traceable.

Do Not Use This Cylinder below 150 psig. i.e. 1.0 Megapascal

Analytical Results

omponents	Requested Mixture	Certified Concentration	Analytical Uncertainty	Assay Dates
ARBON MONOXIDE	60.00 ppm	59.39 ppm	+/-1.00% NIST Traceable	11/18/02 & 11/25/02
NITROGEN	BALANCE GAS			

CALIBRATION STANDARDS USED IN ASSAY

Type	LOT ID	Cylinder No	Concentration	Expiration
NTRM 81678	98060209	XC014007B	49.59 +/- 0.40 ppm C0/N2	07/01/06

ANALYTICAL INSTRUMENTS USED IN ASSAY

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Siemens Ultramat 6E-N9-782	NonDispersive Infrared	11/20/02

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CERTIFICATE OF ANALYSIS
EPA Protocol Gas

CUSTOMER
RTP Compressed Plant
11 TRIANGLE DRIVE
RESEARCH TRI PK, NC 277090000

CUSTOMER PO NO:

Previous Certification Date(s):

CYLINDER NO : CC17861
EXPIRATION DATE : 17-Nov-2005
CERTIFICATION DATE : 25-Nov-2002
CYLINDER PRESSURE : 2000 psig
PRODUCT ID NO : 24014814
LOT NUMBER : 532426

ANALYTICAL INFORMATION

T calibration standard has been certified per the 1997 EPA Traceability Protocol, Document EPA-600/97/121, Using Procedure G1. All Values certified +/-1% NIST Traceable.

Do Not Use This Cylinder below 150 psig. i.e. 1.0 Megapascal

Analytical Results

mponents	Requested Mixture	Certified Concentration	Analytical Uncertainty	Assay Dates
CARBON MONOXIDE	90.00 ppm	88.8 ppm	+/-1.00% NIST Traceable	11/18/02 & 11/25/02
NITROGEN	BALANCE GAS			

CALIBRATION STANDARDS USED IN ASSAY

Type	LOT ID	Cylinder No	Concentration	Expiration
NTRM 82636	98060117	XC013187B	246.20 +/- 2.00 ppm CO/N2	07/01/06

ANALYTICAL INSTRUMENTS USED IN ASSAY

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Siemens 6E N1-L9-0191	NonDispersive Infrared	11/20/02

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APPENDIX F

SAMPLING & ANALYSIS METHODS

(EPA Methods 1, 1A, 2, 3, 10 and 316)

Appendix F.1

Sampling & Analysis Methods

EPA Methods 1 & 1A

216. In Part 60, Appendix A is amended by revising Methods 1, 1A, 2, 2A, 2B, 2C, 2D, 2E, 3, 3B, 4, 5, 5A, 5B, 5D, 5E, 5F, 5G, 5H, 6, 6A, 6B, 7, 7A, 7B, 7C, 7D, 8, 10A, 10B, 11, 12, 13A, 13B, 14, 15, 15A, 16, 16A, 16B, 17, 18, 19, 21, 22, 24, 24A, 25, 25A, 25B, 25C, 25D, 25E, 26, 26A, 27, 28, 28A, and 29 to read as follows:

METHOD 1 - SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

NOTE: This method does not include all of the specifications (*e.g.*, equipment and supplies) and procedures (*e.g.*, sampling) essential to its performance. Some material is incorporated by reference from other methods in this part. Therefore, to obtain reliable results, persons using this method should have a thorough knowledge of at least the following additional test method: Method 2.

1.0 Scope and Application.

1.1 Measured Parameters. The purpose of the method is to provide guidance for the selection of sampling ports and traverse points at which sampling for air pollutants will be performed pursuant to regulations set forth in this part. Two procedures are presented: a simplified procedure, and an alternative procedure (see Section 11.5). The magnitude of cyclonic flow of effluent gas in a stack or duct is the only parameter quantitatively measured in the simplified procedure.

1.2 Applicability. This method is applicable to gas streams flowing in ducts, stacks, and flues. This method cannot be used when: (1) the flow is cyclonic or swirling; or (2) a stack is smaller than 0.30 meter (12 in.) in diameter, or 0.071 m^2 (113 $in.^2$) in cross-sectional area. The simplified procedure cannot be used when the measurement site is less than two stack or duct diameters downstream or less than a half diameter upstream from a flow disturbance.

1.3 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

NOTE: The requirements of this method must be considered before construction of a new facility from which emissions are to be measured; failure to do so may require subsequent alterations to the stack or deviation from the standard procedure. Cases involving variants are subject to approval by the Administrator.

2.0 Summary of Method.

2.1 This method is designed to aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source. A measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. Traverse points are then located within each of these equal areas.

3.0 Definitions. [Reserved]

4.0 Interferences. [Reserved]

5.0 Safety.

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

6.0 Equipment and Supplies.

6.1 Apparatus. The apparatus described below is required only when utilizing the alternative site selection procedure described in Section 11.5 of this method.

6.1.1 Directional Probe. Any directional probe, such as United Sensor Type DA Three-Dimensional Directional Probe, capable of measuring both the pitch and yaw angles of gas flows is acceptable. Before using the probe, assign an identification number to the directional probe, and permanently mark or engrave the number on the body of the probe. The pressure holes of directional probes are susceptible to plugging when used in particulate-laden gas streams. Therefore, a procedure for cleaning the pressure holes by "back-purging" with pressurized air is required.

6.1.2 Differential Pressure Gauges. Inclined manometers, U-tube manometers, or other differential pressure gauges (*e.g.*, magnehelic gauges) that meet the specifications described in Method 2, Section 6.2.

NOTE: If the differential pressure gauge produces both negative and positive readings, then both negative and positive pressure readings shall be calibrated at a minimum of three points as specified in Method 2, Section 6.2.

7.0 Reagents and Standards. [Reserved]

8.0 Sample Collection, Preservation, Storage, and Transport. [Reserved]

9.0 Quality Control. [Reserved]

10.0 Calibration and Standardization. [Reserved]

11.0 Procedure.

11.1 Selection of Measurement Site.

11.1.1 Sampling and/or velocity measurements are performed at a site located at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame. If necessary, an alternative location may be selected, at a position at least two stack or duct diameters downstream and a half diameter upstream from any flow disturbance.

11.1.2 An alternative procedure is available for determining the acceptability of a measurement location not meeting the criteria above. This procedure described in Section 11.5 allows for the determination of gas flow angles at the sampling points and comparison of the measured results with acceptability criteria.

11.2 Determining the Number of Traverse Points.

11.2.1 Particulate Traverses.

11.2.1.1 When the eight- and two-diameter criterion can be met, the minimum number of traverse points shall be: (1) twelve, for circular or rectangular stacks with diameters (or equivalent diameters) greater than 0.61 meter (24 in.); (2) eight, for circular stacks with diameters between 0.30 and 0.61 meter (12 and 24 in.); and (3) nine, for rectangular stacks with equivalent diameters between 0.30 and 0.61 meter (12 and 24 in.).

11.2.1.2 When the eight- and two-diameter criterion cannot be met, the minimum number of traverse points is determined from Figure 1-1. Before referring to the figure, however, determine the distances from the measurement site to the nearest upstream and downstream disturbances, and divide each distance by the stack diameter or equivalent diameter, to determine the distance in terms of the number of duct diameters. Then, determine from Figure 1-1 the minimum number of traverse points that corresponds: (1) to the number of duct diameters upstream; and (2) to the number of diameters downstream. Select the higher of the two minimum numbers of traverse points, or a greater value, so that for circular stacks the number is a multiple of 4, and for rectangular stacks, the number is one of those shown in Table 1-1.

11.2.2 Velocity (Non-Particulate) Traverses. When velocity or volumetric flow rate is to be determined (but not particulate matter), the same procedure as that used for particulate traverses (Section 11.2.1) is followed, except that Figure 1-2 may be used instead of Figure 1-1.

11.3 Cross-Sectional Layout and Location of Traverse Points.

11.3.1 Circular Stacks.

11.3.1.1 Locate the traverse points on two perpendicular diameters according to Table 1-2 and the example shown in Figure 1-3. Any equation (see examples in References 2 and 3 in Section 16.0) that gives the same values as those in Table 1-2 may be used in lieu of Table 1-2.

11.3.1.2 For particulate traverses, one of the diameters must coincide with the plane containing the greatest expected concentration variation (*e.g.*, after bends); one diameter shall be congruent to the direction of the bend. This requirement becomes less critical as the distance from the disturbance increases; therefore, other diameter locations may be used, subject to the approval of the Administrator.

11.3.1.3 In addition, for elliptical stacks having unequal perpendicular diameters, separate traverse points shall be calculated and located along each diameter. To determine the cross-sectional area of the elliptical stack, use the following equation:

$$\text{Square Area} = D_1 \text{ X } D_2 \text{ X } 0.7854$$

Where: D_1 = Stack diameter 1

D_2 = Stack diameter 2

11.3.1.4 In addition, for stacks having diameters greater than 0.61 m (24 in.), no traverse points shall be within 2.5 centimeters (1.00 in.) of the stack walls; and for stack diameters equal to or less than 0.61 m (24 in.), no traverse points shall be located within 1.3 cm (0.50 in.) of the stack walls. To meet these criteria, observe the procedures given below.

11.3.2 Stacks With Diameters Greater Than 0.61 m

(24 in.).

11.3.2.1 When any of the traverse points as located in Section 11.3.1 fall within 2.5 cm (1.0 in.) of the stack walls, relocate them away from the stack walls to: (1) a distance of 2.5 cm (1.0 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger. These relocated traverse points (on each end of a diameter) shall be the "adjusted" traverse points.

11.3.2.2 Whenever two successive traverse points are combined to form a single adjusted traverse point, treat the adjusted point as two separate traverse points, both in the sampling and/or velocity measurement procedure, and in recording of the data.

11.3.3 Stacks With Diameters Equal To or Less Than 0.61 m (24 in.). Follow the procedure in Section 11.3.1.1, noting only that any "adjusted" points should be relocated away from the stack walls to: (1) a distance of 1.3 cm (0.50 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger.

11.3.4 Rectangular Stacks.

11.3.4.1 Determine the number of traverse points as explained in Sections 11.1 and 11.2 of this method. From Table 1-1, determine the grid configuration. Divide the stack cross-section into as many equal rectangular elemental areas as traverse points, and then locate a traverse point at the centroid of each equal area according to the example in Figure 1-4.

11.3.4.2 To use more than the minimum number of traverse points, expand the "minimum number of traverse points" matrix (see Table 1-1) by adding the extra traverse points along one or the other or both legs of the matrix; the final matrix need not be balanced. For example, if a 4 x 3 "minimum number of points" matrix were expanded to 36 points, the final matrix could be 9 x 4 or 12 x 3, and would not necessarily have to be 6 x 6. After constructing the final matrix, divide the stack cross-section into as many equal rectangular, elemental areas as traverse points, and locate a traverse point at the centroid of each equal area.

11.3.4.3 The situation of traverse points being too close to the stack walls is not expected to arise with rectangular stacks. If this problem should ever arise, the Administrator must be contacted for resolution of the matter.

11.4 Verification of Absence of Cyclonic Flow.

11.4.1 In most stationary sources, the direction of stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations which tend to induce swirling; in these instances, the presence or absence of cyclonic flow at the sampling location must be determined. The following techniques are acceptable for this determination.

11.4.2 Level and zero the manometer. Connect a Type S pitot tube to the manometer and leak-check system. Position the Type S pitot tube at each traverse point, in succession, so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane; when the Type S pitot tube is in this position, it is at "0° reference." Note the differential pressure ()p) reading at each traverse point. If a null (zero) pitot reading is obtained at 0° reference at a given traverse point, an acceptable flow condition exists at that point. If the pitot reading is not zero at 0° reference, rotate the pitot tube (up to ±90° yaw angle), until a null reading is obtained. Carefully determine and record the value of the rotation angle (") to the nearest degree. After the null technique has been applied at each traverse point, calculate the average of the absolute values of "; assign " values of 0° to those points for which no rotation was required, and include these in the overall average. If the average value of " is greater than 20°, the overall flow condition in the stack is unacceptable, and alternative methodology, subject to the approval of the Administrator, must be used to perform accurate sample and velocity traverses.

11.5 The alternative site selection procedure may be used to determine the rotation angles in lieu of the procedure outlined in Section 11.4.

11.5.1 Alternative Measurement Site Selection Procedure. This alternative applies to sources where measurement locations are less than 2 equivalent or duct diameters downstream or less than one-half duct diameter upstream from a flow disturbance. The alternative should be limited to ducts larger than 24 in. in diameter where blockage and wall effects are minimal. A directional flow-sensing probe is used to measure pitch and yaw angles of the gas flow at 40 or more traverse points; the resultant angle is calculated and compared with acceptable criteria for mean and standard deviation.

NOTE: Both the pitch and yaw angles are measured from a line passing through the traverse point and parallel to the stack axis. The pitch angle is the angle of the gas flow component in the plane that INCLUDES the traverse line and is parallel to the stack axis. The yaw angle is the angle of the gas flow component in the plane PERPENDICULAR to the traverse line at the traverse point and is measured from the line passing through the traverse point and parallel to the stack axis.

11.5.2 Traverse Points. Use a minimum of 40 traverse points for circular ducts and 42 points for rectangular ducts for the gas flow angle determinations. Follow the procedure outlined in Section 11.3 and Table 1-1 or 1-2 for the location and layout of the traverse points. If the measurement location is determined to be acceptable according to the criteria in this alternative procedure, use the same traverse point number and locations for sampling and velocity measurements.

11.5.3 Measurement Procedure.

11.5.3.1 Prepare the directional probe and differential pressure gauges as recommended by the manufacturer. Capillary tubing or surge tanks may be used to dampen pressure fluctuations. It is recommended, but not required, that a pretest leak check be conducted. To perform a leak check, pressurize or use suction on the impact opening until a reading of at least 7.6 cm (3 in.) H_20 registers on the differential pressure gauge, then plug the impact opening. The pressure of a leak-free system will remain stable for at least 15 seconds.

11.5.3.2 Level and zero the manometers. Since the manometer level and zero may drift because of vibrations and temperature changes, periodically check the level and zero during the traverse.

11.5.3.3 Position the probe at the appropriate locations in the gas stream, and rotate until zero deflection is indicated for the yaw angle pressure gauge. Determine and record the yaw angle. Record the pressure gauge readings for the pitch angle, and determine the pitch angle from the calibration curve. Repeat this procedure for each traverse point. Complete a "back-purge" of the pressure lines and the impact openings prior to measurements of each traverse point.

11.5.3.4 A post-test check as described in Section 11.5.3.1 is required. If the criteria for a leak-free system are not met, repair the equipment, and repeat the flow angle measurements.

11.5.4 Calibration. Use a flow system as described in Sections 10.1.2.1 and 10.1.2.2 of Method 2. In addition, the flow system shall have the capacity to generate two test-section velocities: one between 365 and 730 m/min (1,200 and 2,400 ft/min) and one between 730 and 1,100 m/min (2,400 and 3,600 ft/min).

11.5.4.1 Cut two entry ports in the test section. The axes through the entry ports shall be perpendicular to each other and intersect in the centroid of the test section. The ports should be elongated slots parallel to the axis of the test section and of sufficient length to allow measurement of pitch angles while maintaining the pitot head position at the test-section centroid. To facilitate alignment of the directional probe during calibration, the test section should be constructed of plexiglass or some other transparent material. All calibration measurements should be made at the same point in the test section, preferably at the centroid of the test section.

11.5.4.2 To ensure that the gas flow is parallel to the central axis of the test section, follow the procedure outlined in Section 11.4 for cyclonic flow determination to measure the gas flow angles at the centroid of the test section from two test ports located 90° apart. The gas flow angle measured in each port must be ± 2° of 0°. Straightening vanes should be installed, if necessary, to meet this criterion.

11.5.4.3 Pitch Angle Calibration. Perform a calibration traverse according to the manufacturer's recommended protocol in 5° increments for angles from -60° to +60° at one velocity in each of the two ranges specified above. Average the pressure ratio values obtained for each angle in the two flow ranges, and plot a calibration curve with the average values of the pressure ratio (or other suitable measurement factor as recommended by the manufacturer) versus the pitch angle. Draw a smooth line through the data points. Plot also the data values for each traverse point. Determine the differences between the measured data values and the angle from the calibration curve at the same pressure ratio. The difference at each comparison must be within 2° for angles between 0° and 40° and within 3° for angles between 40° and 60°.

11.5.4.4 Yaw Angle Calibration. Mark the three-dimensional probe to allow the determination of the yaw position of the probe. This is usually a line extending the length of the probe and aligned with the impact opening. To determine the accuracy of measurements of the yaw angle, only the zero or null position need be calibrated as follows: Place the directional probe in the test section, and rotate the probe until the zero position is found. With a protractor or other angle measuring device, measure the angle indicated by the yaw angle indicator on the three-dimensional probe. This should be within 2° of 0°. Repeat this measurement for any other points along the length of the pitot where yaw angle measurements could be read in order to account for variations in the pitot markings used to indicate pitot head positions.

12.0 Data Analysis and Calculations.

12.1 Nomenclature.

L = length

n = total number of traverse points.

P_i = pitch angle at traverse point i, degree.

R_{avg} = average resultant angle, degree.

R_i = resultant angle at traverse point i, degree.

S_d = standard deviation, degree.

W = width.

Y_i = yaw angle at traverse point i, degree.

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

$$D_e = \frac{2\,(L)\,(W)}{L + W} \qquad \textbf{Eq. 1-1}$$

12.3 If use of the alternative site selection procedure (Section 11.5 of this method) is required, perform the following calculations using the equations below: the resultant angle at each traverse point, the average resultant angle, and the standard deviation. Complete the calculations retaining at least one extra significant figure beyond that of the acquired data. Round the values after the final calculations.

12.3.1 Calculate the resultant angle at each traverse point:

$$R_i = \text{arc cosine } [(\text{cosine } Y_i)(\text{cosine } P_i)] \qquad \textbf{Eq. 1-2}$$

12.3.2 Calculate the average resultant for the measurements:

$$R_{avg} = \sum R_i/n \qquad \textbf{Eq. 1-3}$$

12.3.3 Calculate the standard deviations:

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} (R_i - R_{avg})^2}{(n-1)}} \qquad \textbf{Eq. 1-4}$$

12.3.4 Acceptability Criteria. The measurement location is acceptable if $R_{avg} \leq 20°$ and $S_d \leq 10°$.

13.0 Method Performance. [Reserved]

14.0 Pollution Prevention. [Reserved]

15.0 Waste Management. [Reserved]

16.0 References.

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17.0 Tables, Diagrams, Flowcharts, and Validation Data.

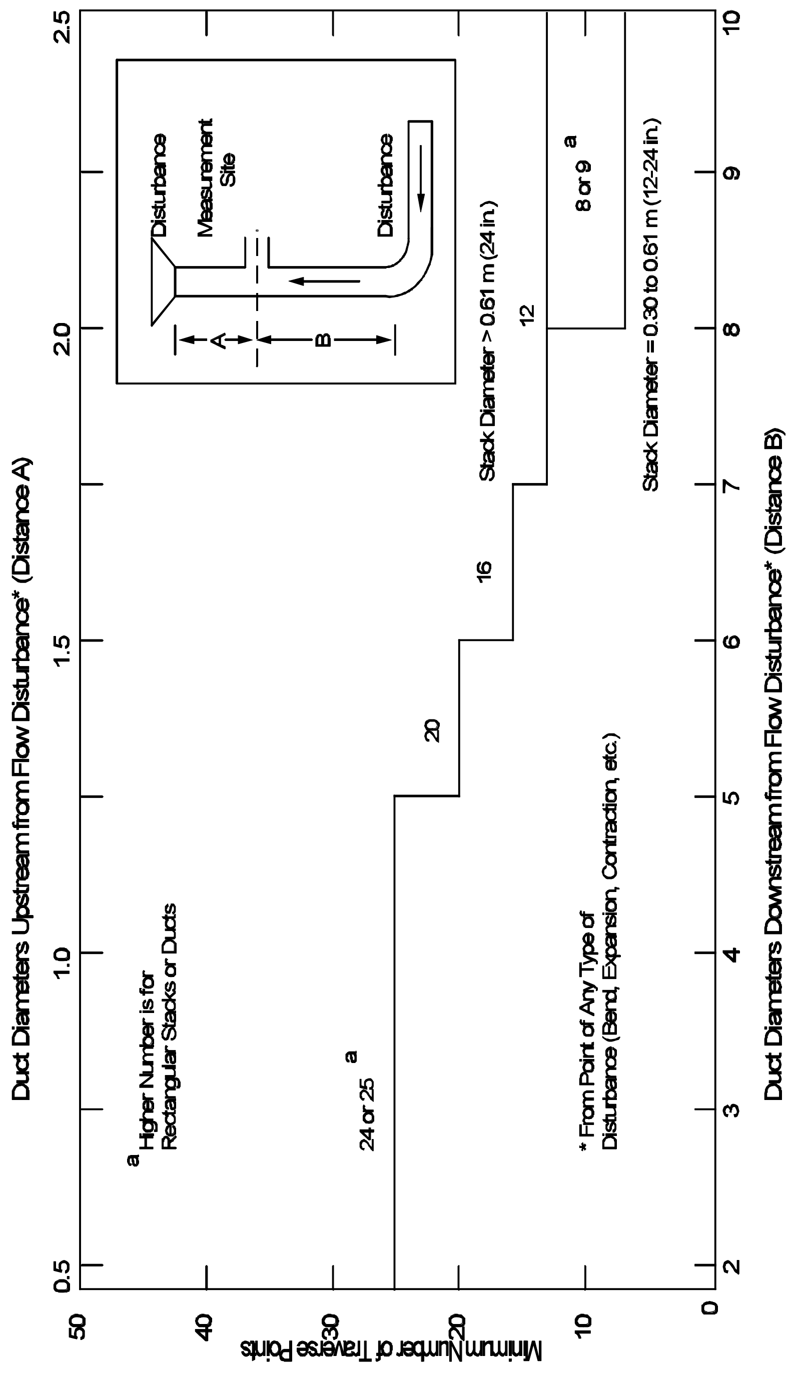

Figure 1-1. Minimum number of traverse points for particulate traverses.

TABLE 1-1. CROSS-SECTION LAYOUT FOR RECTANGULAR STACKS

Number of tranverse points	Matrix layout
9	3 x 3
12	4 x 3
16	4 x 4
20	5 x 4
25	5 x 5
30	6 x 5
36	6 x 6
42	7 x 6
49	7 x 7

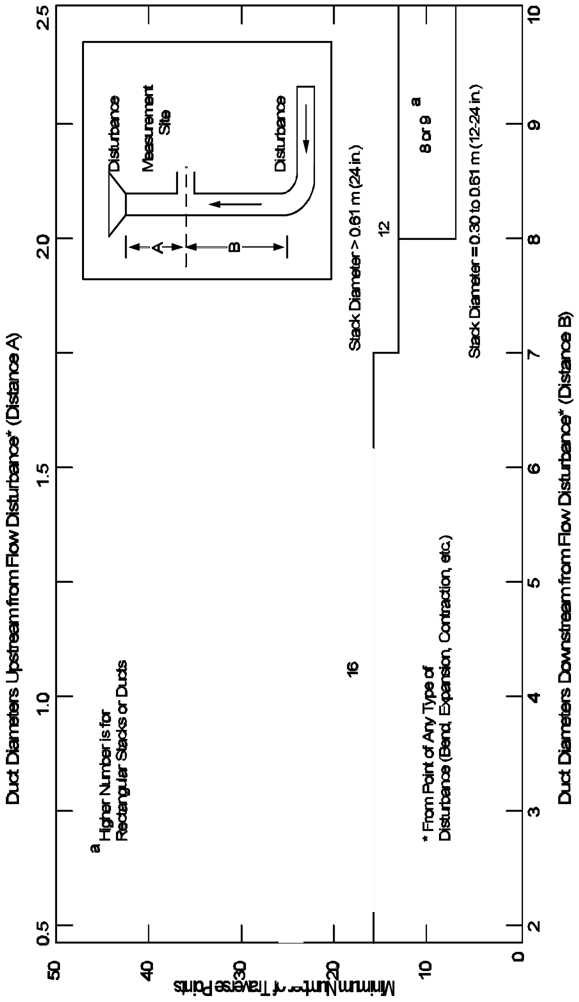

Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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
19 . . .										96.1	91.3	86.8
20 . . .										98.7	94.0	89.5
21 . . .											96.5	92.1
22 . . .											98.9	94.5
23 . . .												96.8
24 . . .												99.9

Traverse Point	Distance % of diameter
1	4.4
2	14.7
3	29.5
4	70.5
5	85.3
6	95.6

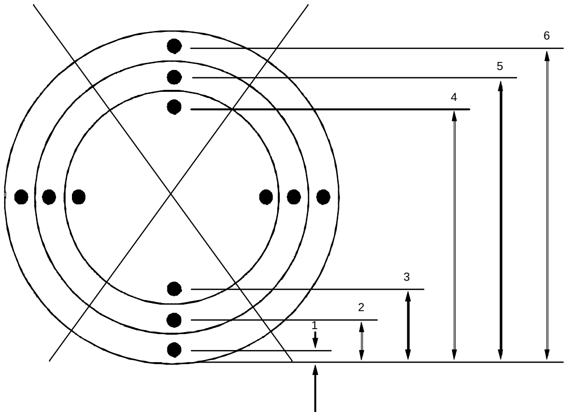

Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points.

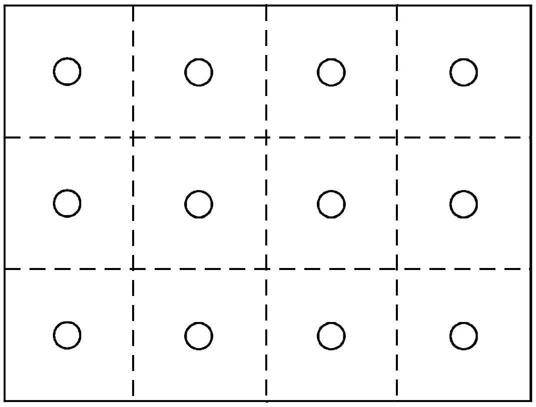

Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with traverse points at centroid of each area.

METHOD 1A - SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES WITH SMALL STACKS OR DUCTS

NOTE: This method does not include all of the specifications (*e.g.*, equipment and supplies) and procedures (*e.g.*, sampling) essential to its performance. Some material is incorporated by reference from other methods in this part. Therefore, to obtain reliable results, persons using this method should have a thorough knowledge of at least the following additional test method: Method 1.

1.0 Scope and Application.

1.1 Measured Parameters. The purpose of the method is to provide guidance for the selection of sampling ports and traverse points at which sampling for air pollutants will be performed pursuant to regulations set forth in this part.

1.2 Applicability. The applicability and principle of this method are identical to Method 1, except its applicability is limited to stacks or ducts. This method is applicable to flowing gas streams in ducts, stacks, and flues of less than about O.30 meter (12 in.) in diameter, or 0.071 m^2 (113 $in.^2$) in cross-sectional area, but equal to or greater than about O.10 meter (4 in.) in diameter, or 0.0081 m^2 (12.57 $in.^2$) in cross-sectional area. This method cannot be used when the flow is cyclonic or swirling.

1.3 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method.

2.1 The method is designed to aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source. A measurement site or a pair of measurement sites where the effluent stream is flowing in a known direction is (are) selected. The cross-section of the stack is divided into a number of equal areas. Traverse points are then located within each of these equal areas.

2.2 In these small diameter stacks or ducts, the conventional Method 5 stack assembly (consisting of a Type S pitot tube attached to a sampling probe, equipped with a nozzle and thermocouple) blocks a significant portion of the cross-section of the duct and causes inaccurate measurements. Therefore, for particulate matter (PM) sampling in small stacks or ducts, the gas velocity is measured using a standard pitot tube downstream of the actual emission sampling site. The straight run of duct between the PM sampling and velocity measurement sites allows the flow profile, temporarily disturbed by the presence of the sampling probe, to redevelop and stabilize.

3.0 Definitions. [Reserved]

4.0 Interferences. [Reserved]

5.0 Safety.

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

6.0 Equipment and Supplies. [Reserved]

7.0 Reagents and Standards. [Reserved]

8.0 Sample Collection, Preservation, Storage, and Transport. [Reserved]

9.0 Quality Control. [Reserved]

10.0 Calibration and Standardization. [Reserved]

11.0 Procedure.

11.1 Selection of Measurement Site.

11.1.1 Particulate Measurements - Steady or Unsteady Flow. Select a particulate measurement site located preferably at least eight equivalent stack or duct diameters downstream and 10 equivalent diameters upstream from any flow disturbances such as bends, expansions, or contractions in the stack, or from a visible flame. Next, locate the velocity measurement site eight equivalent diameters downstream of the particulate measurement site (see Figure 1A-1). If such locations are not available, select an alternative particulate measurement location at least two equivalent stack or duct diameters downstream and two and one-half diameters upstream from any flow disturbance. Then, locate the velocity measurement site two equivalent diameters downstream from the particulate measurement site. (See Section 12.2 of Method 1 for calculating equivalent diameters for a rectangular cross-section.)

11.1.2 PM Sampling (Steady Flow) or Velocity (Steady or Unsteady Flow) Measurements. For PM sampling when the volumetric flow rate in a duct is constant with respect to time, Section 11.1.1 of Method 1 may be followed, with the PM sampling and velocity measurement performed at one location. To demonstrate that the flow rate is constant (within 10 percent) when PM measurements are made, perform complete velocity traverses before and after the PM sampling run, and calculate the deviation of the flow rate derived after the PM sampling run from the one derived before the PM sampling run. The PM sampling run is acceptable if the deviation does not exceed 10 percent.

11.2 Determining the Number of Traverse Points.

11.2.1 Particulate Measurements (Steady or Unsteady Flow). Use Figure 1-1 of Method 1 to determine the number of traverse points to use at both the velocity measurement and PM sampling locations. Before referring to the figure, however, determine the distances between both the velocity measurement and PM sampling sites to the nearest upstream and downstream disturbances. Then divide each distance by the stack diameter or equivalent diameter to express the distances in terms of the number of duct diameters. Then, determine the number of traverse points from Figure 1-1 of Method 1 corresponding to each of these four distances. Choose the highest of the four numbers of traverse points (or a greater number) so that, for circular ducts the number is a multiple of four; and for rectangular ducts, the number is one of those shown in Table 1-1 of Method 1. When the optimum duct diameter location criteria can be satisfied, the minimum number of traverse points required is eight for circular ducts and nine for rectangular ducts.

11.2.2 PM Sampling (Steady Flow) or only Velocity (Non-Particulate) Measurements. Use Figure 1-2 of Method 1 to determine number of traverse points, following the same procedure used for PM sampling as described in Section 11.2.1 of Method 1. When the optimum duct diameter location criteria can be satisfied, the minimum number of traverse points required is eight for circular ducts and nine for rectangular ducts.

11.3 Cross-sectional Layout, Location of Traverse Points, and Verification of the Absence of Cyclonic Flow. Same as Method 1, Sections 11.3 and 11.4, respectively.

12.0 Data Analysis and Calculations. [Reserved]

13.0 Method Performance. [Reserved]

14.0 Pollution Prevention. [Reserved]

15.0 Waste Management. [Reserved]

16.0 References.

Same as Method 1, Section 16.0, References 1 through 6, with the addition of the following:

1. Vollaro, Robert F. Recommended Procedure for Sample Traverses in Ducts Smaller Than 12 Inches in Diameter. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, North Carolina. January 1977.

17.0 Tables, Diagrams, Flowcharts, and Validation Data.

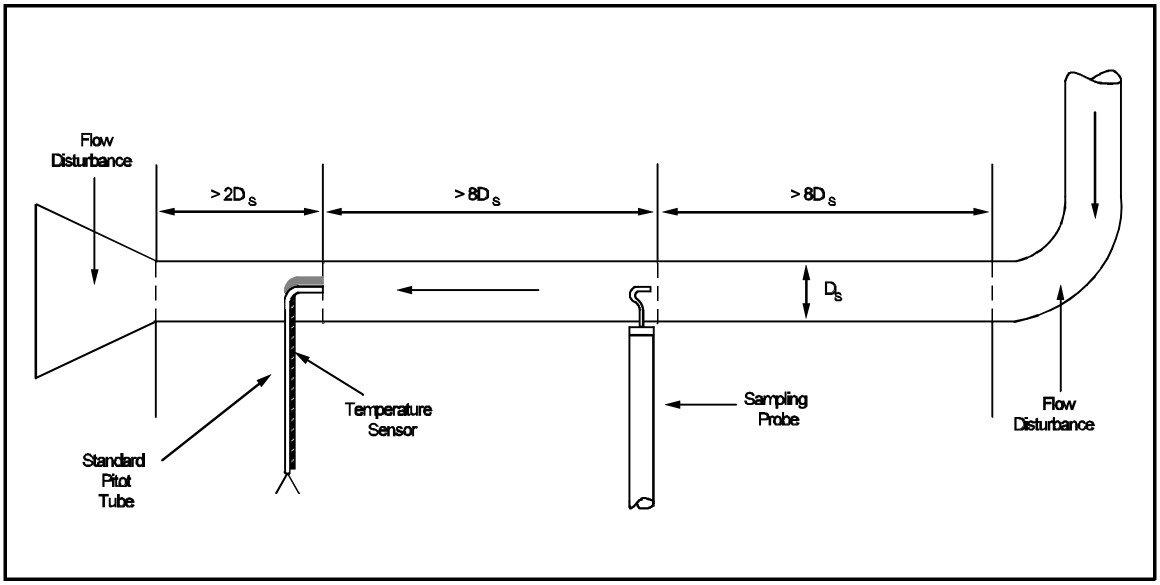

Figure 1A-1. Recommended sampling arrangement for small ducts

Appendix F.2

Sampling & Analysis Methods

EPA Method 2

METHOD 2 - DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE (TYPE S PITOT TUBE)

NOTE: This method does not include all of the specifications (*e.g.*, equipment and supplies) and procedures (*e.g.*, sampling) essential to its performance. Some material is incorporated by reference from other methods in this part. Therefore, to obtain reliable results, persons using this method should have a thorough knowledge of at least the following additional test method: Method 1.

1.0 Scope and Application.

1.1 This method is applicable for the determination of the average velocity and the volumetric flow rate of a gas stream.

1.2 This method is not applicable at measurement sites that fail to meet the criteria of Method 1, Section 11.1. Also, the method cannot be used for direct measurement in cyclonic or swirling gas streams; Section 11.4 of Method 1 shows how to determine cyclonic or swirling flow conditions. When unacceptable conditions exist, alternative procedures, subject to the approval of the Administrator, must be employed to produce accurate flow rate determinations. Examples of such alternative procedures are: (1) to install straightening vanes; (2) to calculate the total volumetric flow rate stoichiometrically, or (3) to move to another measurement site at which the flow is acceptable.

1.3 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method.

2.1 The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Stausscheibe or reverse type) pitot tube.

3.0 Definitions. [Reserved]

4.0 Interferences. [Reserved]

5.0 Safety.

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

6.0 Equipment and Supplies.

Specifications for the apparatus are given below. Any other apparatus that has been demonstrated (subject to approval of the Administrator) to be capable of meeting the specifications will be considered acceptable.

6.1 Type S Pitot Tube.

6.1.1 Pitot tube made of metal tubing (***e.g.***, stainless steel) as shown in Figure 2-1. It is recommended that the external tubing diameter (dimension D_t, Figure 2-2b) be between 0.48 and 0.95 cm (3/16 and 3/8 inch). There shall be an equal distance from the base of each leg of the pitot tube to its face-opening plane (dimensions P_A and P_B, Figure 2-2b); it is recommended that this distance be between 1.05 and 1.50 times the external tubing diameter. The face openings of the pitot tube shall, preferably, be aligned as shown in Figure 2-2; however, slight misalignments of the openings are permissible (see Figure 2-3).

6.1.2 The Type S pitot tube shall have a known coefficient, determined as outlined in Section 10.0. An identification number shall be assigned to the pitot tube; this number shall be permanently marked or engraved on the body of the tube. A standard pitot tube may be used instead of a Type S, provided that it meets the specifications of Sections 6.7 and 10.2. Note, however, that the static and impact pressure holes of standard pitot tubes are susceptible to plugging in particulate-laden gas streams.

Therefore, whenever a standard pitot tube is used to perform a traverse, adequate proof must be furnished that the openings of the pitot tube have not plugged up during the traverse period. This can be accomplished by comparing the velocity head ()p) measurement recorded at a selected traverse point (readable)p value) with a second)p measurement recorded after "back purging" with pressurized air to clean the impact and static holes of the standard pitot tube. If the before and after)p measurements are within 5 percent, then the traverse data are acceptable. Otherwise, the data should be rejected and the traverse measurements redone. Note that the selected traverse point should be one that demonstrates a readable)p value. If "back purging" at regular intervals is part of a routine procedure, then comparative)p measurements shall be conducted as above for the last two traverse points that exhibit suitable)p measurements.

6.2 Differential Pressure Gauge. An inclined manometer or equivalent device. Most sampling trains are equipped with a 10 in. (water column) inclined-vertical manometer, having 0.01 in. H_2O divisions on the 0 to 1 in. inclined scale, and 0.1 in. H_20 divisions on the 1 to 10 in. vertical scale. This type of manometer (or other gauge of equivalent sensitivity) is satisfactory for the measurement of)p values as low as 1.27 mm (0.05 in.) H_20. However, a differential pressure gauge of greater sensitivity shall be used (subject to the approval of the Administrator), if any of the following is found to be true: (1) the arithmetic average of all)p readings at the traverse points in the stack is less than 1.27 mm (0.05 in.) H_20; (2) for traverses of 12 or more points, more than 10 percent of the individual)p readings are below 1.27 mm (0.05 in.) H_20; or (3) for traverses of fewer than 12 points, more than one)p reading is below 1.27 mm (0.05 in.) H_20. Reference 18 (see Section 17.0) describes commercially available instrumentation for the measurement of low-range gas velocities.

6.2.1 As an alternative to criteria (1) through (3) above, Equation 2-1 (Section 12.2) may be used to determine the necessity of using a more sensitive differential pressure gauge. If T is greater than 1.05, the velocity head data are unacceptable and a more sensitive differential pressure gauge must be used.

NOTE: If differential pressure gauges other than inclined manometers are used (*e.g.*, magnehelic gauges), their calibration must be checked after each test series. To check the calibration of a differential pressure gauge, compare)p readings of the gauge with those of a gauge-oil manometer at a minimum of three points, approximately representing the range of)p values in the stack. If, at each point, the values of)p as read by the differential pressure gauge and gauge-oil manometer agree to within 5 percent, the differential pressure gauge shall be considered to be in proper calibration. Otherwise, the test series shall either be voided, or procedures to adjust the measured)p values and final results shall be used, subject to the approval of the Administrator.

6.3 Temperature Sensor. A thermocouple, liquid-filled bulb thermometer, bimetallic thermometer, mercury-in-glass thermometer, or other gauge capable of measuring temperatures to within 1.5 percent of the minimum absolute stack temperature. The temperature sensor shall be attached to the pitot tube such that the sensor tip does not touch any metal; the gauge shall be in an interference-free arrangement with respect to the pitot tube face openings (see Figure 2-1 and Figure 2-4). Alternative positions may be used if the pitot tube-temperature gauge system is calibrated according to the procedure of Section 10.0. Provided that a difference of not more than 1 percent in the average velocity measurement is introduced, the temperature gauge need not be attached to the pitot tube. This alternative is subject to the approval of the Administrator.

6.4 Pressure Probe and Gauge. A piezometer tube and mercury- or water-filled U-tube manometer capable of measuring stack pressure to within 2.5 mm (0.1 in.) Hg. The static tap of a standard type pitot tube or one leg of a Type S pitot tube with the face opening planes positioned parallel to the gas flow may also be used as the pressure probe.

6.5 Barometer. A mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.54 mm (0.1 in.) Hg.

NOTE: The barometric pressure reading may be obtained from a nearby National Weather Service station. In this case, the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be made at a rate of minus 2.5 mm (0.1 in.) Hg per 30 m (100 ft) elevation increase or plus 2.5 mm (0.1 in.) Hg per 30 m (100 ft.) for elevation decrease.

6.6 Gas Density Determination Equipment. Method 3 equipment, if needed (see Section 8.6), to determine the stack gas dry molecular weight, and Method 4 (reference method) or Method 5 equipment for moisture content determination. Other methods may be used subject to approval of the Administrator.

6.7 Calibration Pitot Tube. When calibration of the Type S pitot tube is necessary (see Section 10.1), a standard pitot tube shall be used for a reference. The standard pitot tube shall, preferably, have a known coefficient, obtained either (1) directly from the National Institute of Standards and Technology (NIST), Gaithersburg MD 20899, (301) 975-2002, or (2) by calibration against another standard pitot tube with an NIST-traceable coefficient. Alternatively, a standard pitot tube designed according to the criteria given in Sections 6.7.1 through 6.7.5 below and illustrated in Figure 2-5 (see also References 7, 8, and 17 in Section 17.0) may be used. Pitot tubes designed according to these specifications will have baseline coefficients of 0.99 ± 0.01.

6.7.1 Standard Pitot Design.

6.7.1.1 Hemispherical (shown in Figure 2-5), ellipsoidal, or conical tip.

6.7.1.2 A minimum of six diameters straight run (based upon D, the external diameter of the tube) between the tip and the static pressure holes.

6.7.1.3 A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90° bend.

6.7.1.4 Static pressure holes of equal size (approximately 0.1 D), equally spaced in a piezometer ring configuration.

6.7.1.5 90° bend, with curved or mitered junction.

6.8 Differential Pressure Gauge for Type S Pitot Tube Calibration. An inclined manometer or equivalent. If the single-velocity calibration technique is employed (see Section 10.1.2.3), the calibration differential pressure gauge shall be readable to the nearest 0.127 mm (0.005 in.) H_20. For multivelocity calibrations, the gauge shall be readable to the nearest 0.127 mm (0.005 in.) H_20 for)p values between 1.27 and 25.4 mm (0.05 and 1.00 in.) H_20, and to the nearest 1.27 mm (0.05 in.) H_20 for)p values above 25.4 mm (1.00 in.) H_20. A special, more sensitive gauge will be required to read)p values below 1.27 mm (0.05 in.) H_20 (see Reference 18 in Section 16.0).

7.0 Reagents and Standards. [Reserved]

8.0 Sample Collection and Analysis.

8.1 Set up the apparatus as shown in Figure 2-1. Capillary tubing or surge tanks installed between the manometer and pitot tube may be used to dampen)p fluctuations. It is recommended, but not required, that a pretest leak-check be conducted as follows: (1) blow through the pitot impact opening until at least 7.6 cm (3.0 in.) H_20 velocity head registers on the manometer; then, close off the impact opening. The pressure shall remain stable for at least 15 seconds; (2) do the same for the static pressure side, except using suction to obtain the minimum of 7.6 cm (3.0 in.) H_20. Other leak-check procedures, subject to the approval of the Administrator, may be used.

8.2 Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse (at least once per hour). Record all necessary data on a form similar to that shown in Figure 2-6.

8.3 Measure the velocity head and temperature at the traverse points specified by Method 1. Ensure that the proper differential pressure gauge is being used for the range of)p values encountered (see Section 6.2). If it is necessary to change to a more sensitive gauge, do so, and remeasure the)p and temperature readings at each traverse point. Conduct a post-test leak-check (mandatory), as described in Section 8.1 above, to validate the traverse run.

8.4 Measure the static pressure in the stack. One reading is usually adequate.

8.5 Determine the atmospheric pressure.

8.6 Determine the stack gas dry molecular weight. For combustion processes or processes that emit essentially CO_2, O_2, CO, and N_2, use Method 3. For processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 29.0. For other processes, other methods, subject to the approval of the Administrator, must be used.

8.7 Obtain the moisture content from Method 4 (reference method, or equivalent) or from Method 5.

8.8 Determine the cross-sectional area of the stack or duct at the sampling location. Whenever possible, physically measure the stack dimensions rather than using blueprints. Do not assume that stack diameters are equal. Measure each diameter distance to verify its dimensions.

9.0 Quality Control.

Section	Quality Control Measure	Effect
10.1-10.4	Sampling equipment calibration	Ensure accurate measurement of stack gas flow rate, sample volume

10.0 Calibration and Standardization.

10.1 Type S Pitot Tube. Before its initial use, carefully examine the Type S pitot tube top, side, and end views to verify that the face openings of the tube are aligned within the specifications illustrated in Figures 2-2 and 2-3. The pitot tube shall not be used if it fails to meet these alignment specifications. After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D_t, Figure 2-2b); and (b) the base-to-opening plane distances (dimensions P_A and P_B, Figure 2-2b).

If D_t is between 0.48 and 0.95 cm (3/16 and 3/8 in.), and if P_A and P_B are equal and between 1.05 and 1.50 D_t, there are two possible options: (1) the pitot tube may be calibrated according to the procedure outlined in Sections 10.1.2 through 10.1.5, or (2) a baseline (isolated tube) coefficient value of 0.84 may be assigned to the pitot tube. Note, however, that if the pitot tube is part of an assembly, calibration may still be required, despite knowledge of the baseline coefficient value (see Section 10.1.1). If D_t, P_A, and P_B are outside the specified limits, the pitot tube must be calibrated as outlined in Sections 10.1.2 through 10.1.5.

10.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used; in many instances, the pitot tube is used in combination with other source-sampling components (***e.g.***, thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of other sampling components can sometimes affect the baseline value of the Type S pitot tube coefficient (Reference 9 in Section 17.0); therefore, an assigned (or otherwise known) baseline coefficient value may or may not be valid for a given assembly. The baseline and assembly coefficient values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated. Figures 2-4, 2-7, and 2-8 illustrate interference-free component arrangements for Type S pitot tubes having external tubing diameters between 0.48 and 0.95 cm (3/16 and 3/8 in.). Type S pitot tube assemblies that fail to meet any or all of the specifications of Figures 2-4, 2-7, and 2-8 shall be calibrated according to the procedure outlined in Sections 10.1.2 through 10.1.5, and prior to calibration, the values of the intercomponent spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

NOTE: Do not use a Type S pitot tube assembly that is constructed such that the impact pressure opening plane of the pitot tube is below the entry plane of the nozzle (see Figure 2-6B).

10.1.2 Calibration Setup. If the Type S pitot tube is to be calibrated, one leg of the tube shall be permanently marked A, and the other, B. Calibration shall be performed in a flow system having the following essential design features:

10.1.2.1 The flowing gas stream must be confined to a duct of definite cross-sectional area, either circular or rectangular. For circular cross sections, the minimum duct diameter shall be 30.48 cm (12 in.); for rectangular cross sections, the width (shorter side) shall be at least 25.4 cm (10 in.).

10.1.2.2 The cross-sectional area of the calibration duct must be constant over a distance of 10 or more duct diameters. For a rectangular cross section, use an equivalent diameter, calculated according to Equation 2-2 (see Section 12.3), to determine the number of duct diameters. To ensure the presence of stable, fully developed flow patterns at the calibration site, or "test section," the site must be located at least eight diameters downstream and two diameters upstream from the nearest disturbances.

NOTE: The eight- and two-diameter criteria are not absolute; other test section locations may be used (subject to approval of the Administrator), provided that the flow at the test site has been demonstrated to be or found stable and parallel to the duct axis.

10.1.2.3 The flow system shall have the capacity to generate a test-section velocity around 910 m/min (3,000 ft/min). This velocity must be constant with time to guarantee steady flow during calibration. Note that Type S pitot tube coefficients obtained by single-velocity calibration at 910 m/min (3,000 ft/min) will generally be valid to ±3 percent for the measurement of velocities above

300 m/min (1,000 ft/min) and to ± 6 percent for the measurement of velocities between 180 and 300 m/min (600 and 1,000 ft/min). If a more precise correlation between the pitot tube coefficient ,(C_p), and velocity is desired, the flow system should have the capacity to generate at least four distinct, time-invariant test-section velocities covering the velocity range from 180 to 1,500 m/min (600 to 5,000 ft/min), and calibration data shall be taken at regular velocity intervals over this range (see References 9 and 14 in Section 17.0 for details).

10.1.2.4 Two entry ports, one for each of the standard and Type S pitot tubes, shall be cut in the test section. The standard pitot entry port shall be located slightly downstream of the Type S port, so that the standard and Type S impact openings will lie in the same cross-sectional plane during calibration. To facilitate alignment of the pitot tubes during calibration, it is advisable that the test section be constructed of Plexiglas™ or some other transparent material.

10.1.3 Calibration Procedure. Note that this procedure is a general one and must not be used without first referring to the special considerations presented in Section 10.1.5. Note also that this procedure applies only to single-velocity calibration. To obtain calibration data for the A and B sides of the Type S pitot tube, proceed as follows:

10.1.3.1 Make sure that the manometer is properly filled and that the oil is free from contamination and is of the proper density. Inspect and leak-check all pitot lines; repair or replace if necessary.

10.1.3.2 Level and zero the manometer. Switch on the fan, and allow the flow to stabilize. Seal the Type S pitot tube entry port.

10.1.3.3 Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point (determined as outlined in Section 10.1.5.1), and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

10.1.3.4 Read)p_{std}, and record its value in a data table similar to the one shown in Figure 2-9. Remove the standard pitot tube from the duct, and disconnect it from the manometer. Seal the standard entry port.

10.1.3.5 Connect the Type S pitot tube to the manometer and leak-check. Open the Type S tube entry port. Check the manometer level and zero. Insert and align the Type S pitot tube so that its A side impact opening is at the same point as was the standard pitot tube and is pointed directly into the flow. Make sure that the entry port surrounding the tube is properly sealed.

10.1.3.6 Read)p_s, and enter its value in the data table. Remove the Type S pitot tube from the duct, and disconnect it from the manometer.

10.1.3.7 Repeat Steps 10.1.3.3 through 10.1.3.6 until three pairs of)p readings have been obtained for the A side of the Type S pitot tube.

10.1.3.8 Repeat Steps 10.1.3.3 through 10.1.3.7 for the B side of the Type S pitot tube.

10.1.3.9 Perform calculations as described in Section 12.4. Use the Type S pitot tube only if the values of F_A and F_B are less than or equal to 0.01 and if the absolute value of the difference between $\overline{C}_{p(A)}$ and $\overline{C}_{p(B)}$ is 0.01 or less.

10.1.4 Special Considerations.

10.1.4.1 Selection of Calibration Point.

10.1.4.1.1 When an isolated Type S pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Section 10.1.3. The Type S pitot coefficients measured or calculated, [i.e. $\overline{C}_{p(A)}$ and $\overline{C}p(B)$] will be valid, so long as either: (1) the isolated pitot tube is used; or (2) the pitot tube is used with other components (nozzle, thermocouple, sample probe) in an arrangement that is free from aerodynamic interference effects (see Figures 2-4, 2-7, and 2-8).

10.1.4.1.2 For Type S pitot tube-thermocouple combinations (without probe assembly), select a calibration point at or near the center of the duct, and follow the procedures outlined in Section 10.1.3. The coefficients so obtained will be valid so long as the pitot tube-thermocouple combination is used by itself or with other components in an interference-free arrangement (Figures 2-4, 2-7, and 2-8).

10.1.4.1.3 For Type S pitot tube combinations with complete probe assemblies, the calibration point should be located at or near the center of the duct; however, insertion of a probe sheath into a small duct may cause significant cross-sectional area interference and blockage and yield incorrect coefficient values (Reference 9 in Section 17.0). Therefore, to minimize the blockage effect, the calibration point may be a few inches off-center if necessary. The actual blockage effect will be negligible when the theoretical blockage, as determined by a projected-area model of the probe sheath, is 2 percent or less of the duct cross-sectional area for assemblies without external sheaths (Figure 2-10a), and 3 percent or less for assemblies with external sheaths (Figure 2-10b).

10.1.4.2 For those probe assemblies in which pitot tube-nozzle interference is a factor (*i.e.*, those in which the pitot-nozzle separation distance fails to meet the specifications illustrated in Figure 2-7A), the value of $C_{p(s)}$ depends upon the amount of free space between the tube and nozzle and, therefore, is a function of nozzle size. In these instances, separate calibrations shall be performed with each of the commonly used nozzle sizes in place. Note that the single-velocity calibration technique is acceptable for this purpose, even though the larger nozzle sizes (>0.635 cm or 1/4 in.) are not ordinarily used for isokinetic sampling at velocities around 910 m/min (3,000 ft/min), which is the calibration velocity. Note also that it is not necessary to draw an isokinetic sample during calibration (see Reference 19 in Section 17.0).

10.1.4.3 For a probe assembly constructed such that its pitot tube is always used in the same orientation, only one side of the pitot tube need be calibrated (the side which will face the flow). The pitot tube must still meet the alignment specifications of Figure 2-2 or 2-3, however, and must have an average deviation (σ) value of 0.01 or less (see Section 10.1.4.4).

10.1.5 Field Use and Recalibration.

10.1.5.1 Field Use.

10.1.5.1.1 When a Type S pitot tube (isolated or in an assembly) is used in the field, the appropriate coefficient value (whether assigned or obtained by calibration) shall be used to perform velocity calculations. For calibrated Type S pitot tubes, the A side coefficient shall be used when the A side of the tube faces the flow, and the B side coefficient shall be used when the B side faces the flow. Alternatively, the arithmetic average of the A and B side coefficient values may be used, irrespective of which side faces the flow.

10.1.5.1.2 When a probe assembly is used to sample a small duct, 30.5 to 91.4 cm (12 to 36 in.) in diameter, the probe sheath sometimes blocks a significant part of the duct cross-section, causing a reduction in the effective value of $C_{p(s)}$. Consult Reference 9 (see Section 17.0) for details. Conventional pitot-sampling probe assemblies are not recommended for use in ducts having inside diameters smaller than 30.5 cm (12 in.) (see Reference 16 in Section 17.0).

10.1.5.2 Recalibration.

10.1.5.2.1 Isolated Pitot Tubes. After each field use, the pitot tube shall be carefully reexamined in top, side, and end views. If the pitot face openings are still aligned within the specifications illustrated in Figure 2-2 and Figure 2-3, it can be assumed that the baseline coefficient of the pitot tube has not changed. If, however, the tube has been damaged to the extent that it no longer meets the specifications of Figure 2-2 and Figure 2-3, the damage shall either be repaired to restore proper alignment of the face openings, or the tube shall be discarded.

10.1.5.2.2 Pitot Tube Assemblies. After each field use, check the face opening alignment of the pitot tube, as in Section 10.1.5.2.1. Also, remeasure the intercomponent spacings of the assembly. If the intercomponent spacings have not changed and the face opening alignment is acceptable, it can be assumed that the coefficient of the assembly has not changed. If the face opening alignment is no longer within the specifications of Figure 2-2 and Figure 2-3, either repair the damage or replace the pitot tube (calibrating the new assembly, if necessary). If the intercomponent spacings have changed, restore the original spacings, or recalibrate the assembly.

10.2 Standard Pitot Tube (if applicable). If a standard pitot tube is used for the velocity traverse, the tube shall be constructed according to the criteria of Section 6.7 and shall be assigned a baseline coefficient value of 0.99. If the standard pitot tube is used as part of an assembly, the tube shall be in an interference-free arrangement (subject to the approval of the Administrator).

10.3 Temperature Sensors.

10.3.1 After each field use, calibrate dial thermometers, liquid-filled bulb thermometers, thermocouple-potentiometer systems, and other sensors at a temperature within 10 percent of the average absolute stack temperature. For temperatures up to 405°C (761°F), use an ASTM mercury-in-glass reference thermometer, or equivalent, as a reference. Alternatively, either a reference thermocouple and potentiometer (calibrated against NIST standards) or thermometric fixed points (*e.g.*, ice bath and boiling water, corrected for barometric pressure) may be used. For temperatures above 405°C (761°F), use a reference thermocouple-potentiometer system calibrated against NIST standards or an alternative reference, subject to the approval of the Administrator.

10.3.2 The temperature data recorded in the field shall be considered valid. If, during calibration, the absolute temperature measured with the sensor being calibrated and the reference sensor agree within 1.5 percent, the temperature data taken in the field shall be considered valid. Otherwise, the pollutant emission test shall either be considered invalid or adjustments (if appropriate) of the test results shall be made, subject to the approval of the Administrator.

10.4 Barometer. Calibrate the barometer used against a mercury barometer.

11.0 Analytical Procedure.

Sample collection and analysis are concurrent for this method (see Section 8.0).

12.0 Data Analysis and Calculations.

Carry out calculations, retaining at least one extra significant figure beyond that of the acquired data. Round off figures after final calculation.

12.1 Nomenclature.

A = Cross-sectional area of stack, m^2 (ft^2).

B_{ws} = Water vapor in the gas stream [from Method 4 (reference method) or Method 5], proportion by volume.

C_p = Pitot tube coefficient, dimensionless.

$C_{p(s)}$ = Type S pitot tube coefficient, dimensionless.

$C_{p(std)}$ = Standard pitot tube coefficient; use 0.99 if the coefficient is unknown and the tube is designed according to the criteria of Sections 6.7.1 to 6.7.5 of this method.

D_e = Equivalent diameter.

K = 0.127 mm H_20 (metric units).
0.005 in. H_20 (English units).

K_p = Velocity equation constant.

L = Length.

M_d = Molecular weight of stack gas, dry basis (see Section 8.6), g/g-mole (lb/lb-mole).

M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

n = Total number of traverse points.

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

P_g = Stack static pressure, mm Hg (in. Hg).

P_s = Absolute stack pressure ($P_{bar} + P_g$), mm Hg (in. Hg),

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 = Sensitivity factor for differential pressure gauges.

T_s = Stack temperature, °C (°F).

$T_{s(abs)}$ = Absolute stack temperature, °K (°R).

= 273 + T_s for metric units,

= 460 + T_s for English units.

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

v_s = Average stack gas velocity, m/sec (ft/sec).

W = Width.

$)p$ = Velocity head of stack gas, mm H_20 (in. H_20).

$)p_i$ = Individual velocity head reading at traverse point "i", mm (in.) H_20.

$)p_{std}$ = Velocity head measured by the standard pitot tube, cm (in.) H_20.

$)p_s$ = Velocity head measured by the Type S pitot tube, cm (in.) H_20.

3600 = Conversion Factor, sec/hr.

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

12.2 Calculate T as follows:

$$T = \frac{\sum_{i=1}^{n} \sqrt{)p_i + K}}{\sum_{i=1}^{n} \sqrt{)p_i}}$$

Eq. 2-1

12.3 Calculate D_e as follows:

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

Eq. 2-2

12.4 Calibration of Type S Pitot Tube.

12.4.1 For each of the six pairs of)p readings (*i.e.*, three from side A and three from side B) obtained in Section 10.1.3, calculate the value of the Type S pitot tube coefficient according to Equation 2-3:

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{)p_{std}}{)p}}$$ **Eq. 2-3**

12.4.2 Calculate $\overline{C}_{p(A)}$, the mean A-side coefficient, and $\overline{C}_{p(B)}$, the mean B-side coefficient. Calculate the difference between these two average values.

12.4.3 Calculate the deviation of each of the three A-side values of $C_{p(s)}$ from $\overline{C}_{p(A)}$, and the deviation of each of the three B-side values of $C_{p(s)}$ from $\overline{C}_{p(B)}$, using Equation 2-4:

$$\text{Deviation} = C_{p(s)} - \overline{C}_{p(A \text{ or } B)}$$ **Eq. 2-4**

12.4.4 Calculate F, the average deviation from the mean, for both the A and B sides of the pitot tube. Use Equation 2-5:

$$F_{A \text{ or } B} = \frac{\sum_{i=1}^{3} \left| C_{p(s)} - \overline{C}_{p(A \text{ or } B)} \right|}{3}$$ **Eq. 2-5**

12.5 Molecular Weight of Stack Gas.

$$M_s = M_d\,(1 - B_{ws}) + 18.0\,B_{ws}$$ **Eq. 2-6**

12.6 Average Stack Gas Velocity.

$$v_s = K_p\,C_p\,\sqrt{)p}_{avg}\sqrt{\frac{T_{s(abs)}}{P_s M_s}}$$ **Eq. 2-7**

$$34.97\,\frac{m}{sec}\left[\frac{(g/g\cdot mole)(mm\,Hg)}{(^{\circ}K)(mm\,H_2O)}\right]^{\frac{1}{2}}$$ **Metric**

$$85.49\,\frac{m}{sec}\left[\frac{(lb/lb\text{-}mole)(in.\ Hg)}{(^{\circ}R)(in.\ H_20)}\right]^{\frac{1}{2}}$$ **English**

12.7 Average Stack Gas Dry Volumetric Flow Rate.

$$Q = 3600\,(1 - B_{ws})\,v_s\,A\left|\frac{T_{std}\,P_s}{T_{s(abs)}\,P_{std}}\right|$$ **Eq. 2-8**

13.0 Method Performance. [Reserved]

14.0 Pollution Prevention. [Reserved]

15.0 Waste Management. [Reserved]

16.0 References.

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3. Shigehara, R.T., W.F. Todd, and W.S. Smith. Significance of Errors in Stack Sampling Measurements. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at the Annual Meeting of the Air Pollution Control Association, St. Louis, MO., June 14-19, 1970).

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6. Fluid Meters - Their Theory and Application. American Society of Mechanical Engineers, New York, N.Y. 1959.

7. ASHRAE Handbook of Fundamentals. 1972. p. 208.

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9. Vollaro, R.F. Guidelines for Type S Pitot Tube Calibration. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at 1st Annual Meeting, Source Evaluation Society, Dayton, OH, September 18, 1975.)

10. Vollaro, R.F. A Type S Pitot Tube Calibration Study. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. July 1974.

11. Vollaro, R.F. The Effects of Impact Opening Misalignment on the Value of the Type S Pitot Tube Coefficient. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. October 1976.

12. Vollaro, R.F. Establishment of a Baseline Coefficient Value for Properly Constructed Type S Pitot

Tubes. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. November 1976.

13. Vollaro, R.F. An Evaluation of Single-Velocity Calibration Technique as a Means of Determining Type S Pitot Tube Coefficients. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. August 1975.

14. Vollaro, R.F. The Use of Type S Pitot Tubes for the Measurement of Low Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. November 1976.

15. Smith, Marvin L. Velocity Calibration of EPA Type Source Sampling Probe. United Technologies Corporation, Pratt and Whitney Aircraft Division, East Hartford, CT. 1975.

16. Vollaro, R.F. Recommended Procedure for Sample Traverses in Ducts Smaller than 12 Inches in Diameter. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, NC. November 1976.

17. Ower, E. and R.C. Pankhurst. The Measurement of Air Flow, 4th Ed. London, Pergamon Press. 1966.

18. Vollaro, R.F. A Survey of Commercially Available Instrumentation for the Measurement of Low-Range Gas Velocities. U.S. Environmental Protection Agency, Emission

Measurement Branch, Research Triangle Park, NC. November 1976. (Unpublished Paper).

19. Gnyp, A.W., *et al*. An Experimental Investigation of the Effect of Pitot Tube-Sampling Probe Configurations on the Magnitude of the S Type Pitot Tube Coefficient for Commercially Available Source Sampling Probes. Prepared by the University of Windsor for the Ministry of the Environment, Toronto, Canada. February 1975.

17.0 Tables, Diagrams, Flowcharts, and Validation Data.

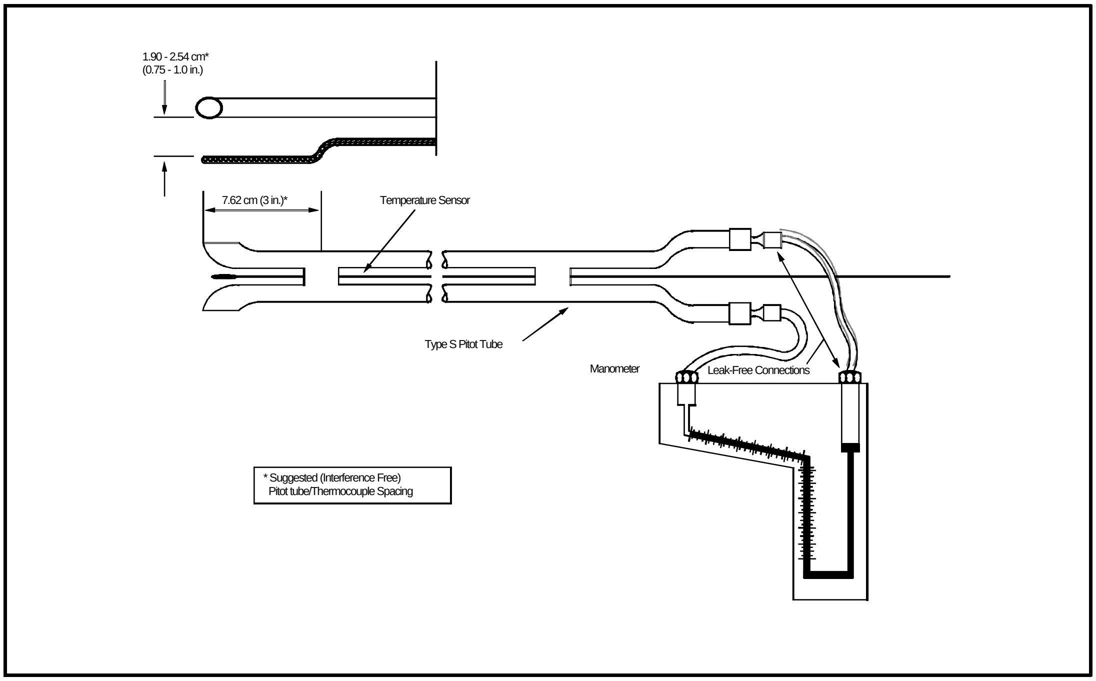
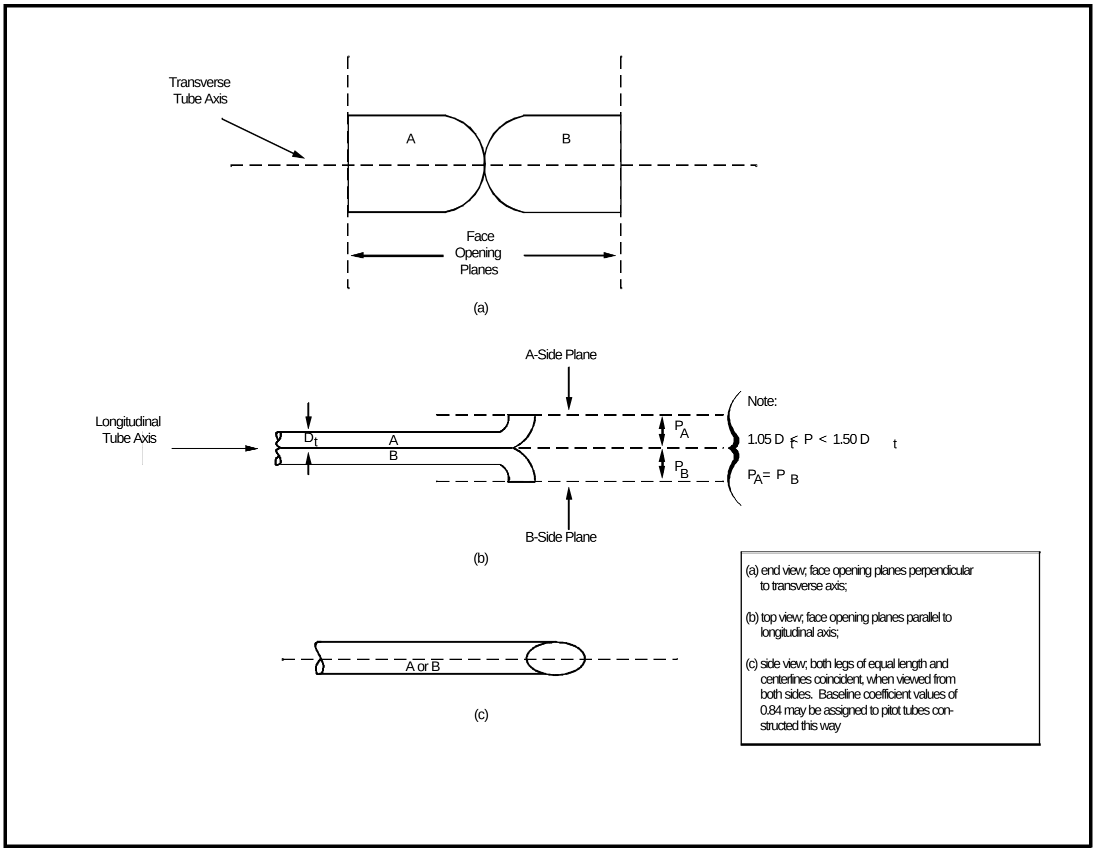


Figure 2-1. Type S Pitot Tube Manometer Assembly.

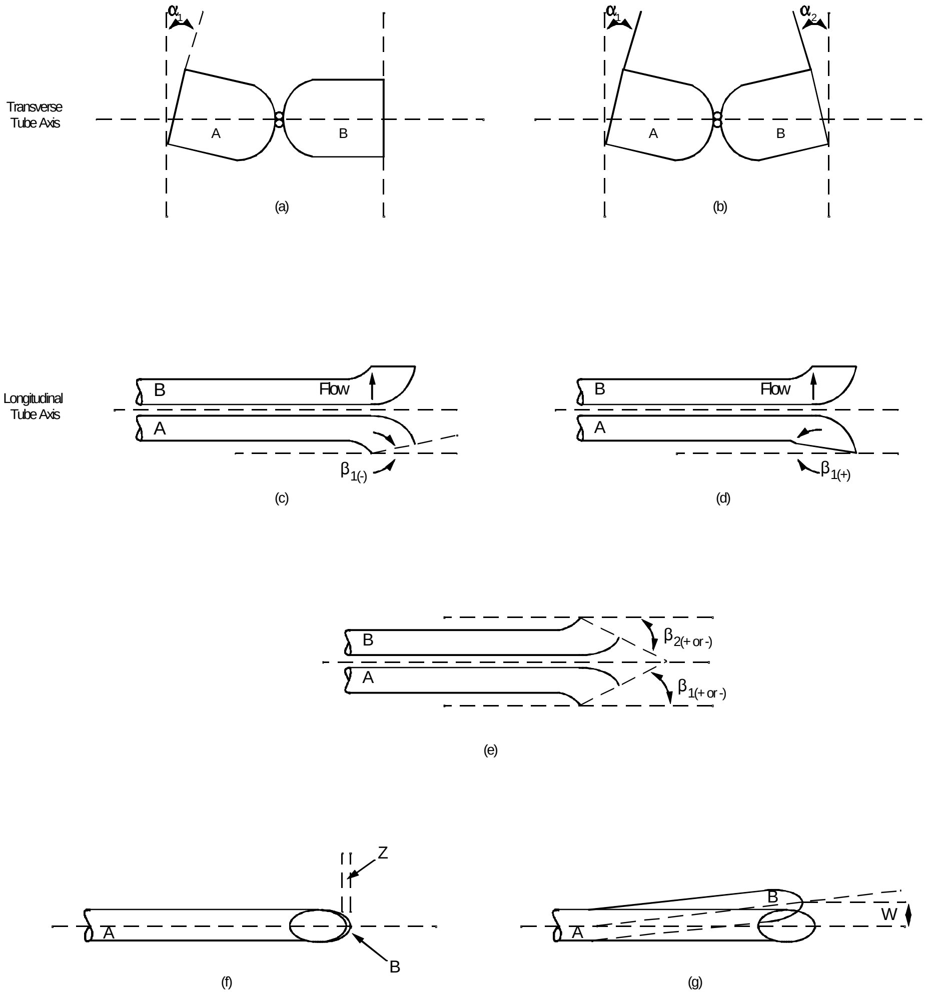


(a) end view; face opening planes perpendicular to transverse axis;

(b) top view; face opening planes parallel to longitudinal axis;

(c) side view; both legs of equal length and centerlines coincident, when viewed from both sides. Baseline coefficient values of 0.84 may be assigned to pitot tubes constructed this way

Figure 2-2. Properly Constructed Type S Pitot Tube.



The types of face-opening misalignment shown above will not affect the baseline value of Cp(s) so long as α_1 and $\alpha_2 < 10°$, β_1 and $\beta_2 < 5°$, $z \le 0.32$ cm (1/8 in.), and $w < 0.08$ cm (1/32 in.) (reference 11.0 in Section 16.0).

Figure 2-3. Types of face-opening misalignments that can result from field use or improper construction of type S pitot tubes.

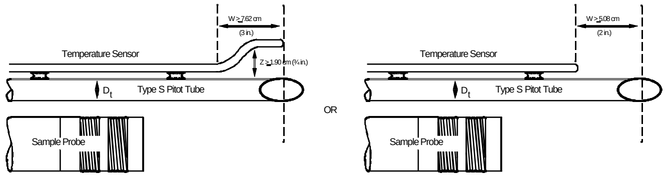


Figure 2-4. Proper temperature sensor placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in).

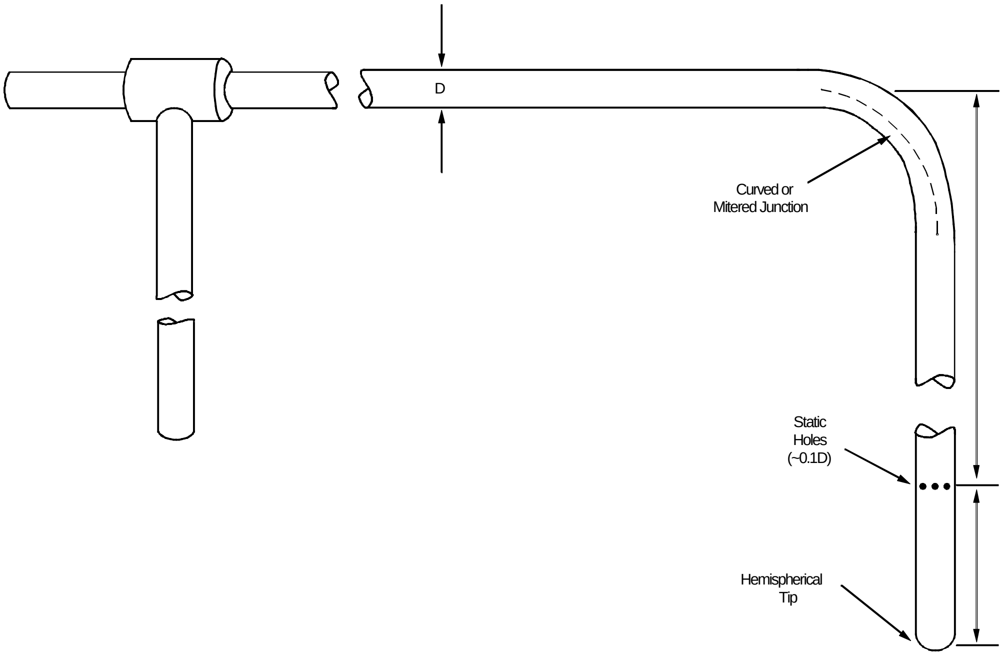


Figure 2-5. Standard pitot tube design specifications.

PLANT ____________________

DATE __________ RUN NO. ____________

STACK DIA. OR DIMENSIONS, m (in.) ____

BAROMETRIC PRESS., mm Hg (in. Hg) ____

CROSS SECTIONAL AREA, m^2 (ft^2) ________

OPERATORS ____________________

PITOT TUBE I.D. NO. ____________

AVG. COEFFICIENT, Cp = __________

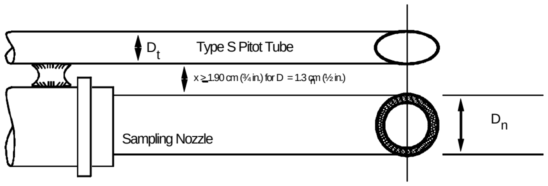
LAST DATE CALIBRATED __________

SCHEMATIC OF STACK

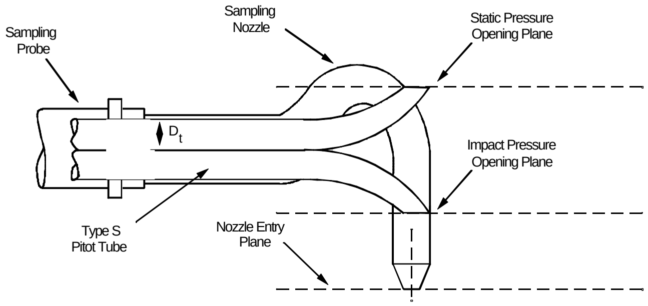
CROSS SECTION

Traverse Pt. No.	Vel. Hd., Δp mm (in.) H_2O	Stack Temperature		P_g mm Hg (in.Hg)	$(\Delta p)^{1/2}$
		T_s, °C (°F)	T_s, °K (°R)		
		Average			

Figure 2-6. Velocity traverse data.



A. Bottom View; showing minimum pitot tube-nozzle separation.



B. Side View; to prevent pitot tube from interfering with gas flow streamlines approaching the nozzle, the impact pressure opening plane of the pitot tube shall be even with or above the nozzle entry plane.

Figure 2-7. Proper pitot tube-sampling nozzle configuration.

PITOT TUBE IDENTIFICATION NUMBER: ________ DATE: __________

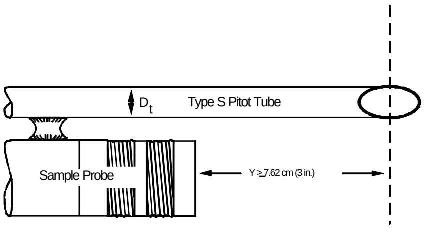


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in).

CALIBRATED BY: ____

	"A" SIDE CALIBRATION			
RUN NO.	ΔP_{std} cm H_2O (in H_2O)	$\Delta P_{(s)}$ cm H_2O (in H_2O)	$C_{p(s)}$	Deviation $C_{p(s)} - C_p(A)$
1				
2				
3				
		$C_{p,avg}$ (SIDE A)		

	"B" SIDE CALIBRATION			
RUN NO.	ΔP_{std} cm H_2O (in H_2O)	$\Delta P_{(s)}$ cm H_2O (in H_2O)	$C_{p(s)}$	Deviation $C_{p(s)} - C_p(B)$
1				
2				
3				
		$C_{p,avg}$ (SIDE B)		

$$F_{A\,or\,B} = \frac{\sum_{i=1}^{3} \left| C_{p(s)} - \overline{C}_{p(A\,or\,B)} \right|}{3} \qquad \textbf{Eq. 2-5}$$

[Cp,avg (side A) - Cp,avg (side B)] *

* Must be less than or equal to 0.01

Figure 2-9. Pitot tube calibration data.

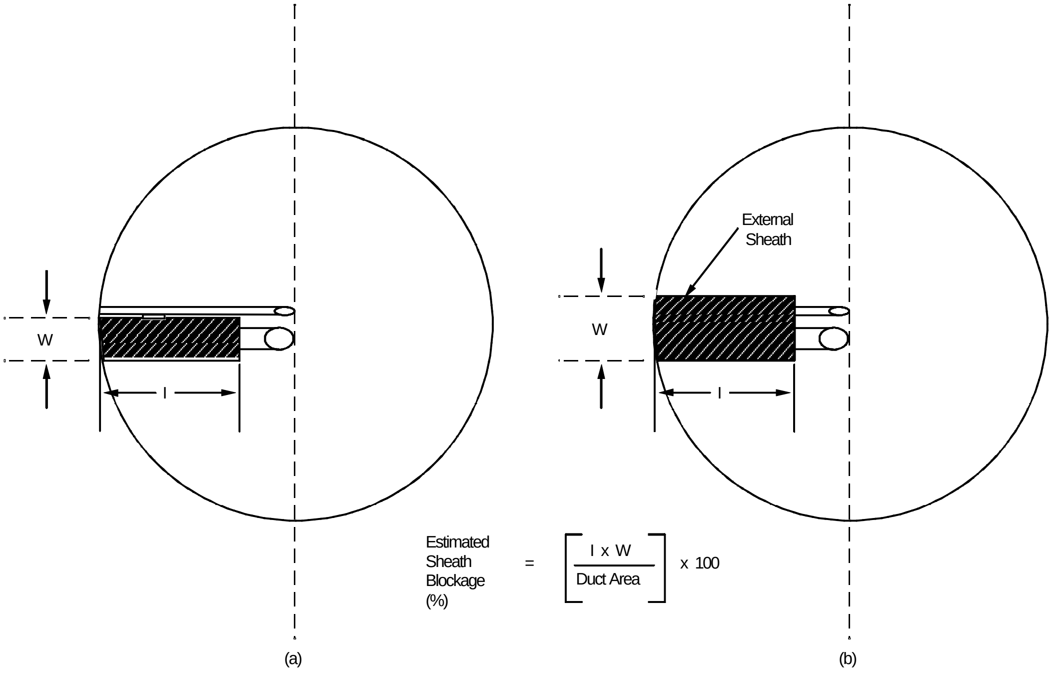


Figure 2-10. Projected-area models for typical pitot tube assemblie

Appendix F.3

Sampling & Analysis Methods

EPA Method 3

METHOD 3 - GAS ANALYSIS FOR THE DETERMINATION OF DRY MOLECULAR WEIGHT

NOTE: This method does not include all of the specifications (*e.g.*, equipment and supplies) and procedures (*e.g.*, sampling) essential to its performance. Some material is incorporated by reference from other methods in this part. Therefore, to obtain reliable results, persons using this method should also have a thorough knowledge of Method 1.

1.0 Scope and Application.

1.1 Analytes.

Analyte	CAS No.	Sensitivity
Oxygen (O_2)	7782-44-7	2,000 ppmv
Nitrogen (N_2)	7727-37-9	N/A
Carbon dioxide (CO_2)	124-38-9	2,000 ppmv
Carbon monoxide (CO)	630-08-0	N/A

1.2 Applicability. This method is applicable for the determination of CO_2 and O_2 concentrations and dry molecular weight of a sample from an effluent gas stream of a fossil-fuel combustion process or other process.

1.3 Other methods, as well as modifications to the procedure described herein, are also applicable for all of the above determinations. Examples of specific methods and modifications include: (1) a multi-point grab sampling method using an Orsat analyzer to analyze the individual grab sample obtained at each point; (2) a method for measuring either CO_2 or O_2 and using stoichiometric calculations to determine dry molecular weight; and (3) assigning a value of 30.0 for dry molecular weight, in lieu of actual measurements, for processes burning natural gas, coal, or oil. These methods and modifications may be used, but are subject to the approval of the Administrator. The method may also be applicable to other processes where it has been determined that compounds other than CO_2, O_2, carbon monoxide (CO), and nitrogen (N_2) are not present in concentrations sufficient to affect the results.

1.4 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method.

2.1 A gas sample is extracted from a stack by one of the following methods: (1) single-point, grab sampling; (2) single-point, integrated sampling; or (3) multi-point, integrated sampling. The gas sample is analyzed for percent CO_2 and percent O_2. For dry molecular weight determination, either an Orsat or a Fyrite analyzer may be used for the analysis.

3.0 Definitions. [Reserved]

4.0 Interferences.

4.1 Several compounds can interfere, to varying degrees, with the results of Orsat or Fyrite analyses. Compounds that interfere with CO_2 concentration measurement include acid gases (*e.g.*, sulfur dioxide, hydrogen chloride); compounds that interfere with O_2 concentration measurement include unsaturated hydrocarbons (*e.g.*, acetone, acetylene), nitrous oxide, and ammonia. Ammonia reacts chemically with the O_2 absorbing solution, and when present in the effluent gas stream must be removed before analysis.

5.0 Safety.

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

5.2 Corrosive Reagents.

5.2.1 A typical Orsat analyzer requires four reagents: a gas-confining solution, CO_2 absorbent, O_2 absorbent, and CO absorbent. These reagents may contain potassium hydroxide, sodium hydroxide, cuprous chloride, cuprous sulfate, alkaline pyrogallic acid, and/or chromous chloride. Follow manufacturer's operating instructions and observe all warning labels for reagent use.

5.2.2 A typical Fyrite analyzer contains zinc chloride, hydrochloric acid, and either potassium hydroxide or chromous chloride. Follow manufacturer's operating instructions and observe all warning labels for reagent use.

6.0 Equipment and Supplies.

NOTE: As an alternative to the sampling apparatus and systems described herein, other sampling systems (*e.g.*, liquid displacement) may be used, provided such systems are capable of obtaining a representative sample and maintaining a constant sampling rate, and are, otherwise, capable of yielding acceptable results. Use of such systems is subject to the approval of the Administrator.

6.1 Grab Sampling (See Figure 3-1).

6.1.1 Probe. Stainless steel or borosilicate glass tubing equipped with an in-stack or out-of-stack filter to remove particulate matter (a plug of glass wool is satisfactory for this purpose). Any other materials, resistant to temperature at sampling conditions and inert to all components of the gas stream, may be used for the probe. Examples of such materials may include aluminum, copper, quartz glass, and Teflon.

6.1.2 Pump. A one-way squeeze bulb, or equivalent, to transport the gas sample to the analyzer.

6.2 Integrated Sampling (Figure 3-2).

6.2.1 Probe. Same as in Section 6.1.1.

6.2.2 Condenser. An air-cooled or water-cooled condenser, or other condenser no greater than 250 ml that will not remove O_2, CO_2, CO, and N_2, to remove excess moisture which would interfere with the operation of the pump and flowmeter.

6.2.3 Valve. A needle valve, to adjust sample gas flow rate.

6.2.4 Pump. A leak-free, diaphragm-type pump, or equivalent, to transport sample gas to the flexible bag. Install a small surge tank between the pump and rate meter to eliminate the pulsation effect of the diaphragm pump on the rate meter.

6.2.5 Rate Meter. A rotameter, or equivalent, capable of measuring flow rate to ± 2 percent of the selected flow rate. A flow rate range of 500 to 1000 ml/min is suggested.

6.2.6 Flexible Bag. Any leak-free plastic (*e.g.*, Tedlar, Mylar, Teflon) or plastic-coated aluminum (*e.g.*, aluminized Mylar) bag, or equivalent, having a capacity consistent with the selected flow rate and duration of the test run. A capacity in the range of 55 to 90 liters (1.9 to 3.2 ft^3) is suggested. To leak-check the bag, connect it to a water manometer, and pressurize the bag to 5 to 10 cm H_2O (2 to 4 in. H_2O). Allow to stand for 10 minutes. Any displacement in the water manometer indicates a leak. An alternative leak-check method is to pressurize the bag to 5 to 10 cm (2 to 4 in.) H_2O and allow to stand overnight. A deflated bag indicates a leak.

6.2.7 Pressure Gauge. A water-filled U-tube manometer, or equivalent, of about 30 cm (12 in.), for the flexible bag leak-check.

6.2.8 Vacuum Gauge. A mercury manometer, or equivalent, of at least 760 mm (30 in.) Hg, for the sampling train leak-check.

6.3 Analysis. An Orsat or Fyrite type combustion gas analyzer.

7.0 Reagents and Standards.

7.1 Reagents. As specified by the Orsat or Fyrite-type combustion analyzer manufacturer.

7.2 Standards. Two standard gas mixtures, traceable to National Institute of Standards and Technology (NIST) standards, to be used in auditing the accuracy of the analyzer and the analyzer operator technique:

7.2.1. Gas cylinder containing 2 to 4 percent O_2 and 14 to 18 percent CO_2.

7.2.2. Gas cylinder containing 2 to 4 percent CO_2 and about 15 percent O_2.

8.0 Sample Collection, Preservation, Storage, and Transport.

8.1 Single Point, Grab Sampling Procedure.

8.1.1 The sampling point in the duct shall either be at the centroid of the cross section or at a point no closer to the walls than 1.0 m (3.3 ft), unless otherwise specified by the Administrator.

8.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight. If an Orsat analyzer is used, it is recommended that the analyzer be leak-checked by following the procedure in Section 11.5; however, the leak-check is optional.

8.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point. Purge the sampling line long enough to allow at least five exchanges. Draw a sample into the analyzer, and immediately analyze it for percent CO_2 and percent O_2 according to Section 11.2.

8.2 Single-Point, Integrated Sampling Procedure.

8.2.1 The sampling point in the duct shall be located as specified in Section 8.1.1.

8.2.2 Leak-check (optional) the flexible bag as in Section 6.2.6. Set up the equipment as shown in Figure 3-2. Just before sampling, leak-check (optional) the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of at least 250 mm Hg (10 in. Hg), plugging the outlet at the quick disconnect, and then turning off the pump. The vacuum should remain stable for at least 0.5 minute. Evacuate the flexible bag. Connect the probe, and place it in the stack, with the tip of the probe positioned at the sampling point. Purge the sampling line. Next, connect the bag, and make sure that all connections are tight.

8.2.3 Sample Collection. Sample at a constant rate (± 10 percent). The sampling run should be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collection of at least 28 liters (1.0 ft^3) of sample gas is recommended; however, smaller volumes may be collected, if desired.

8.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. Within 8 hours after the sample is taken, analyze it for percent CO_2 and percent O_2 using either an Orsat analyzer or a Fyrite type combustion gas analyzer according to Section 11.3.

NOTE: When using an Orsat analyzer, periodic Fyrite readings may be taken to verify/confirm the results obtained from the Orsat.

8.3 Multi-Point, Integrated Sampling Procedure.

8.3.1 Unless otherwise specified in an applicable regulation, or by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less than 0.61 m (24 in.), a minimum of nine shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of 12 traverse points shall be used for all other cases. The traverse points shall be located according to Method 1.

8.3.2 Follow the procedures outlined in Sections 8.2.2 through 8.2.4, except for the following: Traverse all sampling points, and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

9.0 Quality Control.

Section	Quality Control Measure	Effect
8.2	Use of Fyrite to confirm Orsat results.	Ensures the accurate measurement of CO_2 and O_2.
10.1	Periodic audit of analyzer and operator technique.	Ensures that the analyzer is operating properly and that the operator performs the sampling procedure correctly and accurately.
11.3	Replicable analyses of integrated samples.	Minimizes experimental error.

10.0 Calibration and Standardization.

10.1 Analyzer. The analyzer and analyzer operator's technique should be audited periodically as follows: take a sample from a manifold containing a known mixture of CO_2 and O_2, and analyze according to the procedure in Section 11.3. Repeat this procedure until the measured concentration of three consecutive samples agrees with the stated value ± 0.5 percent. If necessary, take corrective action, as specified in the analyzer users manual.

10.2 Rotameter. The rotameter need not be calibrated, but should be cleaned and maintained according to the manufacturer's instruction.

11.0 Analytical Procedure.

11.1 Maintenance. The Orsat or Fyrite-type analyzer should be maintained and operated according to the manufacturers specifications.

11.2 Grab Sample Analysis. Use either an Orsat analyzer or a Fyrite-type combustion gas analyzer to measure O_2 and CO_2 concentration for dry molecular weight determination, using procedures as specified in the analyzer user's manual. If an Orsat analyzer is used, it is recommended that the Orsat leak-check, described in Section 11.5, be performed before this determination; however, the check is optional. Calculate the dry molecular weight as indicated in Section 12.0. Repeat the sampling, analysis, and calculation procedures until the dry molecular weights of any three grab samples differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (0.1 lb/lb-mole).

11.3 Integrated Sample Analysis. Use either an Orsat analyzer or a Fyrite-type combustion gas analyzer to measure O_2 and CO_2 concentration for dry molecular weight determination, using procedures as specified in the analyzer user's manual. If an Orsat analyzer is used, it is recommended that the Orsat leak-check, described in Section 11.5, be performed before this determination;

however, the check is optional. Calculate the dry molecular weight as indicated in Section 12.0. Repeat the analysis and calculation procedures until the individual dry molecular weights for any three analyses differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (0.1 lb/lb-mole).

11.4 Standardization. A periodic check of the reagents and of operator technique should be conducted at least once every three series of test runs as outlined in Section 10.1.

11.5 Leak-Check Procedure for Orsat Analyzer. Moving an Orsat analyzer frequently causes it to leak. Therefore, an Orsat analyzer should be thoroughly leak-checked on site before the flue gas sample is introduced into it. The procedure for leak-checking an Orsat analyzer is as follows:

11.5.1 Bring the liquid level in each pipette up to the reference mark on the capillary tubing, and then close the pipette stopcock.

11.5.2 Raise the leveling bulb sufficiently to bring the confining liquid meniscus onto the graduated portion of the burette, and then close the manifold stopcock.

11.5.3 Record the meniscus position.

11.5.4 Observe the meniscus in the burette and the liquid level in the pipette for movement over the next 4 minutes.

11.5.5 For the Orsat analyzer to pass the leak-check, two conditions must be met:

11.5.5.1 The liquid level in each pipette must not fall below the bottom of the capillary tubing during this 4-minute interval.

11.5.5.2 The meniscus in the burette must not change by more than 0.2 ml during this 4-minute interval.

11.5.6 If the analyzer fails the leak-check procedure, check all rubber connections and stopcocks to determine whether they might be the cause of the leak. Disassemble, clean, and regrease any leaking stopcocks. Replace leaking rubber connections. After the analyzer is reassembled, repeat the leak-check procedure.

12.0 Calculations and Data Analysis.

12.1 Nomenclature.

M_d = Dry molecular weight, g/g-mole (lb/lb-mole).

$\%CO_2$ = 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.

0.280 = 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.

12.2 Nitrogen, Carbon Monoxide Concentration. Determine the percentage of the gas that is N_2 and CO by subtracting the sum of the percent CO_2 and percent O_2 from 100 percent.

12.3 Dry Molecular Weight. Use Equation 3-1 to calculate the dry molecular weight of the stack gas.

$$M_d = 0.440(\%CO_2) + 0.320\ (\%O_2) + 0.280\ (\%N_2 + \%CO) \qquad \textbf{Eq. 3-1}$$

NOTE: The above Equation 3-1 does not consider the effect on calculated dry molecular weight of argon in the effluent gas. The concentration of argon, with a molecular weight of 39.9, in ambient air is about 0.9 percent. A negative error of approximately 0.4 percent is introduced. The tester may choose to include argon in the analysis using procedures subject to approval of the Administrator.

13.0 Method Performance. [Reserved]

14.0 Pollution Prevention. [Reserved]

15.0 Waste Management. [Reserved]

16.0 References.

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2. Conner, William D. and J.S. Nader. Air Sampling with Plastic Bags. Journal of the American Industrial Hygiene Association. 25:291-297. 1964.

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5. Shigehara, R.T., R.M. Neulicht, and W.S. Smith. Validating Orsat Analysis Data from Fossil Fuel-Fired Units. Stack Sampling News. 4(2):21-26. August 1976.

17.0 Tables, Diagrams, Flowcharts, and Validation Data.

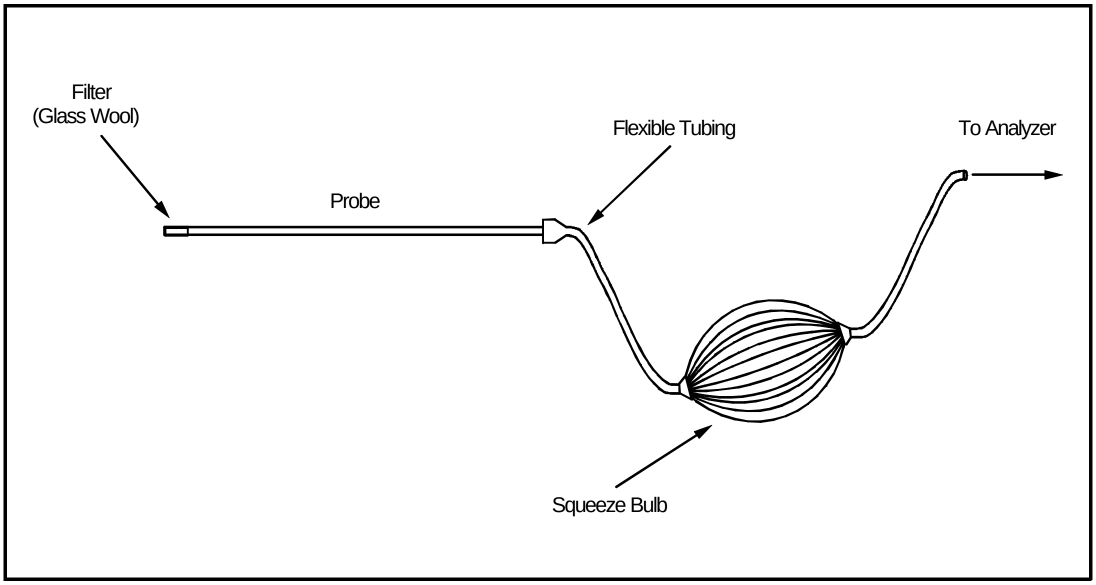

Figure 3-1. Grab-Sampling Train.

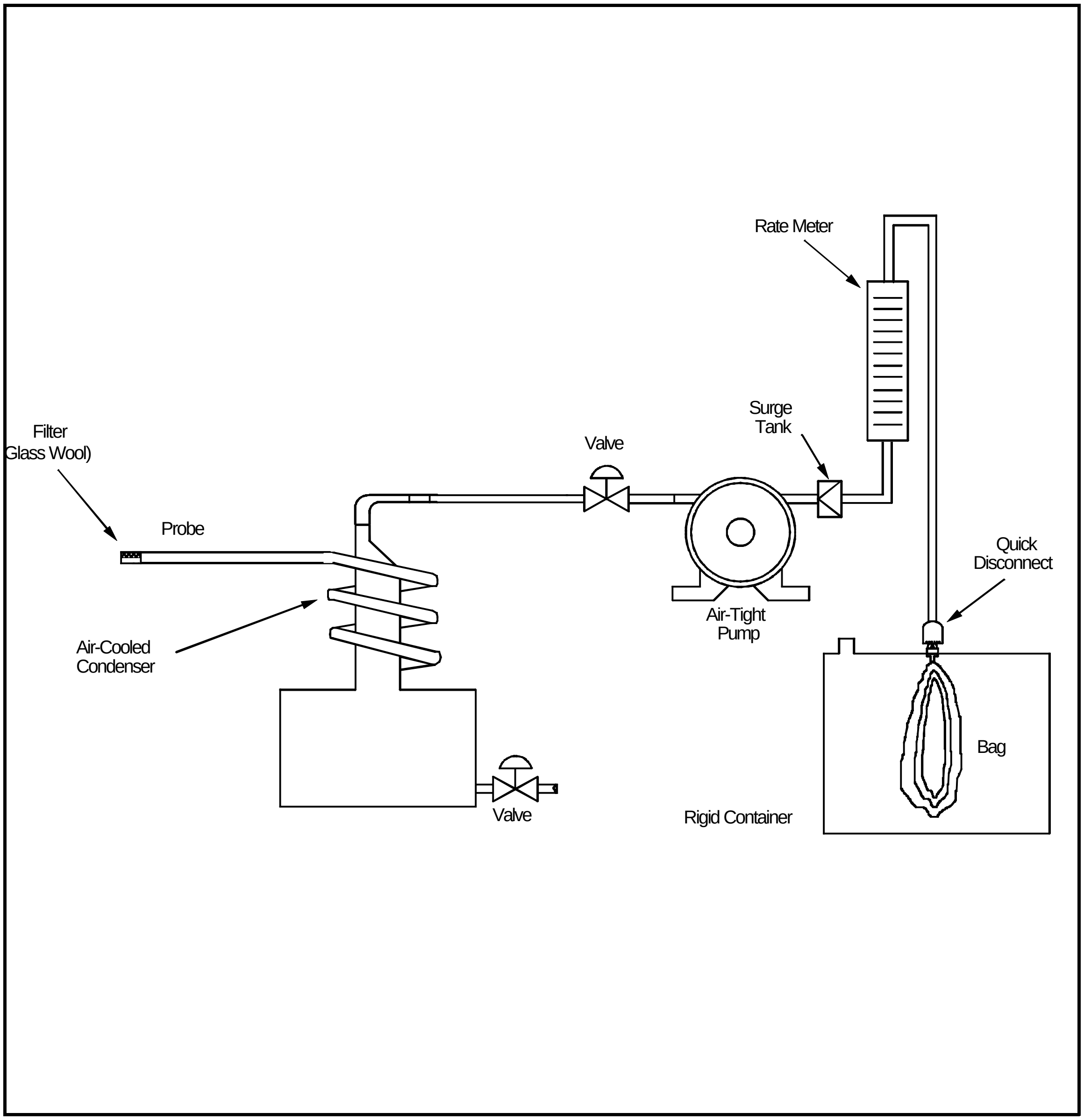

Figure 3-2. Integrated Gas-Sampling Train.

Time	Traverse Point	Q (liter/min)	% Deviation[a]
Average			

[a] %Dev. = $[(Q - Q_{avg})/Q_{avg}] \times 100$ (Must be $\leq \pm$ 10 %)

Figure 3-3. Sampling Rate Data.

Appendix F.4

Sampling & Analysis Methods

EPA Method 10

EMISSION MEASUREMENT TECHNICAL INFORMATION CENTER
NSPS TEST METHOD

Method 10 - Determination of Carbon Monoxide Emissions from Stationary Sources

1. PRINCIPLE AND APPLICABILITY

1.1 Principle. An integrated or continuous gas sample is extracted from a sampling point and analyzed for carbon monoxide (CO) content using a Luft-type nondispersive infrared analyzer (NDIR) or equivalent.

1.2 Applicability. This method is applicable for the determination of carbon monoxide emissions from stationary sources only when specified by the test procedures for determining compliance with new source performance standards. The test procedure will indicate whether a continuous or an integrated sample is to be used.

2. RANGE AND SENSITIVITY

2.1 Range. 0 to 1000 ppm.

2.2 Sensitivity. Minimum detectable concentration is 20 ppm for a 0- to 1000—ppm span.

3. INTERFERENCES

Any substance having a strong absorption of infrared energy will interfere to some extent. For example, discrimination ratios for water (H_2O) and carbon dioxide (CO_2) are 3.5 percent H_2O per 7 ppm CO and 10 percent CO_2 per 10 ppm CO, respectively, for devices measuring in the 1500- to 3000-ppm range. For devices measuring in the 0- to 100-ppm range, interference ratios can be as high as 3.5 percent H_2O per 25 ppm CO and 10 percent CO_2 per 50 ppm CO. The use of silica gel and ascarite traps will alleviate the major interference problems. The measured gas volume must be corrected if these traps are used.

4. PRECISION AND ACCURACY

4.1 Precision. The precision of most NDIR analyzers is approximately ±2 percent of span.

4.2 Accuracy. The accuracy of most NDIR analyzers is approximately ±5 percent of span after calibration.

5. APPARATUS

<u>Note</u>: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

5.1 Continuous Sample (Figure 10-1).

5.1.1 Probe. Stainless steel or sheathed Pyrex glass, equipped with a filter to remove particulate matter.

5.1.2 Air-Cooled Condenser or Equivalent. To remove any excess moisture.

5.2 Integrated Sample (Figure 10-2).

5.2.1 Probe. Same as in Section 5.1.1.

5.2.2 Air-Cooled Condenser or Equivalent. Same as in Section 5.1.2.

5.2.3 Valve. Needle valve, or equivalent, to adjust flow rate.

5.2.4 Pump. Leak-free diaphragm type, or equivalent, to transport gas.

5.2.5 Rate Meter. Rotameter, or equivalent, to measure a flow range from
0 to 1.0 liter per minute (0 to 0.035 cfm).

5.2.6 Flexible Bag. Tedlar, or equivalent, with a capacity of 60 to 90 liters (2 to 3 ft^3). Leak-test the bag in the laboratory before using by evacuating bag with a pump followed by a dry gas meter. When evacuation is complete, there should be no flow through the meter.

5.2.7 Pitot Tube. Type S, or equivalent, attached to the probe so that the sampling rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.

5.3 Analysis (Figure 10-3).

5.3.1 Carbon Monoxide Analyzer. Nondispersive infrared spectrometer, or equivalent. This instrument should be demonstrated, preferably by the manufacturer, to meet or exceed manufacturer's specifications and those described in this method.

5.3.2 Drying Tube. To contain approximately 200 g of silica gel.

5.3.3 Calibration Gas. Refer to Section 6.1.

5.3.4 Filter. As recommended by NDIR manufacturer.

5.3.5 CO_2 Removal Tube. To contain approximately 500 g of ascarite.

5.3.6 Ice Water Bath. For ascarite and silica gel tubes.

5.3.7 Valve. Needle valve, or equivalent, to adjust flow rate.

5.3.8 Rate Meter. Rotameter, or equivalent, to measure gas flow rate of 0 to 1.0 liter/min (0 to 0.035 cfm) through NDIR.

5.3.9 Recorder (Optional). To provide permanent record of NDIR readings.

6. REAGENTS

6.1 Calibration Gases. Known concentration of CO in nitrogen (N_2) for instrument span, prepurified grade of N_2 for zero, and two additional concentrations corresponding approximately to 60 percent and 30 percent of span. The span concentration shall not exceed 1.5 times the applicable source performance standard. The calibration gases shall be certified by the manufacturer to be within 2 percent of the specified concentration.

6.2 Silica Gel. Indicating type, 6- to 16-mesh, dried at 175°C (347°F) for 2 hours.

6.3 Ascarite. Commercially available.

7. PROCEDURE

7.1 Sampling.

7.1.1 Continuous Sampling. Set up the equipment as shown in Figure 10-1 making sure all connections are leak free. Place the probe in the stack at a sampling point, and purge the sampling line. Connect the analyzer, and begin drawing sample into the analyzer. Allow 5 minutes for the system to stabilize, then record the analyzer reading as required by the test procedure. (See Sections 7.2 and 8). CO_2 content of the gas may be determined by using the Method 3 integrated sampling procedure, or by weighing the ascarite CO_2 removal tube and computing CO_2 concentration from the gas volume sampled and the weight gain of the tube.

7.1.2 Integrated Sampling. Evacuate the flexible bag. Set up the equipment as shown in Figure 10-2 with the bag disconnected. Place the probe in the stack, and purge the sampling line. Connect the bag, making sure that all connections are leak free. Sample at a rate proportional to the stack velocity. CO_2 content of the gas may be determined by using the Method 3 integrated sample procedures, or by weighing the ascarite CO_2 concentration from the gas volume sampled and the weight gain of the tube.

7.2 CO Analysis. Assemble the apparatus as shown in Figure 10-3, calibrate the instrument, and perform other required operations as described in Section 8. Purge analyzer with N_2 prior to introduction of each sample. Direct the sample stream through the instrument for the test period, recording the readings. Check the zero and the span again after the test to assure that any drift or malfunction is detected. Record the sample data on Table 10-1.

8. CALIBRATION

Assemble the apparatus according to Figure 10-3. Generally an instrument requires a warm-up period before stability is obtained. Follow the manufacturer's instructions for specific procedure. Allow a minimum time of 1 hour for warmup. During this time check the sample conditioning apparatus, i.e., filter, condenser, drying tube, and CO_2 removal tube, to ensure that each component is in good operating condition. Zero and calibrate the instrument according to the manufacturer's procedures using, respectively, N_2 and the calibration gases.

TABLE 10-1 - FIELD DATA

Location: Date:

Test: Operator:

Clock Time	Rotameter Reading liters/min (cfm)	Comments

9. CALCULATION--CONCENTRATION OF CARBON MONOXIDE

Calculate the concentration of carbon monoxide in the stack using Equation 10—1.

$$C_{CO(stack)} = C_{CO(NDIR)}(1 - F_{CO2}) \qquad \text{Eq. 10-1}$$

where:

$C_{CO(stack)}$ = Concentration of CO in stack, ppm by volume, dry basis.

$C_{CO(NDIR)}$ = Concentration of CO measured by NDIR analyzer, ppm by volume, dry basis.

F_{CO2} = Volume fraction of CO_2 in sample, i.e., percent CO_2 from Orsat analysis divided by 100.

10. ALTERNATIVE PROCEDURE--INTERFERENCE TRAP

The sample conditioning system described in Method 101A, Sections 2.1.2 and 4.2, may be used as an alternative to the silica gel and ascarite traps.

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4. Beckman Instruments, Inc. Models 215A, 315A, and 415A Infrared Analyzers. Beckman Instructions 1635-B, Fullerton, CA. October 1967.
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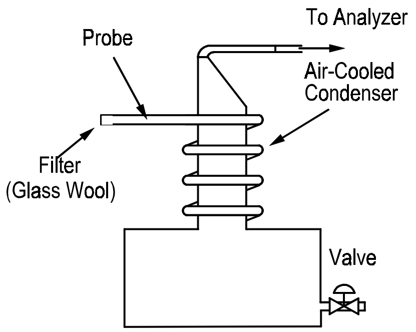

Figure 10-1. Continuous Sampling Train.

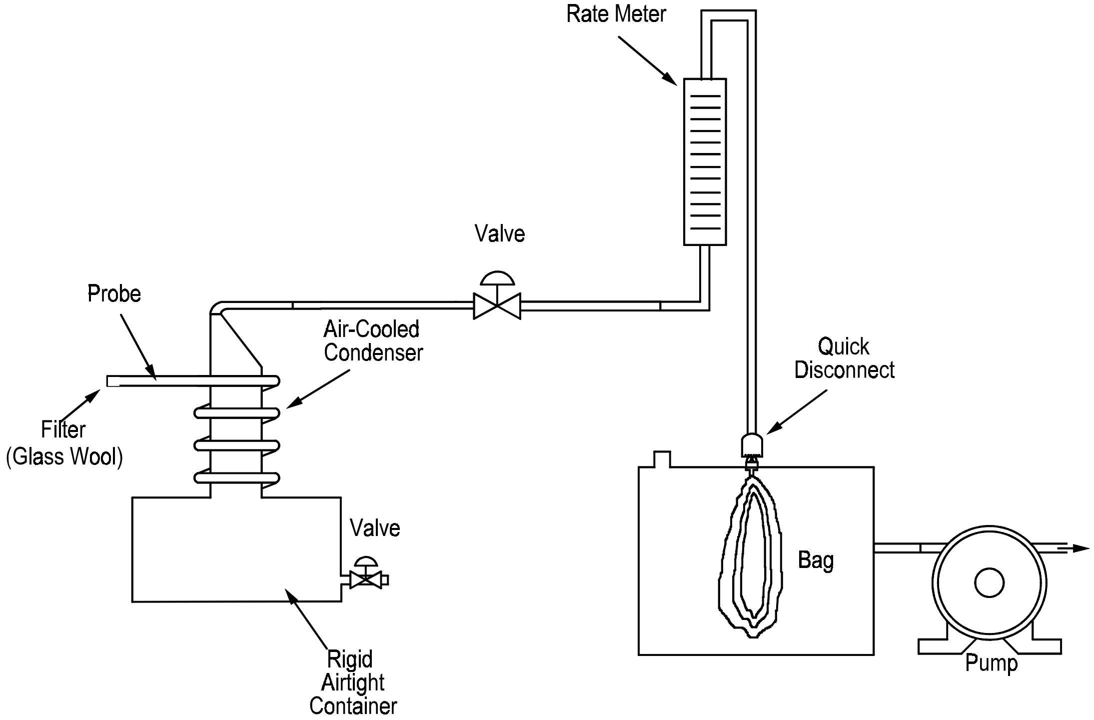

Figure 10-2. Integrated Gas Sampling Train.

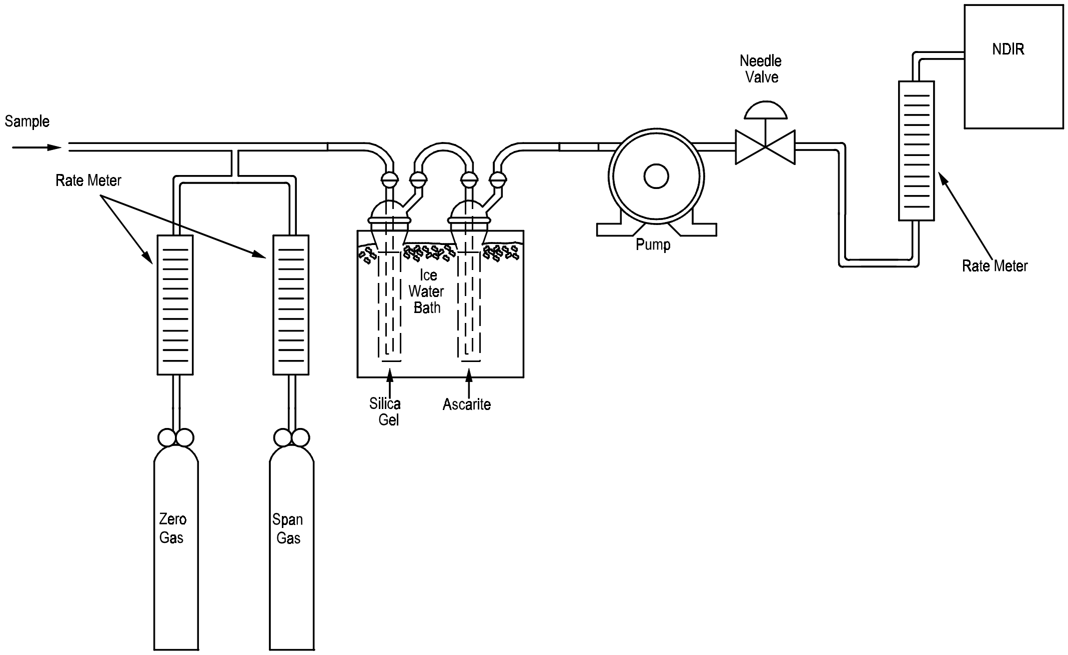

Figure 10-3. Analytical Equipment.

ADDENDA

A. Performance Specifications for NDIR Carbon Monoxide Analyzers.

TABLE A-1. Performance Specifications for NDIR CO Analyzers

Range (minimum)	0-1000 ppm
Output (minimum)	0-10 mV
Minimum detectable sensitivity	20 ppm
Rise time, 90 percent (maximum)	30 seconds
Fall time, 90 percent (maximum)	30 seconds
Zero drift (maximum)	10% in 8 hours
Span drift (maximum)	10% in 8 hours
Precision (maximum)	±2% of full scale
Noise (maximum)	±1% of full scale
Linearity (maximum deviation)	2% of full scale
Interference rejection ratio	CO_2 - 1000:1; H_2O - 500:1

B. Definitions of Performance Specifications.

1. Range - The minimum and maximum measurement limits.

2. Output - Electrical signal which is proportional to the measurement; intended for connection to readout or data processing devices. Usually expressed as millivolts or milliamps full scale at a given impedance.

3. Full Scale - The maximum measuring limit for a given range.

4. Minimum Detectable Sensitivity - The smallest amount of input concentration that can be detected as the concentration approaches zero.

5. Accuracy - The degree of agreement between a measured value and the true value; usually expressed as ± percent of full scale.

6. Time to 90 Percent Response - The time interval from a step change in the input concentration at the instrument inlet to a reading of 90 percent of the ultimate recorded concentration.

7. Rise Time (90 Percent) - The interval between initial response time and time to 90 percent response after a step increase in the inlet concentration.

8. Fall Time (90 Percent) - The interval between initial response time and time to 90 percent response after a step decrease in the inlet concentration.

9. Zero Drift - The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is zero; usually expressed as percent full scale.

10. Span Drift - The change in instrument output over a stated time period, usually 24 hours, of unadjusted continuous operation when the input concentration is a stated upscale value; usually expressed as percent full scale.

11. Precision - The degree of agreement between repeated measurements of the same concentration, expressed as the average deviation of the single results from the mean.

12. Noise - Spontaneous deviations from a mean output not caused by input concentration changes.

13. Linearity - The maximum deviation between an actual instrument reading and the reading predicted by a straight line drawn between upper and lower calibration points.

Appendix F.5

Sampling & Analysis Methods

EPA Method 316 (including Method 4)

APPENDIX A TO PART 63--TEST METHOD

* * * * *

Method 316 - Sampling and Analysis for Formaldehyde Emissions from Stationary Sources in the Mineral Wool and Wool Fiberglass Industries

1.0 Introduction.

This method is applicable to the determination of formaldehyde, CAS Registry number 50-00-0, from stationary sources in the mineral wool and wool fiber glass industries. High purity water is used to collect the formaldehyde. The formaldehyde concentrations in the stack samples are determined using the modified pararosaniline method. Formaldehyde can be detected as low as 8.8×10^{-10} lbs/cu ft (11.3 ppbv) or as high as 1.8×10^{-3} lbs/cu ft (23,000,000 ppbv), at standard conditions over a 1 hour sampling period, sampling approximately 30 cu ft.

2.0 Summary of Method.

Gaseous and particulate pollutants are withdrawn isokinetically from an emission source and are collected in high purity water. Formaldehyde present in the emissions is highly soluble in high purity water. The high purity water containing formaldehyde is then analyzed using the modified pararosaniline method. Formaldehyde in the sample reacts with acidic pararosaniline, and the sodium sulfite, forming a purple chromophore. The intensity of the purple color, measured spectrophotometrically, provides an accurate and precise measure of the formaldehyde concentration in the sample.

3.0 Definitions.

See the definitions in the General Provisions of this Subpart.

4.0 Interferences.

Sulfite and cyanide in solution interfere with the pararosaniline method. A procedure to overcome the interference by each compound has been described by Miksch, et al.

5.0 Safety. (Reserved)

6.0 Apparatus and Materials.

6.1 A schematic of the sampling train is shown in Figure 1. This sampling train configuration is adapted from EPA Method 5, 40 CFR part 60, appendix A, procedures.

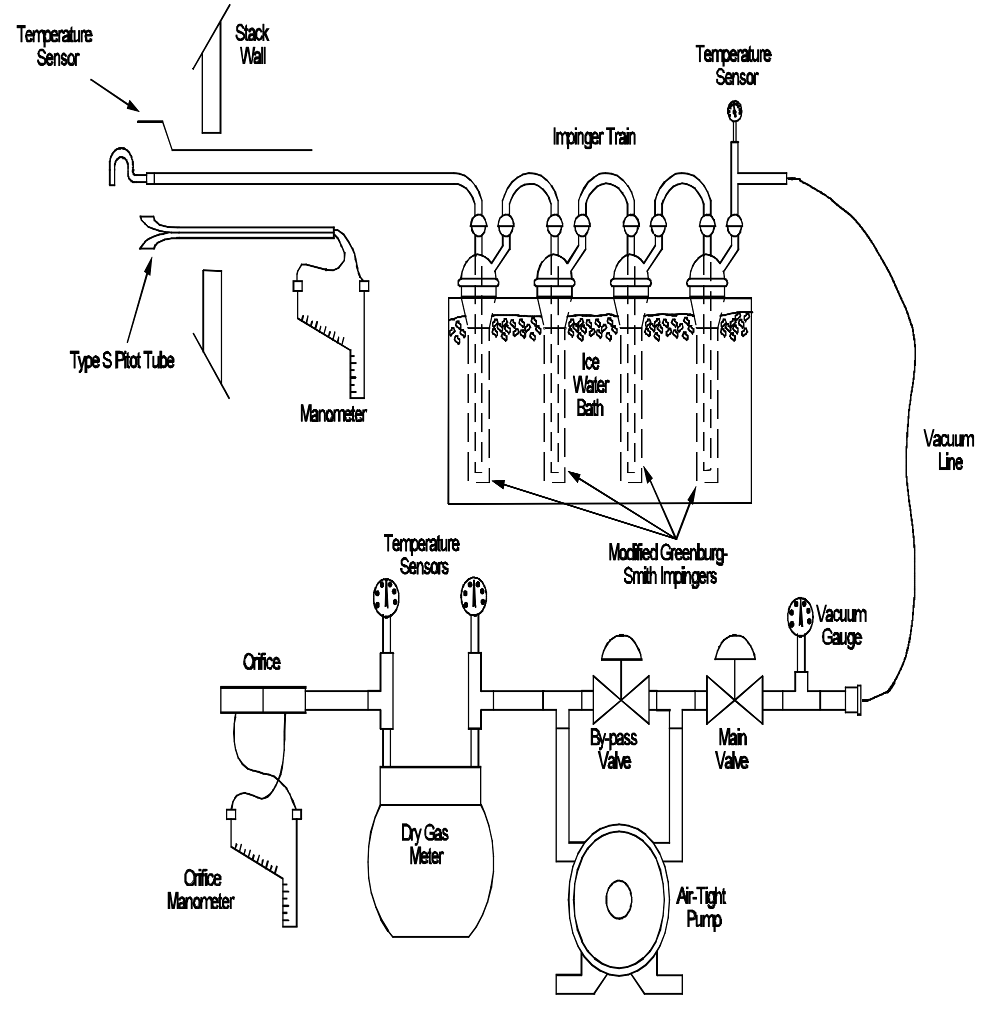

Figure 1. Sampling Train.

The sampling train consists of the following components: probe nozzle, probe liner, pitot tube, differential pressure gauge, impingers, metering system, barometer, and gas density determination equipment.

6.1.1 Probe Nozzle: Quartz, glass, or stainless steel with sharp, tapered (30° angle) leading edge. The taper shall be on the outside to preserve a constant inner diameter. The nozzle shall be buttonhook or elbow design. A range of nozzle sizes suitable for isokinetic sampling should be available in increments of 0.15 cm (1/16 in), e.g., 0.32 to 1.27 cm (1/8 to 1/2 in), or larger if higher volume sampling trains are used. Each nozzle shall be calibrated according to the procedure outlined in Section 10.1.

6.1.2 Probe Liner: Borosilicate glass or quartz shall be used for the probe liner. The probe shall be maintained at a temperature of 120°C ± 14°C (248°F ± 25°F).

6.1.3 Pitot Tube: The pitot tube shall be Type S, as described in Section 2.1 of EPA Method 2, 40 CFR part 60, appendix A, or any other appropriate device. The pitot tube shall be attached to the probe to allow constant monitoring of the stack gas velocity. The impact (high pressure) opening plane of the pitot tube shall be even with or above the nozzle entry plane (see Figure 2-6b, EPA Method 2, 40 CFR part 60, appendix A) during sampling. The Type S pitot tube assembly shall have a known coefficient, determined as outlined in Section 4 of EPA Method 2, 40 CFR part 60, appendix A.

6.1.4 Differential Pressure Gauge: The differential pressure gauge shall be an inclined manometer or equivalent device as described in Section 2.2 of EPA Method 2, 40 CFR part 60, appendix A. One manometer shall be used for velocity-head reading and the other for orifice differential pressure readings.

6.1.5 Impingers: The sampling train requires a minimum of four impingers, connected as shown in Figure 1, with ground glass (or equivalent) vacuum-tight fittings. For the first, third, and fourth impingers, use the Greenburg-Smith design, modified by replacing the tip with a 1.3 cm inside diameters (1/2 in) glass tube extending to 1.3 cm (1/2 in) from the bottom of the flask. For the second impinger, use a Greenburg-Smith impinger with the standard tip. Place a thermometer capable of measuring temperature to within 1°C (2°F) at the outlet of the fourth impinger for monitoring purposes.

6.1.6 Metering System: The necessary components are a vacuum gauge, leak-free pump, thermometers capable of measuring temperatures within 3°C (5.4°F), dry-gas meter capable of measuring volume to within 1 percent, and related equipment as shown in Figure 1. At a minimum, the pump should be capable of 4 cfm free flow, and the dry gas meter should have a recording capacity of 0-999.9 cu ft with a resolution of 0.005 cu ft. Other metering systems may be used which are capable of maintaining sample volumes to within 2 percent. The metering system may be used in conjunction with a pitot tube to enable checks of isokinetic sampling rates.

6.1.7 Barometer: The barometer may be mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in Hg). In many cases, the barometric reading may be obtained from a nearby National Weather Service Station, in which case the station value (which is the absolute barometric pressure) is requested and an adjustment for elevation differences between the weather station and sampling point is applied at a rate of minus 2.5 mm Hg (0.1 in Hg) per 30 m (100 ft) elevation increase (rate is plus 2.5 mm Hg per 30 m (100 ft) of elevation decrease).

6.1.8 Gas Density Determination Equipment: Temperature sensor and pressure gauge (as described in Sections 2.3 and 2.3 of EPA Method 2, 40 CFR part 60, appendix A), and gas analyzer, if necessary (as described in EPA Method 3, 40 CFR part 60, appendix A). The temperature sensor ideally should be permanently attached to the pitot tube or sampling probe in a fixed configuration such that the top of the sensor extends beyond the leading edge of the probe sheath and does not touch any metal. Alternatively, the sensor may be attached just prior to use in the field. Note, however, that if the temperature sensor is attached in the field, the sensor must be placed in an interference-free arrangement with respect to the Type S pitot openings (see Figure 2-7, EPA Method 2, 40 CFR part 60, appendix A). As a second alternative, if a difference of no more than 1 percent in the average velocity measurement is to be introduced, the temperature gauge need not be attached to the probe or pitot tube.

6.2 Sample Recovery.

6.2.1 Probe Liner: Probe nozzle and brushes; bristle brushes with stainless steel wire handles are required. The probe brush shall have extensions of stainless steel, Teflon™, or inert material at least as long as the probe. The brushes shall be properly sized and shaped to brush out the probe liner, the probe nozzle, and the impingers.

6.2.2 Wash Bottles: One wash bottle is required. Polyethylene, Teflon™, or glass wash bottles may be used for sample recovery.

6.2.3 Graduated Cylinder and/or Balance: A graduated cylinder or balance is required to measure condensed water to the nearest 1 mℓ or 1 g. Graduated cylinders shall have division not > 2 mℓ. Laboratory balances capable of weighing to ± 0.5 g are required.

6.2.4 Polyethylene Storage Containers: 500 mℓ wide-mouth polyethylene bottles are required to store impinger water samples.

6.2.5 Rubber Policeman and Funnel: A rubber policeman and funnel are required to aid the transfer of material into and out of containers in the field.

6.3 Sample Analysis.

6.3.1 Spectrophotometer - B&L 70, 710, 2000, etc., or equivalent; 1 cm pathlength cuvette holder.

6.3.2 Disposable polystyrene cuvettes, pathlengh 1 cm, volume of about 4.5 mℓ.

6.3.3 Pipettors - Fixed-volume Oxford pipet (250 $\mu\ell$; 500 $\mu\ell$; 1000 $\mu\ell$); adjustable volume Oxford or equivalent pipettor 1-5 mℓ model, set to 2.50 mℓ.

6.3.4 Pipet tips for pipettors above.

6.3.5 Parafilm, 2° wide; cut into about 1" squares.

7.0 <u>Reagents.</u>

7.1 High purity water: All references to water in this method refer to high purity water (ASTM Type I water or equivalent). The water purity will dictate the lower limits of formaldehyde quantification.

7.2 Silica Gel: Silica gel shall be indicting type, 6-16 mesh. If the silica gel has been used previously, dry at 175°C (350°F) for 2 hours before using. New silica gel may be used as received. Alternatively, other types of desiccants (equivalent or better) may be used.

7.3 Crushed Ice: Quantities ranging from 10-50 lbs may be necessary during a sampling run, depending upon ambient temperature. Samples which have been taken must be stored and shipped cold; sufficient ice for this purpose must be allowed.

7.4 Quaternary ammonium compound stock solution: Prepare a stock solution of dodecyltrimethylammonium chloride (98 percent minimum assay, reagent grade) by dissolving 1.0 gram in 1000 ml water. This solution contains nominally 1000 μg/ml quaternary ammonium compound, and is used as a biocide for some sources which are prone to microbial contamination.

7.5 Pararosaniline: Weigh 0.16 grams pararosaniline (free base; assay of 95 percent or greater, C.I. 42500; Sigma P7632 has been found to be acceptable) into a 100 mℓ flask. Exercise care, since pararosaniline is a dye and will stain. Using a wash bottle with high-purity water, rinse the walls of the flask. Add no more than 25 mℓ water. Then, carefully add 20 mℓ of concentrated hydrochloric acid to the flask. The flask will become warm after the addition of acid. Add a magnetic stir bar to the flask, cap, and place on a magnetic stirrer for approximately 4 hours. Then, add additional water so the total volume is 100 mℓ. This solution is stable for several months when stored tightly capped at room temperature.

7.6 Sodium sulfite: Weigh 0.10 grams anhydrous sodium sulfite into a 100 mℓ flask. Dilute to the mark with high purity water. Invert 15-20 times to mix and dissolve the sodium sulfite. This solution MUST BE PREPARED FRESH EVERY DAY.

7.7 Formaldehyde standard solution: Pipet exactly 2.70 mℓ of 37 percent formaldehyde solution into a 1000 mℓ volumetric flask which contains about 500 mℓ of high-purity water. Dilute to the mark with high-purity water. This solution contains nominally 1000 μg/mℓ of formaldehyde, and is used to prepare the working formaldehyde standards. The exact formaldehyde concentration may be determined if needed by suitable modification of the sodium sulfite method (Reference: J.F. Walker, FORMALDEHYDE (Third Edition), 1964.). The 1000 μg/mℓ formaldehyde stock solution is stable for at least a year if kept tightly closed, with the neck of the flask sealed with Parafilm. Store at room temperature.

7.8 Working formaldehyde standards: Pipet exactly 10.0 mℓ of the 1000 μg/mℓ formaldehyde stock solution into a 100 mℓ volumetric flask which is about half full of high-purity water. Dilute to the mark with high-purity water, and invert 15-20 times to mix thoroughly. This solution contains nominally 100 μg/mℓ formaldehyde. Prepare the working standards from this 100 μg/mℓ standard solution and using the Oxford pipets:

Working Standard, μ/mL	μL or 100 μg/mL Solution	Volumetric Flask Volume (Dilute to mark with water)
0.250	250	100
0.500	500	100
1.00	1000	100
2.00	2000	100
3.00	1500	50

The 100 μg/mℓ stock solution is stable for 4 weeks if kept refrigerated between analyses. The working standards (0.25 - 3.00 μg/mℓ) should be prepared fresh every day, consistent with good laboratory practice for trace analysis. If the laboratory water is not of sufficient purity, it may be necessary to prepare the working standards EVERY DAY. The laboratory MUST ESTABLISH that the working standards are stable - DO NOT assume that your working standards are stable for more than a day unless you have verified this by actual testing for several series of working standards.

8.0 Sample Collection.

8.1 Because of the complexity of this method, field personnel should be trained in and experienced with the test procedures in order to obtain reliable results.

8.2 Laboratory Preparation:

8.2.1 All the components shall be maintained and calibrated according to the procedure described in APTD-0576, unless otherwise specified.

8.2.2 Weigh several 200 to 300 g portions of silica gel in airtight containers to the nearest 0.5 g. Record on each container the total weight of the silica gel plus containers. As an alternative to preweighing the silica gel, it may instead be weighed directly in the impinger or sampling holder just prior to train assembly. 8.3 Preliminary Field Determinations.

8.3.1 Select the sampling site and the minimum number of sampling points according to EPA Method 1, 40 CFR part 60, appendix A, or other relevant criteria. Determine the stack pressure, temperature, and range of velocity heads using EPA Method 2, 40 CFR part 60, appendix A. A leak-check of the pitot lines according to Section 3.1 of EPA Method 2, 40 CFR part 60, appendix A, must be performed. Determine the stack gas moisture content using EPA Approximation Method 4,40 CFR part 60, appendix A, or its alternatives to establish estimates of isokinetic sampling rate settings. Determine the stack gas dry molecular weight, as described in EPA Method 2, 40 CFR part 60, appendix A, Section 3.6. If integrated EPA Method 3, 40 CFR part 60, appendix A, sampling is used for molecular weight determination, the integrated bag sample shall be taken simultaneously with, and for the same total length of time as, the sample run.

8.3.2 Select a nozzle size based on the range of velocity heads so that it is not necessary to change the nozzle size in order to maintain isokinetic sampling rates below 28 ℓ/min (1.0 cfm). During the run do not change the nozzle. Ensure that the proper differential pressure gauge is chosen for the range of velocity heads encountered (see Section 2.2 of EPA Method 2, 40 CFR part 60, appendix A).

8.3.3 Select a suitable probe liner and probe length so that all traverse points can be sampled. For large stacks, to reduce the length of the probe, consider sampling from opposite sides of the stack.

8.3.4 A minimum of 30 cu ft of sample volume is suggested for emission sources with stack concentrations not greater than 23,000,000 ppbv. Additional sample volume shall be collected as necessitated by the capacity of the water reagent and analytical detection limit constraint. Reduced sample volume may be collected as long as the final concentration of formaldehyde in the stack sample is greater than 10 (ten) times the detection limit.

8.3.5 Determine the total length of sampling time needed to obtain the identified minimum volume by comparing the anticipated average sampling rate with the volume requirement. Allocate the same time to all traverse points defined by EPA Method 1, 40 CFR part 60, appendix A. To avoid timekeeping errors, the length of time sampled at each traverse point should be an integer or an integer plus 0.5 min.

8.3.6 In some circumstances (e.g., batch cycles) it may be necessary to sample for shorter times at the traverse points and to obtain smaller gas-volume samples. In these cases, careful documentation must be maintained in order to allow accurate calculations of concentrations.

8.4 Preparation of Collection Train.

8.4.1 During preparation and assembly of the sampling train, keep all openings where contamination can occur covered with Teflon™ film or aluminum foil until just prior to assembly or until sampling is about to begin.

8.4.2 Place 100 mℓ of water in each of the first two impingers, and leave the third impinger empty. If additional capacity is required for high expected concentrations of formaldehyde in the stack gas, 200 mℓ of water per impinger may be used or additional impingers may be used for sampling. Transfer approximately 200 to 300 g of pre-weighed silica gel from its container to the fourth impinger. Care should be taken to ensure that the silica gel is not entrained and carried out from the impinger during sampling. Place the silica gel container in a clean place for later use in the sample recovery.

Alternatively, the weight of the silica gel plus impinger may be determined to the nearest 0.5 g and recorded.

8.4.3 With a glass or quartz liner, install the selected nozzle using a Viton-A O-ring when stack temperatures are < 260°C (500°F) and a woven glass-fiber gasket when temperatures are higher. See APTD-0576 for details. Other connection systems utilizing either 316 stainless steel or Teflon™ ferrules may be used. Mark the probe with heat-resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point.

8.4.4 Assemble the train as shown in Figure 1. During assembly, a very light coating of silicone grease may be used on ground-glass joints of the impingers, but the silicone grease should be limited to the outer portion (see APTD-0576) of the ground-glass joints to minimize silicone grease contamination. If necessary, Teflon™ tape may be used to seal leaks. Connect all temperature sensors to an appropriate potentiometer/display unit. Check all temperature sensors at ambient temperatures.

8.4.5 Place crushed ice all around the impingers.

8.4.6 Turn on and set the probe heating system at the desired operating temperature. Allow time for the temperature to stabilize.

8.5 Leak-Check Procedures.

8.5.1 Pre-test Leak-check: Recommended, but not required. If the tester elects to conduct the pre-test leak-check, the following procedure shall be used.

8.5.1.1 After the sampling train has been assembled, turn on and set probe heating system at the desired operating temperature. Allow time for the temperature to stabilize. If a Viton-a O-ring or other leak-free connection is used in assembling the probe nozzle to the probe liner, leak-check the train at the sampling site by plugging the nozzle and pulling a 381 mm Hg (15 in Hg) vacuum.

NOTE: A lower vacuum may be used, provided that the lower vacuum is not exceeded during the test.

If a woven glass fiber gasket is used, do not connect the probe to the train during the leak-check. Instead, leak-check the train by first attaching a carbon-filled leak-check impinger to the inlet and then plugging the inlet and pulling a 381 mm Hg (15 in Hg) vacuum. (A lower vacuum may be used if this lower vacuum is not exceeded during the test.) Next connect the probe to the train and leak-check at about 25 mm Hg (1 in Hg) vacuum. Alternatively, leak-check the probe with the rest of the sampling train in one step at 381 mm Hg (15 in Hg) vacuum. Leakage rates in excess of (a) 4 percent of the average sampling rate or (b) 0.00057 m^3/min (0.02 cfm), whichever is less, are unacceptable.

8.5.1.2 The following leak-check instructions for the sampling train described in APTD-0576 and APTD-0581 may be helpful. Start the pump with the fine-adjust valve fully open and coarse-valve completely closed. Partially open the coarse-adjust valve and slowly close the fine-adjust valve until the desired vacuum is reached. Do not reverse direction of the fine-adjust valve, as liquid will back up into the train. If the desired vacuum is exceeded, either perform the leak-check at this higher vacuum or end the leak-check, as described below, and start over.

8.5.1.3 When the leak-check is completed, first slowly remove the plug from the inlet to the probe. When the vacuum drops to 127 mm (5 in) Hg or less, immediately close the coarse-adjust valve. Switch off the pumping system and reopen the fine-adjust valve. Do not reopen the fine-adjust valve until the coarse-adjust valve has been closed to prevent the liquid in the impingers from being forced backward in the sampling line and silica gel from being entrained backward into the third impinger.

8.5.2 Leak-checks During Sampling Run:

8.5.2.1 If, during the sampling run, a component change (e.g., impinger) becomes necessary, a leak-check shall be conducted immediately after the interruption of sampling and before the change is made. The leak-check shall be done according to the procedure described in Section 10.3.3, except that it shall be done at a vacuum greater than or equal to the maximum value recorded up to that point in the test. If the leakage rate is found to be no greater than 0.0057 m^3/min (0.02

cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable. If a higher leakage rate is obtained, the tester must void the sampling run.

NOTE: Any correction of the sample volume by calculation reduces the integrity of the pollutant concentration data generated and must be avoided.

8.5.2.2 Immediately after component changes, leak-checks are optional. If performed, the procedure described in section 8.5.1.1 shall be used.

8.5.3 Post-test Leak-check:

8.5.3.1 A leak-check is mandatory at the conclusion of each sampling run. The leak-check shall be done with the same procedures as the pre-test leak-check, except that the post-test leak-check shall be conducted at a vacuum greater than or equal to the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable. If, however, a higher leakage rate is obtained, the tester shall record the leakage rate and void the sampling run.

8.6 Sampling Train Operation.

8.6.1 During the sampling run, maintain an isokinetic sampling rate to within 10 percent of true isokinetic, below 28 ℓ/min (1.0 cfm). Maintain a temperature around the probe of 120°C ± 14°C (248° ± 25°F).

8.6.2 For each run, record the data on a data sheet such as the one shown in Figure 2. Be sure to record the initial dry-gas meter reading. Record the dry-gas meter

Figure 2 - Formaldehyde Field Data

Plant . . . .
Location . . . .
Operator . . . .
Date . . . .
Run No . . . .
Sample box No . . . .
Meter box No . . . .
Meter)H . . . .
C Factor . . . .
Pitot tube coefficient, Op

SCHEMATIC OF STACK CROSS SECTION

Ambient temperature . . . .
Barometric pressure . . . .
Assumed moisture, percent . . . .
Probe length, m (ft) . . . . . .
Nozzle Identification No . . . .
Average calibrated nozzle
diameter, cm (in.) . . . .
Probe heater setting . . . . . .
Leak rate, m^3/min (cfm) . . . . .
Probe liner material . . . . . .
Static pressure, mm Hg (in. Hg) .
Filter No. . . . .

Traverse point number	Sampling time (e) min.	Vacuum mm Hg (in. Hg)	Stack temper- ature (T) °C (°F)	Velocity head ()P) mm (in) H_2O	Pressure differ- ential across orifice meter mm H_2O (in. H_2O)	Gas sample volume m^3 (ft^3)	Gas sample temperature at dry gas meter		Filter holder temper- ature °C (°F)	Temperature of gas leaving condenser or last impinger °C (°F)
							Inlet °C (°F)	Outlet °C (°F)		
Total							Avg.	Avg.		
Average							Avg.			

readings at the beginning and end of each sampling time increment, when changes in flow rates are made, before and after each leak-check, and when sampling is halted. Take other readings required by Figure 2 at least once at each sample point during each time increment and additional readings when significant adjustments (20 percent variation in velocity head readings) necessitate additional adjustments in flow rate. Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse.

8.6.3 Clean the stack access ports prior to the test run to eliminate the chance of sampling deposited material. To begin sampling, remove the nozzle cap, verify that the probe heating system are at the specified temperature, and verify that the pitot tube and probe are properly positioned. Position the nozzle at the first traverse point, with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Nomographs, which aid in the rapid adjustment of the isokinetic sampling rate without excessive computations, are available. These nomographs are designed for use when the Type S pitot tube coefficient is 0.84 ± 0.02 and the stack gas equivalent density (dry molecular weight) is equal to 29 ± 4. APTD-0576 details the procedure for using the nomographs. If the stack gas molecular weight and the pitot tube coefficient are outside the above ranges, do not use the nomographs unless appropriate steps are taken to compensate for the deviations.

8.6.4 When the stack is under significant negative pressure (equivalent to the height of the impinger stem), take care to close the coarse-adjust valve before inserting the probe into the stack in order to prevent liquid from backing up through the train. If necessary, a low vacuum on the train may have to be started prior to entering the stack.

8.6.5 When the probe is in position, block off the openings around the probe and stack access port to prevent unrepresentative dilution of the gas stream.

8.6.6 Traverse the stack cross section, as required by EPA Method 1, 40 CFR part 60, appendix A, being careful not to bump the probe nozzle into the stack walls when sampling near the walls or when removing or inserting the probe through the access port, in order to minimize the chance of extracting deposited material.

8.6.7 During the test run, make periodic adjustments to keep the temperature around the probe at the proper levels. Add more ice and, if necessary, salt, to maintain a temperature of < 20°C (68°F) at the silica gel outlet.

8.6.8 A single train shall be used for the entire sampling run, except in cases where simultaneous sampling is required in two or more separate ducts or at two or more different locations within the same duct, or in cases where equipment failure necessitates a change of trains. An additional train or trains may also be used for sampling when the capacity of a single train is exceeded.

8.6.9 When two or more trains are used, separate analyses of components from each train shall be performed. If multiple trains have been used because the capacity of a single train would be exceeded, first impingers from each train may be combined, and second impingers from each train may be combined.

8.6.10 At the end of the sampling run, turn off the coarse-adjust valve, remove the probe and nozzle from the stack, turn off the pump, record the final dry gas meter reading, and conduct a post-test leak-check. Also, check the pitot lines as described in EPA Method 2, 40 CFR part 60, appendix A. The lines must pass this leak-check in order to validate the velocity-head data.

8.6.11 Calculate percent isokineticity (see Method 2) to determine whether the run was valid or another test should be made.

8.7 Sample Preservation and Handling.

8.7.1 Samples from most sources applicable to this method have acceptable holding times using normal handling practices (shipping samples iced, storing in refrigerator at 2°C until analysis). However, forming section stacks and other sources using waste water sprays may be subject to microbial contamination. For these sources, a biocide (quaternary ammonium compound solution) may be added to collected samples to improve sample stability and method ruggedness.

8.7.2 Sample holding time: Samples should be analyzed within 14 days of collection. Samples must be refrigerated/kept cold for the entire period preceding analysis. After the samples have been brought to room temperature for analysis, any analyses needed should be performed on the same day. Repeated cycles of warming the samples to room temperature/refrigerating/rewarming, then analyzing again, etc., have not been investigated in depth to evaluate if analyte levels remain stable for all sources.

8.7.3 Additional studies will be performed to evaluate whether longer sample holding times are feasible for this method.

8.8 Sample Recovery.

8.8.1 Preparation:

8.8.1.1 Proper cleanup procedure begins as soon as the probe is removed from the stack at the end of the sampling period. Allow the probe to cool. When the probe can be handled safely, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over the tip to prevent losing or gaining particulate matter. Do not cap the probe tightly while the sampling train is cooling because a vacuum will be created, drawing liquid from the impingers back through the sampling train.

8.8.1.2 Before moving the sampling train to the cleanup site, remove the probe from the sampling train and cap the open outlet, being careful not to lose any condensate that might be present. Remove the umbilical cord from the last impinger and cap the impinger. If a flexible line is used, let any condensed water or liquid drain into the impingers. Cap off any open impinger inlets and outlets. Ground glass stoppers, Teflon™ caps, or caps of other inert materials may be used to seal all openings.

8.8.1.3 Transfer the probe and impinger assembly to an area that is clean and protected from wind so that the chances of contaminating or losing the sample are minimized.

8.8.1.4 Inspect the train before and during disassembly, and note any abnormal conditions.

8.8.1.5 Save a portion of the washing solution (high purity water) used for cleanup as a blank.

8.8.2 Sample Containers:

8.8.2.1 Container 1: Probe and Impinger Catches. Using a graduated cylinder, measure to the nearest ml, and record the volume of the solution in the first three impingers. Alternatively, the solution may be weighed to the nearest 0.5 g. Include any condensate in the probe in this determination. Transfer the combined impinger solution from the graduated cylinder into the polyethylene bottle. Taking care that dust on the outside of the probe or other exterior surfaces does not get into the sample, clean all surfaces to which the sample is exposed (including the probe nozzle, probe fitting, probe liner, first three impingers, and impinger connectors) with water. Use less than 400 mℓ for the entire waste (250 mℓ would be better, if possible). Add the rinse water to the sample container.

8.8.2.1.1 Carefully remove the probe nozzle and rinse the inside surface with water from a wash bottle. Brush with a bristle brush and rinse until the rinse shows no visible particles, after which make a final rinse of the inside surface. Brush and rinse the inside parts of the Swagelok (or equivalent) fitting with water in a similar way.

8.8.2.1.2 Rinse the probe liner with water. While squirting the water into the upper end of the probe, tilt and rotate the probe so that all inside surfaces will be wetted with water. Let the water drain from the lower end into the sample container. The tester may use a funnel (glass or polyethylene) to aid in transferring the liquid washes to the container. Follow the rinse with a bristle brush. Hold the probe in an inclined position, and squirt water into the upper end as the probe brush is being pushed with a twisting action through the probe. Hold the sample container underneath the lower end of the probe, and catch any water and particulate matter that is brushed from the probe. Run the brush through the probe three times or more. Rinse the brush with water and quantitatively collect these washings in the sample container. After the brushing, make a final rinse of the probe as describe above.

NOTE: Two people should clean the probe in order to minimize sample losses. Between sampling runs, brushes must be kept clean and free from contamination.

8.8.2.1.3 Rinse the inside surface of each of the first three impingers (and connecting tubing) three separate times. Use a small portion of water for each rinse, and brush each surface to which the sample is exposed with a bristle brush to ensure recovery of fine particulate matter. Make a final rinse of each surface and of the brush, using water.

8.8.2.1.4 After all water washing and particulate matter have been collected in the sample container, tighten the lid so the sample will not leak out when the container is shipped to the laboratory. Mark the height of the fluid level to determine whether leakage occurs during transport.

Label the container clearly to identify its contents.

8.8.2.1.5 If the first two impingers are to be analyzed separately to check for breakthrough, separate the contents and rinses of the two impingers into individual containers. Care must be taken to avoid physical carryover from the first impinger to the second. Any physical carryover of collected moisture into the second impinger will invalidate a breakthrough assessment.

8.8.2.2 Container 2: Sample Blank. Prepare a blank by using a polyethylene container and adding a volume of water equal to the total volume in Container 1. Process the blank in the same manner as Container 1.

8.8.2.3 Container 3: Silica Gel. Note the color of the indicating silica gel to determine whether it has been completely spent and make a notation of its condition. The impinger containing the silica gel may be used as a sample transport container with both ends sealed with tightly fitting caps or plugs. Ground-glass stoppers or Teflon™ caps maybe used. The silica gel impinger should then be labeled, covered with aluminum foil, and packaged on ice for transport to the laboratory. If the silica gel is removed from the impinger, the tester may use a funnel to pour the silica gel and a rubber policeman to remove the silica gel from the impinger. It is not necessary to remove the small amount of dust particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use water or other liquids to transfer the silica gel. If a balance is available in the field, the spent silica gel (or silica gel plus impinger) may be weighed to the nearest 0.5 g.

8.8.2.4 Sample containers should be placed in a cooler, cooled by (although not in contact with) ice. Putting sample bottles in Zip-Lock™ bags can aid in maintaining the integrity of the sample labels. Sample containers should be placed vertically to avoid leakage during shipment. Samples should be cooled during shipment so they will be received cold at the laboratory. It is critical that samples be chilled immediately after recovery. If the source is susceptible to microbial contamination from wash water (e.g. forming section stack), add biocide as directed in section 8.2.5.

8.8.2.5 A quaternary ammonium compound can be used as a biocide to stabilize samples against microbial degradation following collection. Using the stock quaternary ammonium compound (QAC) solution; add 2.5 ml QAC solution for every 100 ml of recovered sample volume (estimate of volume is satisfactory) immediately after collection. The total volume of QAC solution must be accurately known and recorded, to correct for any dilution caused by the QAC solution addition.

8.8.3 Sample Preparation for Analysis

8.8.3.1 The sample should be refrigerated if the analysis will not be performed on the day of sampling. Allow the sample to warm at room temperature for about two hours (if it has been refrigerated) prior to analyzing.

8.8.3.2 Analyze the sample by the pararosaniline method, as described in Section 11. If the color-developed sample has an absorbance above the highest standard, a suitable dilution in high purity water should be prepared and analyzed.

9. Quality Control.

9.1 Sampling: See EPA Manual 600/4-77-02b for Method 5 quality control.

9.2 Analysis: The quality assurance program required for this method includes the analysis of the field and method blanks, and procedure validations. The positive identification and quantitation of formaldehyde are dependent on the integrity of the samples received and the precision and accuracy of the analytical methodology. Quality assurance procedures for this method are designed to monitor the performance of the analytical methodology and to provide the required information to take corrective action if problems are observed in laboratory operations or in field sampling activities.

9.2.1 Field Blanks: Field blanks must be submitted with the samples collected at each sampling site. The field blanks include the sample bottles containing aliquots of sample recover water, and water reagent. At a minimum, one complete sampling train will be assembled in the field staging area, taken to the sampling area, and leak-checked at the beginning and end of the testing (or for the same total number of times as the actual sampling train). The probe of the blank train must be heated during the sample test. The train will be recovered as if it were an actual test sample. No gaseous sample will be passed through the blank sampling train.

9.2.2 Blank Correction: The field blank formaldehyde concentrations will be subtracted from the appropriate sample formaldehyde concentrations. Blank formaldehyde concentrations above 0.25 μg/mℓ should be considered suspect, and subtraction from the sample formaldehyde concentrations should be performed in a manner acceptable to the Administrator.

9.2.3 Method Blanks: A method blank must be prepared for each set of analytical operations, to evaluate contamination and artifacts that can be derived from glassware, reagents, and sample handling in the laboratory.

10. <u>Calibration.</u>

10.1 Probe Nozzle: Probe nozzles shall be calibrated before their initial use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in). Make measurements at three separate places across the diameter and obtain the average of the measurements. The difference between the high and low numbers shall not exceed 0.1 mm (0.004 in). When the nozzle becomes nicked or corroded, it shall be repaired and calibrated, or replaced with a calibrated nozzle before use. Each nozzle must be permanently and uniquely identified.

10.2 Pitot Tube: The Type S pitot tube assembly shall be calibrated according to the procedure outlined in Section 4 of EPA Method 2, or assigned a nominal coefficient of 0.84 if it is not visibly nicked or corroded and if it meets design and intercomponent spacing specifications.

10.3 Metering System.

10.3.1 Before its initial use in the field, the metering system shall be calibrated according to the procedure outlined in APTD-0576. Instead of physically adjusting the dry-gas meter dial readings to correspond to the wet-test meter readings, calibration factors may be used to correct the gas meter dial readings mathematically to the proper values. Before calibrating the metering system, it is suggested that a leak-check be conducted. For metering systems having diaphragm pumps, the normal leak-check procedure will not delete leakages with the pump. For these cases, the following leak-check procedure will apply: make a ten-minute calibration run at 0.00057 m^3/min (0.02 cfm). At the end of the run, take the difference of the measured wet-test and dry-gas meter volumes and divide the difference by 10 to get the leak rate. The leak rate should not exceed 0.00057 m^3/min (0.02 cfm).

10.3.2 After each field use, check the calibration of the metering system by performing three calibration runs at a single intermediate orifice setting (based on the previous field test). Set the vacuum at the maximum value reached during the test series. To adjust the vacuum, insert a valve between the wet-test meter and the inlet of the metering system. Calculate the average value of the calibration factor. If the calibration has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as outlined in APTD-0576.

10.3.3 Leak-check of metering system: The portion of the sampling train from the pump to the orifice meter (see Figure 1) should be leak-checked prior to initial use and after each shipment. Leakage after the pump will result in less volume being recorded than is actually sampled. Use the following procedure: Close the main valve on the meter box. Insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer.

Close off the low side orifice tap. Pressurize the system to 13 - 18 cm (5 - 7 in) water column by blowing into the rubber tubing. Pinch off the tubing and observe the manometer for 1 min. A loss of pressure on the manometer indicates a leak in the meter box. Leaks must be corrected. NOTE: If the dry-gas meter coefficient values obtained before and after a test series differ by > 5 percent, either the test series must be voided or calculations for test series must be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

10.4 Probe Heater: The probe heating system must be calibrated before its initial use in the field according to the procedure outlined in APTD-0576. Probes constructed according to APTD-0581 need not be calibrated if the calibration curves in APTD-0576 are used.

10.5 Temperature gauges: Use the procedure in section 4.3 of USEPA Method 2 to calibrate in-stack temperature gauges. Dial thermometers such as are used for the dry gas meter and condenser outlet, shall be calibrated against mercury-in-glass thermometers.

10.6 Barometer: Adjust the barometer initially and before each test series to agree to within ± 2.5 mm Hg (0.1 in Hg) of the mercury barometer. Alternately, if a National Weather Service Station (NWSS) is located at the same altitude above sea level as the test site, the barometric pressure reported by the NWSS may be used.

10.7 Balance: Calibrate the balance before each test series, using Class S standard weights. The weights must be within ± 0.5 percent of the standards, or the balance must be adjusted to meet these limits.

11.0 Procedure for Analysis.

The working formaldehyde standards (0.25, 0.50, 1.0, 2.0, and 3.0 μg/mℓ) are analyzed and a calibration curve is calculated for each day's analysis. The standards should be analyzed first to ensure that the method is working properly prior to analyzing the samples. In addition, a sample of the high-purity water should also be analyzed and used as a "0" formaldehyde standard.

The procedure for analysis of samples and standards is identical: Using the pipet set to 2.50 mℓ, pipet 2.50 mℓ of the solution to be analyzed into a polystyrene cuvette. Using the 250 $\mu\ell$ pipet, pipet 250 $\mu\ell$ of the pararosaniline reagent solution into the cuvette. Seal the top of the cuvette with a Parafilm square and shake at least 30 seconds to ensure the solution in the cuvette is well-mixed. Peel back a corner of the Parafilm so the next reagent can be added. Using the 250 $\mu\ell$ pipet, pipet 250 $\mu\ell$ of the sodium sulfite reagent solution into the cuvette. Reseal the cuvette with the Parafilm, and again shake for about 30 seconds to mix the solution in the cuvette. Record the time of addition of the sodium sulfite and let the color develop at room temperature for 60 minutes. Set the spectrophotometer to 570 nm and set to read in Absorbance Units. The spectrophotometer should be equipped with a holder for the 1-cm pathlength cuvettes. Place cuvette(s) containing high-purity water in the spectrophotometer and adjust to read 0.000 AU.

After the 60 minutes color development period, read the standard and samples in the spectrophotometer. Record the absorbance reading for each cuvette. The calibration curve is calculated by linear regression, with the formaldehyde concentration as the "x" coordinate of the pair, and the absorbance reading as the "y" coordinate. The procedure is very reproducible, and typically will yield values similar to these for the calibration curve:

Correlation Coefficient:	0.9999
Slope:	0.50
Y-Intercept:	0.090

The formaldehyde concentration of the samples can be found by using the trend-line feature of the calculator or computer program used for the linear regression. For example, the TI-55 calculators use the "X" key (this gives the predicted formaldehyde concentration for the value of the absorbance you key in for the sample). Multiply the formaldehyde concentration from the sample by the dilution factor, if any, for the sample to give the formaldehyde concentration of the original, undiluted, sample (units will be micrograms/mℓ).

11.1 Notes on the Pararosaniline Procedure

11.1.1 The pararosaniline method is temperature-sensitive. However, the small fluctuations typical of a laboratory will not significantly affect the results.

11.1.2 The calibration curve is linear to beyond 4 μg/mℓ formaldehyde, however, a research-grade spectrophotometer is required to reproducibly read the high absorbance values. Consult your instrument manual to evaluate the capability of the spectrophotometer.

11.1.3 The quality of the laboratory water used to prepare standards and make dilutions is critical. It is important that the cautions given in the Reagents section be observed. This procedure allows quantitation of formaldehyde at very low levels, and thus it is imperative to avoid contamination from other sources of formaldehyde and to exercise the degree of care required for trace analyses.

11.1.4 The analyst should become familiar with the operation of the Oxford or equivalent pipettors before using them for an analysis. Follow the instructions of the manufacturer; one can pipet water into a tared container on any analytical balance to check pipet accuracy and precision. This will also establish if the proper technique is being used. Always use a new tip for each pipetting operation.

11.1.5 This procedure follows the recommendations of ASTM Standard Guide D 3614, reading all solutions versus water in the reference cell. This allows the absorbance of the blank to be tracked on a daily basis. Refer to ASTM D 3614 for more information.

12.0 Calculations.

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculations.

12.1 Calculations of Total Formaldehyde.

12.1.1 To determine the total formaldehyde in mg, use the following equation if biocide was *not* used:

Total mg formaldehyde =

$$C_d \times V \times DF\ x\ 0.001\ mg/\mu g$$

where:

C_d = measured conc. formaldehyde, μg/mℓ

V = total volume of stack sample, mℓ

DF = dilution factor

12.1.2 To determine the total formaldehyde in mg, use the following equation if biocide was used:

Total mg formaldehyde =

$$\frac{C_d \times V}{(V-B) \times DF \times 0.001\ mg/\mu g}$$

Where:

C_d = measured conc. formaldehyde, μg/mℓ

V = total volume of stack sample, mℓ

B = total volume of biocide added to sample, mℓ

DF = dilution factor

12.2 Formaldehyde concentration (mg/m^3) in stack gas. Determine the formaldehyde concentration (mg/m^3) in the stack gas using the following equation:

Formaldehyde concentration (mg/m^3) =

$$\frac{K \times [total\ formaldehyde, mg]}{V_m(std)}$$

where:

K = 35.31 cu ft/m^3 for V_m(std) in English units,

or

K = 1.00 m^3/m^3 for V_m(std) in metric units

V_m(std) = volume of gas sample measured by a dry gas meter, corrected to standard conditions, dscm (dscf)

12.3 Average dry gas meter temperature and average orifice pressure drop are obtained from the data sheet.

12.4 Dry Gas Volume: Calculate V_m(std) and adjust for leakage, if necessary, using the equation in Section 6.3 of EPA Method 5, 40 CFR part 60, appendix A.

12.5 Volume of Water Vapor and Moisture Content: Calculated the volume of water vapor and moisture content from equations 5-2 and 5-3 of EPA Method 5.

13.0 Method Performance.

The precision of this method is estimated to be better than ± 5 percent, expressed as ± the percent relative standard deviation.

14.0 Pollution Prevention. (Reserved)

15.0 Waste Management. (Reserved)

16.0 References.

R.R. Miksch, et al., ANALYTICAL CHEMISTRY, November 1981, 53 pp. 2118-2123.

J.F. Walker, FORMALDEHYDE, Third Edition, 1964.

US EPA 40 CFR, Part 60, Appendix A, Test Methods 1-5

APPENDIX G

PROJECT PARTICIPANTS

PROJECT PARTICIPANTS

Affiliation	Name	Responsibility
NAPA	Una Connolly	Project Director
MACTEC Federal Programs, Inc.	John T. Chehaske	Project Director
	Franklin Meadows	Project Manager
	Michael D. Maret	Field Team Leader
	Bernd Haneke	Site Technician
	Nissa Pauley	Site Technician
S. T. Wooten	David K. Glover	Facility Contact
REA Construction	Tim Gaddy	Facility Contact
HEATEC	Ronald M. Henry	Service Manager

QUALITY ASSURANCE PROJECT PLAN & SITE-SPECIFIC TEST PLAN

FORMALDEHYDE EMISSIONS TESTING FROM ASPHALT HEATERS

Prepared for:

National Asphalt Pavement Association
5100 Forbes Boulevard
Lanham, Maryland 20706-4413

March 19, 2003
Revision 1

P:\PES_Projects\Number Projects\5940\QAPP\SSTPQAPPRev1.wpd

Submitted by:

MACTEC Federal Programs, Inc.
5001 S. Miami Blvd., Suite 300
Post Office Box 12077
Durham, NC 27703
(919) 941-0333 FAX (919) 941-0234

APPROVAL SIGNATURE SHEET

Quality Assurance Project Plan & Site-Specific Test Plan

February 24, 2003, Revision No. 0

John T. Chehaske, Project Director MACTEC Federal Programs, Inc.	Date
James Paumier, QA Officer MACTEC Federal Programs, Inc.	Date
Franklin Meadows, Project Manager MACTEC Federal Programs, Inc.	Date
Una Connolly, Project Director National Asphalt Pavement Association	Date
Michael L. Toney, QA Manager OAQPS, EMAD, EMC U. S. Environmental Protection Agency	Date

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DISTRIBUTION LIST

The MACTEC Project Manager will send copies of this plan and all subsequent revisions to the following individuals:

Una Connolly, Director of Environmental & Safety Services, National Asphalt Pavement Association

John T. Chehaske, MACTEC Program Manager

James O. Paumier, MACTEC QA Officer

1.0 PROJECT/TASK ORGANIZATION

Figure 1.1 illustrates the program organization for the Formaldehyde Emissions Testing From Asphalt Heaters project. Each organization and individual shown in Figure 1.1 is described in the following subsections.

1.1 NATIONAL ASPHALT PAVEMENT ASSOCIATION (NAPA)

This study is being funded by the National Asphalt Pavement Association (NAPA) and the State Asphalt Pavement Association (SAPA). NAPA is located in Lanham, Maryland.

1.1.1 NAPA Project Director (NAPA PD)

The NAPA Project Director (NAPA PD) is the NAPA counterpart to the MACTEC Federal Programs, Inc. (MACTEC) Project Director (MACTEC PD). The NAPA PD and the MACTEC PD will work in coordination to ensure all parties are properly prepared and informed. The NAPA PD for this project is Ms. Una Connolly.

1.2 MACTEC FEDERAL PROGRAMS, INC.

MACTEC Federal Programs, Inc. (MACTEC, formerly Pacific Environmental Services, Inc.) will provide overall project management and supervision for each aspect of the project. MACTEC is a nationwide environmental engineering and industrial hygiene firm.

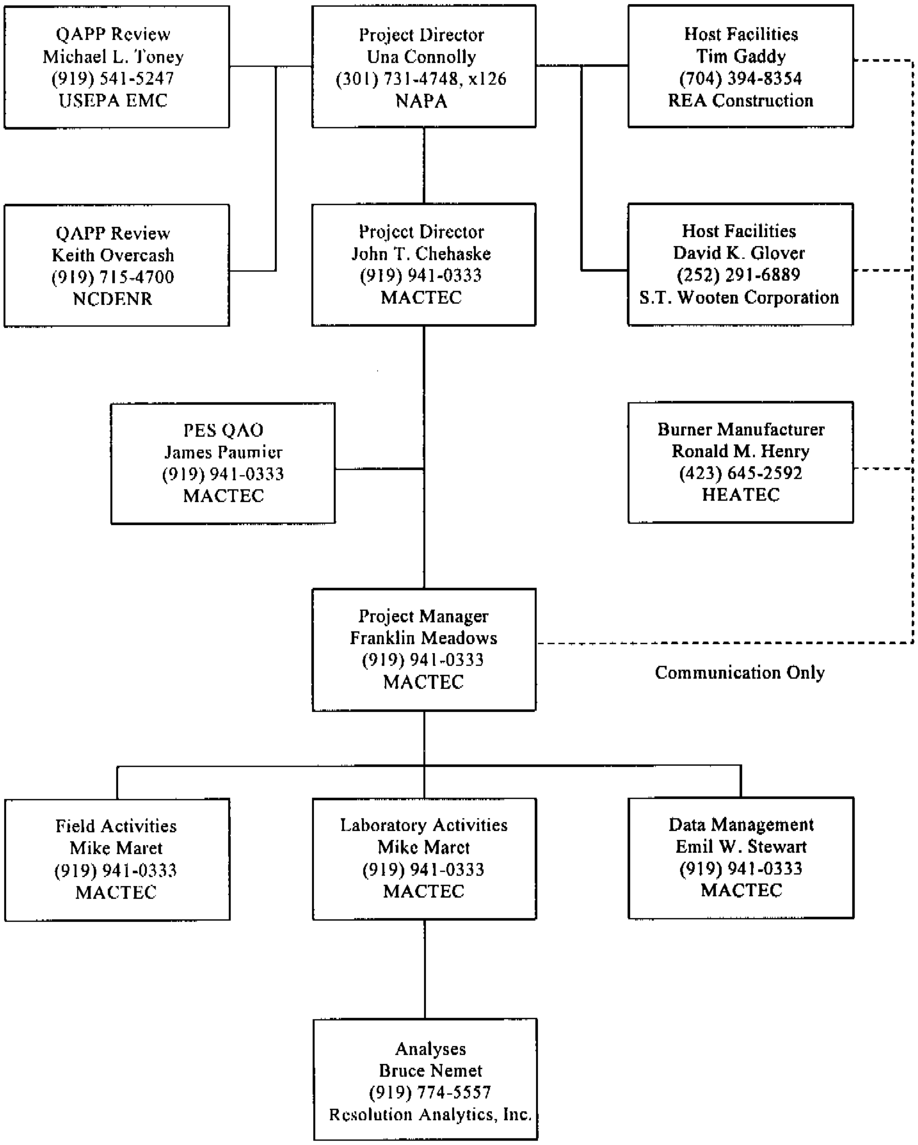


Figure 1.1. Project Organization

1.2.1 MACTEC Project Director

Mr. John T. Chehaske will serve as the MACTEC Project Director (MACTEC PD) and manage the day-to-day activities of the contract. These include selecting the MACTEC Project Manager (PM), tracking project costs, coordinating activities, and communicating project status to the NAPA. Mr. Chehaske is MACTEC's Corporate Director of Air Monitoring with over 30 years of experience in the field of air pollution monitoring. He has directed a variety of test programs, including: hazardous waste burns at cement kilns, VOC testing at printing and coating processes, method development, refuse derived fuel evaluations, and many others.

1.2.2 MACTEC Project Manager (PM)

The MACTEC PM has ultimate responsibility for the successful completion of this project. He is responsible for coordinating activities with the facility personnel, regulatory personnel, and MACTEC employees. The PM is Mr. Franklin Meadows. Mr. Meadows has over 37 years of experience in emissions measurement studies. He has managed complex field testing assignments in support of standards setting and method evaluations. Mr. Meadows served as the PM on numerous assignments under which he developed Site Specific Test Plans, Quality Assurance Project Plans, and report documentation.

1.2.3 MACTEC Quality Assurance Officer (QAO)

The MACTEC QAO is responsible for assuring that all project QA/QC requirements are met. The MACTEC QAO is James Paumier. Mr. Paumier has 10 years of experience executing projects following strict QA/QC requirements.

1.2.4 MACTEC Field Sampling Crew

During the field testing, Mr. Meadows will be assisted by experienced personnel in the assembly, operation, sample recovery activities associated with the sampling trains being used, sample analysis, data reduction and interpretation of results, and report documentation. MACTEC will provide platforms (scaffold or man lifts) to support the test team personnel and test equipment.

1.2.5 Resolution Analytics, Inc. (RAI)

Under contract to MACTEC, Resolution Analytics, Inc., located in Sanford, North Carolina, will be responsible for analyzing the formaldehyde samples. The analyses will be performed under the direction of Mr. Bruce Nemet.

1.3 HOST FACILITIES

NAPA has selected four facilities located in North Carolina as host facilities for the planned testing program. Two are owned and operated by REA Construction and two are owned and operated by S. T. Wooten Corporation. They include:

REA Construction
North Mecklenburg Plant
Charlotte, NC
No. 2 Oil-fired HOS

REA Construction
Mallard Creek Plant
Charlotte, NC
Natural Gas-fired HOS

Mr. Tim Gaddy, Commercial Contracts Manager is the point of contact for both REA Construction facilities.

S.T Wooten Corporation
255 Material Drive
Franklinton, NC
No. 2 Oil-fired HOS

S. T. Wooten Corporation
2710 Commerce Road
Wilson, NC
No. 2 Oil-fired HOS

Mr. David K. Glover, Asphalt Production Manager, is the point of contact for both S. T. Wooten Corporation facilities.

1.4 HEATEC

HEATEC is the manufacturer of the burners used at the four host facilities. HEATEC will be responsible for installing heat sinks on each burner so that the burners can operate continuously for the duration of the testing. Also, HEATEC will modify the burner exhaust stacks per MACTEC direction and measure fuel usage during each measurement run. HEATEC is represented by Mr. Ronald M. Henry, Service Manager and Mr. Mark D. Moon, P.E., Design Engineering Manager.

1.5 U. S. ENVIRONMENTAL PROTECTION AGENCY (USEPA)

At the request of the NAPA, the USEPA's Emission Measurement Center (EMC) has agreed to review this QAPP/SSTP. The QA Manager at the EMC responsible for reviewing the QAPP/SSTP is Mr. Michael L. Toney.

1.6 NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES (NCDENR)

The NCDENR representative is Mr. Keith Overcash, Director of Air Quality.

2.0 PROBLEM DEFINITION/BACKGROUND

In 2000, the U.S. Environmental Protection Agency's (USEPA) Office of Air Quality Planning and Standards (OAQPS) published Section 11.1 in their Compilation of Air Pollutant Emission Factors, 5th Edition, Volume 1: Stationary Point and Area Sources, more commonly know as AP-42. Section 11.1 provides emission factors for Hot Mix Asphalt (HMA) manufacturing facilities and ancillary operations. Ancillary operations include the heating system for the asphalt cement storage facilities. There are three types of heating systems that are used to maintain requsite asphalt cement temperatures in the storage tanks: hot oil heat transfer, direct-fired, and electric probes. The hot oil heat transfer system is the most common system in use today and the direct-fired system is phasing out.

The hot oil heat transfer system involves heating a specially designed heat transfer oil to specified temperatures and pumping the hot oil through a piping system that passes through the asphalt cement storage tank. The heat is provided by burning a fossil fuel. The flue gas generated from the combustion of the fossil fuel is emitted into the environment. The flue gas consists of typical products of combustion and incomplete combustion.

The heat input capacity of the burners in hot oil systems (HOS) generally range in size from less than 1 million BTUs per hour to 1.5 million BTUs per hour. The burners are operated to heat oil on an as-needed basis, which is based on the desired asphalt cement storage temperature. Once the asphalt cement reaches the specified temperature, the burner will shut down and remain inactive until the asphalt cement cools and its temperature drops below the temperature setting, just like any household heating system. The asphalt cement storage tanks are insulated to slow down the cooling process. The result is that the burners do not run continuously around the clock. HEATEC will install heat sinks on each burner so that the burners can operate continuously for the duration of the testing.

The list of emission factors for a HOS published by the USEPA in AP-42 Section 11.1 includes only hazardous air pollutants, including formaldehyde, for a HOS burning No. 2 fuel oil. They were derived from a single stack test conducted in the 1980s. Because of the small size of the burners in terms of heat input capacity, HOS emissions have been considered insignificant when estimating emissions from a HMA facility, or they have been exempted by state regulations because the heat input rating falls below state regulatory thresholds. However, in 2002, several states have insisted that emissions be calculated for HOS at HMA facilities, and concerns have been raised by the states and the HMA industry regarding the reliability of the HOS emission factor for formaldehyde.

When the formaldehyde emission factor for asphalt HOS was compared to the formaldehyde emission factor published for combustion of fuel oil in an industrial furnace or boiler in AP-42 Section 1.3, the HOS emission factor was found to be three orders of magnitude higher. While it is accepted that small combustion units are not as efficient as industrial sized combustion units, the USEPA agreed with NAPA that the combustion efficiency of a small combustion burner is unlikely to be three orders of magnitude lower. Summarized below are the AP-42 emission factors from fuel oil combustion and hot oil heaters.

Source	Emission Factor lb/10^3 gal
Fuel Oil Combustion	0.035-0.061
Hot Oil Burner	27

On May 1, 2002, HMA Industry representatives met with representatives from the USEPA and the North Carolina Department of Environment and Natural Resources (NCDENR) in Raleigh, North Carolina, to discuss the situation regarding the formaldehyde emission factor for HOS as listed in Section 11.1, Table 11.1-13. This emission factor was based on data from a single stack test. The USEPA recognizes that a single stack test does not constitute a statistically significant database. However, if that is all they have, they will use a single stack test to determine and publish emission factors. They account for the small quantity of data by assigning the lowest condfidence rating from the confidence rating scale established by the OAQPS. The USEPA representative at the meeting stated that he believes at least four separate HOS need to be stack tested to establish an emission factor that would be assigned a higher confidence rating.

The USEPA representative discussed his review of the original stack test from which the original formaldehyde emission factor was derived (the emission factor was actually derived by a firm contracted by the USEPA to conduct this type of work). He found that there was probably some deficiencies in the report and insufficient information to verify the derivation of the emission factor. He was able to verify that Method SW846/0011 was used. After considerable discussion among the participants of the meeting, it was determined that stack testing should be conducted to establish a more reliable emission factor for formaldehyde from asphalt cement HOS. It was also determined that Reference Method 316 would be used for this stack testing project.

3.0 PROJECT/TASK DESCRIPTION

NAPA is conducting this testing effort to develop emission factors for formaldehyde emissions from HOS burners at HMA plants. This project entails working with personnel representing NAPA, MACTEC, REA Construction, S. T. Wooten Corporation, USEPA, NCDENR, and HEATEC. NAPA has contracted the testing efforts to MACTEC. The primary objective of this testing project will be to accurately determine formaldehyde concentrations and mass emission rates from HOS burners. Because carbon monoxide (CO) is also a product of incomplete combustion, determinations of CO concentrations and mass emission rates will also be made. The results will be used by NAPA to develop emission factors for formaldehyde and CO. This Quality Assurance Project Plan/Site-Specific Test Plan (QAPP/SSTP) presents an overview of the procedures MACTEC proposes to follow to accomplish this objective.

3.1 WORK TO BE PERFORMED

The USEPA has recommended to NAPA that at least four different HOS burners be tested in order to obtain sufficient data to constitute a statistically significant data base. In order to satisfy this recommendation, NAPA has selected four HMA plants, all located in North Carolina, to serve as host facilities for the planned testing program. Three of the burners are No. 2 oil-fired and one of the burners is natural gas-fired. The testing program includes preparation of this QAPP/SSTP, field testing, and report documentation.

3.1.1 Field Testing

At each of the four facilities, testing will be performed at the exhaust stack of the HOS burner for the following pollutants: formaldehyde as per EPA Method 316 and CO as per EPA

Method 10. This will require accurate determinations of burner exhaust gas volumetric flow rates, pollutant concentrations, and fuel usage during each individual test run. Accurate determinations of these pollutants/parameters are considered to be critical to the success of this test program. The test methods used in this test program will comply with the technical criteria described in the reference methods and the quality standards described in this document.

Once on-site at each facility, the MACTEC test crew will set up the test equipment and perform miscellaneous pretest activities including: measuring the stacks and calculating sample traverse point locations, conducting cyclonic flow checks, conducting preliminary velocity and temperature traverses, performing initial calibrations and bias checks on the CO analyzer, and making final preparations for testing. The actual testing at each facility will consist of a minimum of three valid test runs. The minimum sample time for each test run will be one hour.

At the conclusion of the field test, MACTEC will pack up the samples and test equipment, restore the test sites, and return to the MACTEC office in Research Triangle Park, NC. Post test activities will include cleanup, maintenance, and calibration of MACTEC's test equipment, and transfer of the formaldehyde samples to RAI for analysis.

3.2 SCHEDULE FOR IMPLEMENTATION

Specific test dates have not been established pending approval of this QAPP/SSTP. Testing will be conducted in early 2003. The S.T. Wooten facilities in Wilson and Franklinton will be tested first during the same field trip. The REA North Mecklenburg and Mallard Creek facilities will be tested during the next field trip.

3.3 REPORTS

MACTEC will prepare and submit a draft report summarizing the results of MACTEC's test results to the NAPA Project Director. The draft report will include a summary and discussion of the results as well as copies of field data and any laboratory results. Once NAPA has reviewed the draft report and provided written comments, MACTEC will make any revisions and submit a final report.

4.0 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

4.1 DATA QUALITY OBJECTIVES

The overall objective of this test program is to quantify the uncontrolled formaldehyde and carbon monoxide (CO) emissions from HOS burners. The data will be used by NAPA to develop emission factors for HOS burners. To obtain data which will satisfy this objective, the test design must provide enough representative data to be statistically useful and standards for accuracy, precision and completeness of data must be met. Section 8.0 discusses the specific quality control procedures and criteria used to determine compliance with these quality objectives.

4.2 CRITERIA FOR MEASUREMENT DATA

The following standards for representativeness, precision, accuracy and completeness have been established for this project:

- The representativeness of the formaldehyde and CO data will be insured by testing four separate HOS burners, three oil-fired and one natural gas-fired.

- The HOS burners will be operated at high-fire, constant load conditions.

- Triplicate samples for formaldehyde and CO, each 60 minutes in duration, will be collected simultaneously over a several hour work day to account for fluctuations over time. If any test runs need to be aborted, a replacement test run will be performed to ensure three data points for each parameter. The USEPA has established three test runs as the minimum number for statistical purposes.

- The formaldehyde detection limit is 11.3 ppbv based on a sample volume of 30 dry standard cubic feet.

- The carbon monoxide detection limit is 0.2 ppmv on a range of 0-100 ppm.

- Formaldehyde sample break-through must be < 20%.

- The targets for precision, accuracy and completeness are summarized below

Precision	Formaldehyde CO	< 20% RSD 5% RSD
Accuracy	Formaldehyde CO	90% 10%
Completeness	Formaldehyde CO	100% 100%

RSD - Relative Standard Deviation

5.0 SPECIALIZED TRAINING

Personnel involved in this project have been trained in equivalent or similar tasks and have from 2 to 38 years of experience in the duties similar to the ones they will be performing. All MACTEC personnel have basic field safety training.

Each of the four sites will require the test personnel to work from scaffold or portable man lifts. Fall protection consisting of full body harnesses and lanyards will be required for all personnel working on scaffold or man lifts.

The field sampling crew will be equipped with standard personal protective gear (e.g., hard hats, safety shoes, eye goggles, and gloves). In addition, each person will be equipped with hearing protection. All personnel will be required to wear DOT approved safety traffic vests. Traffic cones will be used for traffic control in close proximity to the work areas.

The formaldehyde analyses will be performed by Resolution Analytics, Inc. whose laboratory personnel are qualified and trained in all aspects of wet chemical analyses.

6.0 DOCUMENTATION AND RECORDS

Records for this project will include a field test log, field data sheets, sample custody records, computer data files for each run, and QA reports to management. These records and the draft final report will be subject to an internal review before submission to NAPA.

6.1 FIELD OPERATION RECORDS

Field testing activities will be documented on standardized pre-formatted forms. Test personnel will record data on "Field Data Sheets" designed for documentation of stack gas parameters, sampling equipment operating parameters, and ambient conditions. CO concentrations will be continuously monitored and the results will be logged using a data logger and a chart recorder. Sample recovery activities will be recorded on a "Sample Recovery Data Sheet" that will document moisture catch, sample description, and sample identification and labeling. Quality Control samples such as field and reagent blanks will also be documented on the "Sample Recovery Data Sheet." A sample "Chain-of- Custody" will be completed for each set of formaldehyde samples from each facility. If corrective action is required during any segment of the field testing activities, the reason for the correction and the action taken will be noted on the "Corrective Action Report." All entries on these forms will be written in indelible ink. If correction action is required on the form, a single line will be made through the error and the correction will be dated and initialed. Any blank spaces will have a line drawn through to ensure it is not later filled in. Example field data sheets appear in Appendix A.

Field test personnel will have access to this QAPP/SSTP and general field procedures in the form of expanded USEPA reference methods. If any procedure becomes unclear the test crew can refer to these as a step-by-step reference.

6.2 LABORATORY RECORDS

RAI will provide sample tracking forms, case narratives describing the analytical procedures used, including any anomalies and any modifications to procedures, data handling records, and lab notes, for inclusion in the final report.

6.3 DRAFT AND FINAL REPORTS

The final report will include all raw field data, analytical data, and records. A summary of any outliers or findings will be presented in the report. The report will undergo an internal review before submittal. After submittal, the report will be filed at MACTEC for a period of no less than three years. The file will also include disk copies of all electronic data used in the development of the report.

7.0 SAMPLING PROCESS DESIGN

The emission factors for formaldehyde and CO published in AP-42, Section 1.3, for oil-fired HOS burners are expressed as pounds of pollutant per 1,000 gallons of fuel burned (lb/10^3 gal), specifically 0.024 - 0.061 lb/10^3 gal for formaldehyde and 5 lb/10^3 gal for CO. The goal of this testing program is designed to gather the necessary emissions and process data necessary for the development of emission factors expressed in the same units. This will entail the accurate measurement of formaldehyde and CO concentrations and mass emission rates, and accurate determination of fuel usage during each test.

Formaldehyde and CO will be determined using EPA Methods 316 and 10, respectively. When applied and used correctly, these methods produce accurate results. Testing will consist of conducting triplicate 1-hour measurement runs for formaldehyde and CO at each facility.

The sampling process design at each of the four facilities is identical. Each burner has a single stack that will need to be modified to meet the requirements of EPA Method 1 (REA North Mecklenburg, REA Mallard Creek and S.T. Wooten, Wilson) or EPA Method 1A (S.T. Wooten, Franklinton). The REA North Mecklenburg facility is unique in that the HOS burner has a heat exchanger on the stack. This stack will require a taller stack extension because of the heat exchanger.

TABLE 7.1

TEST SCHEDULE

Date(s)	**Activity**	**Comments**
Day 1	Prepare/mobilize	
Day 2	Travel to site, set-up equipment, perform preliminary measurements	
Day 3	Conduct three 1-hr sampling runs for CO and formaldehyde, pack up equipment, return travel	
Day 4	Cleanup /calibrate equipment, transport samples to lab	

TABLE 7.2

SAMPLE & ANALYSIS MATRIX

Collection Media	**Analyte**	**Analysis By**	**Number of Samples**
CARBON MONOXIDE - EPA METHOD 10			
Continuous NDIR	Carbon monoxide	MACTEC	12 samples[a]
FORMALDEHYDE - EPA METHOD 316			
Probe & 1st impinger	Formaldehyde	RAI	12 samples[a]
2nd & 3rd impinger	Formaldehyde	RAI	12 samples[a]
Blanks	Formaldehyde	RAI	4 reagent blanks[b] 4 field blanks[c]

[a] Three samples at each facility.
[b] One water and one reagent blank at each facility
[c] One field blank at each facility

8.0 SAMPLING METHOD REQUIREMENTS

The sampling methods and procedures used for this field test are discussed below. MACTEC anticipates performing three test runs at each facility, using standard operating procedures specified in the reference sampling methods. Copies of the EPA Test Methods are included in Appendix B.

8.1 LOCATION OF MEASUREMENT SITES

The measurement sites at each of the four facilities will be modified to exceed the minimum requirements of EPA Methods 1 or 1A. The measurement sites at the four facilities are schematically similar, although different in size. Dimensional data on the measurement sites follow.

8.1.1 REA Construction - North Mecklenburg Facility

Depicted in Figure 8.1 is a simplified schematic of the existing stack and the modifications that will be required. The modifications will include removal of the mesh bird screen and installation of a stack extension. The stack extension will be 48 inches in length.

Once the modifications are complete, the measurement site will meet the requirements of EPA Method 1, ***"Sample and Velocity Traverse for Stationary Sources".*** The sample test ports will be located 62 inches (4.4 stack diameters) downstream of the nearest flow disturbance (asphalt tank heater) and 28 inches (2.0 stack diameters) upstream of the nearest flow disturbance (atmosphere). According to EPA Method 1 criteria, this location requires 24 sample traverse points, 12 along each of two perpendicular diameters. An additional port (1" pipe

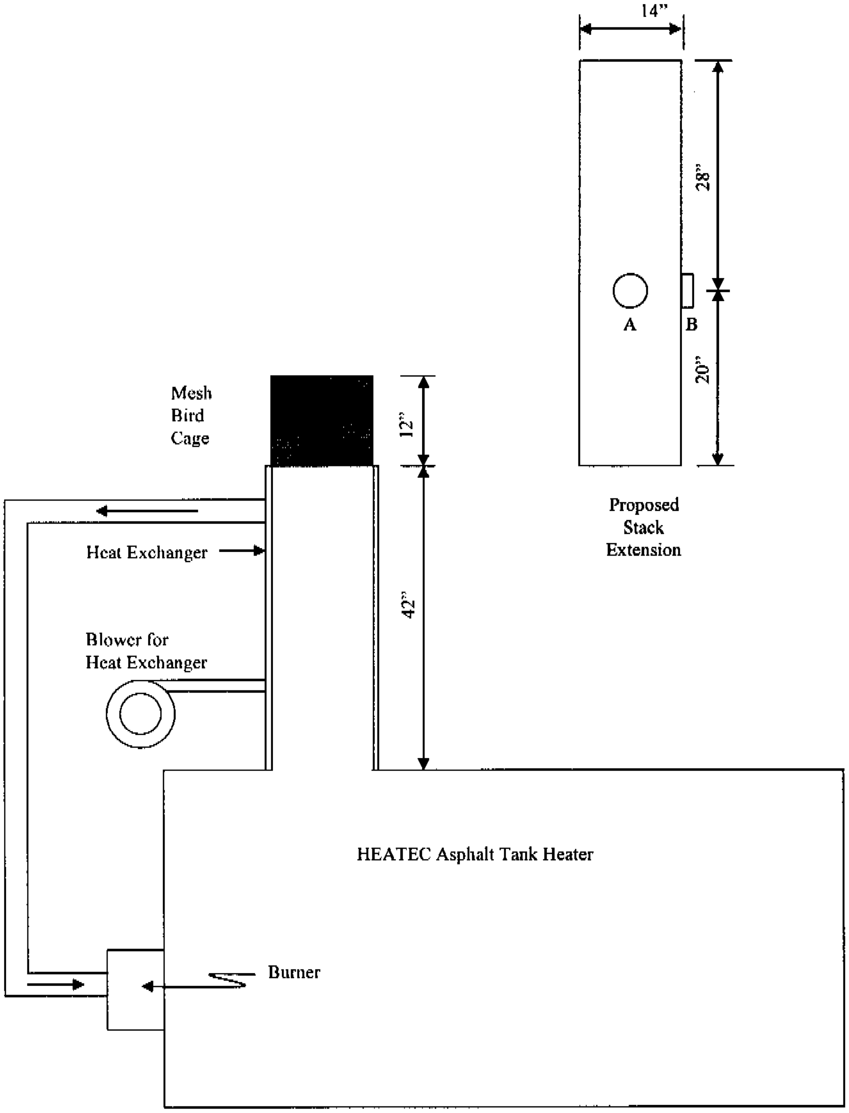


Figure 8.1 Proposed Stack Modifications for the REA North Mecklenburg Facility

coupling) will be installed 12 inches upstream (not shown) of the asphalt tank heater and will be used for the CO sample probe.

8.1.2 REA - Mallard Creek and S.T. Wooten - Wilson Facilities

The measurements sites at these two facilities are identical. Depicted in Figure 8.2 is a simplified schematic of the existing stack(s) and the modifications that will be required. The modifications will include removal of the mesh bird screen(s) and installation of a stack extension. A stack extension, 49 inches long, will be added to facilitate testing.

Once the modifications are complete, the measurement sites will meet the requirements of EPA Method 1, ***"Sample and Velocity Traverses for Stationary Sources"***. The measurement site will be located in a 14-inch inner diameter (ID) round, vertical stack 63 inches (4.5 stack diameters) downstream of the nearest flow disturbance (asphalt tank heater) and 28 inches (2.0 stack diameters) upstream of the nearest flow disturbance (atmosphere). According to EPA Method 1 criteria, this location requires 24 sample traverse points, 12 along each of two perpendicular diameters. One additional port (1" pipe coupling) will be installed 34 inches downstream of the asphalt tank heater and will be used for the CO sample probe.

8.1.3 S.T. Wooten - Franklinton Facility

The HOS burner and stack at the S.T. Wooten, Franklinton facility is schematically identical to the REA Mallard Creek and S.T. Wooten, Wilson facilities, except it is a much smaller system. The existing stack has an inner diameter of nine inches; therefore, this stack and measurement site will be subject to the requirements of EPA Method 1A, ***"Sample and Velocity Traverses for Stationary Sources With Small Stack or Ducts"***. EPA Method 1A requires two measurement sites, one for pollutant sampling and one for velocity measurements.

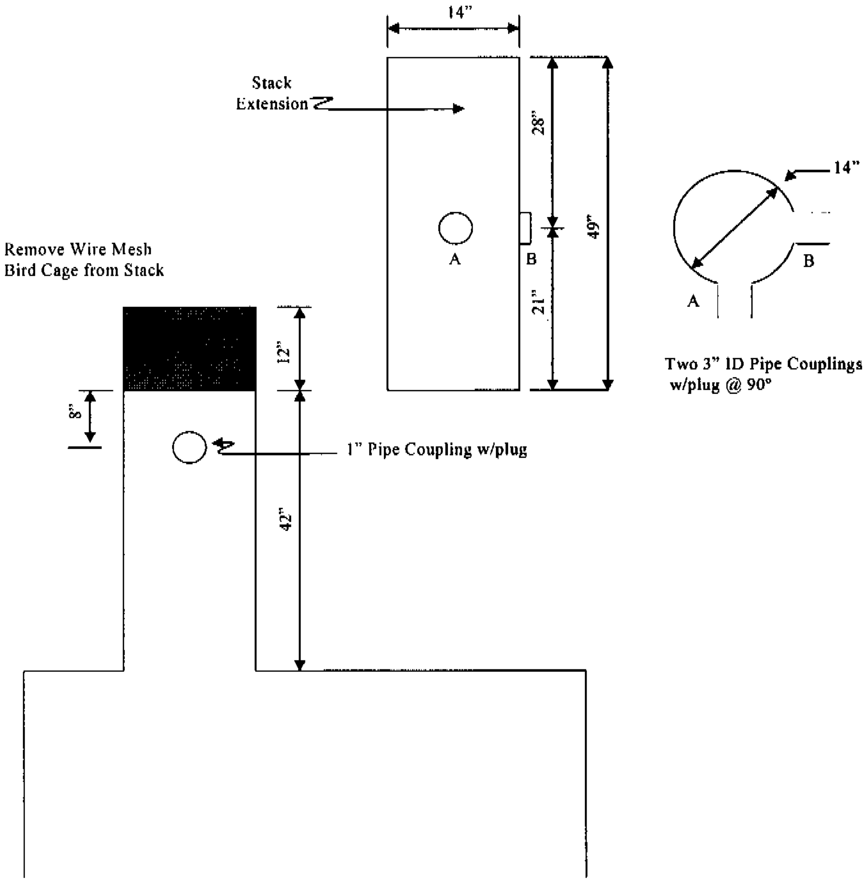


Figure 8.2 Proposed Stack Modifications for the REA Mallard Creek and Wooten Wilson Facilities.

Figure 8.3 depicts a simplified schematic of the existing stack and the modifications that will be required. The modifications will include removal of the mesh bird screens and installation of a stack extension. Once the modifications are complete, the pollutant measurement site will be located 42 inches (4.7 stack diameters) downstream of the nearest flow disturbance (asphalt tank heater) and 54 inches (6.0 stack diameters) upstream of the nearest flow disturbance (atmosphere). According to EPA Method 1A criteria, this location requires 24 sample traverse points, 12 along each of two perpendicular diameters. The velocity measurement site will be located 36 inches downstream of the sampling measurement site and 18 inches (2.0 stack diameters) upstream of the nearest flow disturbance (atmosphere). Twenty four velocity traverse points, 12 along each of two diameters, will be used to be consistent with the sample traverse points. One additional port (1" pipe coupling) will be installed near the base of the stack and will be used for the CO sample probe.

8.2 DETERMINATION OF STACK GAS VELOCITY

EPA Method 2, ***"Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)"***, will be used to determine gas velocity at the sampling point. A Type S pitot tube, constructed according to Method 2 geometric criteria and having an assigned coefficient of 0.84, will be connected to a differential pressure gage (manometer) and to measure velocity pressure (ΔP) at each sample traverse point. The exhaust gas temperature will also be measured at each sample traverse point using a Type K thermocouple connected to a potentiometer. The average exhaust gas velocity will be calculated using the average square roots of the velocity pressure, average exhaust gas temperature, exhaust gas molecular weight, and absolute stack pressure.

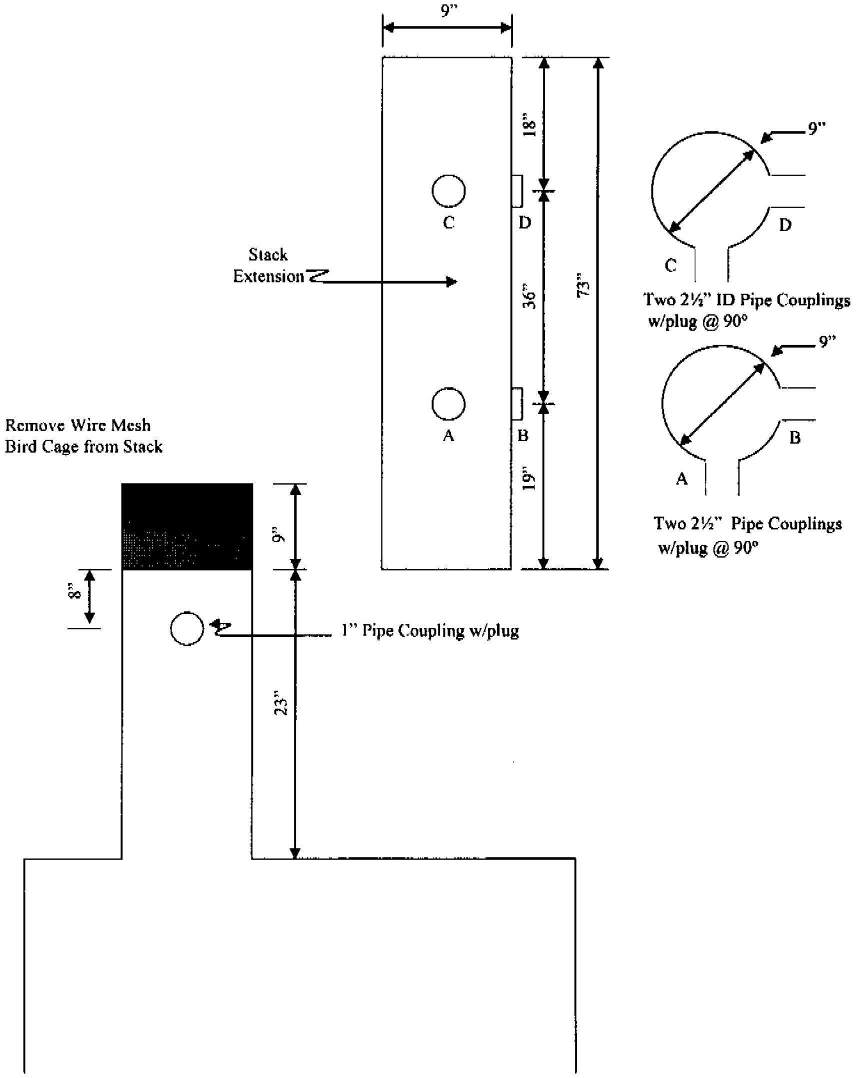


Figure 8.3 Proposed Stack Modifications for the Wooten Franklinton Facility.

8.3 DETERMINATION OF CARBON DIOXIDE, OXYGEN, AND DRY MOLECULAR WEIGHT

EPA Method 3, ***"Gas Analysis for the Determination of Dry Molecular Weight"***, will be used to determine dry molecular weight of the stack gas. During each formaldehyde and CO measurement run, grab samples will be collected using Fyrite® analyzers for determination of percent (%) concentrations carbon dioxide (CO_2) and oxygen (O_2). The balance will be assumed to be nitrogen (N_2). These data will be used to calculate dry molecular weight.

8.4 DETERMINATION OF STACK GAS MOISTURE CONTENT

EPA Method 4, ***"Determination of Moisture Content in Stack Gases"***, will be used to determine stack gas moisture content. This method will be conducted simultaneously with the EPA Method 316 formaldehyde measurement run. The impingers will be weighed on a top-loading balance before and after each measurement run. The net weight gain will be converted to an equivalent volume of air and compared to the total sample volume to calculate moisture content.

8.5 DETERMINATION OF FORMALDEHYDE CONCENTRATIONS

EPA Method 316, ***"Sampling and Analysis for Formaldehyde Emissions from Stationary Sources in the Mineral Wool and Wool Fiberglass Industries",*** will be used to determine formaldehyde concentrations. This method is applicable to the determination of formaldehyde concentrations from stationary sources. Gaseous and particulate pollutants are withdrawn isokinetically from the stack and are collected in high purity water. Formaldehyde present in the emissions is highly soluble in high purity water. The high purity water sample containing formaldehyde is then analyzed using the modified pararosaniline method.

Formaldehyde in the sample reacts with acidic pararosaniline, and sodium sulfite, forming a purple chromophore. The intensity of the purple color, measured spectrophotometrically, provides an accurate and precise measure of the formaldehyde concentration in the sample. Using this method, formaldehyde can be detected as low as 11.3 parts per billion by volume (ppbv) or as high as 23,000,000 ppbv, based on a 1-hour sampling period and a sample volume of 30 cubic feet.

8.6 DETERMINATION OF CARBON MONOXIDE CONCENTRATIONS

EPA Method 10, ***"Determination of Carbon Monoxide Emissions From Stationary Sources"***, will be used to measure carbon monoxide concentrations in the stack gas. During each formaldehyde measurement run, a stack gas sample will be extracted continuously from the sampling point and analyzed for CO using a non-dispersive infrared analyzer (NDIR) with gas filter correlation (GFC). The NDIR/GFC will be operated on the range of 0-100 parts per million by volume (ppmv). The output from the NDIR will be monitored using a data logger and chart recorder.

8.7 DETERMINATION OF FUEL USAGE

Fuel usage rates will be the responsibility of NAPA and will be determined using data on the fuel nozzle and fuel pressure. The nozzle size and pressure relates to a specific flow rate. MACTEC has been assured by HEATEC that the fuel usage rates can be determined to within ±1% accuracy using this procedure. No. 2 fuel oil usage rates will be expressed in gallons per hour. Natural gas usage will be expressed in cubic feet per hour.

8.8 SELECTION AND PREPARATION OF SAMPLE CONTAINERS

Glass containers used to collect and/or transport formaldehyde samples will be commercially pre-cleaned prior to use.

8.9 PRESERVATION METHODS AND MAXIMUM HOLDING TIMES

All formaldehyde samples will be stored and transported in sealed containers away from dust and other ambient causes of contamination. The samples will be stored in coolers with blue ice to maintain a temperature at 2 °C until analysis. The formaldehyde samples will be analyzed within 14 days of collection.

8.10 IDENTIFY INDIVIDUALS RESPONSIBLE FOR CORRECTIVE ACTION

The MACTEC Field Team Leader will be on-site during all sampling and cleanup procedures, and will serve as the individual responsible for devising and implementing any corrective actions which may be necessary while in the field. As necessary, the MACTEC PM will provide assistance in devising and implementing any corrective actions deemed necessary.

9.0 SAMPLE HANDLING AND CUSTODY

9.1 SAMPLE CUSTODIANS

The sample custodians are identified below. These individuals will be responsible for maintaining the proper chain of custody procedures during this testing program. They are also responsible for the samples during substrate preparation, sample collection, sample recovery, and analysis.

Mike Maret
MACTEC Federal Programs, Inc.
5001 S. Miami Blvd, Suite 300
RTP, NC 27709-12077
919/941-0333 (ph) 919/941-0234 (fax)

Bruce Nemet
Resolution Analytics, Inc.
2733 Lee Avenue
Sanford, NC 27330
919/774-5557 (ph) 919/776-6785 (fax)

9.2 SAMPLE LABELING SCHEME

Table 9.1 shows the formaldehyde sample labeling scheme.

Each test run will have a unique alpha-numeric code to be used only for sample components from that test run. This code will include information on the run number and sample component. The sample components are described in a one or two word phrase such as: rinse, etc.

TABLE 9.1

FORMALDEHYDE SAMPLE LABELING SCHEME

Facility/Run No.	Pollutant	Sample Description	Sample ID Code
REA North Mecklenburg			
NM-F-1	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	NM-F-1(A) NM-F-1(B)
NM-F-2	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	NM-F-2(A) NM-F-2(B)
NM-F-3	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	NM-F-3(A) NM-F-3(B)
NM-F-FB	Formaldehyde Field Blank	Probe & 1st Impinger 2nd & 3rd Impinger	NM-F-FB(A) NM-F-FB(B)
NM-F-RB	Formaldehyde	Reagent Blank	NM-F-RB
REA Mallard Creek			
MC-F-1	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	MC-F-1(A) MC-F-1(B)
MC-F-2	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	MC-F-2(A) MC-F-2(B)
MC-F-3	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	MC-F-3(A) MC-F-3(B)
MC-F-FB	Formaldehyde Field Blank	Probe & 1st Impinger 2nd & 3rd Impinger	MC-F-FB(A) MC-F-FB(B)
MC-F-RB	Formaldehyde	Reagent Blank	MC-F-RB

TABLE 9.1 (Concluded)

Facility/Run No.	Pollutant	Sample Description	Sample ID Code
Wooten Franklinton			
WF-F-1	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	WF-F-1(A) WF-F-1(B)
WF-F-2	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	WF-F-2(A) WF-F-2(B)
WF-F-3	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	WF-F-3(A) WF-F-3(B)
WF-F-FB	Formaldehyde Field Blank	Probe & 1st Impinger 2nd & 3rd Impinger	WF-F-FB(A) WF-F-FB(B)
WF-F-RB	Formaldehyde	Reagent Blank	WF-F-RB
Wooten Wilson			
WW-F-1	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	WW-F-1(A) WW-F-1(B)
WW-F-2	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	WW-F-2(A) WW-F-2(B)
WW-F-3	Formaldehyde	Probe & 1st Impinger 2nd & 3rd Impinger	WW-F-3(A) WW-F-3(B)
WW-F-FB	Formaldehyde Field Blank	Probe & 1st Impinger 2nd & 3rd Impinger	WW-F-FB(A) WW-F-FB(B)
WW-F-RB	Formaldehyde	Reagent Blank	WW-F-RB

9.3 SAMPLE STORAGE AND PRESERVATION

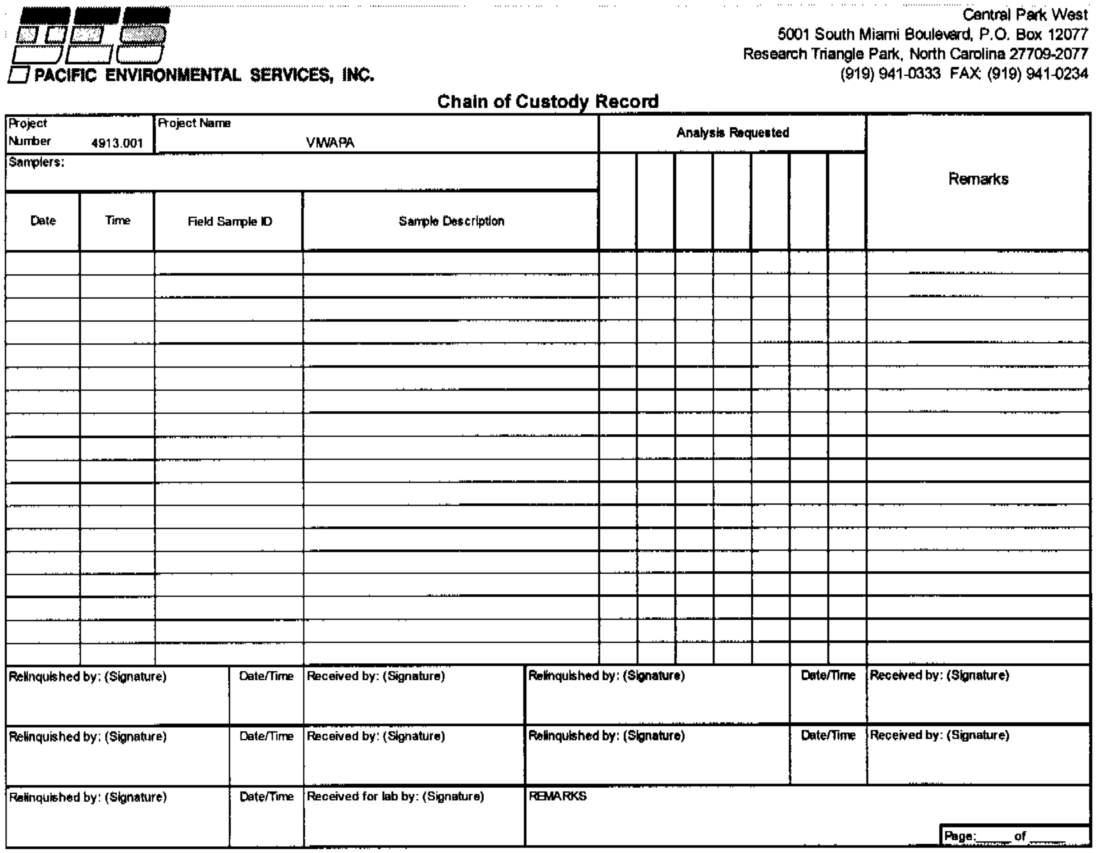
All MACTEC formaldehyde samples will be stored and transported in sealed containers away from dust and other ambient causes of contamination. The samples will be stored in either a freezer or coolers with blue ice to maintain a temperature at 2 °C.

9.4 FIELD DATA

All data sheets from the test location and sample recovery activities will be collected at the end of each test day by the Field Team Leader and kept in his custody. The original field data sheets will remain in MACTEC custody. Copies will be included with the draft and final reports.

9.5 CHAIN OF CUSTODY PROCEDURES

Chain of custody records will be implemented once sample substrates are prepared. After collection, each sample container will be labeled and inspected prior to packaging for transport. MACTEC will maintain custody of the samples during transport back to the MACTEC office in Research Triangle Park, NC. Samples will be stored in MACTEC's RTP laboratory which has restricted access. MACTEC will be utilizing RAI for formaldehyde sample analyses and will relinquish the samples to them using appropriate Sample Chain of Custody protocol. An example Chain of Custody form appears in Figure 9.1.



PACIFIC ENVIRONMENTAL SERVICES, INC.

Central Park West
5001 South Miami Boulevard, P.O. Box 12077
Research Triangle Park, North Carolina 27709-2077
(919) 941-0333 FAX (919) 941-0234

Chain of Custody Record

Project Number 4913.001		Project Name VMAPA		Analysis Requested							Remarks
Samplers:											
Date	Time	Field Sample ID	Sample Description								

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for lab by: (Signature)	REMARKS		Page:_____ of _____

Figure 9.1 Example Chain of Custody Form.

10.0 ANALYTICAL METHOD REQUIREMENTS

Formaldehyde samples will be analyzed in accordance with the procedures specified in EPA Method 316. The analyses will be performed by Resolution Analytics, Inc. (RAI) of Sanford, North Carolina. Analyses will include samples, and field, reagent, and laboratory blanks.

Fourteen days has been established as the holding time for sample analysis after sample collection. Once the samples are in the laboratory, RAI will prepare a formaldehyde standard solution. The standard solution is stable for a period of four weeks if kept refrigerated between analyses. Using the standard solution, RAI will prepare formaldehyde working standards daily. The laboratory must establish that the formaldehyde working standards are stable. This will be demonstrated by actual testing. The working standards will be analyzed and a calibration curve will be calculated for each day's analysis. The standards will be analyzed first to ensure that the method is working properly prior to analyzing the samples. In addition, a sample of the laboratory's high purity water will be analyzed and used as a "0" formaldehyde standard. The formaldehyde content of the water must be <0.005 μg/ml. The quality of the laboratory water used to prepare standards and make dilutions is critical.

The procedure for analysis of standards and samples is identical. The standards and samples will be analyzed following the procedures in Section 11.0 of Method 316 using a spectrophotometer wave length of 570 nm and set to read in Absorbance Units. The calibration curve will be calculated using linear regression. All samples from the four facilities will include analysis of the "A" and "B" fractions of the sample, so that formaldehyde sample break-through can be ascertained.

11.0 QUALITY CONTROL REQUIREMENTS

The goal of the QC program is to ensure, to the highest degree possible, the accuracy of the data collected and quantify the accuracy. This section describes specific procedures for equipment preparation, on-site sampling, and sample recovery that affect sample quality, and laboratory analysis.

11.1 REAGENTS AND GLASSWARE PREPARATION

All sample train glassware and sample recovery apparatus will be preconditioned following the procedures of Method 316. All sampling train components and sample recovery apparatus coming in contact with the sample will be soaked in hot soapy water (Alconox®), followed by three rinses each with tap water, and high purity water. All glassware will then be capped with cleaned aluminum foil (or other inert material).

High purity water (ASTM Type I) or equivalent will be used to collect formaldehyde in the impingers and to recover the samples. The water will be provided by the analytical laboratory (RAI) and will be analyzed before use for formaldehyde content. All samples will be recovered into and stored in certified, pre-cleaned glass sample bottles.

11.2 CALIBRATION OF APPARATUS

The preparation and calibration of source sampling equipment is essential in maintaining data quality. Brief descriptions of the calibration procedures to be used by MACTEC follow.

11.2.1 Barometric Pressure

MACTEC uses aneroid barometers which are calibrated against a barometric pressure value reported by a nearby National Weather Service station, and corrected for elevation.

11.2.2 Temperature Sensors

Type K thermocouples will be checked for proper operation using the procedures described in Section 3.4.2 of the Quality Assurance Handbook, Volume III, 1994. Each temperature sensor will be initially checked over the expected range of use against an ASTM 3C or 3F thermometer. Electronic temperature readouts will be checked using a thermocouple simulator having a range of 0-2400 °F.

11.2.3 Pitot Tubes

MACTEC uses S-type pitot tubes which are constructed according to EPA Method 2 specifications. Pitot tube dimensions are checked against EPA Method 2 dimensional criteria. Pitot tubes not meeting these criteria are rejected. Pitot tubes meeting these criteria are assigned a baseline coefficient of 0.84 and need not be calibrated.

11.2.4 Differential Pressure Gauges

MACTEC uses Dwyer differential pressure gauges (inclined/inclined-vertical manometers). Manometers are primary standards and need no calibration.

11.2.5 Dry Gas Meter and Orifice

The EPA Method 316 metering system consists primarily of a dry gas meter for measuring sample volume and an orifice for adjusting sampling rate. Calibration of the metering system will include initial calibration of the dry gas meter and orifice, and post-test calibration of the dry gas meter. The calibrations will follow the procedures given in Section 10.3 of Method 316. The initial calibration requires the dry gas meter to be within ± 1% of a reference value. The post-test dry gas meter calibration must be within 5% of the initial calibration.

11.3 ON-SITE SAMPLING

MACTEC will perform the following checks on the sampling equipment.

11.3.1 Measurement Sites

The dimensional data on the stacks in this QAPP/SSTP are based on preliminary information obtained during the pretest site surveys. Prior to sampling, all stacks and stack extensions will be carefully measured and sketches will be made showing the sample test port locations, up and down stream distances to obstructions, and inner stack diameters. Inside dimensions will be checked to determine uniformity of the stack cross-sectional area and the sample test ports will be checked to verify that they do not extend beyond the inside wall. The stack inside dimensions, wall thickness, and sample port depths will be measured to the nearest 1/16 inch.

Once the dimensional data are obtained, MACTEC will calculate the number of sample traverse points as per EPA Method 1, and conduct tests on each stack to check for the presence of cyclonic or non-parallel flow.

11.3.2 Barometric Pressure.

Barometric pressure will be recorded at the beginning and end of each test run. The average will be used for test run calculations. If necessary, adjustments will be made for elevation depending on the actual location of the barometer.

11.3.3 Velocity Measurements

All velocity measurement apparatus will be assembled, leveled, zeroed, and leak-checked prior to use and at the end of each test run. The static pressure will be determined at a single point near the center of the stack cross-section. The stack gas stream will also be checked for cyclonic flow. If cyclonic conditions are evident, they will either be eliminated, or if no other options are possible, the "alignment method" will be used for sampling.

Apparatus	**QC Check**	**Criteria**	**Corrective Action**
Manometer	Leveled and zeroed before and after each test.	Bubble leveler must indicate level conditions. Manometer must read zero.	Re-level and re-zero. Note in test log.
Pitot	Check for chips in Pitot. Perform leak check on pitot lines before and after each test run.	Pitot lines must indicate no leak over a 15 second period at a ΔP of 3 inches of water.	Repair or replace pitots. A post test leak check failure indicates the run must be voided and repeated.

11.3.4 Moisture

The EPA Method 316 trains will be used to determine stack gas moisture. During sampling, the exit gas of the last impinger will be maintained below 68°F to ensure adequate condensation of the stack gas water vapor. The total moisture will be determined gravimetrically using an electronic platform balance with 0.1 gram sensitivity.

Apparatus	QC Check	Criteria	Corrective Action
Impinger Glassware	Monitor Exit Temperature	Exit temperature to be kept below 68°F.	Add more ice.
Electronic Balance	Reference Weight	Reading within 0.1 grams of known standard	Recalibrate and reweigh.

11.3.5 EPA Method 316 Sampling Trains

The field sampling QA/QC for EPA Method 316 will begin in the sample recovery area. The impingers will be charged with high purity water and silica gel, then weighed to the nearest 0.1 gram on a top loading electronic balance. The sample trains will be assembled without attaching the sample probe. At the sampling site the sample probe will be attached to the sample train and a leak check will be conducted. Any leaks found in excess of 0.02 cfm will be corrected prior to beginning the test runs. Leak checks will also be conducted before and after any sample train component changes, and upon completion of each test run. Probe heaters will be maintained within allowable ranges throughout the test runs.

Apparatus	QC Check	Criteria	Corrective Action
Probe Heaters	Monitor Temperature	Temperature to be kept 248 ± 25°F.	Adjust Heater Setting.
Isokinetic Sampling Train	Leak Check	Leak Rate of less than 0.02 cfm.	Adjust Sample Volume or Retest.

11.3.6 EPA Method 10 Carbon Monoxide Analyzer

The field sampling QA/QC activities for EPA Method 10 will be more vigorous than specified in the reference method. Specific QA/QC activities include:

Activity	Criteria
– Calibration error	< 5% of calibration gas value
– Sampling system bias	< 5% of span
– Zero and calibration draft test	± 3% of span

In addition, initial up- and down-scale response time checks will be conducted.

11.4 EPA METHOD 316 SAMPLE RECOVERY

Sample recovery will be performed in an on-site laboratory van under the supervision of the MACTEC Field Team Leader. Recovery of the formaldehyde sample trains will be performed following the procedures of Method 316. In addition to the field blank, blanks will be taken of the reagent grade water. The sample recovery apparatus will be made of pre-cleaned Teflon® or glass. Before recovery, the impingers will be weighed to the nearest 0.1 grams so that the moisture content of the gas stream can be calculated. The sample train cleanup will be accomplished by rinsing each sample train component from the nozzle up to and including the "U" bend between the third and fourth impingers. The rinse up to and including the first impinger will be recovered separately from the rest of the sample train so that separate analyses can be performed on each fraction for the purpose of calculating formaldehyde collection efficiency. All sample containers will be tared and then re-weighed following sample recovery, so that sample integrity can be ascertained.

11.5 EPA METHOD 316 LABORATORY ANALYSIS

The formaldehyde samples will be analyzed following the procedures of EPA Method 316. Field blanks and reagent blanks will be used to check for contamination. They will be processed in the same way the field samples are processed. Field blank concentrations will be subtracted from the appropriate sample formaldehyde concentrations. Blank concentrations above 0.25 μg/ml will be considered suspect and will not be subtracted from the sample formaldehyde concentrations.

12.0 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Prior to the field test, MACTEC will prepare a packing list identifying the sampling equipment, instrumentation, and supplies necessary for the planned field testing. As part of this activity, MACTEC will inspect each piece of sampling equipment to ensure that it is in good repair and that the initial calibrations are still current. MACTEC will also prepare spare sampling systems and supplies, so that interruptions in the testing program can be minimized in the event of equipment malfunctions. All the equipment and supplies will be readied in a staging area in MACTEC's laboratory, then loaded onto a MACTEC van for transport to the test sites.

Upon arrival at the test site, MACTEC will inspect all the sampling equipment to verify that it arrived in good condition. After inspecting the equipment, MACTEC will set up the sample preparation and recovery area, and organize the equipment and work area, so that it is functional and safe, and commence the pre-test activities.

13.0 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

MACTEC's sampling equipment is calibrated according to the criteria specified in the EPA Methods 2, 316 and 10. The range of calibration is specified for all environmental measurements to encompass the range of probable experimental values.

13.1 CALIBRATION AND PREPARATION OF SAMPLING APPARATUS

The preparation and calibration of source sampling equipment is essential in maintaining data quality. MACTEC will follow the calibration routines described in the EPA Methods.

13.2 CALIBRATION OF ANALYTICAL INSTRUMENTS

All formaldehyde sample analysis for this effort will be conducted by MACTEC's subcontractor, RAI. MACTEC has assurances from RAI that all analytical instruments and equipment used to process and analyze the samples will be calibrated according to standard operating procedures for laboratory standards.

14.0 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Typically the manufacturer states purity levels on the packages of reagents and sampling media. High purity water used for collection of formaldehyde and the rinsing of the train will meet the requirements of ASTM Type I water. MACTEC will ensure that blanks of all water and reagents used in the test are analyzed as discussed in Section 11 for the reagents.

15.0 NON-DIRECT MEASUREMENTS

For this project, data will either be measured directly (e.g., temperature, velocity head, etc.) or calculated from directly measured data. Project data will be recorded manually for Method 316 and on a data logger for Method 10. Method 316 observations will be recorded in ink on preformatted data sheets.

16.0 DATA MANAGEMENT

16.1 USE OF NON-MEASUREMENT DATA

All data used in this project will be measured directly, calculated from direct measurement data, or consist of notes and observations concerning any problems implementing the procedures. The notes and observations recorded during the field testing will be provided for assessment in a separate section of the draft final report.

16.2 USE OF CALCULATED DATA

EPA Method 316 will be used to determine the concentration of formaldehyde. The laboratory analytical results provide total mass of formaldehyde per sample. The total formaldehyde concentration in the stack gas will be calculated using the mass of formaldehyde in the sample and the volume of air sampled. Using the concentration and the stack gas volumetric flow rate, the formaldehyde mass emission rate will be calculated. The mass emission rate (pounds per hour) and the fuel rate (gallon per hour) will be used by NAPA to calculate the emission factor expressed as pounds of pollutant per gallon of fuel fired.

16.3 LIFE CYCLE OF DATA

Project data will be recorded in ink on preformatted data sheets. Method 10 instrument readouts will be saved to a disk file and subsequently printed. These data sheets and samples will be returned from the field to MACTEC. The samples will be transferred by MACTEC to RAI for analysis. RAI will use standard laboratory tracking procedures. The field data will be input into software designed to generate information on gas stream conditions based on data provided.

When the laboratory analysis is complete, MACTEC will receive laboratory analytical reports from RAI and will combine the analytical data with the MACTEC field data to calculate the concentrations. Calculated results, copies of field data sheets, and raw analytical data will all be included in the draft and final reports. The original data sheets, analytical data, and disk copies of the software used in the calculations will be stored on file at MACTEC for a period of no less than three years after the end date of the project.

16.4 DATA RECORDING

Extreme care will be exercised to ensure hand recorded data are written accurately and legibly. Additionally, the forms have been formatted for easy use. Errors and discrepancies will be noted in the field log book.

16.5 DATA COLLECTION AND VALIDATION

The MACTEC Field Team Leader will review field data sheets looking for inconsistencies in such parameters as: temperatures, pressures, velocity head, sample volume, etc. The Field Team Leader will also review sample components and sample recovery sheets looking for inconsistencies. Errors and discrepancies will be noted in the field log book.

16.6 DATA PROCESSING AND TRACKING

Individual data points will be transformed into calculated results using a series of equations. The equations have been incorporated into software for efficiency. As a QC check, dummy values will be input to the software and the results will be checked against expected values. The MACTEC PM will keep a data tracking log during the data processing and reporting phase of the project.

16.7 DATA STORAGE AND RETRIEVAL

The original data sheets, analytical data, and disk copies of the software used in the calculations will be stored on file at MACTEC for a period of no less than three years after the end date of the project.

17.0 ASSESSMENTS AND RESPONSE ACTIONS

17.1 ON-SITE PROCEDURE AUDIT

There will be no QA coordinator on-site to observe testing. Data collected will be evaluated according to the criteria listed in Section 4.0.

17.2 INTERNAL DATA REVIEW

MACTEC personnel with technical expertise in the field of air emissions testing, who have had minimal or no involvement with the field data collection, will provide a thorough review of the data. Reviewers will determine if the project activities were technically adequate, competently performed, and properly documented.

17.3 ASSESSMENTS

Using the quality indicators and associated criteria as listed in Section 4.0 and tabulated in Table 17.1, NAPA will make assessments as to whether the results are adequate for their intended use. Results and any recommendations will be documented in the Draft Final Report.

TABLE 17.1

QUALITY INDICATORS & CRITERIA

Activity	Quality Indicator	Criteria
1	Method 316 sample volume	> 30 cubic feet
2	Method 316 sample time	> or equal to 60 minutes
3	Method 316 formaldehyde concentration	> 11.3 parts per billion by volume
4	Method 316 formaldehyde break-through	< 20%
5	Average isokinetic ratio	> 90 & < 110 %
6	Perform 12 one-hour Method 316 runs	100 % completeness
7	Perform 12 one-hour Method 10 runs	100 % completeness

18.0 REPORTS TO MANAGEMENT

Because each of the four field tests are short-term tasks, no written formal reports to management will be generated. Informal communications (voice mail, email, fax, letter, or memo) with the NAPA PD will be made on an as-needed basis. A formal report of the test and its results will be submitted to the NAPA PD after the test is completed. The report will include documentation of the outcome of the test, all test results, the results of QA assessments, the comparisons of the data to the criteria given in Section 4.0, the procedures and methodologies followed, and any conclusions and recommendations derived from evaluating the results of the test.

19.0 DATA REVIEW, VERIFICATION, AND VALIDATION

The purpose of this section is to state criteria for accepting, rejecting, or qualifying the test data. This discussion focuses on the quality indicators and criteria listed in Table 17.1.

The main objective is to accurately determine formaldehyde emissions from HOS burners, so it is imperative that sufficient sample is collected and that formaldehyde is detected in the samples.

Variability or failure to meet all the criteria in Table 17.1 may be an indicator of inconsistent or erroneous data, and will require examination of possible causes of data rejection.

As stated earlier, this sampling project will consist of 12 test runs, three at each of the four facilities. MACTEC's goal is to have at 12 successful runs.

20.0 VERIFICATION AND VALIDATION METHODS

The purpose of validation is to assess the degree to which the data meets the quality specifications outlined in the QAPP. If deviations are noted, the validation procedures can be used to assess the effect the deviation will have on test data usability.

20.1 SAMPLING DESIGN

This test program is designed to gather data that will be used by NAPA to develop formaldehyde emission factors for HMA plant's HOS burners.

20.2 SAMPLE COLLECTION PROCEDURES

Actual procedures documented in field logs and data sheets will be checked against the procedures described in the QAPP. Deviations from the QAPP will be classified as acceptable or unacceptable, and critical and non-critical. Significant changes will be documented in the draft and final reports.

20.3 SAMPLE HANDLING

Sample custody will be maintained for each sample component. Sample custody from the field to the laboratory and within the departments of the laboratory will be checked. All deviations will be documented in the draft and final reports.

20.4 ANALYTICAL PROCEDURES

The analytical procedures performed during the test program will be checked against those described in the QAPP. Deviations from the QAPP will be classified as acceptable or unacceptable, critical and non-critical, and will be documented in the draft and final reports.

20.5 QUALITY CONTROL

QC samples and procedures performed during the test program will be checked against those described in the QAPP. Omissions will be discussed in the final report. QC results of the blank analyses will be reviewed and described in the draft and final reports.

20.6 CALIBRATION

Documentation of equipment calibration (nozzles, dry gas meter, thermocouples, etc.) will be checked against the values used in data collection. Errors and omissions will be discussed in the draft final report.

20.7 DATA PROCESSING

The data processing system will be checked by using example raw data for which calculated values are already known. The example data are input into the system and the calculated results are compared to the known. Hand calculations will be used to spot check the data processing system.

21.0 RECONCILIATION WITH USER REQUIREMENTS

Results obtained from the project will be evaluated with respect to the quality indicators described in Section 4.0 of this document. Results will be checked for collection efficiency (accuracy), precision, and completeness. Qualitative assessments will be made on meeting sampling, sample recovery, and analytical precision requirements of the methods. These will be discussed with the NAPA PD during preparation of the draft and final reports. The NAPA PD will evaluate whether the project met the objectives of the sampling design, and whether departures from the QA/QC guidelines are acceptable. The conclusions will be included in the draft and final reports. The following subsections show the calculations involved.

21.1 SAMPLE BREAK-THROUGH DETERMINATION

Sample break-through is a measure of the amount of a compound of interest that passes through the sample media without being collected in the media. The amount of formaldehyde sample break-through will be determined by analyzing the contents of the 1st and 2nd impingers separately from the 3rd impinger. The percent break-through (% BT) will be calculated as follows:

$$\% BT = \frac{Amt.\ in\ 2^{nd}\ \&\ 3^{rd}\ impingers}{Amt.\ in\ 1^{st},\ 2^{nd}\ \&\ 3^{rd}\ impingers}\ x\ 100$$

21.2 PRECISION

Precision is the repeatability of the result. In this project, precision will be measured using the results of the three replicate measurement runs at each site. The precision is expressed as relative standard deviation (RSD).

21.3 COMPLETENESS

Completeness refers to the amount of data gathered compared to the amount of data required in the project design. MACTEC has a 80 % completeness standard for this project.

$$\%Completeness = \frac{Amount\ of\ Data\ Collected}{Amount\ of\ Data\ Required\ by\ QAPP} \times 100$$

APPENDICES

Appendix A

Example Field Data Sheets

Appendix B

EPA Test Methods 1, 1A, 2-4, 10 and 316