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Clean Air Act Emission Testing of the T-38C Aircraft Engines

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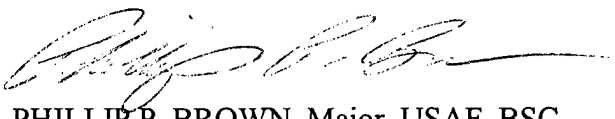

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13. ABSTRACT *(Maximum 200 words)*

The Report is the product of an emissions testing program designed to document, characterize, and evaluate emissions from the T-38C aircraft engines modifications. The purpose of the emissions testing program was to develop emission factors for the tested engines under representative load conditionss. Testing was performed by Environmental Quality Management, Inc. (EQM). Testing was conducted for criteria and hazardous air pollutants.

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ACRONYMS

AFB	Air Force Base
AFIERA	Air Force Institute for Environment, Safety, and Occupational Health Risk Analysis
CDRL	Contract Data Requirements List
CEM	continuous emissions monitoring
CFM	cubic feet per minute
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOT	Department of Transportation
DSCFM	dry standard cubic feet per minute
EQ	Environmental Quality Management, Inc.
FID	flame ionization detector
HAP	Hazardous Air Pollutant
IATA	International Aviation Transportation Association
ICAO	International Civil Aviation Organization
IXRF	Iridium X-ray Fluorescence
MCE	carbon mass rate – exhaust
MCF	carbon mass rate – fuel
MCI	carbon mass rate – inlet air
NIOSH	National Institute of Occupational Safety and Health
NO_X	Nitrogen Oxides
NMHC	Non Methane Hydrocarbons
PAH	Polynuclear Aromatic Hydrocarbons
PIC	product of incomplete combustion
PM	Particulate Matter
RSEQ	Risk Analysis Environmental Quality
SAP	Sampling and Analysis Plan
SEM	scanning electron microscopy
SPO	System Program Office
TPM	Technical Program Manager
THC	total hydrocarbon
VOC	volatile organic compound

REFERENCES

- Title 40, Code of Federal Regulations, part 60, Appendix A
- Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, January 2002
- http://www.epa.gov/ttn/emc/tmethods.html
- http://www.epa.gov/epaoswer/hazwaste/test/methdev.thm
- Aircraft Engine Emissions, International Standards and Recommended Practices-Environmental Protection, Annex 16, Volume II, First Edition

EXECUTIVE SUMMARY

The J85-GE-5R aircraft engine is a modified version of the J85-GE-5M engine which currently powers the T-38 Talon aircraft (T38C and T38A respectively). In order to evaluate the impact of the engine modifications on emissions, a comprehensive emission measurement program was conducted at Moody AFB and Randolph AFB. A single J85-GE-5M engine was tested in a hush house at Moody AFB to measure criteria and select hazardous air pollutants. At Randolph AFB, gaseous emissions were measured directly behind a T-38C test aircraft equipped with two J85-GE-5R engines. The purpose of testing at both locations was to compare on-wing emissions versus test-stand emissions.

The results from this test program will be used to evaluate potential environmental impacts that may be created by the bed down of the modified engine at various Air Force Bases.

I. OBJECTIVES

The purpose of this program was to determine emission factors for the J85-GE-5R and J85-GE-5M engines under representative engine load conditions and compare test-stand emissions with on-wing emissions. In addition, the emissions data were compared to the J85-GE-5H emissions to determine if the engine modifications affected emissions. Testing was conducted for criteria pollutants and select hazardous air pollutants (HAPs).

II. SAMPLING METHODOLOGY

Sampling was performed for criteria pollutants and those HAPs that are products of incomplete combustion (PICs) from the J85-GE-5M engine at Moody AFB. Gaseous criteria pollutants were measured from the T-38 with PMP Aircraft at Randolph AFB. Environmental Protection Agency (EPA) emissions test methods (Title 40, Code of Federal Regulations, Part 60, Appendix A) were followed during this test program. The test methods were modified where necessary due to the unique circumstances encountered during the program: i.e., high flow rates, unique exhaust configuration, and a large volume of dilution (ambient) air in the exhaust gas stream. A custom EPA Method 5 was employed due to the physical configuration of the test

cell. The nature of each test location did not permit a full cross-section traverse; instead, single point sampling was performed via a slipstream and engine sampling rake. A verification was made through the use of a multi-point gaseous sampling system in the hush house augmenter tube to assure that the sample point was representative of the entire exhaust stream. The following is a list of the constituents of the exhaust stream that were measured at Moody AFB along with the corresponding EPA test methods used:

- Filterable and condensible particulate (EPA Methods 5 and 202[1]).
- Aldehydes and ketones (EPA 0011[2] and TO-05).
- Volatile organic compounds (VOCs) (EPA Method 0030).
- Oxygen and carbon dioxide (EPA Method 3A).
- Carbon monoxide (EPA Method 10).
- Nitrogen oxides (EPA Method 7E).
- Non-methane hydrocarbons (NMHCs) (EPA Method 25A).
- Polynuclear Aromatic Hydrocarbons (NIOSH Method 5506)

Sampling was not performed for sulfur dioxide and metals in the engine exhaust streams. Historic testing of metals provided random results with a number of interferences. Sulfur dioxide emissions are reported based on the procedure documented by AFIERA. ("Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, "January 2002). This procedure estimates that sulfur dioxide emissions can be calculated by assuming all sulfur in the fuel undergoes complete oxidation to SO_2. Dioxins/furans and other HAPs not listed in this report would not have been emitted in significant quantities to be readily detected by conventional sampling methods. Therefore, these compounds were not part of the emissions testing program.

Ambient air samples were collected for total non-methane hydrocarbons, carbon dioxide, oxygen, and carbon monoxide in order to complete the f-factor and carbon balance flow models. Due to historic ambient air monitoring programs and the proximity of the test facilities to contributing sources, correction for ambient pollutants was not performed.

II.1A Engine Testing Considerations/Complications

The engine was tested at four actual flight settings. Nominal engine conditions for emissions sampling are provided below:

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[1] Unless otherwise noted, test methods taken from 40 CFR 60, Appendix A; http://www.epa.gov//ttn/emc/tmethods.html.

[2] From EPA SW-846, http://www.epa.gov//epa.oswer/hazwaste/test/methdev.htm

- Idle (I)
- Intermediate (N)
- Military (M)
- Afterburner (AB)

Emissions tests at Moody AFB comprised three 2-hour sampling runs for each pollutant at the first three power settings with the exception of the aldehydes/ketones and polynuclear aromatic hydrocarbons tests. Due to sample volume requirements needed to meet method detection limits, aldehydes/ketones were collected over the 6-hour sampling period. At the afterburner setting, a single 10-minute sample run was conducted for gaseous pollutants only.

Testing at Randolph AFB consisted of approximately 15 minutes of sampling time at each engine setting.

III. RESULTS

III.1A Criteria Pollutants

Results of the criteria pollutants are presented in Tables III-1 and III-2. The tables present both emission rates and factors for NO_x, CO, total particulate, NMHC, SO_2, and CO_2 for each engine at each engine test condition. The emissions presented are the average of each of the sampling runs. Results of individual runs are presented in Section 5 of this report. A summary of the historic J85-GE-5H emissions data is provided in Table III-3 for comparison. These data were collected during a separate emission measurement program in March 1997.

Table III-4 is a detail of the particulate emissions from the J85-GE-5M engine tested at Moody AFB. The condensable particulate fraction at idle and intermediate consists mostly of unburned fuel. It was noted in the field that the condensable fraction was heavily discolored (yellow) with fuel. The organic fraction of the condensible particulate has been removed from these results.

III.2B Hazardous Air Pollutants

Table III-5 depicts the average HAP emissions for each power setting. This table summarizes volatile and aldehyde/ketones compounds. The 11 HAPs shown in Table III-5 are the most frequently detected HAPs that are combustion by-products. Within this table, HAPs have been totaled for each power setting. The remaining HAP data that was analyzed during this sampling program is presented in Section 5 of this report.

TABLE III-1
J85-GE-5M ENGINE (MOODY AFB)
CRITERIA POLLUTANT
EMISSION FACTOR SUMMARY
(lbs/1000 lbs fuel)

	Idle	Intermediate	Military	Afterburner
Exhaust Flow, dscfm	118,704	293,150	544,312	611,727
Fuel Flow, lbs/hr	525	1,045	2,550	7,695
Pollutant				
Nitrogen Oxides (NOx)	0.79	1.81	1.65	1.21
Carbon Monoxide (CO)	191.41	48.90	25.35	10.19
Total Non Methane Hydrocarbons	21.11	1.62	0.45	0.65
Carbon Dioxide (CO_2)	3,503	3,048	3,092	3,116
Sulfur Dioxide (SO_2)[(a)]	0.90	0.90	0.90	0.90
Total Particulate	6.30	10.72	3.66	(b)

(a) - Sulfur dioxide emissions based on sulfur content in fuel (0.045%).
As noted in "Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, January 2002".
(b) - Particulate sampling not performed at afterburner.

TABLE III-2
T-38C WITH PMP TALON (RANDOLPH AFB)
CRITERIA POLLUTANT
EMISSION FACTOR SUMMARY
(lbs/1000 lbs fuel)

	Idle	Intermediate	Military	Afterburner
Exhaust Flow, dscfm	24,956	82,241	120,532	141,922
Fuel Flow per Engine, lbs/hr [(a)]	520	1,030	2,220	7,695[(b)]
Pollutant				
Nitrogen Oxides (NOx)	1.08	0.70	1.92	6.23
Carbon Monoxide (CO)	177.45	65.07	30.99	53.43
Total Non Methane Hydrocarbons	14.61	2.42	0.65	6.06
Carbon Dioxide (CO_2)	2,838	3,025	3,084	7,423
Sulfur Dioxide (SO_2) [(c)]	0.90	0.90	0.90	0.90

(a) - Fuel flow per engine. The T-38 with PMP Talon operates on two J85-GE-5R engines.
(b) - Fuel flow is estimated
(c) - Sulfur dioxide emissions based on sulfur content in fuel (0.045%).
As noted in "Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, January 2002".

TABLE III-3
J85-GE-5H ENGINE (LAUGHLIN AFB)
CRITERIA POLLUTANT
EMISSION FACTOR SUMMARY
(lbs/1000 lbs fuel)

	Idle	Intermediate	Military	Afterburner
Exhaust Flow, dscfm	54,302	127,046	283,270	232,850
Fuel Flow, lbs/hr	434	950	2,740	8,138
Pollutant				
Nitrogen Oxides (NOx)	1.14	1.74	2.92	2.09
Carbon Monoxide (CO)	211.97	123.43	36.40	14.19
Total Non Methane Hydrocarbons	34.02	5.66	0.58	2.29
Carbon Dioxide (CO_2)	2,732	2,953	3,106	3,129
Total Particulate	4.70	1.79	1.13	0.25

NOTE: These data were obtained during a separate emission measurement program in March 1997.

TABLE III-4
J85-GE-5M (MOODY AFB)
EMISSIONS FACTOR SUMMARY
PARTICULATE

	Run Number									
	1		2		3		Composite		Average	
Flow Rate, dscfm[a]	**118,704**		**118,704**		**118,704**		**118,704**		**118,704**	
Fuel Flow, lbs/hr	**525**		**525**		**525**		**525**		**525**	
	lb/hr	**lbs/ 1000 lbs fuel**	**lb/hr**	**lbs/ 1000 lbs fuel**	**lb/hr**	**lbs/ 1000 lbs fuel**	**lb/hr**	**lbs/1000 lbs fuel**	**lb/hr**	**lbs/1000 lbs fuel**
IDLE										
Filterable	1.61	3.06	0.86	1.64	1.26	2.39	0.73	1.39	0.95	1.80
Condensible[d]	3.21	6.12	2.36	4.49	2.21	4.21	2.51	4.79	2.36	4.50
Total Particulate	4.82	9.17[c]	3.22	6.13	3.47	6.60	3.24	6.18	3.31	6.30
INTERMEDIATE										
Flow Rate, dscfm[b]	**293,150**		**293,150**		**293,150**		**293,150**		**293,150**	
Fuel Flow, lbs/hr	**1,045**		**1,045**		**1,045**		**1,045**		**1,045**	
Filterable	3.54	3.39	3.20	3.07	3.12	2.98	1.29	1.24	2.65	2.54
Condensible	7.80	7.46	14.60	13.97	10.38	9.94	7.48	7.16	8.55	8.19
Total Particulate	11.34	10.85	17.80	17.03[c]	13.50	12.92	8.77	8.40	11.20	10.72
MILITARY										
Flow Rate, dscfm[b]	**544,312**		**544,312**		**544,312**		**544,312**		**544,312**	
Fuel Flow, lbs/hr	**2,550**		**2,550**		**2,550**		**2,550**		**2,550**	
Filterable	9.11	3.57	9.16	3.59	8.18	3.21	4.57	1.79	7.30	2.86
Condensible	6.30	2.47	ND	ND	ND	ND	6.08	2.39	2.03	0.80
Total Particulate	15.41	6.04[c]	9.16	3.59	8.18	3.21	10.65	4.18	9.33	3.66

(a) – Exhaust flow rate determined by F-factor
(b) – Exhaust flow rate determined by Carbon Balance
(c) – This run not included in averages.
(d) - Aqueous fraction only, see note below.

NOTE: Particulate measurements not made at Afterburner. It appears that hydrocarbons from unburned fuel are in the impinger solution at the idle and intermediate power settings. This accounts for the majority of the condensable fraction.

TABLE III-5
J85-GE-5M ENGINE (MOODY AFB)
EMISSION FACTOR SUMMARY
(lbs/1000 lbs fuel)

	Idle	Intermediate	Military
Exhaust Flow, dscfm	118,704	293,150	544,312
Fuel Flow, lbs/hr	525	1,045	2,550
Pollutant			
Formaldehyde	2.26	0.35	0.024
Acetaldehyde	0.24	0.02	0.002
Acrolein	0.31	0.01	0.001
MEK	0.08	0.01	0.001
Benzene	0.03	0.02	0.003
Toluene	0.03	0.01	0.0009
Ethylbenzene	0.007	0.002	0.00005
m,p-Xylene	0.02	0.008	0.0004
naphthalene	0.0829	0.00595	0.00466
o-Xylene	0.02	0.005	0.0002
Styrene	0.008	0.002	0.00007
Total HAPs	3.09	0.44	0.04

IV. CONCLUSIONS

During this emission measurement program, several emission phenomena were noted and are summarized below.

- At the idle, intermediate, and military, there was a discoloration in the Method 5 sampling train impingers. The discoloration was heaviest at idle and decreased as power increased. The discoloration was a heavy yellow at the idle setting and was slightly cloudy at military. The yellow material appeared to be unburned JP-8+100 fuel which can be attributed to the engine operating inefficiently at idle. Therefore, the condensible particulate fraction contained unburned fuel. The organic fraction (primarily unburned fuel) of the condensible particulate was approximately 30% at the idle setting and 4% at intermediate. The condensible particulate fraction presented in Table III-4 includes only the aqueous fraction.

- On each particulate filter, the mass collected began to "run" across the filter surface, indicating an organic fraction. When the filter is recovered, a clean ring can be seen on the outer edge of the filter where the filter is held during sampling. This clean ring became discolored over time as the particulate coating was absorbed into the filter material.

- The NO_X data varied the most between the engine and slipstream. This was caused by the high percentage (90%+) of NO_2 in the sample stream behind the engine. The NO_2 converted to N and 0_2 by the time the sample reached the slipstream. Therefore, the mass of NO_X at the slipstream was lower. This is not the expected trend. During a past program, the NO_X concentration was predominantly NO at the engine and NO_2 at the slipstream. This is the expected pattern. NO combines with O_2 in the augmenter tube to form NO_2 at the slipstream.

- The on-wing and test-stand emissions were comparable at all settings with the exception of A/B. At each location the sampling time at afterburner was limited. At Moody AFB, the engine malfunctioned and sampling time was limited to approximately 3 minutes. At Randolph AFB, the engine sampling rake broke after approximately 5 minutes of sampling. Also, the engine sampling rake at Randolph AFB was much closer (approx. 12 feet closer) to the engine exhaust. This position impacts the emission results. In addition, the engine can operate at several different afterburner modes. The engines tested during this program may have operated in different AB modes, resulting in varying emission results.

- During the test program, a field balance accurate to 0.1 mg was used to provide a qualitative measure of particulate gain. During past sampling programs, particulate gain was minimal. Oftentimes the filter weighed less after sampling, due to handling of the filter. The field balance provided an instant indication of particle gain and allowed for sample volume adjustment in the field if necessary.

- The particles in the exhaust stream are predominantly less than 2.5 microns in size (range from 88% - 92% of the total particles). These particles are primarily carbon soot. The larger particles, 2.5 to 10 microns, were found to be agglomerates of smaller combustion particles. These agglomerates accounted for 7% to 12% of the particle total. The largest particles, 7.5 to 10+ microns, were found to be angular particles that are believed to have been cooled and

deposited on a surface and suspended during the test program. Approximately 1% of the particles were greater than 7.5 microns.

- Emissions detected with the use of JP-8+100 were not significantly different from historical emissions detected with the use of JP-8 fuel.

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SECTION 1

INTRODUCTION

This Emissions Summary Report has been prepared by Environmental Quality Management, Inc. (EQ) under Delivery Order 0002 of the Occupational and Environmental Health Assessments Contract (Contract Number F41624-01-D-9012) supporting the Air Force Occupational and Environmental Health programs around the world. This contract is administered by the Air Force Institute for Environment, Safety, and Occupational Health Risk Analysis/Risk Analysis Environmental Quality (AFIERA/RSEQ), Brooks Air Force Base (AFB), Texas.

The project requirements are described in the delivery order and its attached Statement of Work and Contract Data Requirements Lists (CDRL's).

The project includes:

- Preparation of the Sampling and Analysis Plan (SAP) Submitted 15 April 2002, A004).
- Preparation of the Site Survey Report (Submitted 8 April 2002, A011).
- Preparation of monthly progress, status, and management reports (Ongoing, A001).
- Preparation of conference agenda and minutes (A008).
- Preparation of a summary Scientific and Technical Report (this document, A003).

Testing at Moody AFB involved emissions measurement directly behind the engine and at the hush house exhaust for one J85-GE-5M engine operating on a test stand. Testing at Randolph AFB involved gaseous emission measurement directly behind the engine exhaust while a T-38C with PMP aircraft was operating in the hush house. This data was compared to the test-stand emissions data collected at Moody AFB and the historic J85-GE-5H data collected by EQ.

1.1 PROJECT OBJECTIVES

Emission measurement from the J85-GE-5M engine and the T-38C Talon involved several overall project objectives:

1) Provide sufficient data to determine engine "bed down" conformity analysis for compliance with state implementation plans and federal implementation plans for the purpose of attaining or maintaining the national ambient air quality standards.

2) Determine if emission variances exist between on-wing emissions and test-stand emissions.

3) Examine the engine intake modification and its effect on engine emissions.

4) Measure emissions directly behind the aircraft engine and at the hush house exhaust to note pollutant mixing in the augmentor tube. Measure emissions directly behind the aircraft engine at Randolph AFB and compare these data to the engine emission results collected at Moody AFB.

5) Determine if emissions from the J85-GE-5M and -5R modified engine vary from historic emissions data collected from the J85-GE-5H by EQ.

1.2 TEST ENGINE AND LOCATION

1.2.1 J85-GE-5M and -5R

Two J85-GE-5M single-shaft, turbojet engines power the Northrup T-38 Talon. Two J85-GE-5R engines power the T-38C with PMP Talon. The engines are manufactured by General Electric and used throughout the world. The engines consist of a nine-stage compressor section using axial flow, a two-stage axial flow turbine section, and has afterburning capabilities. The overall pressure ratio is 7.0:1. The T-38 aircraft is used as a trainer aircraft due to its ability to reproduce the flying characteristics of a supersonic operational fighter aircraft.

1.2.2 Test Facility

The J85-GE-5M engine was tested in a T-10 hush house at Moody Air Force Base in Valdosta, Georgia. The T-38C Talon was tested in a T-12 hush house located at Randolph Air Force Base in San Antonio, Texas. Facility hush houses were operated by Air Force personnel during testing.

SECTION 2

FACILITY AND SAMPLING APPARATUS DESCRIPTION

As stated in Section 1, testing of the J85-GE-5R engine was performed at Moody AFB and Randolph AFB utilizing JP-8+100 jet fuel. Due to the physical layout of the hush house testing location, the engine exhaust could not be sampled safely or cost-effectively using traditional EPA-recommended emission testing methodologies (Title 40, Code of Federal Regulations, Part 60, Appendix A). In addition, the traditional International Civil Aviation Organization (ICAO) sampling method (Aircraft Engine Emissions, International Standards and Recommended Practices – Environmental Protection, Annex 26, Volume II, First Edition) does not address particulate or HAP analysis, therefore, unique sampling approaches were developed. A description of the Hush house, sampling system apparatus, and general sampling methodology is provided in this section. A more detailed description of the sampling methodology is provided in Sections 3 and 4.

2.1 MOODY AFB HUSH HOUSE OVERVIEW

Military aircraft jet turbine engines are tested in indoor enclosures designed to restrain the engines or aircraft and to provide suitable environmental protection (i.e., noise reduction) while testing occurs. These facilities are known as hush houses. The building functions include supply air filtration, noise suppression, exhaust diversion, and technical support for various test functions. The layout of a typical hush house interior and exterior are illustrated in Figure 2-1. Exterior layout of the T-10 hush house at Moody AFB is included as Figure 2-2. During the test process, an isolated engine is mounted in the rear of the hangar-like enclosure with the exhaust nozzle pointing toward the augmenter tube and out of the building (Figure 2-3). The engine exhaust is directed out of the test facility and into the ambient air via a horizontal elliptical duct (the augmenter tube) which finally directs the air flow upward via a terminal deflector plate in

the blast box (Figure 2-4). The hush house emits combustion products mixed with filtered dilution air directly to the atmosphere at the augmenter tube terminus.

For this test program, the test team collected samples directly behind the engine exhaust nozzle and prior to the exit of a T-10 hush house augmenter tube, near the point of entry into the blast box (Figure 2-5).

2.2 RANDOLPH AFB HUSH HOUSE

As described above, military aircraft jet turbine engines are tested in indoor enclosures designed to restrain the engines or aircraft and to provide suitable environmental protection while testing occurs, namely hush houses. The T-12 hush house utilized for testing at Randolph AFB was smaller than the T-10 hush house used at Moody AFB. During the test process, the aircraft was mounted in the rear of the hangar-like enclosure with the exhaust nozzle pointing toward the augmenter tube and out of the building (see Figure 2-6).

For this test program, the test team collected samples directly behind the engine exhaust nozzles for gaseous emissions only (see Figure 2-7).

2.3 ENGINE EXHAUST SAMPLING RAKE SYSTEM (MOODY AFB AND RANDOLPH AFB)

As part of the test program at Moody AFB, gaseous emissions directly behind the engine were measured at timed intervals (approximately every 30 minutes) in a similar manner described by ICAO. At each location the engine rake was mounted in front of the augmentor tube. Engine exhaust sampling was conducted using a cruciform rake mounted approximately 172 inches downstream from the engine exhaust tip. The cruciform could not be sampled directly behind the engine due to the position of the engine on the test stand. A schematic diagram of the rake assembly is illustrated in Figure 2-8. This system was utilized during a previous test program and was obtained by AFIERA for use during this portion of the engine study. The rake contained eight 1/8-inch orifice ports spaced across four rake arms. A mixed exhaust sample was drawn from the 8 ports and transferred via a single stainless steel tube through filtered and heated

Teflon® lines to the combustion and diluent gas conditioning system and analyzers. The photograph in Figure 2-9 shows the rake assembly mounted behind the J85-GE-5M engine. The rake was installed behind the engine during all phases of engine testing except afterburner.

As part of the test program at Randolph AFB, gaseous emissions were measured for approximately 5 minutes at each setting in a similar manner described by ICAO. Engine exhaust sampling at Randolph AFB was conducted using a cruciform rake mounted approximately 16 inches downstream from the exhaust. The rake contained six 1/8-inch orifice ports spaced across four rake arms. A mixed exhaust sample was drawn from the six ports and transferred via a single stainless steel tube through filtered and heated Teflon® lines to the combustion and diluent gas conditioning system and analyzers. The photograph in Figure 2-7 shows the rake assembly mounted behind the T-38C Talon aircraft tested. The rake was constructed to fit the dimensions of the Randolph AFB T-12 hush house and installed behind the engine during all phases of engine testing except afterburner.

2.4 AUGMENTER TUBE SLIPSTREAM SAMPLING SYSTEM (MOODY AFB)

Access to the area of emissions exhaust is restricted during operation of engines in the hush house due to safety concerns including high temperatures, high velocity and vibration, excessive noise, and the potential of exposure to the exhaust gases. It was therefore necessary to devise a sampling scheme that allowed sampling to be conducted from a remote location, requiring modification to existing point source EPA emission test procedures.

The slipstream (or side-stream) sampling system shown in Figures 2-10, 2-11, and 2-12 was constructed to measure jet engine emissions from the Langley AFB hush house as part of the F100-PW-100 jet engine emission tests conducted in November 1996. Similarities between that testing program and the current sampling effort allowed the sampling system to be applied to the J85-GE-5M engine sampling program completed at the Moody AFB T-10 hush house. The system was designed to extract an augmenter tube exhaust sample to permit use of standard source emission test methods that could not be applied immediately behind the test engine or in the augmenter tube.

A stainless steel pipe, 10 inches in diameter, was utilized to extract a side-stream sample of the diluted engine emissions at a point upstream of the augmenter tube exit. The duct was centered in the augmenter tube and extended approximately 10 feet into the augmenter tube. The duct was supported inside the augmenter tube by two sets of support stands. The duct was directed horizontally toward the rear of the blast box and then turned at an angle out of the blast box to the top of the deflector shield wall, where a transition to a 24-inch by 24-inch square duct occurred. The duct was constructed of stainless steel seamless pipe with flanged ends. Each section was bolted together at the flanged end. Each piece was 10 feet in length except for the inlet and elbows. The larger square duct provided a decrease in gas velocity and a suitable sampling location for applying standard emission testing methods. The inlet to the slipstream was circular, similar to the inlet of a large Method 5 sampling nozzle. At the end of the square duct was a deflector plate to vent emissions upward away from ground activities (see Figures 2-13, 2-14, and 2-15).

The stainless steel slipstream ductwork was supported inside the augmenter tube by attaching pipe risers to existing bolts in the U-channels inside the augmenter tube. Four radial arms with sampling ports were used inside the augmenter tube. Each arm was attached to the hush house wall. Attachments were made to the 10 inch pipe with 10 inch pipe collars and bolts. All bolts were secured with a washer, lock washer, a nut, and a second nut to secure the

lock. Bulkhead fittings were used to provide sampling ports through the C-Channel in the first support brace. Sampling lines were directed through an iron pipe conduit to the exit. The conduit was secured to the supporting braces via bolts and U-clamps. The duct was then fastened to the blast box and supporting scaffolding outside the blast box. This approach provided structural integrity, reduced the cross sectional exposure profile of freestanding duct, and subjected the duct only to radial flow forces on the plate, or turbulent forces along the entire exposed length. Scaffolding fixed to the hush house and ground supported the rectangular ductwork outside the hush house. Scaffolding was secured to each other and to 1/2-inch-thick plywood on the ground to provide further vibration support.

This sample collection structure provided full use of the hush house for purposes other than emission testing. Once the sampling structure was installed, the hush house was used for testing of other engines as needed. This structure did not interfere with the normal operation of the hush house.

Engine exhaust samples were collected at multiple locations along the slipstream. Gaseous emission (CO, NO_x, CO_2, and TNMHC) samples were collected at the slipstream crossbrace from 12 sample ports installed in the brace. Particulate and HAP emission samples were collected from sample ports in the slipstream outside of the hush house.

The locations of the sampling points for the slipstream sampling rake were positioned using EPA Method 1 criterion. Since the augmenter tube is oval shaped and EPA Method 1 does not accommodate this configuration, the points will be determined across the major axis assuming a circular diameter. Similarly, the points across the minor axis were calculated assuming a circular diameter. The slipstream duct was positioned in the center of the augmenter tube. Although the oval cross sectional shape of the augmenter tube is not addressed in EPA Method 1, locating the sampling point inlet at least 1/2 diameter prior to the exit of the tube was consistent with the basic tenets of EPA Method 1. Samples of the augmenter tube exhaust were obtained for combustion and diluent gas analysis using the cruciform rake assembly mounted in the augmenter tube.

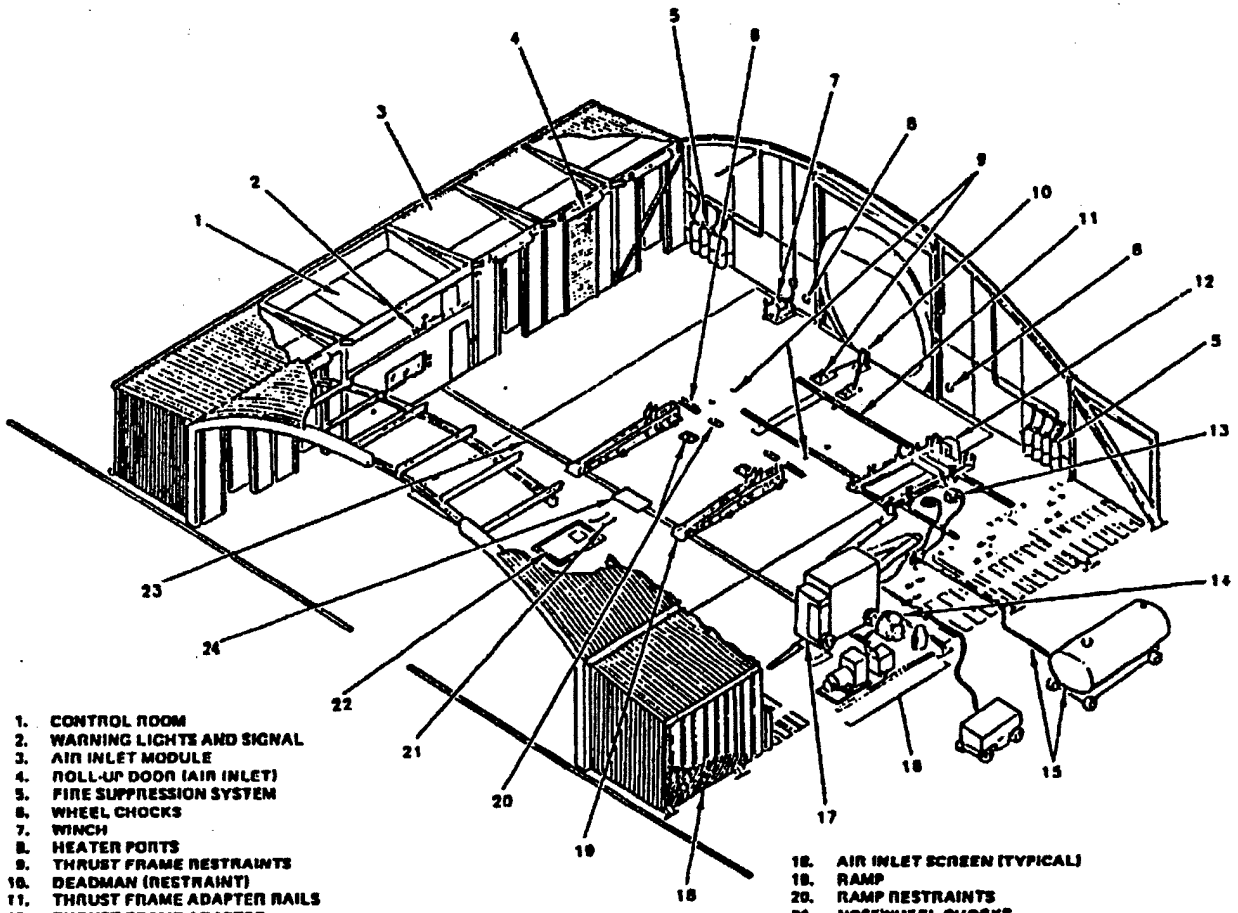

Figure 2-1. Overview of Typical Hush House Physical Layout

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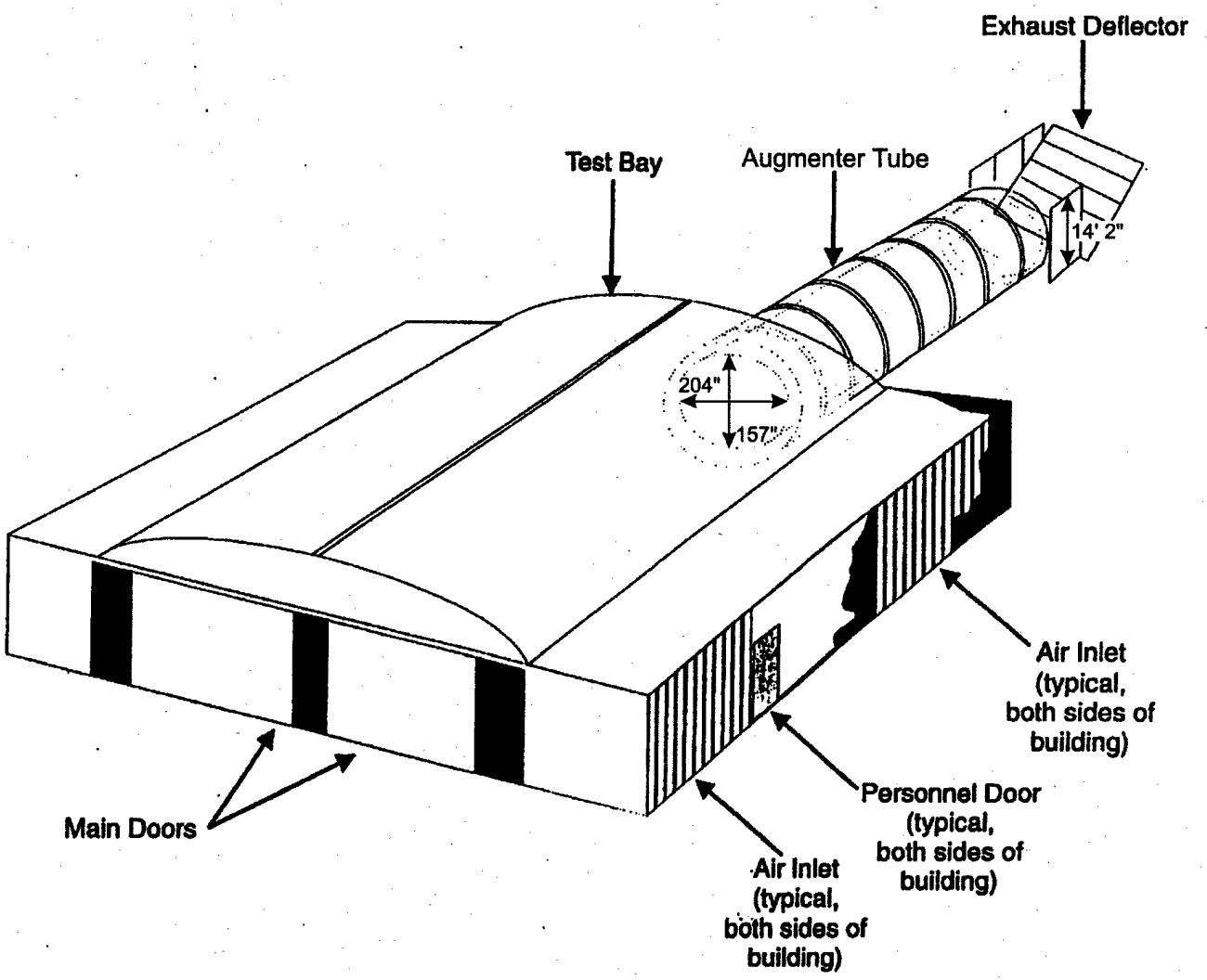

Figure 2-2. Overview of T-10 Hush House Physical Layout
Moody AFB

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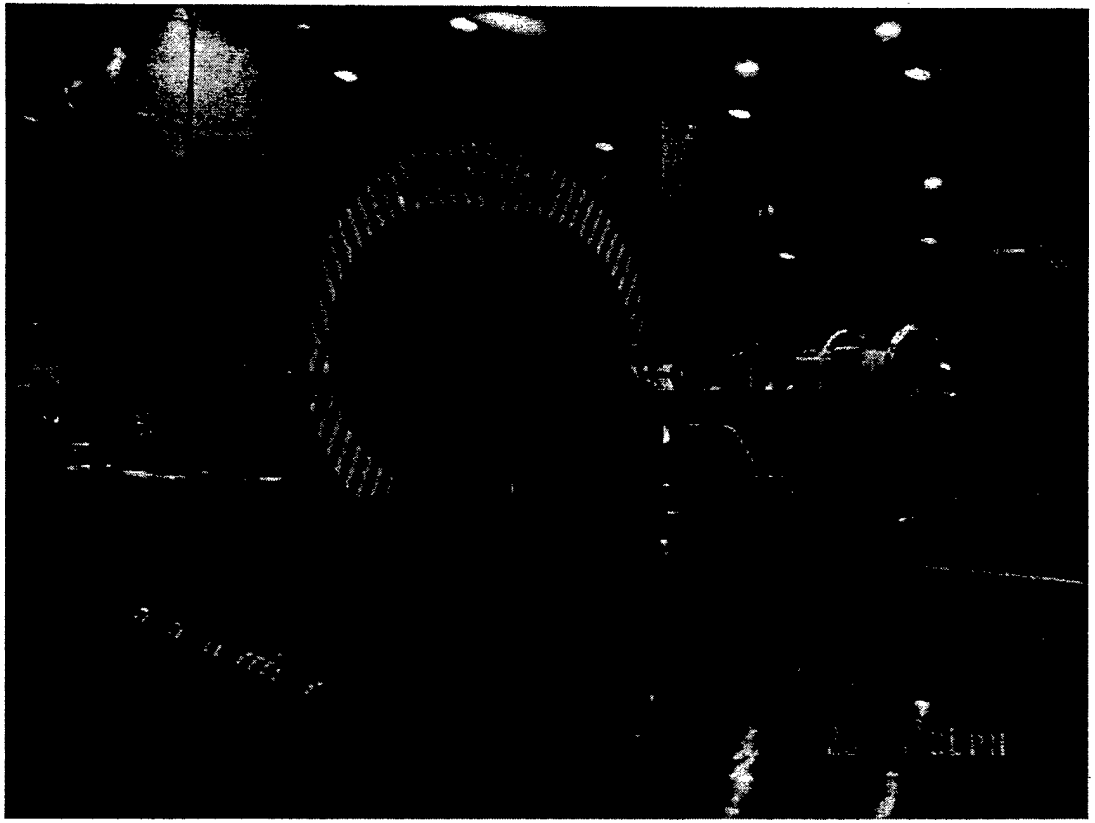

Figure 2-3. Engine Mounted for Testing in T-10 Hush House at Moody AFB

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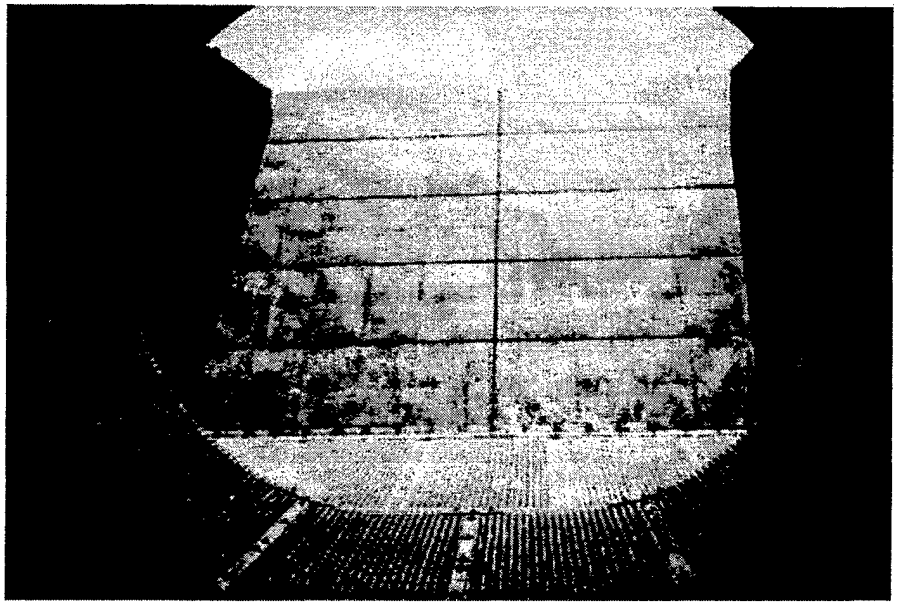

Figure 2-4. Exhaust Deflector Plate, T-10 Hush House at Moody AFB

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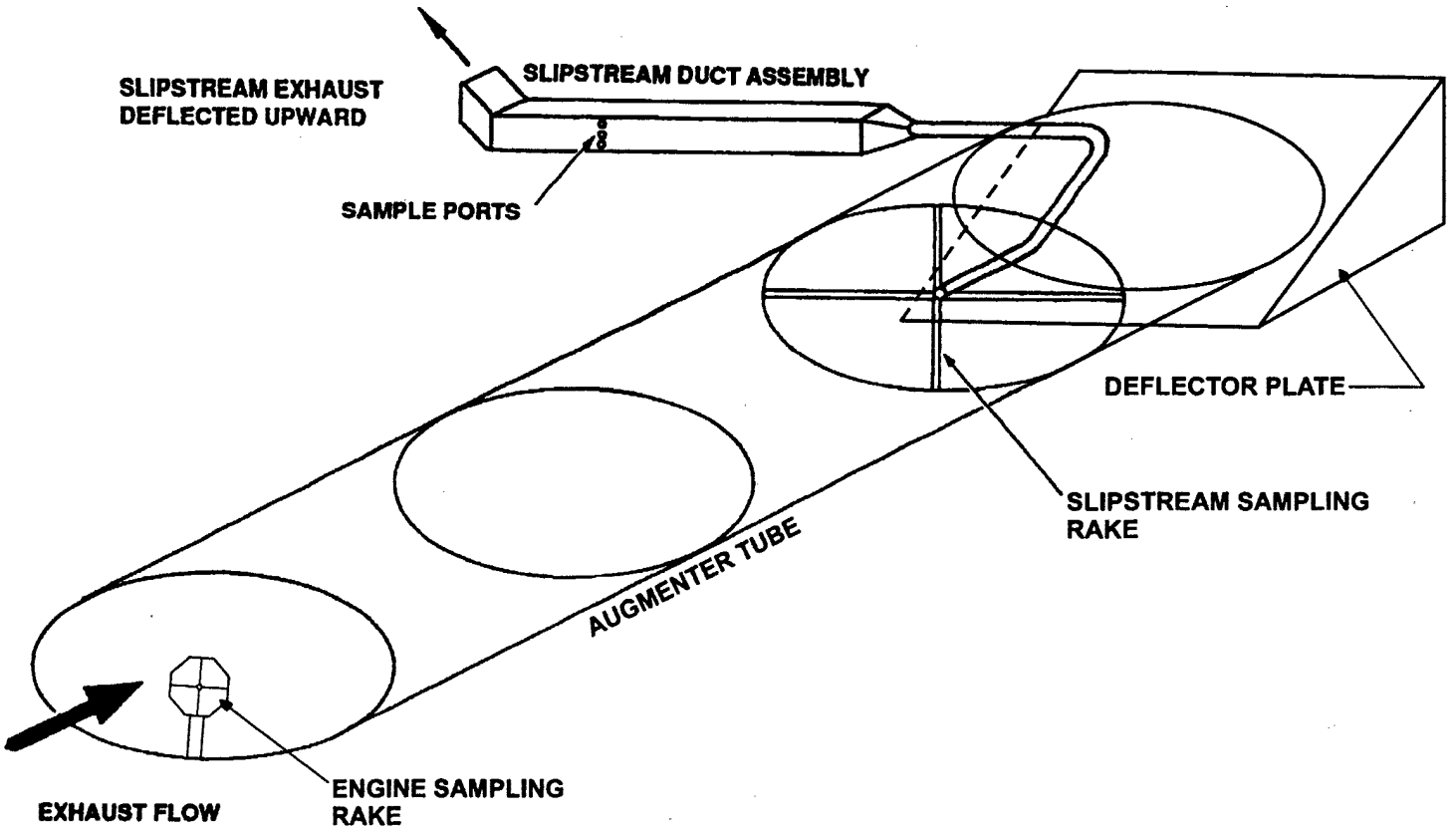

Figure 2-5. Orthogonal View of Slipstream Sampling Apparatus
Moody AFB

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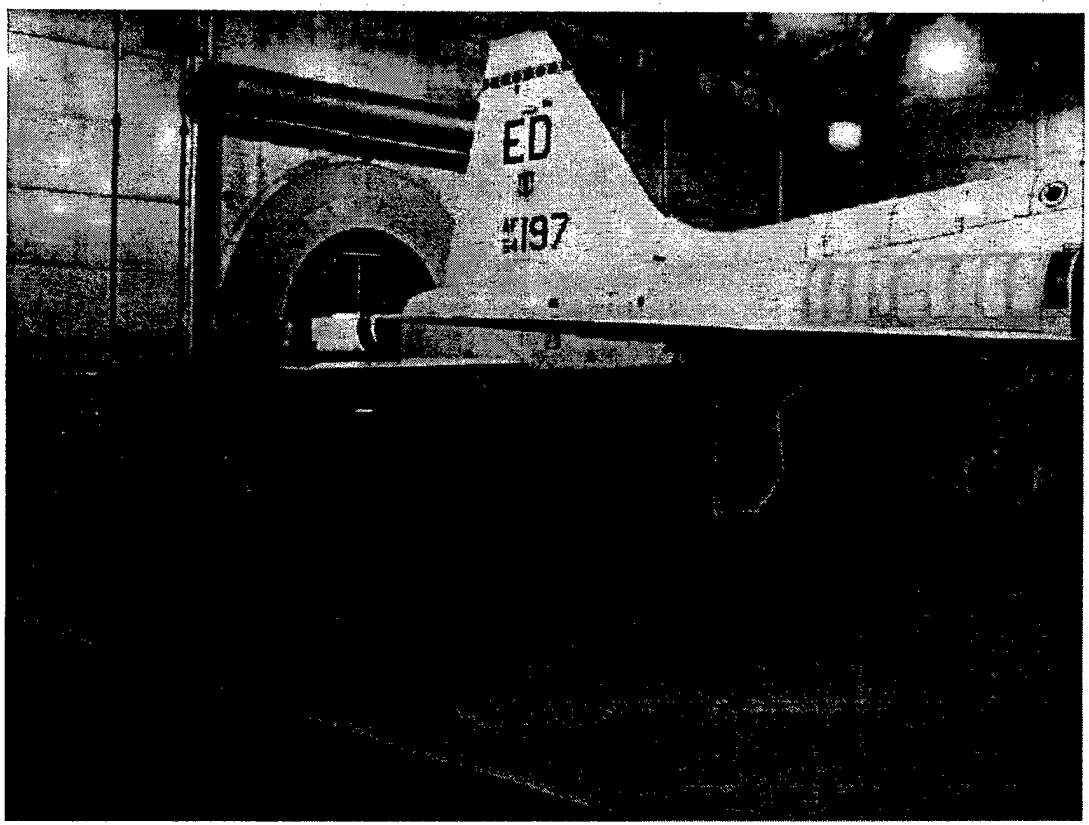

Figure 2-6. Testing of T-38C Talon at Randolph AFB T-12 Hush House

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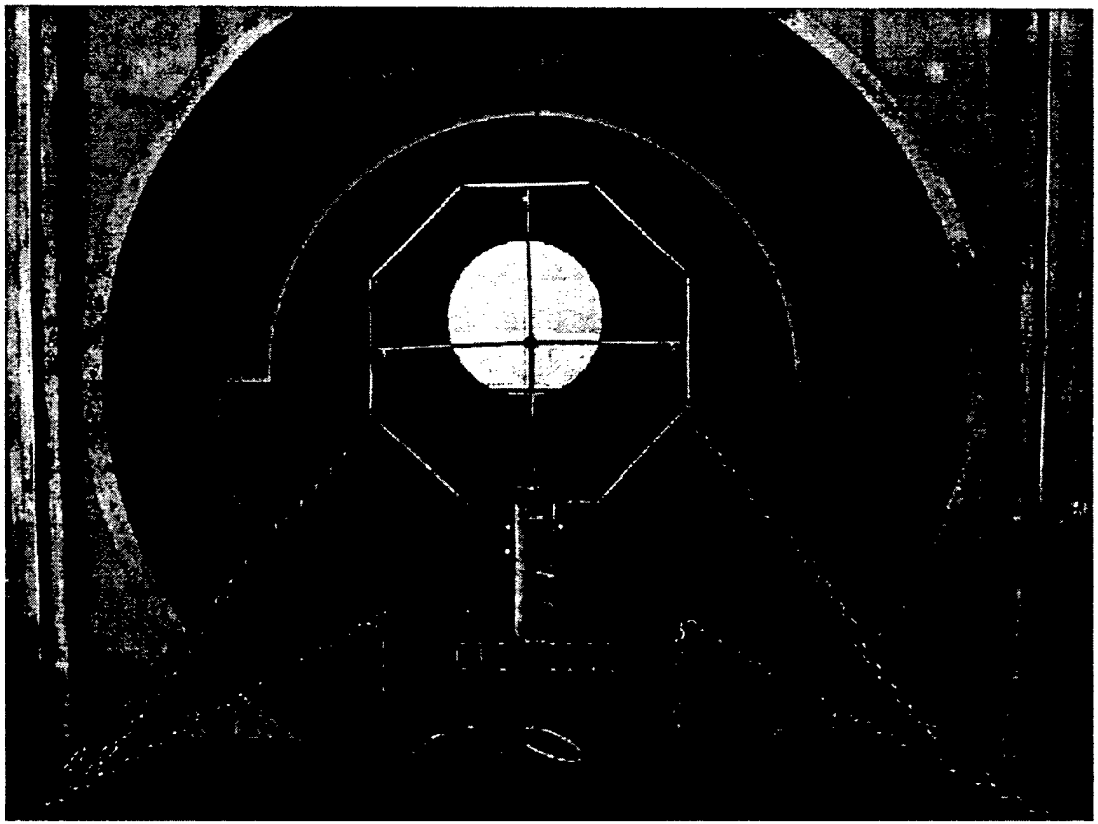

Figure 2-7. Engine Rake at Randolph AFB (Front View into Round Augmenter Tube of T-12 Hush House)

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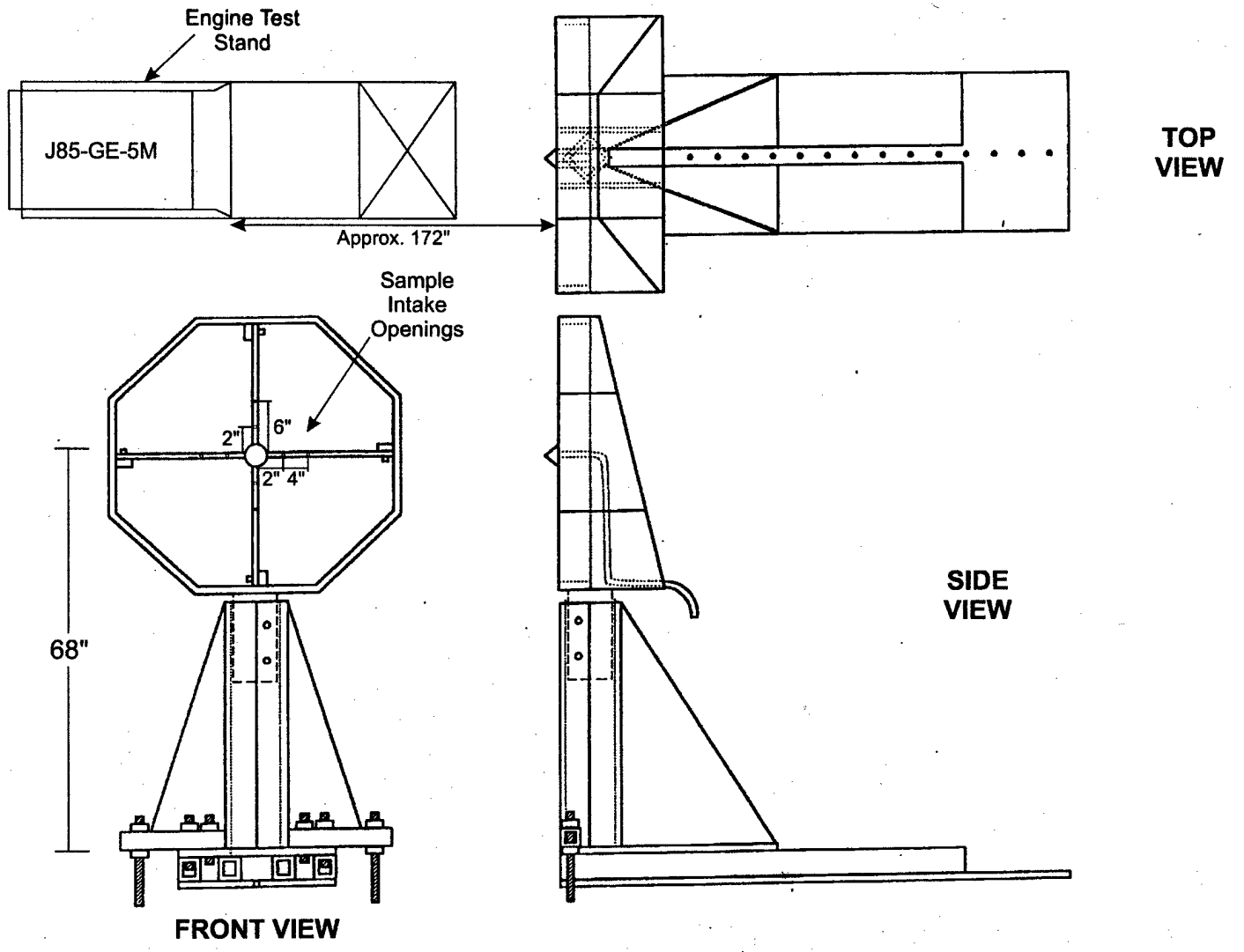

Figure 2-8. Engine Rake Assembly
Moody AFB

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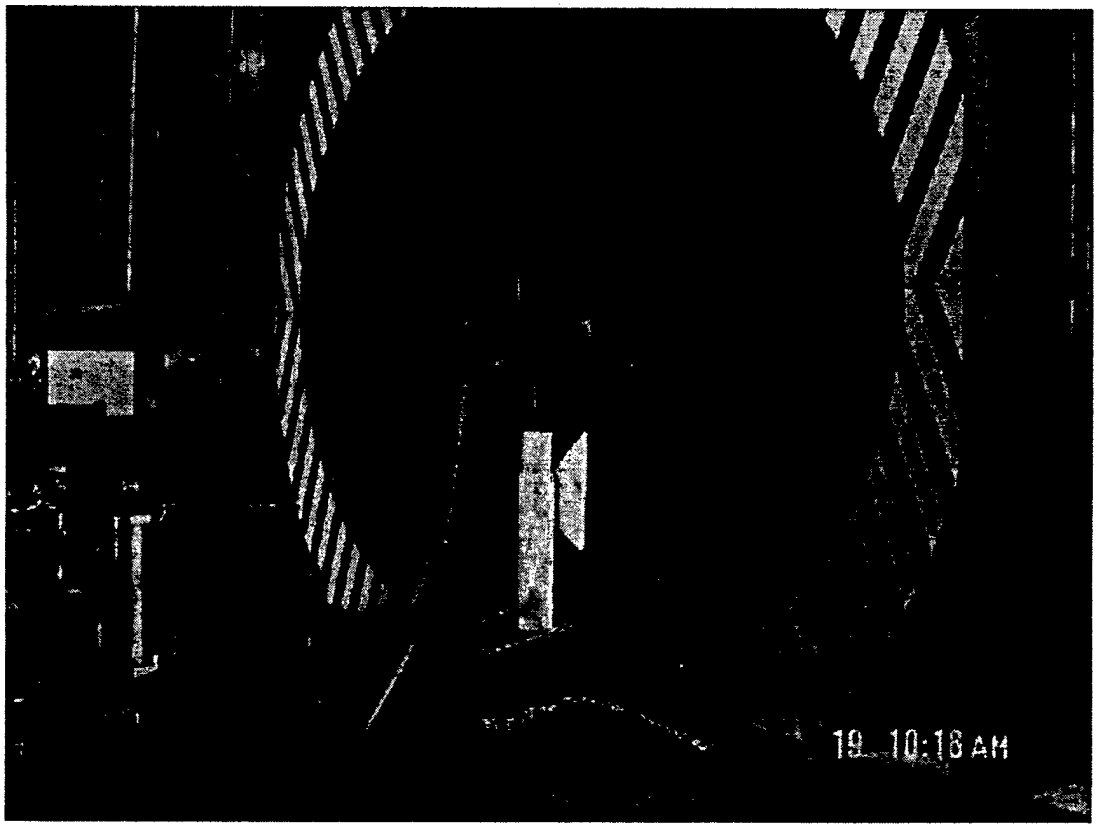

Figure 2-9. Engine Sampling Rake
Moody AFB

EQ ENVIRONMENTAL QUALITY MANAGEMENT, INC.

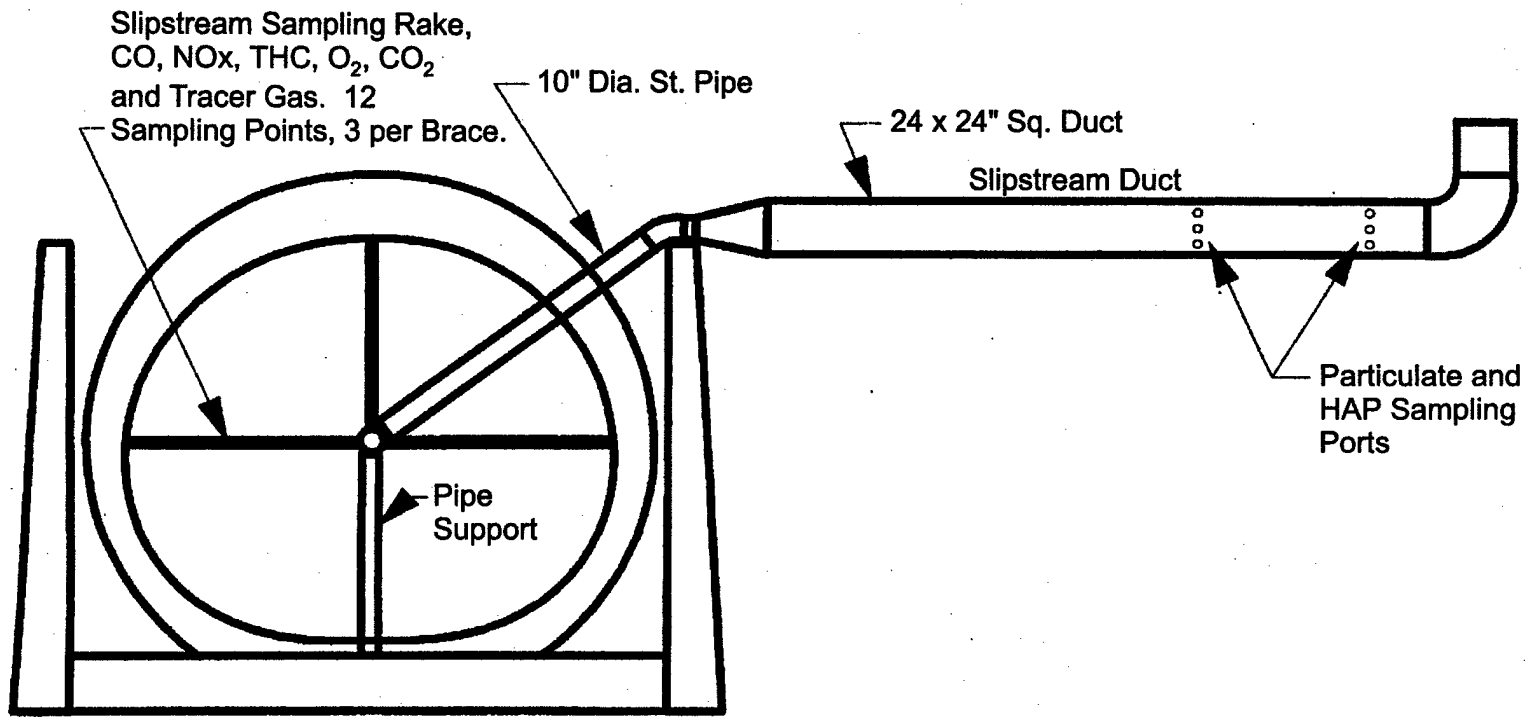

Figure 2-10. Augmenter Tube Slipstream Sampling System
(Front View into Augmenter Tube) at Moody AFB

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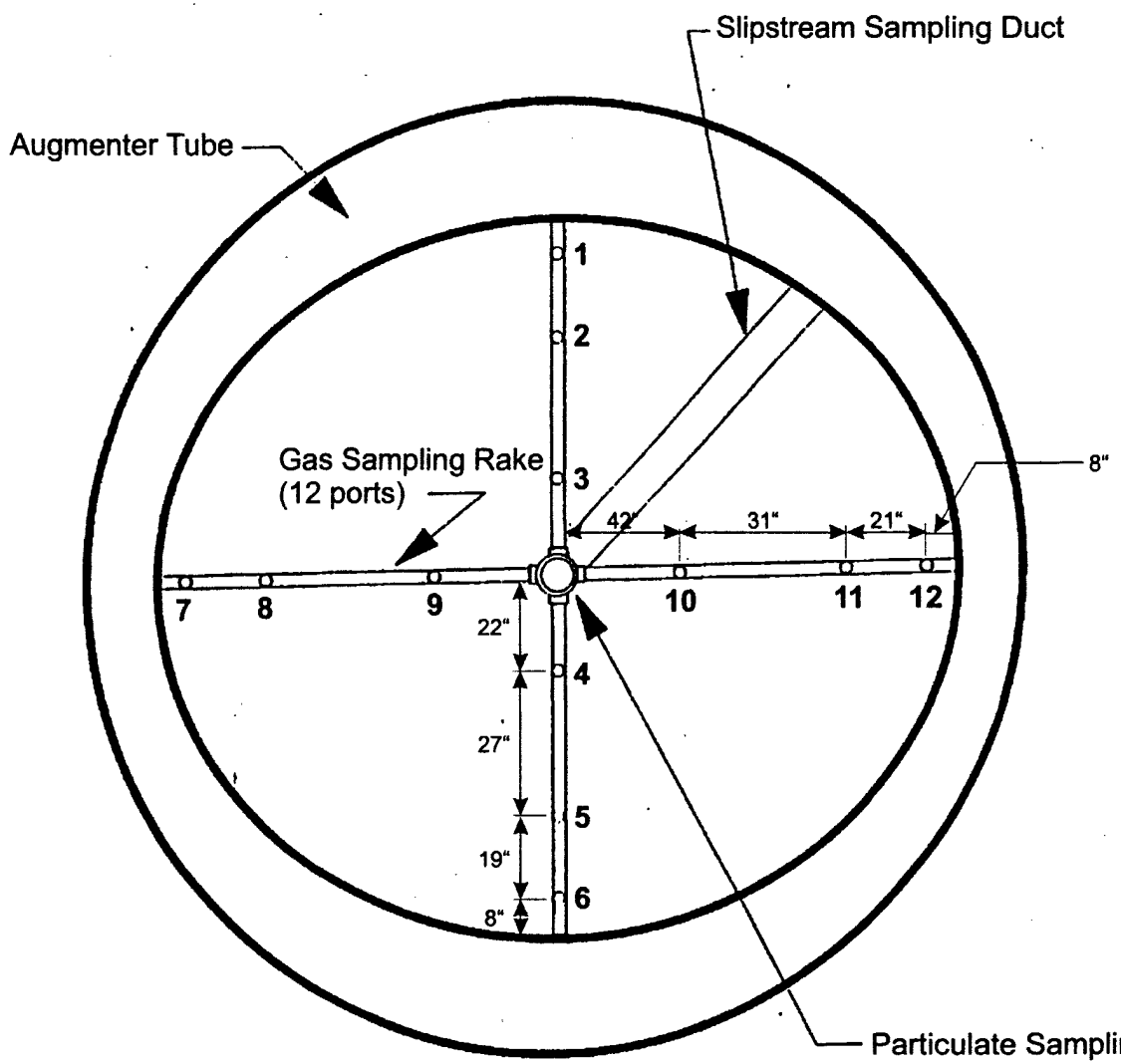

Figure 2-11. Augmenter Tube Slipstream Sampling Rake (View from Test Engine)
Moody AFB

EQ ENVIRONMENTAL QUALITY MANAGEMENT, INC.

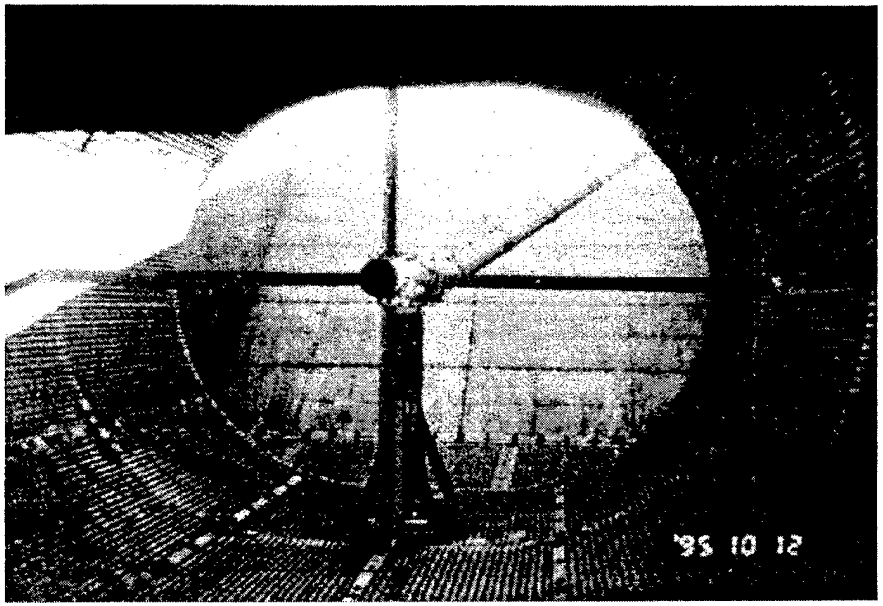

Figure 2-12. Augmenter Tube Slipstream Extraction Tube and Gas Sampling
Moody AFB

EQ ENVIRONMENTAL QUALITY MANAGEMENT, INC.

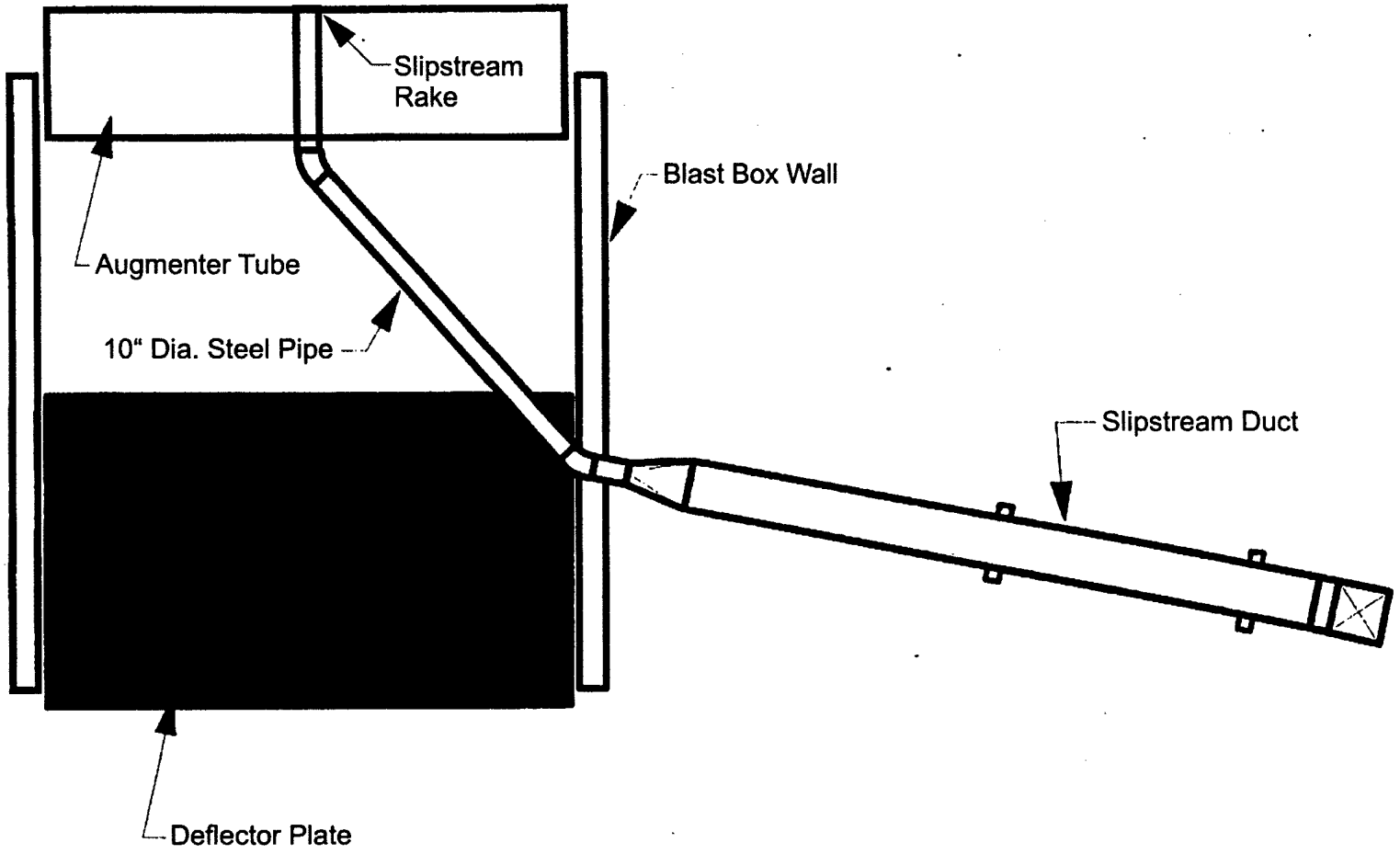

Figure 2-13. Augmenter Tube Slipstream Sampling System
(Top View into Augmenter Tube and Deflector Plate) at Moody AFB

EQ ENVIRONMENTAL QUALITY MANAGEMENT, INC.

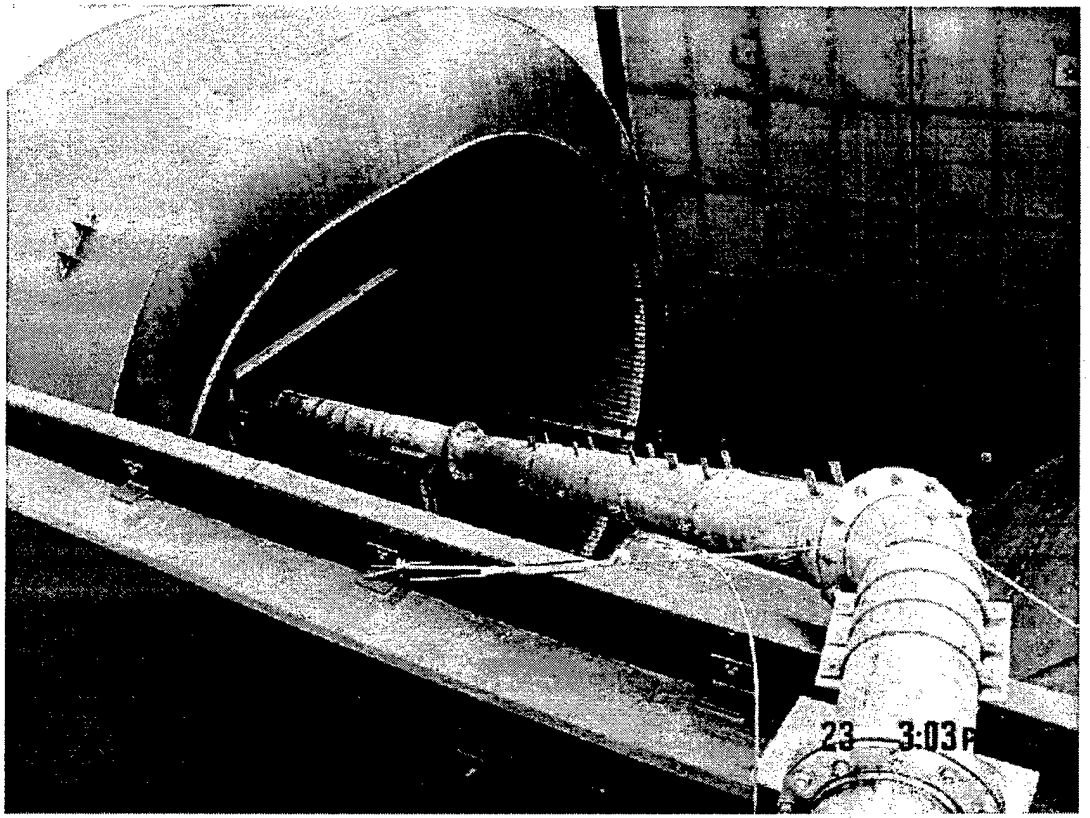

Figure 2-14. Slipstream Transition to T-10 Hush House Exit
Moody AFB

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Figure 2-15. Augmenter Tube Slipstream Sampling System Duct
Moody AFB

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SECTION 3

SAMPLING PROCEDURES AND METHODS

The sample program completed at Moody AFB involved sample collection of emissions from one J85-GE-5M engine at three locations (see Figure 2-5): 1) directly behind the engine (gaseous emissions and select HAPs), 2) at the hush house augmenter tube exit (particulate and HAP), and 3) at the intake to the slipstream inside the augmenter tube (gaseous emissions). The purpose of the multiple sample locations was to note the variance (if any) in gaseous emissions (CO, NO_x, TNMHC) inside the hush house augmenter tube and to look at pollutant dilution and secondary pollutant formation by sampling directly behind the engine. (The sample program completed at Randolph AFB involved sample collection of gaseous emissions from one J85-GE-5M engine at the first location only.) A breakdown of the target pollutants for each engine setting is provided in Table 3-1.

Due to the complexity of the test program, several items are summarized here for consideration. Each item is discussed in more detail in the following sections.

- The exhaust emissions were diluted with cooling air as they pass through the hush house augmenter tube. Sample run times were extended in an attempt to attain the lowest detection limits.

- Engine exhaust velocities in the rear of the augmenter tube at the idle setting were expected to be very low, possibly unmeasurable. A hot wire was used to measure exhaust velocity in the slipstream at the rear of the hush house, and the flow was calculated.

- Particulate measurements at the hush house exhaust were run at an isokinetic sampling rate while attempting to maximize sample volume and retain filter integrity as well as particle catch. Sample run times were 3 hours at the idle setting and 2 hours at the remaining settings.

TABLE 3-1. J85-GE-5M, MOODY AFB TARGET EXHAUST POLLUTANTS FOR EACH ENGINE SETTING

	Sampling Duration	Particulate Matter	HAPs (VOC, ALD/KEY)	NO_X	TNMHC	CO	CO_2	O_2
Idle	9 hours (Three 3-hour test runs)	X	X	X	X	X	X	X
Intermediate	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X
Military	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X
Afterburner	25 minutes (Five 5-minute runs)			X	X	X	X	X

Note: Grab samples for benzene and formaldehyde were collected directly behind the engine at idle, intermediate, and military.

- One composite particulate sample was collected at each setting. This sample was collected in conjunction with the three replicate sample runs in an attempt to obtain a measurable quantity of particulate matter.

- One particulate sample at each setting was analyzed by scanning electron microscopy for particle size distribution (by particle count) and morphology (see Table 3-2).

- All sampling was conducted while the aircraft was burning JP-8+100 fuel.

TABLE 3-2. PERCENTAGES OF CARBON PARTICLES IN VARIOUS DIAMETER RANGES BY NUMBER OF PARTICLES

	Idle	Intermediate	Military	
Filter Number	**PC001**	**PC002**	**PC003**	**Blank**
Diameter Range (um)				
.5-2.5	92.4%	88.2%	89.4%	NA*
2.5-5.0	6.7%	10.8%	8.7%	
5.0-7.5	1.0%	1.0%	1.0%	
7.5-10	0.0%	0.0%	1.0%	
>10	0.0%	0.0%	0.0%	

*NA – Insufficient particles for a valid statistical analysis

3.1 GENERAL SAMPLING CONSIDERATIONS/COMPLICATIONS

Access to the interior of the hush house was restricted to periods when the engine/aircraft was not operating. It was therefore necessary to devise a sampling scheme that allowed sampling to be conducted from a remote location, requiring some modification to existing test procedures. The slipstream sampling approach allowed particulate matter and HAP testing personnel to be located outside the exclusion zone.

The physical structure of the exhaust through the augmenter tube did not allow for use of the traditional isokinetic sampling methodologies (Title 40, Code of Regulations, Part 60, Appendix A, Methods 1-5). Complicating factors included large amounts of dilution air and limited testing windows. Based on these considerations, several assumptions were made to address the unique nature of this program. Assumptions included homogeneous mixing of the exhaust stream (verification of this assumption was made in the field); theoretical methods for determining air flow through the system; and particulate distribution behavior equivalent to gaseous. These assumptions were based on previous engine testing programs.

3.1.1 Pollutant Distribution in the Augmenter Tube

The test program was based on the assumption that, as the exhaust gas exits the test stand through the augmenter tube, the exhaust stream from the engine and the dilution air have reached a homogeneous mixture. A sample drawn from each of the 12 sample points on the slipstream support (Figure 2-11) showed that the gas stream was homogeneous in the hush house augmenter tube at approximately 60 feet behind the jet engine exhaust point. The complete mixing of exhaust gases and the dilution air are the result of the very turbulent flow from the jet engine exhaust and rough (open-pore) augmenter tube surface. Particulate size distribution in the engine exhaust has been shown to be significantly less than 10 microns (μm) in size. Because of the size of the particles, it was assumed that they behaved as an aerosol or gas and that pollutants were distributed evenly throughout the test stand exhaust. Since it was assumed that all particulate (and those contaminants bound to the particulate) would behave as an aerosol, any point in the augmentor tube would have the same concentration of pollutants. This assumption was used as the basis to conduct single-point (center-point) isokinetic sampling at one point in the exhaust, which would be representative of all points in this engine test exhaust.

3.2 EMISSION MEASUREMENT APPROACH

Sampling was performed for criteria pollutants and those HAPs that are products of incomplete combustion (PICs). The following compounds were monitored from the slipstream sampling system at the rear of the hush house augmenter tube (Moody AFB):

- Filterable and condensible particulate (EPA Methods 5 and 202), including particle size distribution.
- Aldehydes and ketones (EPA Method 0011).
- Volatile organic compounds (VOCs) (EPA Method 0030), including 1,3 butadiene.
- Oxygen and carbon dioxide (EPA Method 3A).
- Carbon monoxide (EPA Method 10).
- Nitrogen oxides (EPA Method 7E).

- Total hydrocarbons (THCs) (EPA Method 25A). Total hydrocarbons reported as total non-methane hydrocarbons.
- Methane (EPA Method 25A).
- Polynuclear Aromatic Hydrocarbons (NIOSH Method 5506)
- Benzene and formaldehyde (grab samples directly behind the engine).

The following compounds were monitored from the engine rake sampling (Moody and Randolph AFB):

- Oxygen and carbon dioxide (EPA Method 3A).
- Carbon monoxide (EPA Method 10).
- Nitrogen oxides (EPA Method 7E).
- Total hydrocarbons (THCs) (EPA Method 25A).
- Methane (EPA Method 25A).

The engine exhaust system was not sampled for sulfur dioxide, metals or semi-volatiles. Sulfur dioxide emissions were determined by measuring the sulfur content in the JP-8+100 fuel and converting sulfur mass emissions to sulfur dioxide mass emissions. This is based on the procedure documented by AFIERA ("Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations," January 2002). Concentrations of the following metals were determined in the fuel analysis: antimony, arsenic, barium, beryllium, cadmium, cobalt, chromium, copper, lead, manganese, mercury, nickel, phosphorus, selenium, silver, thallium, and zinc. Dioxins, furans, semi-volatiles and HAPs not discussed in the subsequent text were emitted in quantities too small to be detected by the sampling methods proposed in this program. Therefore, these pollutants were not included in the sampling program.

Grab samples were collected behind the engine at the engine rake to determine the concentration of benzene and formaldehyde. This was performed from the idle to military engine settings.

The unique feature in conducting emissions testing for this engine was that the exhaust stream at the T-10 and T-12 hush house exhausts were diluted with ambient air (significantly diluted at the T-10 hush house). This presented two problems: (1) the volume of exhaust gas was significantly increased; and (2) dilution of the exhaust made it difficult to detect various pollutants. Sample run times were extended and analytical methods were revised in order to

reduce the detection limits. During past emission measurement programs, ambient pollutants were monitored in order to correct the measured exhaust parameters. Due to the location of the hush houses at Moody AFB and Randolph AFB, the influence of other pollutant contributing sources was minimal. Therefore, ambient air monitoring was limited to CO_2, CO, and TNMHC in order to complete the carbon balance calculations.

3.2.1 Flow Rate Measurement

As stated previously, standard flow rate measurements could not be performed at the test locations due to the hush house configuration. Engine exhaust flow was determined by theoretical methods (carbon balance and F-factors). An attempt was made to measure the flow directly by fixing a pitot tube to the engine rake at a single point. Velocity readings were taken in this manner while the engine operated at idle and intermediate settings. Flow calculations were questionable, because the volume of air entering the augmenter tube was not definitive. However, this method provided an additional point for comparison. The use of multiple-flow measurement/calculation methods provided a firm basis for identifying and rejecting outlier data. For example, the calculated exhaust flow using the f-factor methodology showed a decrease in airflow between the military and afterburner settings. Therefore, carbon balance was used as the selected flow methodology. The flow data collected by all methods for the engine at different operating conditions. An established relationship was expected between engine operating level and total flow. All flow measurement methods were anticipated to provide valid data at one or more operating conditions. The data evaluation identified which measurement deviates from that relationship, and whether that deviation can be attributed to a physical parameter such as temperature, oxygen concentration, etc. If the deviation was predicted (e.g., high oxygen concentration impact on F-factor calculation), that data was discarded. If there was no obvious physical explanation, best-fit estimates at other loads were used to identify and reject the outlier methodology.

Inlet concentrations for some compounds were measured as part of the theoretical flow determination method using carbon balance and F-factors. At the inlet location, THC was measured using a hydrocarbon analyzer identical to the one that measured engine exhaust gas THC. An inlet carbon dioxide (CO_2) measurement was also required as input to the theoretical

flow model. An ambient CO_2 monitor was used to measure the inlet CO_2 concentration during each test run.

The J85-GE-5H engine was tested by EQ in the past. The exhaust flow was calculated using identical theoretical methods including tracer gas methodologies. The most representative flow determination method was carbon balance. These flows were used for comparison with the exhaust flows determined in this program.

Section 4 discusses in detail the methodologies that were applied to calculate air flow at the hush house engine test facilities.

3.2.2 Pretest Measurement

Preliminary test data for the Moody AFB sampling program was obtained at the slipstream during the shakedown runs. Preliminary flow rate data and gas composition data were collected. Augmenter tube and slipstream sampling geometry measurements were obtained and recorded, and sampling point distances verified. A preliminary velocity traverse was performed in the slipstream utilizing a calibrated S-type pitot tube and a Dwyer inclined manometer to determine velocity profiles. However, flow was not detectable using this methodology. Therefore, a hot wire anemometer was used to measure velocity and flow was back-calculated. Exhaust gas temperatures were observed with a calibrated direct readout pyrometer equipped with a chromel-alumel thermocouple.

A check for the presence or absence of cyclonic flow ("swirling" stack gas flow that is not flowing parallel to the stack walls) was conducted in the slipstream. Preliminary test data was used for nozzle sizing and sampling rate determinations. Probe nozzles, pitot tubes, metering systems, and temperature measurement devices were calibrated on site as specified in Section 5 of EPA Method 5 test procedures.

3.2.3 Gaseous Emission Measurement

Continuous emission analyzers were utilized to measure gaseous pollutants at several locations during both the Moody and Randolph AFB test programs. NO_x, CO, TNMHC, CO_2, and O_2 were measured continuously according to the procedures in EPA Methods 7E, 10, 25A, and 3, respectively. In order to measure the relatively low concentration of CO_2 in the exhaust stream, an

analyzer equivalent to a Siemens Ultramat SE analyzer, was used. This analyzer meets the specifications established by Pratt & Whitney Engineers during prior test programs.

At Moody AFB, two complete sets of continuous emission analyzers were used to monitor emissions. One set of analyzers was dedicated to the slipstream system. The slipstream intake contained 12 sample intake ports (Figure 2-11). Each port was sampled individually so that pollutant distribution was verified. In addition, a composite sample was collected from all 12 points after pollutant distribution was verified. The second complete set of continuous emission analyzers alternated monitoring between the hush house cooling air intake and the engine cruciform directly behind the engine. The cruciform contained eight sample intake ports (Figure 2-8) that were used to collect a composite sample directly behind the engine. A heated sampling line was run to each location and a tee valve installed so that the sample stream could be diverted at approximately 30-minute intervals.

Similarly, a complete set of continuous emission analyzers was utilized at Randolph AFB to monitor emissions from the engine cruciform directly behind the engine. The cruciform contained six sample intake ports (Figure 2-7) that were used to collect a composite sample directly behind the engine.

3.2.4 Particulate Measurement

The collection of particulate matter from aircraft engines is difficult due to the lack of particulate present in the exhaust stream. The aircraft engines are highly efficient and thus produce minimal particulate matter, and the exhaust stream may be slightly diluted. Due to the difficulty in obtaining a measurable quantity of particulate matter from the engine exhaust using EPA test methodologies, the method was adapted to provide the best opportunity for particle collection. EPA Method 5 was utilized, but the sample run times were extended to three hours in length at the idle setting and two hours in length for the remaining settings. In past programs, a one-hour test duration was utilized and the isokinetic sampling rate was maximized in order to increase the sample volume. This resulted in filter material loss to the impingers and a high vacuum on the filter holder which resulted in filter material adhering to the support frit gasket. This caused filter material loss and a negative net mass gain with respect to filterable particulate matter.

In order to minimize method error and maximize the potential for particle gain, EPA Method 5 was followed in order to gain regulatory acceptance; the sample run time was extended to three hours at idle setting and two hours at intermediate and military while maintaining a steady sample flow rate so the filter material was not pulled to the impinger solutions. A Teflon filter support frit without a rubber gasket was used to minimize filter loss during sample recovery. The entire Method 5 sample was measured as total particulate. Therefore, the filterable fraction and condensible fraction were added together to provide a total particulate matter result. This assisted in accounting for any filter loss that may have carried to the impingers.

EPA Method 5I was considered as part of this program. This method is specific to low particulate concentrations and uses a smaller filter and increased sample rate. This method was considered but was not utilized based on past experience. In past sampling, the smaller filter surface area increased the method error when a small portion of the filter was lost. This resulted in a loss of mass.

In a further attempt to collect a measurable quantity of particulate matter, a composite particulate sample was also conducted at each setting simultaneously with the three sample runs. The composite sample run followed EPA Method 5 procedures for a 9- or 6-hour duration.

In order to assess the success of particle collection in the field, an analytical balance was brought to the test site for field weighing of the sample filters. The field weights were used as a qualitative indication of the particle catch on the filters. This indication allowed the test team to make adjustments in the field to maximize the opportunity for particle collection.

For each engine setting, one particulate sample was analyzed by scanning electron microscopy (SEM) equipped with an Iridium X-ray Fluorescence (IXRF) digital image system to determine the particle size distribution by count and the aerodynamic particle shape. The EPA Method 5 filter media was modified for the sample to accommodate the SEM analysis. A polycarbonate filter media was used. The exact filter media was discussed with the analytical laboratory based on the intent of gaining the highest possible quantity of measurable particulate matter. Based on inspection of the polycarbonate filter at idle setting, run times were shortened to approximately half duration of the remaining two runs. This was completed so that particulate matter collected on the filter did not become so dense that the SEM would not be effective.

3.2.5 Hazardous Air Pollutant Sampling

Sampling for select HAPs was conducted at the slipstream. Based on historical sampling programs, volatile organic compounds, aldehydes and ketones, and Polynuclear Aromatic Hydrocarbons (PAH) were the target of the sampling program. Volatiles were sampled at the slipstream using EPA Method 0030 and aldehydes and ketones were measured according to the procedures in EPA Method 0011. One aldehyde/ketone and PAH sample was collected at each setting in order to maximize sample volume. Three volatile samples were collected at each setting. National Institute of Occupational Safety and Health (NIOSH) Method 5506 was used to collect a sample for PAH at each setting. A sample was drawn through an in-stack filter across an XAD-2 resin trap at approximately 1 lpm. A single 1-hour sample was collected over each setting.

3.2.6 Direct Engine Exhaust Measurement

During each sample run, a single sample was collected directly behind the engine for gaseous pollutant analysis at the idle, intermediate, and military settings. The sample was collected from the engine cruciform situated directly behind the engine. These data were compared to the gaseous emissions data collected at the slipstream to note dilution ratios and possible secondary chemistry with the dilution air.

At the idle, intermediate and military engine settings a single grab sample was collected for Benzene and Formaldehyde. Benzene was collected via TO Method 14 and Formaldehyde was analyzed via TO Method 11.

3.2.7 Emissions Test Methods

The following paragraphs discuss methods that were utilized for emissions testing. Furthermore, Appendix B presents the emissions sampling methods in greater detail, including descriptions of all exhaust emissions test sampling trains, sample preparation, sample procedures, sample recovery, and analytical procedures.

3.2.7.1 Particulate Sampling

EPA Method 5 was used for particulate sampling at the slipstream exhaust at Moody AFB. The sampling train utilized to perform particulate sampling conformed to EPA Reference Methods 5 and 202 for the collection of both filterable particulate and back-half condensible particulate. One particulate sample at each setting was submitted for analysis of particle size distribution and shape. The particulate was analyzed using a scanning electron microscope (SEM) equipped with an IXRF iridium digital image system.

3.2.7.2 Aldehyde and Ketone

The sampling train utilized to perform aldehyde and ketone sampling at Moody AFB conformed to EPA Method 0011. In order to increase sample volume and meet method detection limits, a single sample was collected at each setting. For example, at the idle setting, a 9-hour sample was collected.

3.2.7.3 VOCs

The sampling train utilized to perform VOC sampling at Moody AFB conformed to EPA Reference Method 0030. Table 3-3 lists the VOCs that were analyzed for in each sample. Three VOC samples were collected at each setting and ran simultaneously with the particulate runs.

3.2.7.4 Polynuclear Aromatic Hydrocarbons

National Institute of Occupational Safety and Health (NIOSH) Method 5506 was used to collect a sample for PAH at each setting. A sample was drawn through an in-stack filter across and XAD-2 resin trap at approximately 1 lpm. A single 1-hour sample was collected over each setting.

3.2.7.5 Carbon Monoxide, Carbon Dioxide, Oxides of Nitrogen, and Oxygen

Sampling was performed using a continuous emissions monitoring system (CEM) for oxygen and carbon dioxide (EPA Method 3A), carbon monoxide (EPA Method 10), and nitrogen oxides (EPA Method 7E) at both Moody AFB and Randolph AFB. Due to the expected low concentration of CO_2 in the exhaust stream, Siemens Ultramat 5E was used. The analyzer has

TABLE 3-3. SUMMARY OF SOURCE TARGET COMPOUNDS FOR VOLATILE ORGANIC COMPOUNDS

VOST Compounds – Clean Air Act List	
Acetone	trans-1,2-Dichloroethene
Benzene	1,2-Dichloropropane
Bromodichloromethane	cis-1,3-Dichloropropene
Bromomethane	trans-1,3-Dichloropropene
Bromoform	Ethylbenzene
2-Butanone	2-Hexanone
1,3 Butadiene	Methylene chloride
Carbon disulfide	4-Methyl-2-pentanone
Carbon tetrachloride	Styrene
Chlorobenzene	1,1,2,2-Tetrachloroethane
Chlorodibromomethane	Tetrachloroethene
Chloroethane	Toluene
Chloroform	1,1,1-Trichloroethane
Chloromethane	1,1,2-Trichloroethane
1,1-Dichloroethane	Trichloroethene
1,2-Dichloroethane	Trichlorofluoromethane
1,1-Dichloroethene	Vinyl acetate
Cis-1,2-Dichloroethene	M,P-Xylene
	O-Xylene

the ability to measure the concentration in several ranges: 0-2%, 0-5%, and 0-10% CO_2 with accuracy to three decimal places.

3.2.7.6 Methane and Non-methane Hydrocarbons (NMHC)

NMHCs were measured directly at Moody AFB and Randolph AFB using a J.U.M. Model 109A methane/non-methane hydrocarbon analyzer. The Model 109A contains two flame ionization detectors (FIDs). The sample is split before being sent to the respective FIDs. One fraction is passed through a catalytic converter to combust all non-methane hydrocarbons (to CO_2) before the sample is measured in the FID. The methane residual in the sample is the only component that is measured by that detector. The other sample fraction is sent to the second FID, which measures the total hydrocarbon concentration of the sample. Both FIDs are initially calibrated with a methane calibration standard, so both the total hydrocarbon and the methane residual are measured as methane. The difference between these two values is automatically determined and reported as non-methane hydrocarbons by the Model 109A.

Any sampling configuration which splits the sample stream, analyzes one fraction for total hydrocarbons and catalyzes the remaining fraction to remove non-methane hydrocarbons before analysis of the methane residual was considered the equivalent of the J.U.M. Model 109A. The equivalent analyzer configurations can employ two parallel hydrocarbon analyzers, with a J.U.M. Model 900 NMHC-cutter treating one fraction of the sample, or using a single hydrocarbon analyzer and catalytic pre-cutter, with the FID alternating between the total and methane residual fractions. The analyzer was challenged with a zero and span gas at the beginning and end of each sample day to calibrate and assess the instrument's calibration.

3.2.8 Hush House Inlet Air Sampling

Due to the location of the Moody T-10 and Randolph T-12 hush houses, the influence of ambient pollutants on the measured concentrations from the engine exhaust were negligible. Therefore, the hush house inlet was monitored for CO, CO_2, O_2, and TNMHC in order to complete the carbon balance and f-factor flow calculation.

Sampling was performed using a continuous emissions monitoring system (CEM) for oxygen and carbon dioxide (EPA Method 3A), carbon monoxide (EPA Method 10), and total non-methane hydrocarbons (EPA Method 25A). Due to the expected low concentration of CO_2 in the exhaust stream at the slipsteam, a low concentration CO_2 monitor was utilized to measure CO_2. The CO_2 analyzer had the ability to measure the concentration in several ranges: 0-1,000 ppm, 0-1% and 0-5% CO_2.

3.3 ENGINE TESTING MATRIX

3.3.1 Engine Shakedown Runs

Prior to the commencement of emission testing, a preliminary set of gaseous emission and exhaust flow data were determined at each setting except afterburner. The purpose of the shakedown runs was to determine the expected gaseous pollutant concentrations so that the appropriate calibration gases could be determined. Also, the preliminary flow measurements were used at Moody AFB to select the proper sample nozzle diameter.

During the shakedown runs, several measurements were made at multiple idle settings. The fuel flow was adjusted at small increments and gaseous emissions were measured at the slipstream rake to note the variance in emissions with fuel flow near idle.

3.3.2 Engine Test Settings

Emissions testing was performed on the J85-GE-5R engine at four power settings. These power settings are the following:

- Idle.
- Intermediate.
- Military.
- Afterburner.

At Moody AFB, emissions testing comprised three emissions tests for each pollutant at each power setting where possible. At the idle setting, three 3-hour emission test runs were conducted. Due to sample volume and method detection limit requirements, the aldehyde/ketone sample was composited over the 6- or 9-hour period. The other particulate matter and volatile samples ran for 2 or 3 hours based on the particulate gain. The engine was brought down to a safe operating level so that the test team personnel could access sampling equipment for approximately 10 minutes in between each sample run. All engine settings were defined by engine operators so that the engine could be run continuously (or as long as practical) at idle, intermediate, military, and afterburner. EQ adjusted the sample collection procedure to accommodate the reduced operating time at the afterburner setting. Approximately five 5-minute samples of gaseous pollutants (NO_X, CO, TNMHC, CO_2, O_2) were sampled at the afterburner setting. Table 3-4 lists engine type, number of power settings, and number and types of samples that were collected.

At Randolph AFB, 30-minutes of combined readings at idle, intermediate, military, and afterburner were collected from two engines.

3.3.3 Engine Emission Trend Development

In addition to the settings listed in Table 3-4, a sample run from idle to military was conducted. The purpose of the run was to sample for gaseous pollutants throughout the engine

TABLE 3-4. ENGINE EMISSION SAMPLING MATRIX – MOODY AFB

Pollutant/Method	Sample Location				Sample Duration (A) (Minutes)	Number of Samples per Setting	Total Number of Samples	Engine Setting			
	Engine Rake	Slipstream Rake	Slipstream	Ambient				Idle	Intermediate	Military	After-burner (B)
Particulate/EPA Method 5202			X		120/180	3	9	X	X	X	
Aldehydes and Ketones/EPA Method 0011			X		360/540	1	3	X	X	X	
VOC/EPA Method 0030			X		120/180	3	9	X	X	X	
Carbon Monoxide/EPA Method 10	X	X		X	120/30	3	12	X	X	X	X
Carbon Dioxide and Oxygen/ EPA Method 3A	X	X		X	120/30	3	12	X	X	X	X
Oxides of Nitrogen/EPA Method 7E	X	X			120/30	3	12	X	X	X	X
Total Hydrocarbons/ EPA Method 25A	X	X		X	120/30	3	12	X	X	X	X
Methane/EPA Method 25A	X	X			120/30	3	12	X	X	X	X
Benzene/TO-14	X										
Formaldehyde/TO-11	X										

A – 30 minute samples were collected at the engine rake. 180-minute test runs were conducted at idle.
B – The engine rake was removed prior to sampling at afterburner. The sample times was reduced to 5 minutes.

power band. The engine throttle position was increased in small increments at 10-minute intervals so that gaseous emission data could be collected at the slipstream rake to develop an emission trend for the engine. These data are presented in Table 5-1.

3.4 ENGINE TEST CYCLE DATA

In order to correlate the aircraft engine emissions data with the engine operation, facility personnel compiled selected engine test cycle data during testing. The engine test monitoring system at the test stand constantly monitors a variety of engine parameters during engine testing. For the purpose of emissions sampling, a select number of these parameters were provided to the Support Program Office (SPO) for emission factor development. These parameters will assist in noting the effect of a specific pollutant for a specific engine load condition. The following data was compiled by facility personnel:

- Fuel flow at each load.
- Engine rpm at each load.
- Thrust at each load.
- Test cell temperature.

Table 3-5 presents engine operating data.

TABLE 3-5. ENGINE OPERATING DATA

Power Setting	Fuel Flow (lbs/hr)		%RPM (Average)		lb/Thrust (Average)	Cell Temperature
J85-GE-5M (Moody AFB)						
Idle	525		49.5		55	83
Intermediate	1,045		85.5		808	86
Military	2,550		99.7		2,521	77
Afterburner	7,695		99.8		3,450	88
T-38 (with PMP) Talon (Randolph AFB)						
Engine	1	2	1	2	Not Recorded	
Idle	520	520	50	49		
Intermediate	980	1080	85	85		
Military	2,200	2,240	100	100		
Afterburner	15,390	15,390	100	100		

3.5 JP-8+100 FUEL SAMPLING AND ANALYSIS

The proximate/ultimate JP-8+100 fuel analysis and level of nitrogen was determined for the facility in order to develop a custom F-factor and to document fuel characteristics during emissions testing. Table 3-6 lists the fuel analysis requirements. One fuel sample at each setting was collected over the period of testing and composited. EQ collected these samples and shipped them to the appropriate laboratory for analysis.

In addition to the proximate/ultimate JP-8+100 fuel analysis, EQ submitted a portion of the composited sample for analysis of the metals listed in Table 3-7.

TABLE 3-6. JP-8+100 FUEL ANALYSIS

Parameter	Analytical Method	Result
Btu/lb	ASTM D-240	19,300 Btu/lb
Sulfur %	ASTM D-2622	0.0496%
Carbon %	ASTM D-5291	85.52%
Nitrogen %	ASTM 4629	0.0007%
Hydrogen %	ASTM D-5291	14.18%
Ash %	ASTM D482	<0.001%
Naphthenes %	PONA Analysis	45.6%
Aromatics %	PONA Analysis	23.5%
Parafins %	PONA Analysis	30.4%
Olefins %	PONA Analysis	0.5%

TABLE 3-7. SUMMARY OF SOURCE TARGET METALS FROM JP-8 FUEL ANALYSIS

Metal	Analytical Method	Analytical Result (mg/kg)
Antimony	6010	<0.05
Arsenic	6010	<0.063
Barium	6010	<0.025
Beryllium	6010	<0.0025
Cadmium	6010	<0.013
Chromium	6010	<0.013
Cobalt	6010	<0.013
Copper	6010	0.025 (MDL = 0.025)
Lead	6010	<0.063
Manganese	6010	0.013 (MDL = 0.013)
Mercury	7470	<0.0005
Nickel	6010	0.038
Phosphorus	365.2	1.2 (MDL =0.025)
Selenium	6010	0.13
Silver	6010	0.013
Thallium	6010	0.075
Zinc	6010	0.025

Note: A sample and duplicate were submitted for analysis. The highest concentration is recorded in the table above.

3.6 EMISSION TEST SCHEDULE AND RESPONSIBILITIES

Figure 3-1 shows the time-line for engine testing. The time-lines depict activities and the time each activity required for equipment setup, shakedown runs, emissions testing, and demobilization at the test facility.

The following is a breakout of the general tasks conducted during each of the three phases:

- **Equipment setup** - Setup of the slipstream and calibration of sampling equipment took 5 days. This involved setting up the exhaust rake and slipstream sampling systems, sampling equipment, the flow measurement system, and the mobile laboratory. EQ worked with base personnel so that the facility test schedule was not interrupted.

- **Shakedown** - During this important period, the test team and engine test stand operators became familiar with the operational procedures of the test program. The test team gathered preliminary information at each of the engine test settings. This information was vital to ensure that the scheduled test runs were conducted accurately and efficiently.

- **Testing** - The test team completed three test runs at a single engine setting in one sample day. Testing was completed in 3 days.

- **Teardown** - Teardown of the equipment was accomplished in 2 days.

3.6.1 Personnel Responsibilities

The nature of this test program dictates that the members of the sampling team be highly skilled. The program was staffed at the appropriate level with the necessary skill levels to perform each task. Each team member was actively involved in the collection of emissions samples, fuel samples, sample recovery, data reduction, and sample shipment. Table 3-8 lists the personnel categories and the required qualifications and tasks. The test team functioned as an integrated unit to complete the test program efficiently and without compromising data quality.

MOODY AFB TEST SCHEDULE

DAY	April 18 Th	April 19 F	April 20 S	April 21 Su	April 22 M	April 23 T	April 24 W	April 25 Th	April 26 F	April 27 S	April 28 Su
MOODY DAY No.	1	2	3	4	5	6	7	8	9	10	11
	M,S										
Idle											
Intermediate											
Military											
Afterburner											
Engine Trend Curve Idle - Military						SD			D	D, M	

RANDOLPH AFB TEST SCHEDULE

DAY	April 29 M	April 30 T	May 1 W	May 2 Th
DAY No.	1	2	3	4
	S	S,SD		D
Idle				
Intermediate				
Military				
Afterburner				

Mobilize	M
Setup	S
Shakedown	SD
Test	T
Teardown	D

Figure 3-1. Time-Line for J85-GE-5R Engine Testing

TABLE 3-8. BREAKOUT OF MOODY AFB FIELD TEAM PERSONNEL AND RESPONSIBILITIES

Personnel	Responsibilities/Qualifications
EQ Project Manager	Acted as liaison between Base personnel, sample team, and AFIERA/RSEQ. Coordinated engine operation with testing. Assisted in equipment preparation and sample recovery. Set up and constructed sampling equipment.
EQ Team Leaders	Assumed technical responsibility for overall sampling effort and sample recovery. Set up and calibrated equipment. Operated VOST system. Supervised International Aviation Transportation Association (IATA)/DOT certification of shipment of hazardous materials (hazardous sample media, i.e., acetone); and acted as field sample custodian.
CEM Operator	Operated and calibrated CEM systems.
Particulate Matter Train Operator	Operated particulate matter sampling train and composite train and assisted in sample recovery.
Aldehyde and Ketone Train Operator	Operated aldehyde and ketone sampling train.

BREAKOUT OF RANDOLPH AFB FIELD TEAM PERSONNEL AND RESPONSIBILITIES

Personnel	Responsibilities/Qualifications
EQ Project Manager	Acted as liaison between Base personnel, sample team, and AFIERA/RSEQ. Coordinated engine operation with testing. Assisted in equipment preparation and sample recovery. Set up sampling equipment.
CEM Operator	Operated and calibrated CEM system.
Sampling Technician	Provided sampling support to the above personnel.

SECTION 4

CALCULATION OF AIRFLOW

The calculation of emission rates for this test program required accurate measurement of both inlet (ambient) airflow as well as total exhaust flow (combustion products plus excess air). The total exhaust flow was required to quantify mass emission rates for the parameters being measured.

Whenever possible, standard EPA flow measurement methods were used to quantify airflow. However, this test location did not provide adequate measurement locations for traditional flow measurements. Three alternate flow measurement techniques were employed at this location. These measurement techniques were the following:

- Direct measurement.
- Carbon balance for the calculation of inlet and total exhaust flow.
- F-factor for the calculation of inlet and total exhaust flow.

Each method had advantages and disadvantages that varied in significance depending on the specific conditions of each test run. The objective of the test program was to ensure that at least two independent techniques for measuring airflow were available for each test run.

An attempt was made to directly measure the engine exhaust velocity. A pitot tube was attached at a single point to the engine cruciform. This was used as an additional data point for comparison.

4.1 CALCULATION OF INLET AND OUTLET AIRFLOW USING A CARBON BALANCE

This method calculates both inlet and outlet airflow rates using a carbon mass balance. Conservation of matter requires that the total carbon mass rate in the exhaust (MCE) equal the sum of the total carbon mass rate in the fuel (MCF) and the carbon mass rate in the inlet air (MCI).

$$MCE = MCF + MCI \qquad \textit{Equation 1}$$

A similar conservation of total mass states that the total mass rate in the exhaust (ME) equals the total mass rate in the fuel (MF) plus the total mass rate at the inlet (MI).

$$ME = MF + MI \qquad \textit{Equation 2}$$

Finally, the mass rate of carbon also can be derived as the total mass rate at each location times the percent carbon by weight (% C_x) in each stream.

$$MCE = ME \times \% C_e/100 \qquad \textit{Equation 3}$$
$$MCF = MF \times \% C_f/100 \qquad \textit{Equation 4}$$
$$MCI = MI \times \% C_i/100 \qquad \textit{Equation 5}$$

The percent carbon by weight was measured in all streams and the mass rate of fuel burned was also measured. This left four unknown variables, ME, MI, MCE, and MCI, and five independent equations.

To solve for inlet mass flow rate, substitute Equation 2 into Equation 3.

$$MCE = (MF \times \% C_e/100) + (MI \times \% C_e/100)$$

Then substitute that equation into Equation 1.

$$(MF \times \% C_e/100) + (MI \times C_e/100) = MCF + MCI$$

Substitute Equations 4 and 5 to get:

$$(MF \times \% C_e/100) + (MI \times \% C_e/100) = (MF \times \% C_f/100) + (MI \times \% C_i/100)$$

Rearrange factors to get the inlet mass rate.

$$MI = MF\left(\frac{\% C_f - \% C_e}{100}\right)\Big/\left(\frac{\% C_e - \% C_i}{100}\right)$$

By similar derivation, rearrange Equation 2, substitute into Equation 5, substitute the results into Equation 1, and then substitute Equations 3 and 4 to get the following:

$$MI = ME - MF \qquad \textit{Equation 2}$$

$MCI = (ME \times \% C_i/100) - (MF \times \% C_i/100)$ *Equation 5 using Equation 2*

$MCE = MCF + (ME \times \% C_i/100) - (MF \times \% C_i/100)$ *Equation 1 using Equation 5*

$$\left(ME \times \frac{\% C_e}{100}\right) = \left(MF \times \frac{\% C_f}{100}\right) + \left(ME \times \frac{\% C_i}{100}\right) - \left(MF \times \frac{\% C_i}{100}\right)$$ *Substitute Equations 3 and 4*

$$ME = MF\left(\frac{\% C_f - \% C_i}{100}\right) \Big/ \left(\frac{\% C_e - \% C_i}{100}\right)$$

The mass emission rates can be converted to volumetric flow rates by dividing by molecular weight and multiplying by standard volume. For example:

$$QE = \frac{ME \times 385.35}{MW_e}$$

Where:

QE = Wet standard volumetric flow rate, $\frac{wscf}{min}$.

ME = Total exhaust flow rate, $\frac{lb}{min}$.

MW_e = Wet molecular weight exhaust stream, $\frac{lb}{lb\ mole}$.

385.35 = Standard molar volume, $\frac{scf}{lb\ mole}$.

The fuel mass rate was measured directly during each test run, and the $\% C_f$ was determined by the fuel analysis.

The wet molecular weights of the exhaust gas streams were determined by EPA Reference Methods 3A and 4 (40 CFR 60). These methods measure the percent moisture (% M) of the gas stream and percent carbon dioxide ($\% CO_2$) and oxygen ($\% O_2$) in the gas stream on a dry basis, which were used to calculate the molecular weight as follows:

$$MW_e = \left[\left\{\left(\% CO_2 \times 0.48\right) + \left(\% O_2 \times 0.32\right) + \left(\left(\% CO + \% N_2\right) * 0.28\right)\right\} * \left(1 - \frac{\% M}{100}\right)\right] + (\% M \times 0.18)$$

Where:

% M = Moisture content as a percent.

For the purpose of calculating a molecular weight, (% CO + % N_2) was assumed to be (1 - % CO_2 - % O_2). Calculation of the carbon content of the exhaust gas stream used the % CO_2 as determined by Method 3A, plus additional measurements of carbon monoxide (% CO) and total hydrocarbons (% THC) by EPA Reference Methods 10 and 25A (40 CFR 60, Appendix A). The % THC was stated on the basis of methane (CH_4). The carbon monoxide (CO) and carbon dioxide (CO_2) concentrations were measured on a dry basis and must be converted to a wet basis using the measured moisture content of the exhaust gas. THC was measured on a wet basis.

$$\% CO_2 \text{ (wet)} = \% CO_2 \text{ (dry)} \times \left(1 - \frac{\% M}{100}\right)$$

$$\% CO \text{ (wet)} = \% CO \text{ (dry)} \times \left(1 - \frac{\% M}{100}\right)$$

The total carbon content of the exhaust gas stream is equal to the sum of % CO_2, % CO, and % THC on a wet basis times the ratio of carbon molecular weight to the total wet molecular weight of the gas stream.

$$\% C_e = (\% CO_2 \text{ wet} + \% CO \text{ wet} + \% THC) \times \frac{12.01}{MW_e}$$

A similar calculation was required for the inlet air volumetric flow rate, but the following simplifying assumptions were made:

- Dry ambient air is composed of 20.9% oxygen and 79.1% nitrogen.
- Ambient humidity represents the moisture content of the inlet air.

The major drawback to this measurement method was the use of extremely low carbon concentration values at the inlet, and relatively low concentrations at the exhaust to modify the very high carbon concentrations in the fuel. As excess air increased, the inlet flow would be indistinguishable from the outlet flow. The major advantage of this procedure was that the only additional data that were required to calculate flow were: the inlet flow; CO, CO_2, and THC values; and ambient humidity.

4.2 CALCULATION OF AIRFLOW USING F-FACTORS

F-factors relate the volume of combustion products to the heat content of fuel. F-factors generally are used for combustion sources when the exhaust stream flow rate is known, but the fuel heat input must be determined. In this case, the fuel input was determined easily and the volumetric flow of combustion air was difficult to determine. The F-factor relationship was used to calculate the total airflow based on a fuel firing rate.

F-factors are published for a variety of fuels and usually are expressed in units of dry standard cubic feet per British thermal unit (dscf/Btu or dscm)/joule (J). For this test program, specific F-factors were determined through ultimate analysis of the fuel components on a weight percent basis and fuel density.

- Ultimate analysis of jet fuel (i.e., hydrogen, carbon, sulfur, nitrogen, oxygen, and density (pounds per gallon [lb/gal]) on a mass basis (% wt).

To determine the air volumetric flow rate, the following additional information was required:

- The concentrations of oxygen, carbon monoxide, and moisture content in the exhaust stream after combustion.
- Fuel firing rate, gallons per minute (gal/min).

The F-factor, dry basis, was calculated from the ultimate analysis of the jet fuel as follows:

$$F_d = K[(K_{hd} \% H) + (K_c \% C) + (K_s \% S) + (K_n \% N) - (K_o \% O)]/GCV$$

(Equation 19-13, 40 CFR 60, Appendix A, Method 19)

If the heat input components (K, GCV) are eliminated from the equation, an F-factor based on fuel mass is derived.

$$F_{md} = [(K_{hd} \% H) + (K_c \% C) + (K_s \% S) + (K_n \% N) - (K_o \% O)]$$

Where:

F_d = Volume of combustion components per unit of heat content, scf/million Btu.
F_{md} = Volume of combustion component on a dry basis per pound of fuel, scf/lb.
% H, % C, % S, % N, % O = Weight percents of hydrogen, carbon, sulfur, nitrogen, and oxygen in the jet fuel.
GCV = Gross calorific value of the fuel consistent with the ultimate analysis, Btu/lb.
K = Conversion factor, 10^{-5}.
K_{hd} = 3.64 (scf/lb)/(%).
K_c = 1.53 (scf/lb)/(%).
K_s = 0.53 (scf/lb)/(%).
K_n = 0.14 (scf/lb)/(%).
K_o = 0.46 (scf/lb)/(%).

Stoichiometric combustion calculations assume that the carbon in the fuel is burned completely to produce carbon dioxide and water with no excess air (and no significant formation of nitrogen dioxide or carbon monoxide). The air stoichiometric volumetric flow rate (dry basis) was determined by simply multiplying the measured fuel firing rate by the F-factors.

$$\left(\text{Fuel firing rate, } \frac{\text{gal}}{\text{min}}\right)\left(\text{fuel density, } \frac{\text{lb}}{\text{gal}}\right)\left(F_{md}, \frac{\text{scf}}{\text{lb}}\right) = \text{dry combustion air flow, } \frac{\text{scf}}{\text{min}}$$

The percent excess air (EA) during actual combustion was calculated using the following formula:

$$\%\,EA = \left[\frac{\%\,O_2 - 0.5\%\,CO}{20.9 - (\%\,O_2 - 0.5\%\,CO)}\right] x\ 100$$

Where:

% O_2, % CO = Measured percents of oxygen, and carbon monoxide, in the exhaust gas.
20.9 is the percent dry oxygen in ambient air.

Total dry combustion flow (including) excess air equals:

$$\text{Total dry air flow} = \left[(\text{dry combustion air flow})\left(1 + \frac{\%\,EA}{100}\right)\right]$$

This simplifies to:

$$\text{Total dry combustion flow, } \frac{\text{scf}}{\text{min}} = (\text{dry combustion air}) * \left(\frac{20.9}{20.9 - \%O_2 + 0.5\%CO} \right)$$

The inlet airflow is equal to the total dry combustion air plus the fraction of oxygen in the inlet used for the combustion of hydrogen in the fuel. The nitrogen associated with this oxygen fraction of the inlet air was included in the F_d calculation.

This inlet oxygen fraction can be derived from the same F-factor calculations presented in EPA Method 19.

$$F_{mo} = K\,[K_{hi}\,\%H]$$

Where:

F_{mo} = Volume of inlet oxygen used to combust hydrogen per unit of fuel fired, scf/lb.
K_{hi} = 0.96 (scf/lb)/%.
% H = Weight percent of hydrogen in the fuel as stated previously.

Then the total dry inlet airflow is the following:

$$\text{Dry inlet air} = \left[\text{fuel firing rate, } \frac{\text{gal.}}{\text{min}}\right]\left[\text{fuel density, } \frac{\text{lb}}{\text{gal.}}\right][F_{md} + F_{mo}] * \left[\frac{20.9}{20.9 - \%O_2 + 0.5\%CO}\right]$$

The inlet air then can be corrected back to actual conditions using the ambient temperature and humidity. The total exhaust flow can be adjusted to actual conditions using the measured exhaust moisture content and temperature.

There are limitations to the use of these F-factors for calculations of airflow from jet engines. The concentration of carbon monoxide in the combustion stream normally is so low that it is insignificant in the excess air calculation, but it has been included to cover operation during periods of incomplete combustion. If the combustion is so incomplete that large quantities of the fuel are exhausted as carbon (soot) or volatile hydrocarbons (THC), the % C of the fuel must be reduced to account for the reduced formation of combustion products.

The second limitation arises when high levels of excess air are present. At high excess air levels, the carbon monoxide concentration becomes zero, but the oxygen content of the combustion gas approaches ambient concentrations (20.9 % O_2). The excess air equation becomes unreliable at a concentration of 20.9 % oxygen as this equation is undefined due to division by zero. As a general rule, these F-factor calculations will be unreliable any time the combustion gas contains more than 18.5 % oxygen.

SECTION 5

RESULTS

J85-GE-5R aircraft engine exhaust emissions were characterized to determine the concentration, mass emission rate, and emission factor relative to JP-8+100 fuel flow for criteria and select hazardous air pollutants. A single J85-GE-5M engine was tested on a test stand in a hush house at Moody AFB and the gaseous emissions from a T-38C with PMP Talon were measured directly behind the engine at Randolph AFB. Sampling was performed at Moody AFB for nitrogen oxides (NO_X), carbon monoxide (CO), carbon dioxide (CO_2), non-methane hydrocarbons (NMHC), particulate matter (PM), particle size characterization, aldehyde and ketones, and volatile organic compounds. Also, the condensable particulate matter fraction was analyzed to determine the presence of organics. At Randolph AFB, NO_X, CO, NMHC, CO_2, and O_2 were recorded at each setting. Semi-volatile organic compounds, metals, and sulfur dioxide emissions were not part of the scope or work for this engine. Historical aircraft engine emission sampling has noted that the semi-volatile analysis has provided non-detected and scattered detected values. Metals analysis has also shown mainly non-detect values, which was confirmed by an analysis of the fuel. Sulfur dioxide emissions are reported based on the procedure documented by AFIERA ("Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations," January 2002). This procedure estimates that sulfur dioxide in the fuel undergoes complete oxidation to SO_2. The sulfur content in JP-8+100 fuel was determined during testing to assure consistency with published results. Ambient measurements for CO, CO_2, O_2, and NMHC were made in order to complete carbon balance and f-factor calculations. Emission rates were not corrected for ambient pollutants due to the lack of contributing sources in the vicinity of the test facility.

As part of the emission testing program, samples were collected directly behind the aircraft engine at both Moody and Randolph Air Force Bases, at the end of the augmenter tube where the engine exhaust exits the hush house, and in the slipstream duct at Moody AFB. As described in Section 2 and shown in Figure 2-8, a stainless steel rake with multiple sampling

nozzles was installed directly behind the engine to collect gaseous, benzene, and formaldehyde emissions data at the idle, intermediate, and military engine settings. Near the end of the augmenter tube, where the emissions exhaust the hush house, a stainless steel slipstream sampling system was installed to transfer the engine exhaust out of the hush house to a safe location for sampling. The slipstream rake, shown in Figure 2-11, consists of 12 sample intake nozzles that were used to determine pollutant distribution in the augmenter tube and to collect a gaseous emission sample from each of the 12 points. After the slipstream had exited the hush house, the slipstream duct was utilized to extract manual samples for PM, aldehyde and ketones, and volatile organic compounds. These sampling locations are referred to as the engine rake and slipstream rake accordingly. The purpose of sampling at multiple locations was to study the pollutant mass emission rates as they traveled from the engine to the atmosphere and note if any secondary chemistry occurred during the residence time in the augmenter tube.

A similar engine rake was utilized at Randolph AFB to measure emissions directly behind the engine. The emissions data are discussed in this section.

5.1 GASEOUS POLLUTANTS

Gaseous emissions were collected at the engine rake and slipstream rake for the J85-GE-5M engine tested at Moody AFB. Gaseous emissions were collected directly behind the T-38C with PMP aircraft at Randolph AFB. The results of the sampling at each location are provided in the following sections.

5.1.1 Gaseous Emissions

Prior to the actual emission test runs at each engine setting at Moody AFB, a series of shakedown runs were performed to note gaseous pollutant concentrations and the point where CO emissions decrease and NO_X emissions increase. Data was collected at the idle, intermediate, and military power settings as well as at several interim power settings to note the variation of NO_X, CO, CO_2, O_2, and NMHC.

Table 5-1 and Figure 5-1 present the gaseous emissions data collected at various power settings during the shakedown runs. It can be seen that at approximately 25% power (871 lbs/hr fuel flow), the CO emissions begin to decrease significantly.

TABLE 5-1
J85-GE-5M (Moody AFB)
GASEOUS EMISSIONS SUMMARY
EMISSION TREND SUMMARY
ENGINE RAKE

Power Setting (Fuel Flow, lbs/hr)	O_2 Dry %	CO_2 Dry %	NO_x Dry ppm	NMHC Wet ppm (as CH_4)	CO Dry ppm
Idle (525)	19.7	0.6	3.8	167	687
(698)	19.9	0.5	3.9	80	466
(871)	19.9	0.5	4.3	46	340
(930)	19.9	0.7	5.0	31	309
Intermediate (1,045)	19.8	0.5	6.2	17	231
Military (2,550)	19.0	1.2	16.2	7	184

Tables 5-2 and 5-3 contain the gaseous emission summary for the gaseous emission samples collected directly behind the engine and at the slipstream near the end of the augmenter tube for the J85-GE-5R engine tested at Moody AFB. As can be seen in Table 5-4, the CO, NMHC, and CO_2 emission rates compare well, while the NO_X data tended to be higher directly behind the engine. The NO_X concentration directly behind the engine was predominantly NO_2. As the NO_2 traveled down the augmenter tube, the NO_2 dispersed into N and O_2 resulting in a decrease in NO_X at the slipstream. This is confirmed by the high NO concentration at the slipstream and little NO_2.

A summary of the on-wing emissions from the T-38C with PMP Talon Aircraft operated at Randolph AFB is shown in Table 5-5. The emission factors differed slightly from those collected at Moody AFB. The differences are minimal and the emission factors are in the same order of magnitude. The difference in emissions between Moody AFB and Randolph AFB can be attributed to the position of the sampling rake behind the engine. At Randolph AFB the engine rake was positioned approximately 3 feet behind the engine. At Moody AFB the engine

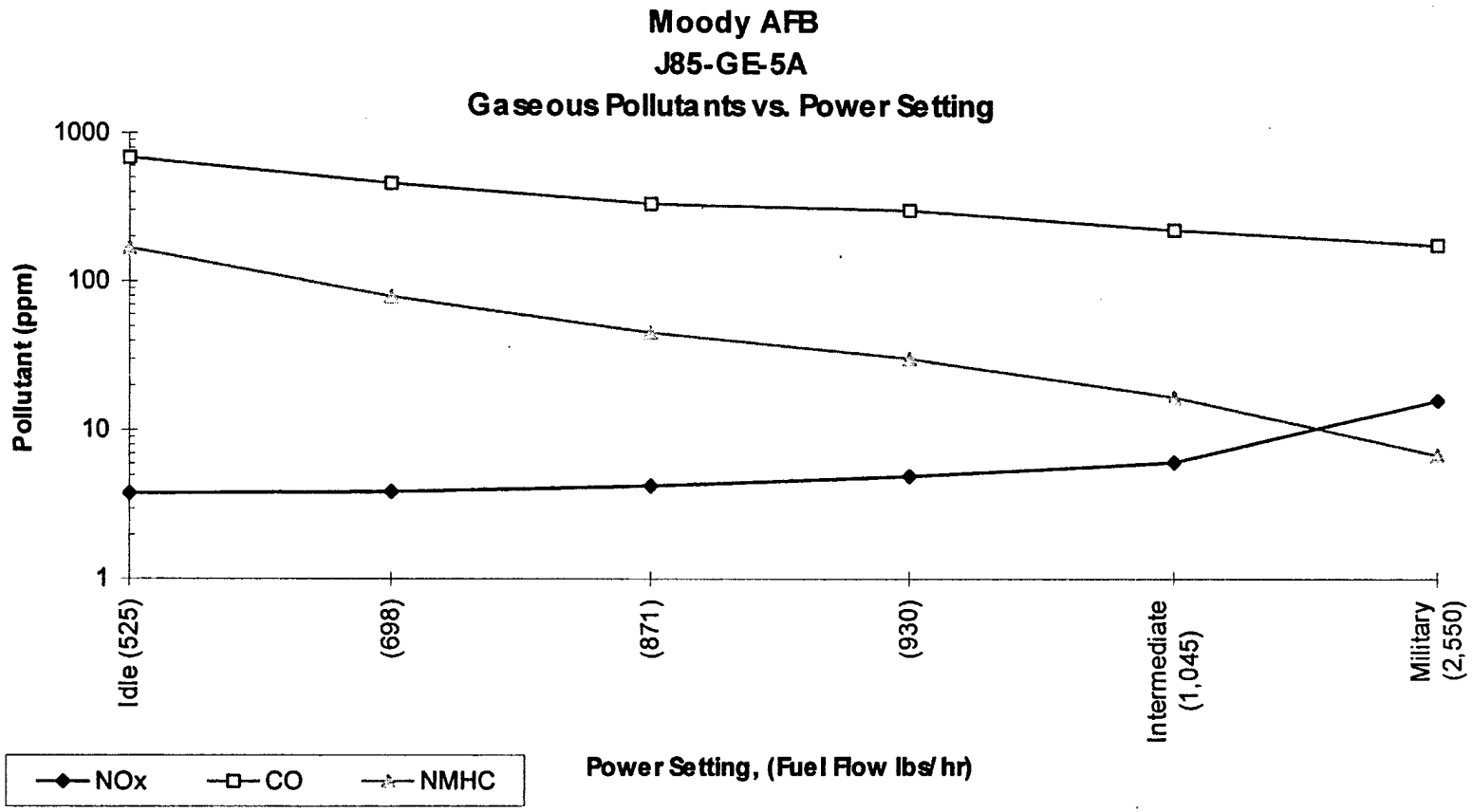

Figure 5-1. Gaseous Pollutants (ppm) vs. Power Setting (Fuel flow, lbs/hr)

TABLE 5-2
J85-GE-5M (Moody AFB)
SLIPSTREAM RAKE
EMISSION FACTOR SUMMARY

	Idle[a]			Intermediate[b]			Military			Afterburner		
Flow Rate dscfm	118,704			293,150			544,312			611,727		
Fuel Flow lbs/hr	525			1,045			2,550			7,695		
Analyte	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel
Nitrogen Oxides (NOx)[C]	0.50	0.41	0.79	0.90	1.89	1.81	1.10	4.21	1.65	2.10	9.33	1.21
Carbon Monoxide (CO)	188.60	100.49	191.41	40.00	51.11	48.90	27.20	64.54	25.35	29.40	78.37	10.19
THC (as CH_4)	35.80	11.08	21.11	2.30	1.69	1.62	0.80	1.16	0.45	3.30	5.02	0.65
Carbon Dioxide (CO_2)[d]	2,200	1,839	3,503	1,600	3,185	3,048	2,100	7,868	3,092	5,700	23,980	3,116

(a) - Idle flow rates calculated by F-Factor methodology.
(b) - Intermediate, Military and Afterburner flow rates calculated using carbon balance methodology.
(c) - The majority (approximately 90%) of the NO_X concentration is NO. This is not the typical NO_X trend.
(d) – Measured CO_2 emissions are approximately 10% higher than the theoretical CO_2 emission rate.

TABLE 5-3
J85-GE-5M (Moody AFB)
ENGINE RAKE
EMISSION FACTOR SUMMARY

	Idle[a]			Intermediate[b]			Military			Afterburner[d]		
Flow Rate dscfm	33,249			56,863			84,120			73,548		
Fuel Flow lbs/hr	525			1,045			2,550			7,695		
Analyte	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	Lbs/ 1000 lbs fuel
Nitrogen Oxides (NO_X)[c]	3.6	0.8	1.5	5.7	2.3	2.2	16.0	9.6	3.8	41.0	21.6	2.8
Carbon Monoxide (CO)	693.0	92.6	176.4	211.6	52.6	50.3	187.0	68.6	27.0	170.5	54.7	7.1
THC (as CH_4)	161.4	12.4	23.6	9.7	1.4	1.3	2.0	0.4	0.2	9.2	1.7	0.2
Carbon Dioxide (CO_2)	7000	1560	3030	8000	3119	3048	14000	7869	3086	48000	24207	3123

[a] - Idle flows calculated by F-Factor methodology.
[b] - Intermediate, Military and Afterburner flow rates calculated using carbon balance methodology.
[c] - The majority (approximately 90%) of the NO_X concentration is NO_2.
[d] - The sampling time at afterburner was limited to 3 minutes due to engine malfunction.

TABLE 5-4
J85-GE-5M (Moody AFB)
EMISSION FACTOR COMPARISON
CRITERIA POLLUTANTS
lbs/1000 lbs fuel

	ENGINE RAKE				SLIPSTREAM			
	Idle[a]	**Intermediate[b]**	**Military**	**Afterburner**	**Idle[a]**	**Intermediate[b]**	**Military**	**Afterburner**
Flow Rate dscfm	33,249	56,863	84,120	73,548	118,704	293,150	544,312	611,727
Fuel flow lbs/hr	525	1,045	2,550	7,695	525	1,045	2,550	7,695
Nitrogen Oxides (NO_X)[c]	1.63	2.22	3.79	2.81	0.79	1.81	1.65	1.21
Carbon Monoxide (CO)	191.46	50.29	26.96	7.11	191.41	48.90	25.35	10.19
THC (as CH_4)	25.65	1.34	0.17	0.17	21.10	1.62	0.45	0.65
Carbon Dioxide (CO_2)	3,030	3,048	3,086	3,123	3,504	3,048	3,092	3,116
Sulfur Dioxide (SO_2)	1.00	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Particulate	(d)	(d)	(d)	(d)	6.30	10.72	3.66	(d)

(a) - Idle flow rates calculated by F-Factor methodology.
(b) - Intermediate, Military and Afterburner flow rates calculated using carbon balance methodology.
(c) - The majority (approximately 90%) of the NOx concentration is NO_2 at the engine rake; NO at the Slipstream.
(e) - Particulate data not collected.

TABLE 5-5
T-38 TALON (Randolph AFB)
ENGINE RAKE
EMISSION FACTOR SUMMARY

	Idle[a]			Intermediate[b]			Military			Afterburner[c]		
Flow Rate dscfm	25,101			82,241			120,532			141,922		
Fuel Flow lbs/hr[e]	1,040			2,060			4,440			15,390		
Analyte	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel	ppmvd	lbs/hr	lbs/ 1000 lbs fuel
Nitrogen Oxides (NO_X)[d]	6.30	1.12	1.08	2.40	1.44	0.70	9.90	8.53	1.92	94.30	95.94	6.23
Carbon Monoxide (CO)	1,686	184.55	177.45	374.00	134.04	65.07	262.00	137.60	30.99	1,328	822.26	53.43
THC (as CH_4)	2,11.60	15.19	14.61	24.30	4.99	2.42	9.70	2.91	0.65	264.00	93.34	6.06
Carbon Dioxide (CO_2)	17,000	2,952	2,839	11,000	6,232	3,025	17,000	13,691	3,084	117,000	114,245	7,423

(a) - Idle flow rates calculated by F-Factor methodology.
(b) - Intermediate, Military and Afterburner flow rates calculated using carbon balance methodology.
(c) - Due to the limited sample time at Afterburner, the CO_2 and O_2 values at Afterburner are based on the engine rake data at Moody AFB.
(d) - The majority (approximately 90% of the NO_X concentration is NO_2.
(f) - Fuel flow per engine. The T-38 Talon operates on two J85 engines.

rake was positioned approximately 15 feet behind the engine. The difference in position is due to the physical configuration of the engine on the test stand.

A summary of the stock J85-GE-5H emissions data is presented in Table III-3 in the Executive Summary. These data were collected using a slipstream in a test cell at Laughlin AFB. The test cell and slipstream configurations are much different than those in this program, but the data is presented for comparison purposes. The NO_X emission factor of 1.1 lbs/1000 lbs fuel at idle is identical to the NO_X emission index for the T-38. CO is approximately 191 lbs/1000 lbs fuel for the J85-GE-5M and 212 lbs/1000 lbs fuel for the J85-GE-5H. NMHC emissions were higher from the unmodified engine at 34 lbs/1000 lbs fuel compared to 21 lbs/1000 lbs fuel at the idle setting. At the intermediate power setting, the CO and NMHC emissions were higher on the unmodified engine, but the NO_X emissions were similar, 1.7 lbs/1000 lbs fuel (J85-GE-5H) compared to 1.8 lbs/1000 lbs fuel (J85-GE-5M). At military, the historic NO_X emission index was 3 lbs/1000 lbs fuel, but during this program the emission index was 2 lb/1000 lbs fuel. CO was 36 lbs/1000 lbs fuel historically and 31 lbs/1000 lbs fuel for the T-38 aircraft. NMHC were 0.6 and 0.5 lb/1000 lbs fuel for the J85-GE-5H and J85-GE-5M engines respectively.

The afterburner data collected at Moody AFB was comparable to the historic data set. Also, the engine rake data and slipstream data were comparable for the testing conducted at Moody AFB. The afterburner data at Randolph AFB for the T-38C with PMP was not similar to the data collected at Moody AFB. At both locations, the sample time at afterburner was limited. During the J85-GE-5M testing at Moody AFB, the engine reached afterburner for a 3-minute period, but could not return to afterburner due to a failed fuel delivery problem. At Randolph AFB during testing of the T-38C with PMP Talon, the engine sampling rake was destroyed after approximately 5 minutes of sampling. Therefore, the afterburner data collected at Randolph AFB appears to be an outlier since the J85-GE-5M data compares well with the historic J85-GE-5H data set.

5.2 VOLATILE ORGANIC COMPOUNDS

Speciation of volatile organic compounds was performed at the hush house exhaust for the engine at each engine setting with the exception of afterburner. The highest emission rate of volatiles was at the idle setting. This has been the typical trend in historic engine emission

testing. Due to the inefficiencies in engine operation at idle, unburned hydrocarbons tend to be present in the exhaust stream resulting in higher organic emissions. The VOC HAP total at idle was 0.13 lb/1000 lbs fuel. The detected compounds at each setting were similar to the speciated HAPs determined in historical test programs. Typically, naphthalene, benzene, toluene, ethylbenzene, xylene and styrene were detected in the exhaust stream. A summary of the volatile emissions is provided in Tables 5-6 through 5-8.

5.2.1 Speciated Pollutant Comparison

Samples for benzene and formaldehyde were collected directly behind the engine and at the slipstream duct to note the variation in emissions at the idle, intermediate, and military settings. The benzene emissions determined directly behind the engine are summarized in Table 5-9. These data were typically one order of magnitude higher than the benzene emissions at the slipstream shown in Tables 5-6 through 5-8. At idle the emission factor for benzene behind the engine was 0.74 lb/1000 lbs fuel and 0.03 lb/1000 lbs fuel at the slipstream. At the intermediate engine setting, the benzene emission factor was 0.02 lb/1000 lbs fuel at the slipstream and 0.24 lb/1000 lbs fuel at the engine exhaust. Formaldehyde samples collected at the idle, intermediate, and military settings behind the engine were compared to the formaldehyde data collected at the slipstream duct. These data are presented in Tables 5-10 and 5-11. The formaldehyde data collected behind the engine, shown in Table 5-10, provided an engine emission factor of 1.45 lbs/1000 lbs fuel at idle, 1.64 lbs/1000 lbs fuel at intermediate, and 0.18 lb/1000 lbs fuel at military. The formaldehyde data collected at the slipstream, shown in Table 5-11, indicate an emission factor of 2.26 lbs/1000 lbs fuel at idle, 0.35 lb/1000 lbs fuel at intermediate, and 0.02 lb/1000 lbs fuel at military.

5.3 ALDEHYDE AND KETONES

Aldehyde and ketone data was collected at the slipstream duct for the idle, intermediate and military settings. These data are summarized in Table 5-11. The emission rates were highest at the idle setting, which is consistent with the data trends seen in this program. Formaldehyde was the pollutant emitted in the highest quantity at 2.26 lbs/1000 lbs fuel at idle. As the engine

TABLE 5-6.
J85-GE-5M (MOODY AFB)
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
Idle
(Flow by f-factor)

	Run Number											
	1				2				3				Average	
Flow Rate, dscfm	118,704				118,704				118,704					
Fuel Flow, lbs/hr	525				525				525					
	lb/hr		lbs/1,000 lbs fuel		lb/hr		lbs/1,000 lbs fuel		lb/hr		lbs/1,000 lbs fuel		lb/hr	lbs/1,000lbs fuel
Analyte	CAS number	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit		
Chloromethane*	74-87-3	2.72E-04		5.18E-04		4.40E-07		8.38E-07		1.51E-04		2.89E-04		1.41E-04	2.69E-04
Bromomethane*	74-83-9		2.72E-05		5.18E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Chloroethane*	75-00-3		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Freon 11 (Trichlorofluoromethane)	75-69-4	1.46E-04		2.78E-04		1.24E-04		2.36E-04		2.16E-04		4.11E-04		1.62E-04	3.08E-04
1,1-Dichloroethane*	75-34-3		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Carbon Disulfide*	75-15-0		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Acetone	67-64-1	4.21E-04		8.01E-04		1.38E-03		2.63E-03		1.29E-02		2.46E-02		4.90E-03	9.33E-03
Methylene Chloride*	75-09-2	9.40E-05		1.79E-04		9.54E-05		1.82E-04			3.59E-05		6.85E-05	6.31E-05	1.20E-4
trans-1,2-Dichloroethene	156-60-5		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
1,1-Dichloroethene*	75-35-4		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Vinyl Acetate*	108-05-4		1.73E-04		3.30E-4		1.80E-04		3.44E-04		1.80E-04		3.42E-04	ND	ND
cis-1,2-Dichloroethene*	156-59-2		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3		1.73E-04		3.30E-4		1.80E-04		3.44E-04	1.08E-03		2.05E-03		3.60E-04	6.83E-04
Chloroform*	67-66-3		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
1,1,1-Trichloroethane*	71-55-6		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Carbon Tetrachloride*	56-23-5	8.16E-05		1.55E-04		4.38E-05		8.35E-05		4.62E-05		8.08E-05		5.72E-05	1.09E-04
Benzene*	71-43-2	1.43E-03		2.73E-03		1.86E-03		3.54E-03		4.47E-02		8.51E-02		1.60E-02	3.05E-02
1,2-Dichloroethane*	107-06-2		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Bromodichloromethane	75-27-4		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
4-Methyl-2-pentanone*	108-10-1		1.73E-04		3.30E-4		1.80E-04		3.44E-04		1.80E-04		3.42E-04	ND	ND
Toluene*	108-88-3	9.28E-04		1.77E-03		1.68E-03		3.19E-03		4.08E-02		7.78E-02		1.45E-02	2.76E-02
1,1,2-Trichloroethane*	79-00-5		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Tetrachloroethene*	127-18-4		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
2-Hexanone	591-78-6		1.73E-04		3.30E-4		1.80E-04		3.44E-04		1.80E-04		3.42E-04	ND	ND
Dibromochloromethane	124-48-1		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Chlorobenzene*	108-90-7		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
Ethyl Benzene*	100-41-4	2.18E-04		4.15E-04		4.67E-04		8.89E-04		1.09E-02		2.08E-02		3.87E-03	7.38E-03
m,p-Xylene*	108-38-3	7.27E-04		1.39E-03		1.55E-03		2.95E-03		3.62E-02		6.90E-02		1.28E-02	2.44E-02
o-Xylene*	95-47-6	4.53E-04		8.62E-04		1.04E-03		1.98E-03		2.36E-02		4.50E-02		8.73E-03	1.59E-02
Styrene*	100-42-5	1.11E-04		2.12E-04		3.04E-04		5.79E-04		1.20E-02		2.29E-02		4.14E-03	7.89E-03
Bromoform*	75-25-2		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		3.46E-05		6.60E-05		3.61E-05		6.87E-05		3.59E-05		6.85E-05	ND	ND
1,3-Butadiene*	106-99-0	1.88E-04		3.58E-04		5.16E-04		9.82E-04		1.82E-02		3.47E-02		6.31E-03	1.20E-02

* Hazardous Air Pollutant (HAP)
ND – Compound not detected at this detection limit. Compound may be present at a value less than the detection limit

TABLE 5-7.
J85-GE-5M (MOODY AFB)
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
INTERMEDIATE
(Flow by Carbon Balance)

	Run Number									
	1			2			3			
Flow Rate, dscfm	293,150			293,150			293,150			
Fuel Flow, lbs/hr	1045.0			1045.0			1045.0		Average	
Analyte	CAS number	lb/hr Detected	lb/hr Detection Limit	lbs/1,000 lbs fuel Detected	lbs/1,000 lbs fuel Detection Limit	lb/hr Detected	lb/hr Detection Limit	lbs/1,000 lbs fuel Detected	lbs/1,000 lbs fuel Detection Limit	lb/hr	Lbs/1,000lbs fuel
Chloromethane*	74-87-3	6.13E-04		5.87E-04		4.40E-07		4.21E-07		3.65E-04	3.49E-04	3.26E-04	3.12E-04
Bromomethane*	74-83-9	1.09E-04		1.04E-04			1.01E-04		9.66E-04		9.60E-05		9.18E-05	1.02E-04	9.75E-05
Chloroethane*	75-00-3	9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05	9.18E-05	9.86E-05	9.44E-05
Freon 11 (Trichlorofluoromethane)	75-69-4	1.39E-03		1.33E-03		1.01E-03		9.66E-04		1.06E-03	1.01E-03	1.15E-03	1.10E-03
1,1-Dichloroethene*	75-34-3		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
Carbon Disulfide*	75-15-0		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
Acetone	67-64-1	3.56E-03		3.41E-03		1.79E-03		1.71E-03		1.60E-03	1.53E-03	2.32E-03	2.22E-03
Methylene Chloride*	75-09-2	5.64E-04		5.40E-04		5.76E-04		5.51E-04		5.95E-04	5.69E-04	5.78E-04	5.53E-04
trans-1,2-Dichloroethene	156-60-5		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
1,1-Dichloroethane*	75-35-4		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
Vinyl Acetate*	108-05-4		4.95E-04		4.73E-04		5.05E-04		4.83E-04		4.80E-04		4.59E-04	ND	ND
cis-1,2-Dichloroethene*	156-59-2		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-04		9.18E-05	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3	2.19E-03		2.09E-03		7.57E-04		7.25E-04		4.99E-04		4.78E-04		1.15E-03	1.10E-03
Chloroform*	67-66-3		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
1,1,1-Trichloroethane*	71-55-6		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
Carbon Tetrachloride*	56-23-5	3.86E-04		3.69E-04		2.93E-04		2.80E-04		3.17E-04	3.03E-04			3.32E-04	3.18E-04
Benzene*	71-43-2	3.37E-02		3.23E-02		2.03E-02		1.96E-02		1.92E-02	1.84E-02			2.45E-02	2.34E-02
1,2-Dichloroethane*	107-06-2		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
Bromodichloromethane	75-27-4		9.89E-05		9.47E-05		1.01E-04		9.66E-04		9.60E-05		9.18E-05	ND	ND
cis-1,3-Dichloropropene*	10061-01-5	9.89E-05		9.47E-05		1.01E-04		9.66E-04			9.60E-05		9.18E-05	9.86E-05	9.44E-05
trans-1,3-Dichloropropene*	10061-02-6	9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05		9.18E-05		9.86E-05	9.44E-05
4-Methyl-2-pentanone*	108-10-1		4.95E-04		4.73E-03		5.05E-04		4.83E-04		4.80E-04		4.59E-04	ND	ND
Toluene*	108-88-3	1.64E-02		1.57E-02		1.02E-02		9.76E-03		9.12E-03		8.72E-03		1.19E-02	1.14E-02
1,1,2-Trichloroethane*	79-00-5		9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05		9.18E-05	ND	ND
Tetrachloroethene*	127-18-4		9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05		9.18B-05	ND	ND
2-Hexanone	591-78-6		4.95E-04		4.73E-05		5.05E-04		4.83E-04		4.80E-04		4.59E-04	ND	ND
Dibromochloromethane	124-48-1		9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05		9.18E-05	ND	ND
Chlorobenzene*	108-90-7		9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05		9.18E-05	ND	ND
Ethyl Benzene*	100-41-4	3.44E-03		3.30E-03		2.24E-03		2.14E-03		1.78E-03		1.70E-03		2.49E-03	2.38E-03
m,p-Xylene*	108-38-3	1.08E-02		1.03E-02		7.27E-03		6.96E-03		5.85E-03		5.60E-03		7.97E-03	7.62E-03
o-Xylene*	95-47-6	6.85E-03		6.55E-03		4.60E-03		4.41E-03		3.69E-03		3.54E-03		5.05E-03	4.83E-03
Styrene*	100-42-5	4.12E-03		3.94E-03		1.74E-03		1.66E-03		1.80E-03		1.73E-03		2.55E-03	2.44E-03
Bromoform*	75-25-2		9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05		9.18E-05	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		9.89E-05		9.47E-05		1.01E-04		9.66E-05		9.60E-05		9.18E-05	ND	ND
1,3-Butadiene*	106-99-0	9.70E-03		9.28E-03		4.85E-03		4.64E-03		4.52E-03	4.13E-03			6.29E-03	6.02E-03

* Hazardous Air Pollutant (HAP)

ND – Compound not detected at this detection limit. Compound may be present at a value less than the detection limit.

TABLE 5-8.
J85-GE-5M (MOODY AFB)
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
Military
(Flow by Carbon Balance)

	Run Number											
	1				2		3					
Flow Rate, dscfm	544,313				544,313		544,313					
Fuel Flow, lbs/hr	2550				2550		2550				Average	
		lb/hr		lbs/1,000 lbs fuel		lb/hr		lbs/1,000 lbs fuel		lb/hr		lbs/1,000lbs fuel
Analyte	CAS number	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit		
Chloromethane*	74-87-3	3.51E-04		1.38E-04		4.40E-07		1.73E-07		2.43E-04		9.54E-04	1.98E-04	7.79E-05
Bromomethane*	74-83-9		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Chloroethane*	75-00-3		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Freon 11 (Trichlorofluoromethane)	75-69-4	8.77E-04		3.44E-04		8.30E-04		3.26E-04		1.17E-03		4.58E-04		9.59E-04	3.76E-04
1,1-Dichloroethane*	75-34-3		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Carbon Disulfide*	75-15-0		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Acetone	67-64-1		8.77E-04		3.44E-04		1.38E-03		5.43E-04		1.22E-03		4.77E-04	ND	ND
Methylene Chloride*	75-09-2	3.68E-04		1.44E-04		4.70E-04		1.84E-04		1.10E-03		4.29E-04		6.46E-04	2.52E-04
trans-1,2-Dichloroethene	156-60-5		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
1,1-Dichloroethene*	75-35-4		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Vinyl Acetate*	108-05-4		8.77E-04		3.44E-04		1.38E-03		5.43E-04		1.22E-03		4.77E-04	ND	ND
cis-1,2-Dichloroethene*	156-59-2		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3		8.77E-04		3.44E-04		1.38E-03		5.43E-04		1.22E-03		4.77E-04	ND	ND
Chloroform*	67-66-3		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
1,1,1-Trichloroethane*	71-55-6		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Carbon Tetrachloride*	56-23-5	4.03E-04		1.58E-04		3.60E-04		1.41E-04		3.65E-04		1.43E-04		3.76E-04	1.47E-04
Benzene*	71-43-2	6.14E-03		2.41E-03		6.61E-03		2.59E-03		6.86E-03		2.69E-03		6.54E-03	2.56E-03
1,2-Dichloroethane*	107-06-2		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Bromodichloromethane	75-27-4		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
4-Methyl-2-pentanone*	108-10-1		8.77E-04		3.44E-04		1.38E-03		5.43E-04		1.22E-03		4.77E-04	ND	ND
Toluene*	108-88-3	2.74E-03		1.07E-03		2.16E-03		8.46E-04		2.09E-03		8.21E-04		2.33E-03	9.12E-04
1,1,2-Trichloroethane*	79-00-5		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Tetrachloroethene*	127-18-4		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
2-Hexanone	591-78-6		8.77E-04		3.44E-04		1.38E-03		5.43E-04		1.22E-03		4.77E-04	ND	ND
Dibromochloromethane	124-48-1		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Chlorobenzene*	108-90-7		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
Ethyl Benzene*	100-41-4	3.68E-04		1.44E-04			2.77E-04		1.09E-04		2.43E-04		9.54E-05	1.23E-04	4.80E-05
m,p-Xylene*	108-38-3	1.47E-03		5.78E-04		7.19E-04		2.82E-04		1.12E-03		4.39E-04		1.10E-03	4.33E-04
o-Xylene*	95-47-6	7.37E-04		2.89E-04		3.87E-04		1.52E-04		6.57E-04		2.58E-04		5.94E-04	2.33E-04
Styrene*	100-42-5	2.10E-04		8.25E-05		2.77E-04		1.09E-04		3.41E-04		1.34E-04		1.84E-04	7.22E-05
Bromoform*	75-25-2		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		1.75E-04		6.88E-05		2.77E-04		1.09E-04		2.43E-04		9.54E-05	ND	ND
1,3-Butadiene*	106-99-0		8.77E-04		3.44E-04		1.38E-03		5.43E-04		1.22E-03		4.77E-04	ND	ND

* Hazardous Air Pollutant (HAP)
ND - Compound not detected at this detection limit. Compound may be present at a value less than the detection limit

TABLE 5-9.
J85-GE-5M (Moody AFB)
ENGINE RAKE
EMISSION FACTOR SUMMARY
BENZENE
(Flow By Carbon Balance)

	Idle		Intermediate		Military	
Flow Rate dscfm	188,704		293,150		544,313	
Fuel Flow lbs/hr	525		1,045		2550	
Analyte	lbs/hr	lbs/1000 lbs fuel	lbs/hr	lbs/1000 lbs fuel	lbs/hr	lbs/1000 lbs fuel
Benzene	3.90E-01	7.42E-01	2.46E-01	2.35E-01	4.63E-02	1.82E-02

TABLE 5-10.
J85-GE-5M (Moody AFB)
ENGINE RAKE
EMISSION FACTOR SUMMARY
Formaldehyde
(Flow By Carbon Balance)

	Idle		Intermediate		Military	
Flow Rate dscfm	118,704		293,150		544,313	
Fuel Flow lbs/hr	525		1,045		2550	
Analyte	lbs/hr	lbs/1000 lbs fuel	lbs/hr	lbs/1000 lbs fuel	lbs/hr	lbs/1000 lbs fuel
Formaldehyde	7.60E-01	1.45E+00	1.71E+00	1.64E+00	4.57E-01	1.79E-01

TABLE 5-11.
J85-GE-5M (Moody AFB)
SLIPSTREAM RAKE
EMISSION FACTOR SUMMARY
ADELHYDE/KETONES

	Idle		Intermediate		Military	
Flow Rate dscfm	118,704		293,150		544,313	
Fuel Flow lbs/hr	525		1,045		2,550	
Analyte	lbs/hr	lbs/ 1000 lbs fuel	lbs/hr	lbs/ 1000 lbs fuel	lbs/hr	lbs/ 1000 lbs fuel
Formaldehyde	1.19E+00	2.26E+00	3.64E-01	3.48E-01	6.10E-02	2.39E-02
Acetaldehyde	1.28E-01	2.44E-01	2.00E-02	1.93E-02	4.00E-03	1.55E-03
Acrolein	1.65E-01	3.13E-01	1.30E-02	1.28E-02	3.00E-03	1.31E-03
Propanal	4.10E-02	7.83E-02	1.30E-02	1.28E-02	3.00E-03	1.31E-03
Crotonaldehyde	6.20E-02	1.18E-01	1.30E-02	1.28E-02	3.00E-03	1.31E-03
Isobutraldehyde / Methyl Ethyl Ketone	4.10E-02	7.83E-02	1.30E-02	1.28E-02	3.00E-03	1.31E-03
Benzaldehyde	4.10E-02	7.83E-02	1.30E-02	1.28E-02	3.00E-03	1.31E-03
Isopentanal (Isovaleraldehyde)	4.10E-02	7.83E-02	1.30E-02	1.28E-02	3.00E-03	1.31E-03
Pentanal (Valeraldehyde)	1.28E-01	2.44E-01	1.30E-02	1.28E-02	3.00E-03	1.31E-03
o-Tolualdehyde	4.90E-02	9.40E-02	1.30E-02	1.28E-02	3.00E-03	1.31E-03
Hexanal (Hexaldehyde)	4.10E-02	7.83E-02	1.30E-02	1.28E-02	3.00E-03	1.31E-03

moved from idle to the higher engine settings the emissions decreased accordingly. Formaldehyde emissions were 0.02 lb/1000 lbs fuel at military.

5.4 POLYNUCLEAR AROMATIC HYDROCARBONS

Samples for polynuclear aromatic hydrocarbons were collected at the slipstream for the J85-GE-5M engine. A summary of the results for the idle, intermediate, and military settings is provided in Table 5-12. Naphthalene and 2-methylnaphthalene were detected at the idle setting only.

5.5 POLLUTANT MIXING IN THE AUGMENTER TUBE

Pollutant mixing in the augmenter tube was examined at Moody AFB through the use of 12 sampling points within the augmenter tube fixed to the slipstream rake. The points were positioned according the to procedures in EPA Method 1 and are provided in Figure 5-2. By investigating the mixing of emissions from the engine, we could define the profile within the augmenter tube (at the point of collection, the slipstream rake) for the engine emissions. At each engine setting, CO concentrations were compared to each other. As shown in Table 5-13, the concentrations of CO varied by 22%, 12%, and 9% between the highest and lowest values observed from the 12 sampling points at idle, intermediate, and military respectively. This indicated that CO was well distributed with the ambient air entering the hush house and into the augmenter tube. The slight variance in emissions does not impact sample collection since the gaseous emissions were collected at all 12 slipstream rake intake points and averaged and the inorganic and volatile samples were collected from the slipstream duct where there was a slight increase in concentration. The data showed at the tested conditions, that stratification of the engine exhaust was not significant.

5.6 PARTICULATE MATTER

The total particulate emissions are presented in Table 5-14. The results represent the total particulate, condensable (aqueous fraction only), and filterable exiting the hush house.

TABLE 5-12.
J85-GE-5M (MOODY AFB)
SLIPSTREAM RAKE
EMISSION FACTOR SUMMARY
POLYNUCLEAR AROMATIC HYDROCARBONS

			Run Number									
			IDLE		INTERMEDIATE		MILITARY				Average	
		Flow Rate, dscfm [a]	118,704		293,150		544,313					
		Fuel Flow, lbs/hr	525		1045		2550					
			lb/hr	lbs/1000lbs fuel	lb/hr	lbs/1000lbs fuel	lb/hr		lbs/1000lbs fuel			
Analyte	CAS Number	HAP?	Detected / Detection Limit	Detected / Detection Limit	Detected / Detection Limit	Detected / Detection Limit	Detected / Detection Limit		Detected / Detection Limit		lb/hr	lbs/1000lb fuel
Naphthalene	91-20-3	Yes	4.35E-02	8.29E-02	6.22E-03	5.95E-03	1.19E-02		4.66E-03		1.45E-02	2.76E-02
2-Methylnapthlene	91-57-6	Yes	6.77E-02	1.29E-01	6.22E-03	5.95E-03	1.19E-02		4.66E-03		2.26E-02	4.30E-01
2-Chloronapthalene	91-58-7	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Acenapthene	83-32-9	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Acenapthylene	208-96-8	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Fluorene	86-73-7	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Phenanthrene	85-01-8	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Anthracene	120-12-7	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Fluoranthene	206-44-0	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Pyrene	129-00-0	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Chrysens	218-01-9	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Benzo(a)anthracene	56-55-3	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Benzo(b)fluoranthene	205-99-2	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Benzo(k)fluoranthene	207-08-9	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Benzo(a)pyrene	50-32-8	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Indeno(1,2,3-c,d)pyrene	193-3-5	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Dibenz(a,h)anthracene	53-70-3	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND
Benzo(g,h,I)perylene	191-24-2	Yes	4.84E-03	9.21E-03	6.22E-03	5.95E-03	1.19E-02		4.66E-03		ND	ND

(a) – Idle Flow rates calculated by F-Factor; Intermediate, Military and Afterburner flow rates calculated by carbon balance.
ND – Compound not detected at this detection limit. Compound may be present at a value less than the detection limit.

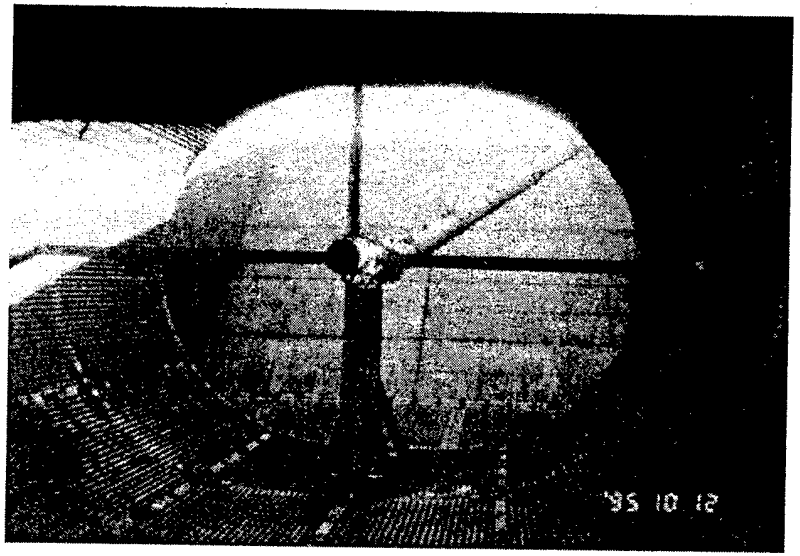

Figure 5-2. Augmenter Tube Side-Stream Extraction Tube and Gas Sampling

EQ ENVIRONMENTAL QUALITY MANAGEMENT, INC.

TABLE 5-13.
J85-GE-5M (Moody AFB)
SLIPSTREAM RAKE INTAKE
SAMPLE POINT DATA COMPARISON

	Idle	Intermediate	Military
Sample Point	**CO (ppm)**	**CO (ppm)**	**CO (ppm)**
1	209	*35.3*	25.1
2	**220**	35.8	25.1
3	209	37.4	25.8
4	178	39.9	**26.5**
5	177	**40.3**	26.2
6	195	**40.3**	26.1
7	205	*35.3*	*24.0*
8	174	35.6	24.3
9	202	37.2	25.8
10	188	39.7	25.6
11	173	39.4	25.0
12	*171*	39.6	24.7
Maximum	220	40.3	26.5
Minimum	171	35.3	24.0

Note: Values are uncorrected averages for runs 1 and 2 of each condition.
Bold represents the maximum value at each condition.
Italics represent the minimum value(s) at each condition.

TABLE 5-14.
J85-GE-5M (MOODY AFB)
EMISSIONS FACTOR SUMMARY
PARTICULATE

	Run Number									
	1		2		3		Composite		Average	
Flow Rate, dscfm[a]	**118,704**		**118,704**		**118,704**		**118,704**		**118,704**	
Fuel Flow, lbs/hr	**525**		**525**		**525**		**525**		**525**	
	lb/hr	**lbs/ 1000 lbs fuel**	**lb/hr**	**lbs/ 1000 lbs fuel**	**lb/hr**	**lbs/ 1000 lbs fuel**	**lb/hr**	**lbs/1000 lbs fuel**	**lb/hr**	**lbs/1000 lbs fuel**
IDLE										
Filterable	1.61	3.06	0.86	1.64	1.26	2.39	0.73	1.39	0.95	1.80
Condensible[d]	3.21	6.12	2.36	4.49	2.21	4.21	2.51	4.79	2.36	4.50
Total Particulate	4.82	9.17[c]	3.22	6.13	3.47	6.60	3.24	6.18	3.31	6.30
INTERMEDIATE										
Flow Rate, dscfm[b]	**293,150**		**293,150**		**293,150**		**293,150**		**293,150**	
Fuel Flow, lbs/hr	**1,045**		**1,045**		**1,045**		**1,045**		**1,045**	
Filterable	3.54	3.39	3.20	3.07	3.12	2.98	1.29	1.24	2.65	2.54
Condensible	7.80	7.46	14.60	13.97	10.38	9.94	7.48	7.16	8.55	8.19
Total Particulate	11.34	10.85	17.80	17.03[c]	13.50	12.92	8.77	8.40	11.20	10.72
MILITARY										
Flow Rate, dscfm[b]	**544,312**		**544,312**		**544,312**		**544,312**		**544,312**	
Fuel Flow, lbs/hr	**2,550**		**2,550**		**2,550**		**2,550**		**2,550**	
Filterable	9.11	3.57	9.16	3.59	8.18	3.21	4.57	1.79	7.30	2.86
Condensible	6.30	2.47	ND	ND	ND	ND	6.08	2.39	2.03	0.80
Total Particulate	15.41	6.04[c]	9.16	3.59	8.18	3.21	10.65	4.18	9.33	3.66

(a) – Exhaust flow rate determined by F-factor
(b) – Exhaust flow rate determined by Carbon Balance
(c) – This run not included in averages.
(d) - Aqueous fraction only, see note below.

NOTE: Particulate measurements not made at Afterburner. It appears that hydrocarbons from unburned fuel are in the impinger solution at the idle and intermediate power settings. This accounts for the majority of the condensable fraction.

TABLE 5-15.
PERCENTAGES OF CARBON PARTICLES IN VARIOUS DIAMETER RANGES BY NUMBER OF PARTICLES

	Idle	Intermediate	Military	
Filter Number	**PC001**	**PC002**	**PC003**	**Blank**
Diameter Range (um)				
.5-2.5	92.4%	88.2%	89.4%	NA*
2.5-5.0	6.7%	10.8%	8.7%	
5.0-7.5	1.0%	1.0%	1.0%	
7.5-10	0.0%	0.0%	1.0%	
>10	0.0%	0.0%	0.0%	

*NA - Insufficient particles for a valid statistical analysis

PERCENTAGES OF CARBON PARTICLES IN VARIOUS DIAMETER RANGES BY ESTIMATED MASS OF PARTICLES

	Idle	Intermediate	Military	
Filter Number	**PC001**	**PC002**	**PC003**	**Blank**
Diameter Range (um)				
.5-2.5	34.8%	26.9%	18.4%	NA*
2.5-5.0	39.2%	51.4%	27.9%	
5.0-7.5	26.0%	21.6%	14.3%	
7.5-10	0.0%	0.0%	39.3%	
>10	0.0%	0.0%	0.0%	

*NA - Insufficient particles for a valid statistical analysis

The particulate sampling methodology was improved in several ways over past sampling campaigns in order to improve the detection limit in the exhaust stream. EQ and USAF personnel reviewed the historic sampling procedures and developed the following improvements:

- The sample run times were extended to 2 hours in length. This allowed for a larger sample volume and larger particle catch.
- A field balance was used to ensure that a positive mass gain on the filter was obtained. This allowed the field team to adjust the sample volume in the field as necessary.
- A Teflon filter frit without a gasket was used in the filter housing. This set-up prevented the filter from sticking to the frit.

The improvements made the particulate sampling much more representative of the engine emissions.

The filterable particulate emission results for this engine were higher than the historic data set. This is attributed to the improved particle collection during this program. The engine also noted a similar emission trend pattern. The filterable emission index was 1.8 lbs/1000 lbs fuel at idle, 2.5 lbs/1000 lbs fuel at intermediate, and 2.9 lbs/1000 lbs fuel at military. The condensable particulate matter was considerably higher than the past program indicated. It was noted in the field that the condensable fraction had a heavy yellow discoloration at idle, a murky yellow color at intermediate, and a cloudy consistency at military. It appeared that unburned fuel passed through the engine and into the exhaust stream. The organic fraction of the condensible particulate matter was removed from the results.

5.6.1 Particle Characterization

During one run at each setting, a particle sample was collected on a silver membrane filter for analysis via scanning electron microscopy to count the particles in each size range. The results of the particle counts are provided in Table 5-15. The analysis determined that the majority of particulate matter (>99%) was below 10 microns in size with >89% of the particles at a diameter <2.5 microns. The pore size of the filter was 0.5 micron; therefore, particles less than 0.5 micron in diameter may have passed through the filter. Additional analysis was performed to examine particles less than 0.5 micron by transmission electron microscopy (TEM) and elemental analysis of particles less than 10 microns by automated SEM.

Three types of material were detected on each of the filters. One type of material is composed of particles, primarily carbon in nature, greater than 0.5 Φm. These particles make up approximately three-quarters of the larger particles. A second type of material is composed of non-carbon particles, primarily containing silicon, greater than 0.5 Φm. The third type of material is composed of aggregated carbon particles generally smaller than 0.5 Φm. The particles greater than 0.5 Φm in all three samples generally have similar lengths and widths. The average aspect ratio (length to width) for the non-carbon particles is 1.8. Many of the particle aggregates are consistent with carbon soot. Others appear to be degraded soot aggregates.

5.7 EXHAUST FLOW DETERMINATION

The engine exhaust flow was determined using several methods in order to provide an opportunity to review data sets and disregard outliers. Carbon balance and F-factor were used to determine the exhaust flow rate. The F-Factor methodology provided the most representative exhaust flow data at the idle setting. Carbon balance provided the most representative trend for the remaining settings. As shown in Tables 5-3 and 5-5, the flow models provided representative data. The engine rake flow at Moody AFB (1 engine) was approximately half of the airflow directly behind the T-38C (2 engines) at Randolph. The idle results did not follow this trend. The engine's inefficiency tended to provide varying data which impacted the calculations. The afterburner flow at the engine rake at Moody AFB (Table 5-3) was calculated to be less than the military flow. During testing, the engine developed a malfunction that disabled operation at afterburner. Only a single 3-minute sample was collected, which did not allow for triplicate measurement. A longer sample time may have provided more representative results. The carbon balance and F-Factor flow calculation methods provided good correlation.

5.8 FUEL ANALYSIS

Fuel samples were collected during the emission test program from the fuel line feeding the engine. The fuel was analyzed to determine the presence of select metals and other physical parameters. In the sample, small quantities of selenium, zinc, silver, and thallium were present. The fuel analysis results are presented in Tables 5-16 and 5-17.

TABLE 5-16. JP-8 FUEL ANALYSIS

Parameter	Analytical Method	Result
Btu/lb	ASTM D-240	19,300 Btu/lb
Sulfur %	ASTM D-2622	0.0496%
Carbon %	ASTM D-5291	85.52%
Nitrogen %	ASTM 4629	0.0007%
Hydrogen %	ASTM D-5291	14.18%
Ash %	ASTM D482	<0.001%
Naphthenes %	PONA Analysis	45.6%
Aromatics %	PONA Analysis	23.5%
Parafins %	PONA Analysis	30.4%
Olefins %	PONA Analysis	0.5%

TABLE 5-17. SUMMARY OF SOURCE TARGET METALS FROM JP-8 FUEL ANALYSIS

Metal	Analytical Method	Analytical Result (mg/kg)
Antimony	6010	<0.05
Arsenic	6010	<0.063
Barium	6010	<0.025
Beryllium	6010	<0.0025
Cadmium	6010	<0.013
Chromium	6010	<0.013
Cobalt	6010	<0.013
Copper	6010	0.025 (MDL = 0.025)
Lead	6010	<0.063
Manganese	6010	0.013 (MDL = 0.013)
Mercury	7470	<0.0005
Nickel	6010	0.038
Phosphorus	365.2	1.2 (MDL =0.025)
Selenium	6010	0.13
Silver	6010	0.013
Thallium	6010	0.075
Zinc	6010	0.025

Note: A sample and duplicate were submitted for analysis. The highest concentration is recorded in the table above.

5.9 ENGINE OPERATION

During the emission test program, specific engine parameters were monitored to note engine performance. Facility personnel were responsible for collecting and maintaining the operating data and for operating the engine in a safe manner. A summary of the engine operation is provided in Table 5-18.

TABLE 5-18
ENGINE OPERATING DATA

Power Setting	Fuel Flow (lbs/hr)		%RPM (Average)		lb/Thrust (Average)	Cell Temperature (Average F)
J85-GE-5R (Moody AFB)						
Idle	525		49.5		55	83
Intermediate	1,045		85.5		808	86
Military	2,550		99.7		2,521	77
Afterburner	7,695		99.8		3,450	88
T-38C with PMP Talon (Randolph AFB)						
Engine	1	2	1	2	Not Recorded	
Idle	520	520	50	49		
Intermediate	980	1080	85	85		
Military	2,200	2,240	100	100		
Afterburner	7,695	7,695	100	100		

APPENDIX A

EXAMPLE CALCULATIONS

EXAMPLE CALCULATIONS FOR POLLUTANT EMISSIONS

1. Volume of dry gas sampled corrected to standard conditions, ft^3.
   Note: Vm must be corrected for leakage if any leakage rates exceed La.

$$Vmstd = 17.647 \, x \, Vm \, x \, Y \left[\frac{Pbar + \frac{\Delta H}{13.6}}{TM, ^\circ R} \right]$$

2. Volume of water vapor at standard conditions, ft^3.

$$Vwstd = 0.04707 \text{ x } Vlc$$

3. Moisture content in stack gas, dimensionless.

$$Bws = \frac{Vwstd}{Vwstd + Vmstd}$$

4. Dry molecular weight of stack gas, lb/lb-mole.

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

5. Molecular weight of stack gas, lb/lb-mole.

$$Ms = Md(1\text{-}Bws) + 18Bws$$

6. Stack velocity at stack conditions, f/s.

$$Vs = (85.49) \, (Cp) \left(avg \sqrt{\Delta} \, P \right) \sqrt{\frac{Ts, ^\circ R}{(Ps)(Ms)}}$$

7. Stack gas volumetric flow rate at stack conditions, cfm.

$$Qs = 60 \text{ x } Vs \text{ x } As$$

8. Dry stack gas volumetric flow rate at standard conditions, cfm.

$$Qsstd = (17.647) \, (Qs) \left(\frac{Ps}{Ts} \right) (1 - Bws)$$

EXAMPLE CALCULATIONS FOR POLLUTANT EMISSIONS (continued)

9. Concentration in gr/dscf.

$$Cs = (0.01543)\left(\frac{Mn}{Vmstd}\right)$$

10. Pollutant mass emission rate, lb/h.

$$\text{pmr, lb / hr} = \left(\frac{\text{Cs}}{7000}\right) \text{x Qsstd x 60}$$

11. Pollutant mass emission rate, lb/MM Btu.

$$\text{pmr, lb / MM Btu} = \left(\frac{\text{pmr, lb/hr}}{\text{MM Btu/hr}}\right)$$

12. F-factor (Fd).

$$\text{Fd} = \frac{10^6\left(3.64\,\text{x}\,\%\text{H}\right) + \left(1.53\,\text{x}\,\%\text{C}\right) + \left(0.57\,\text{x}\,\%\text{S}\right) + \left(0.14\,\text{x}\,\%\text{N}\right) - \left(0.46\,\text{x}\,\%0_2\right)}{\text{GCV}\left(\text{Btu/lb}\right)}$$

13. F-factor, pollutant mass emission rate, lb/MM Btu (O_2-based).

$$= \frac{\text{lb / dscf x F x 20.9}}{\left(20.9 - \%\text{O}_2\right)}$$

14. Heat input, MM Btu/hr fuel.

$$= \frac{\text{GVC(Btu / lb)} * \text{Feed Rate(lb / hr)}}{10^6}$$

15. Heat input, MM Btu/hr, F-factor.

$$= \frac{\text{Qsstd}}{\text{Fd}} \text{x}\left[\left(20.9 - \%\text{O}_2\right) + 20.9\right] \text{x 60}$$

NOMENCLATURE AND DIMENSIONS

An = Cross-sectional area of sampling nozzle, sq.ft.

As = Cross-sectional area of stack, sq.ft.

Bws = Proportion by volume of water vapor in the gas stream, dimensionless

Cp = Pitot tube coefficient, dimensionless

Cs = Concentration of pollutant matter in stack gas – dry basis, grains per standard cubic foot (gr/dscf)

% CO = Percent of carbon monoxide by volume, dry basis

% CO_2 = Percent of carbon dioxide by volume, dry basis

♠H = Average pressure drop across the sampling meter flow orifice, inches of water (in.H_20)

GCV = Gross calorific value, Btu/lb

I = Percent of isokinetic sampling

La = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.020 cubic foot per minute or 4% of the average sampling rate, whichever is less

Md = Dry molecular weight, lb/lb-mole

Mn = Total amount of pollutant matter collected, milligrams (mg)

Ms = Molecular weight of stack gas (wet basis), lb/lb-mole

% N_2 = Percent of nitrogen by volume, dry basis

% O_2 = Percent of oxygen by volume, dry basis

♠P = Velocity head of stack gas, inches of water (in.H_2O)

Pbar = Barometric pressure, inches of mercury (in.Hg)

NOMENCLATURE AND DIMENSIONS (continued)

Ps	=	Absolute stack gas pressure, inches of mercury (in.Hg)
Pstd	=	Gas pressure at standard conditions, inches of mercury (29.92 in.Hg)
pmr	=	Pollutant matter emission rate, pounds per hour (lb/h)
Qs	=	Volumetric flow rate – wet basis at stack conditions, actual cubic feet per minute (acfm)
Qsstd	=	Volumetric flow rate – dry basis at standard conditions, dry standard cubic feet per minute (dscfm)
Tm	=	Average temperature of dry gas meter, ER
Ts	=	Average temperature of stack gas, ER
Tstd	=	Temperature at standard conditions, (528ER)
Vlc	=	Total volume of liquid collected in impingers and silica gel, ml
Vm	=	Volume of dry gas sampled at meter conditions, cu. ft.
Vmstd	=	Volume of dry gas sampled at standard conditions, cu. ft.
Vs	=	Average stack gas velocity at stack conditions, ft/s
Vwstd	=	Volume of water vapor at standard conditions, scf
Y	=	Dry gas meter calibration factor, dimensionless
ι	=	Total sampling time, minutes

NOTE: Standard condition = 68EF and 29.92 in. Hg

CARBON BALANCE FLOW METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Engine
Test Run No.:	1	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Inlet Conc. CO2, ppm	C2I	0
Inlet Conc. CO, ppm	CO1	0.00
Inlet Conc. THC, ppm	TC1	1.78
Outlet Conc. THC, wet ppm	TCE	179.8007
Outlet Conc. O2, dry percent	O2D	19.96323
Outlet Conc. CO2, dry percent	C2D	0.640847
Outlet Conc. CO, dry ppm	COD	898.5752
Outlet Moisture, percent	BWE	1.5
Carbon Content of Fuel, wt fraction	FC	0.8552
Conversion Constant, percent/ppm	KC1	0.0001
Conversion Constant, min/hour	KC2	0.016667
Conversion Constant, dscm/dscf	KQM	0.02831
Mass rate Fuel Burn, lb/hr	MF	525
Inlet Moisture, percent	BWI	1.5

Calculations

Wet Mole. Weight Exhaust, lb/lbmole

MWE = ((28)+(0.16*C2D)+(0.04*O2D))+(1-(BWE/100))+0.18*BWE
MWE = ((28)+(0.16*0.64)+(0.04*20.0))*(1-(1.5/100))+0.18*1.5
MWE = 28.73755

Wet Mole. Weight Inlet (Ambient), lb/lbmole

MWI = (28.84*(1-(BWI/100)))+(0.18*BWI)
MWI = (28.84*(1-(1.5/100)))+(0.18*1.5)
MWI = 28.6774

Wet Conc. CO2 in Exhaust, wet %

C2E = C2D*(1-(BWE/100))
C2E = 0.64*(1-(1.5/100))
C2E = 0.631235

Wet Conc. CO in Exhaust, wet %

COE = KC1*COD*(1-(BWE/100))
COE = 0.0001*899*(1-(1.5/100))
COE = 0.08881

Weight Fraction Carbon in Exhaust

CE = (C2E+COE+(KC1*TCE))*12.01/MWE/100
CE = (0.631+0.0888+(0.0001*180))*12.01/28.74/100
CE = 0.003001

Weight Fraction Carbon in Inlet

CI = KC1*(C2I+COI+TCI)*12.01/MWI/100
CI = 0.0001*(0+0+1.8)*12.01/28.68/100
CI = 7.47E-07

Mass Rate Exhaust, lb/hr

ME = MF*(FC-CI)/(CE-CI)
ME = 525*(0.8552-7.5E-07)/(0.003-7.5E-07)
ME = 149658.8

Exhaust Wet Standard Flowrate, wscf/min

QCE_{tw} = KC2*ME*385.35/MWE
QCE_{tw} = 0.016667*149,659*385.35/28.74
QCE_{tw} = 33447.62

Exhaust Dry Standard Flowrate, dscf/min

QCE_{td} = ((100-BWE)/100)*QCE_{tw}
QCE_{td} = ((100-1.5)/100)*33,448
QCE_{td} = 82945.91

Mass Rate Inlet, lb/hr

MI = MF*(FC-CE)/(CE-CI)
MI = 525*(0.8552-0.003)/(0.003-7.5E-07)
MI = 149133.8

Inlet Wet Std. Vol. Flow, wscf/min

QCI_{tw} = KC2*MI*385.35/MWI
QCI_{tw} = 0.016667*149,134*385.35/28.68
QCI_{tw} = 33400.2

Inlet Dry Std. Vol. Flow, dscf/min

QCI_{td} = ((100-BWI)/100)*QCI_{tw}
QCI_{td} = ((100-1.5)/100)*33,400
QCI_{td} = 32898.2

CARBON BALANCE FLOW METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Slipstream
Test Run No.:	1	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Inlet Conc. CO2, ppm	C2I	0
Inlet Conc CO, ppm	CO1	0
Inlet Conc THC, ppm	TC1	1.783333
Outlet Conc THC, wet ppm	TCE	41.36188
Outlet Conc O2, dry percent	O2D	20.69613
Outlet Conc. CO2, dry percent	C2D	0.230523
Outlet Conc CO, dry ppm	COD	212.1769
Outlet Moisture, percent	BWE	1.5
Carbon Content of Fuel, wt fraction	FC	0.8552
Conversion Constant, percent/ppm	KC1	0.0001
Conversion Constant, min/hour	KC2	0.016667
Conversion Constant, dscm/dscf	KQM	0.02831
Mass rate Fuel Burn, lb/hr	MF	525
Inlet Moisture, percent	BWI	1.5

Calculations

Wet Mole. Weight Exhaust, lb/lbmole
MWE = {(28)+(0.16*C2D)+(0.04*O2D))+(1-(BWE/100))+0.18*BW
MWE = 28.70176

Wet Mole. Weight Inlet (Ambient), lb/lbmole
MWI = (28.84*(1-(BWI/100)))+(0.18*BWI)
MWI = 28.6774

Wet Conc. CO2 in Exhaust, wet %
C2E = C2D*(1-(BWE/100))
C2E = 0.227065

Wet Conc. CO in Exhaust, wet %
COE = KC1*COD*(1-(BWE/100))
COE = 0.020899

Weight Fraction Carbon in Exhaust
CE = (C2E+COE+(KC1*TCE))*12.01/MWE/100
CE = 0.001055

Weight Fraction Carbon in Inlet
CI = KC1*(C2I+COI+TCI)*12.01/MWI/100
CI = 7.47E-07

Mass Rate Exhaust, lb/hr
ME = MF*(FC-CI)/(CE-CI)
ME = 425917.3

Exhaust Wet Standard Flowrate, wscf/min
QCE_{1w} = KC2*ME*385.35/MWE
QCE_{1w} = 95308.05

Exhaust Dry Standard Flowrate, dscf/min
QCE_{1d} = ((100-BWE)/100)*QCE_{1w}
QCE_{1d} = 93878.43

Mass Rate Inlet, lb/hr
MI = MF*(FC-CE)/(CE-CI)
MI = 425392.3

Inlet Wet Std Vol Flow, wscf/min
QCI_{1w} = KC2*MI*385.35/MWI
QCI_{1w} = 95271.42

Inlet Dry Std. Vol. Flow, dscf/min
QCI_{1d} = ((100-BWI)/100)*QCI_{1w}
QCI_{1d} = 93842.36

CARBON BALANCE FLOW METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Engine
Test Run No ·	2	Test Date:	4/24/02
Engine Type·	T38		
Test Condition:	Idle		

Inputs

Inlet Conc. CO2, ppm	C2I	0.040126
Inlet Conc. CO, ppm	CO1	0.00
Inlet Conc. THC, ppm	TC1	-4.72
Outlet Conc. THC, wet ppm	TCE	155.5164
Outlet Conc. O2, dry percent	O2D	19.91824
Outlet Conc. CO2, dry percent	C2D	0.710671
Outlet Conc. CO, dry ppm	COD	691.9983
Outlet Moisture, percent	BWE	1.5
Carbon Content of Fuel, wt fractio	FC	0.8552
Conversion Constant, percent/ppr	KC1	0.0001
Conversion Constant, min/hour	KC2	0.016667
Conversion Constant, dscm/dscf	KQM	0.02831
Mass rate Fuel Burn, lb/hr	MF	525
Inlet Moisture, percent	BWI	1.5

Calculations

Wet Mole Weight Exhaust, lb/lbmole	MWE =	((28)+(0.16*C2D)+(0.04*O2D))+(1-(BWE/100))+0 18*BW
	MWE =	28.74678
Wet Mole. Weight Inlet (Ambient), lb/lbmole	MWI =	(28.84*(1-(BWI/100)))+(0 18*BWI)
	MWI =	28.6774
Wet Conc. CO2 in Exhaust, wet %	C2E =	C2D*(1-(BWE/100))
	C2E =	0 700011
Wet Conc. CO in Exhaust, wet %	COE =	KC1*COD*(1-(BWE/100))
	COE =	0.068162
Weight Fraction Carbon in Exhaust	CE =	(C2E+COE+(KC1*TCE))*12 01/MWE/100
	CE =	0.003274
Weight Fraction Carbon in Inlet	CI =	KC1*(C2I+COI+TCI)*12.01/MWI/100
	CI =	-2E-06
Mass Rate Exhaust, lb/hr	ME =	MF*(FC-CI)/(CE-CI)
	ME =	137041.2
Exhaust Wet Standard Flowrate, wscf/min	QCE_{1w} =	KC2*ME*385.35/MWE
	QCE_{1w} =	30617.85
Exhaust Dry Standard Flowrate, dscf/min	QCE_{1d} =	((100-BWE)/100)*QCE_{1w}
	QCE_{1d} =	30158.58
Mass Rate Inlet, lb/hr	MI =	MF*(FC-CE)/(CE-CI)
	MI =	136516.2
Inlet Wet Std. Vol. Flow, wscf/min	QCI_{1w} =	KC2*MI*385.35/MWI
	QCI_{1w} =	30574.34
Inlet Dry Std. Vol. Flow, dscf/min	QCI_{1d} =	((100-BWI)/100)*QCI_{1w}
	QCI_{1d} =	30115.73

CARBON BALANCE FLOW METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Slipstream
Test Run No.:	2	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Inlet Conc. CO2, ppm	C2I	0.040126
Inlet Conc. CO, ppm	CO1	0.00
Inlet Conc. THC, ppm	TC1	-4.72
Outlet Conc. THC, wet ppm	TCE	35.56174
Outlet Conc. O2, dry percent	O2D	20.65843
Outlet Conc. CO2, dry percent	C2D	0.2309
Outlet Conc. CO, dry ppm	COD	186.8948
Outlet Moisture, percent	BWE	1.5
Carbon Content of Fuel, wt fractio	FC	0.8552
Conversion Constant, percent/ppr	KC1	0.0001
Conversion Constant, min/hour	KC2	0.016667
Conversion Constant, dscm/dscf	KQM	0.02831
Mass rate Fuel Burn, lb/hr	MF	525
Inlet Moisture, percent	BWI	1.5

Calculations

Wet Mole. Weight Exhaust, lb/lbmole
MWE = ((28)+(0.16*C2D)+(0.04*O2D))+(1-(BWE/100))+0.18*BW
MWE = 28.70033

Wet Mole. Weight Inlet (Ambient), lb/lbmole
MWI = (28.84*(1-(BWI/100)))+(0.18*BWI)
MWI = 28.6774

Wet Conc. CO2 in Exhaust, wet %
C2E = C2D*(1-(BWE/100))
C2E = 0.227436

Wet Conc. CO in Exhaust, wet %
COE = KC1*COD*(1-(BWE/100))
COE = 0.018409

Weight Fraction Carbon in Exhaust
CE = (C2E+COE+(KC1*TCE))*12.01/MWE/100
CE = 0.001044

Weight Fraction Carbon in Inlet
CI = KC1*(C2I+COI+TCI)*12.01/MWI/100
CI = -2E-06

Mass Rate Exhaust, lb/hr
ME = MF*(FC-CI)/(CE-CI)
ME = 429396.2

Exhaust Wet Standard Flowrate, wscf/min
QCE_{1w} = KC2*ME*385.35/MWE
QCE_{1w} = 96091.3

Exhaust Dry Standard Flowrate, dscf/min
QCE_{1d} = ((100-BWE)/100)*QCE_{1w}
QCE_{1d} = 94649.93

Mass Rate Inlet, lb/hr
MI = MF*(FC-CE)/(CE-CI)
MI = 428871.2

Inlet Wet Std Vol. Flow, wscf/min
QCI_{1w} = KC2*MI*385.35/MWI
QCI_{1w} = 96050.56

Inlet Dry Std. Vol. Flow, dscf/min
QCI_{1d} = ((100-BWI)/100)*QCI_{1w}
QCI_{1d} = 94609.8

CARBON BALANCE FLOW METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Engine
Test Run No.:	3	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Inlet Conc. CO2, ppm	C2I	0.058618
Inlet Conc. CO, ppm	CO1	0.10
Inlet Conc. THC, ppm	TC1	-9.91
Outlet Conc. THC, wet ppm	TCE	141.55
Outlet Conc. O2, dry percent	O2D	19.91144
Outlet Conc CO2, dry percent	C2D	0.746357
Outlet Conc. CO, dry ppm	COD	688.438
Outlet Moisture, percent	BWE	1.5
Carbon Content of Fuel, wt fraction	FC	0.8552
Conversion Constant, percent/ppm	KC1	0.0001
Conversion Constant, min/hour	KC2	0.016667
Conversion Constant, dscm/dscf	KQM	0.02831
Mass rate Fuel Burn, lb/hr	MF	525
Inlet Moisture, percent	BWI	1.5

Calculations

Wet Mole. Weight Exhaust, lb/lbmole	MWE =	((28)+(0.16*C2D)+(0.04*O2D))+(1-(BWE/100))+0.18*BW
	MWE =	28.75214
Wet Mole. Weight Inlet (Ambient), lb/lbmole	MWI =	(28.84*(1-(BWI/100)))+(0.18*BWI)
	MWI =	28.6774
Wet Conc. CO2 in Exhaust, wet %	C2E =	C2D*(1-(BWE/100))
	C2E =	0.735162
Wet Conc. CO in Exhaust, wet %	COE =	KC1*COD*(1-(BWE/100))
	COE =	0.067811
Weight Fraction Carbon in Exhaust	CE =	(C2E+COE+(KC1*TCE))*12.01/MWE/100
	CE =	0.003413
Weight Fraction Carbon in Inlet	CI =	KC1*(C2I+COI+TCI)*12.01/MWI/100
	CI =	-4.1E-06
Mass Rate Exhaust, lb/hr	ME =	MF*(FC-CI)/(CE-CI)
	ME =	131385.2
Exhaust Wet Standard Flowrate, wscf/min	QCE_{1w} =	KC2*ME*385.35/MWE
	QCE_{1w} =	29348.73
Exhaust Dry Standard Flowrate, dscf/min	QCE_{1d} =	((100-BWE)/100)*QCE_{1w}
	QCE_{1d} =	28908.5
Mass Rate Inlet, lb/hr	MI =	MF*(FC-CE)/(CE-CI)
	MI =	130860.2
Inlet Wet Std. Vol. Flow, wscf/min	QCI_{1w} =	KC2*MI*385.35/MWI
	QCI_{1w} =	29307.63
Inlet Dry Std. Vol. Flow, dscf/min	QCI_{1d} =	((100-BWI)/100)*QCI_{1w}
	QCI_{1d} =	28868.02

CARBON BALANCE FLOW METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Slipstream
Test Run No.:	3	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Inlet Conc. CO2, ppm	C2I	0.058618
Inlet Conc. CO, ppm	CO1	0.099488
Inlet Conc THC, ppm	TC1	-9.91333
Outlet Conc. THC, wet ppm	TCE	28.30817
Outlet Conc. O2, dry percent	O2D	20.41542
Outlet Conc. CO2, dry percent	C2D	0.206798
Outlet Conc. CO, dry ppm	COD	166.6191
Outlet Moisture, percent	BWE	1.5
Carbon Content of Fuel, wt fractio	FC	0.8552
Conversion Constant, percent/ppr	KC1	0.0001
Conversion Constant, min/hour	KC2	0.016667
Conversion Constant, dscm/dscf	KQM	0.02831
Mass rate Fuel Burn, lb/hr	MF	525
Inlet Moisture, percent	BWI	1.5

Calculations

Wet Mole. Weight Exhaust, lb/lbmole	MWE =	((28)+(0.16*C2D)+(0 04*O2D))+(1-(BWE/100))+0.18*BW
	MWE =	28.68696
Wet Mole. Weight Inlet (Ambient), lb/lbmole	MWI =	(28.84*(1-(BWI/100)))+(0.18*BWI)
	MWI =	28.6774
Wet Conc. CO2 in Exhaust, wet %	C2E =	C2D*(1-(BWE/100))
	C2E =	0.203696
Wet Conc. CO in Exhaust, wet %	COE =	KC1*COD*(1-(BWE/100))
	COE =	0.016412
Weight Fraction Carbon in Exhaust	CE =	(C2E+COE+(KC1*TCE))*12.01/MWE/100
	CE =	0.000933
Weight Fraction Carbon in Inlet	CI =	KC1*(C2I+COI+TCI)*12.01/MWI/100
	CI =	-4.1E-06
Mass Rate Exhaust, lb/hr	ME =	MF*(FC-CI)/(CE-CI)
	ME =	478947.6
Exhaust Wet Standard Flowrate, wscf/min	QCE_{1w} =	KC2*ME*385.35/MWE
	QCE_{1w} =	107230
Exhaust Dry Standard Flowrate, dscf/min	QCE_{1d} =	((100-BWE)/100)*QCE_{1w}
	QCE_{1d} =	105621.5
Mass Rate Inlet, lb/hr	MI =	MF*(FC-CE)/(CE-CI)
	MI =	478422.6
Inlet Wet Std Vol. Flow, wscf/min	QCI_{1w} =	KC2*MI*385.35/MWI
	QCI_{1w} =	107148.2
Inlet Dry Std. Vol. Flow, dscf/min	QCI_{1d} =	((100-BWI)/100)*QCI_{1w}
	QCI_{1d} =	105540.9

F-FACTOR METHOD
EXAMPLE CALCULATIONS

Client: Moody AFB
Test Run No.: 1
Engine Type: T38
Test Condition: Idle

Location: Engine
Test Date: 4/24/02

Inputs

Outlet Conc. THC, wet ppm	TCE	179.8007143
Outlet Conc. O2, dry percent	O2D	19.95323397
Outlet Conc. CO2, dry percent	C2D	0.640947449
Outlet Conc. CO, dry ppm	COD	698.5751987
Outlet Moisture, percent	BWE	2
Carbon Content of Fuel, wt fraction	FC	0.8552
Hydrogen Content of Fuel, % by wt	FH	14.18
Sulfur Content of Fuel, % by wt	FS	0.0496
Nitrogen Content of Fuel, % by wt	FN	0.0007
Oxygen Content of Fuel, % by wt	FO	0.2199
Conversion Constant, %/ppm	KC_1	0.0001
Calc. Constant min/hour	KC_2	0.016666667
Mass rate Fuel Burn, LB/HR	MF	525
Inlet Moisture	BWI	0.6335

Calculations

F FACTOR FOR FUEL, scf/lb Fuel

FMD = (3.64*FH)+(1.53*FC*100)+(0.57*FS)+(0.14*FN)-(0.46*FO)
FMD = (3.64*14.18)+(1.53*0.8552*100)+(0.57*0.0496)+(0.14*0.0007)-(0.46*0.2199)
FMD = 182.39

EXCESS AIR IN EXHAUST, dimensionless fraction

EAF = (O2D-(0.00005*COD))/(20.9-(O2D-(0.00005*COD)))
EAF = (20.0-(0.00005*699))/(20.9-(20.0-(0.00005*699)))
EAF = 20.51

STOICHIOMETRIC AIR REQUIRED, scf/min

$QS = MF*FMD*KC_2$
QS = 525*182.39*0.016667
QS = 1,596

EXHAUST DRY STANDARD FLOWRATE, dscf/min

$QFE_1 = QS*(1+EAF)$
$QFE_1 = 1,596*(1+20.51)$
$QFE_1 = 34,326$

EXHAUST WET STANDARD FLOWRATE, wscf/min

$QWE_1 = QFE_1/(1-BWE/100)$
$QWE_1 = 34,326/(1-2/100)$
$QWE_1 = 35,026$

NITROGEN IN EXHAUST, % dry basis

ND = 100-(O2D+C2D+(COD*KC_1)+(TCE*KC_1*(1-(BWE/100))))
ND = 100-(20.0+0.64+(699*0.0001)+(180*0.0001*(1-(2/100))))
ND = 79.31

INLET DRY STANDARD VOLUMETRIC FLOW, dscf/min

$QFI_1 = QFE_1*((ND/100)/(1-(20.9/100)))$
$QFI_1 = 34,326*((79.31/100)/(1-(20.9/100)))$
$QFI_1 = 34,416$

INLET WET STANDARD VOLUMETRIC FLOW, wscf/min

$QWI_1 = QFI_1/(1-BWI/100)$
$QWI_1 = 34,416/(1-0.6335/100)$
$QWI_1 = 34,636$

F-FACTOR METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Slipstream
Test Run No:	1	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Outlet Conc. THC, wet ppm	TCE	41.361875
Outlet Conc. O2, dry percent	O2D	20.69613051
Outlet Conc. CO2, dry percent	C2D	0.230523148
Outlet Conc. CO, dry ppm	COD	212.1769922
Outlet Moisture, percent	BWE	2
Carbon Content of Fuel, wt fraction	FC	0.8562
Hydrogen Content of Fuel, % by wt	FH	14.18
Sulfur Content of Fuel, % by wt	FS	0.0496
Nitrogen Content of Fuel, % by wt	FN	0.0007
Oxygen Content of Fuel, % by wt	FO	0.2199
Conversion Constant, %/ppm	KC_1	0.0001
Calc. Constant min/hour	KC_2	0.016666667
Mass rate Fuel Burn, LB/HR	MF	525
Inlet Moisture	BWI	0.6335

Calculations

F FACTOR FOR FUEL, scf/lb Fuel

FMD = (3.64*FH)+(1.53*FC*100)+(0.57*FS)+(0.14*FN)-(0.46*FO)
FMD = 182.39

EXCESS AIR IN EXHAUST, dimensionless fraction

EAF = (O2D-(0.00005*COD))/(20.9-(O2D-(0.00005*COD)))
EAF = 96.46

STOICHIOMETRIC AIR REQUIRED, scf/min

QS = MF*FMD*KC_2
QS = 1,566

EXHAUST DRY STANDARD FLOWRATE, dscf/min

QFE_1 = QS*(1+EAF)
QFE_1 = 155,513

EXHAUST WET STANDARD FLOWRATE, wscf/min

QWE_1 = QFE_1*(1-BWE/100)
QWE_1 = 153,887

NITROGEN IN EXHAUST, % dry basis

ND = 100-(O2D+C2D+(COD*KC_1)+(TCE*KC_1*(1-(BWE/100))))
ND = 79.05

INLET DRY STANDARD VOLUMETRIC FLOW, dscf/min

QFI_1 = QFE_1*((ND/100)/(1-(20.9/100)))
QFI_1 = 155,411

INLET WET STANDARD VOLUMETRIC FLOW, wscf/min

QWI_1 = QFI_1*(1-BWI/100)
QWI_1 = 156,402

F-FACTOR METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Engine
Test Run No.:	2	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Outlet Conc. THC, wet ppm	TCE	155.5164
Outlet Conc. O2, dry percent	O2D	19.91824
Outlet Conc. CO2, dry percent	C2D	0.710671
Outlet Conc. CO, dry ppm	COD	691.9983
Outlet Moisture, percent	BWE	2
Carbon Content of Fuel, wt fraction	FC	0.8552
Hydrogen Content of Fuel, % by wt	FH	14.18
Sulfur Content of Fuel, % by wt	FS	0.0498
Nitrogen Content of Fuel, % by wt	FN	0.0007
Oxygen Content of Fuel, % by wt	FO	0.2199
Conversion Constant, %/ppm	KC_1	0.0001
Calc Constant min/hour	KC_2	0.016667
Mass rate Fuel Burn, LB/HR	MF	525
Inlet Moisture	BWI	0.6335

Calculations

F FACTOR FOR FUEL, scf/lb Fuel

FMD = (3.64*FH)+(1.53*FC*100)+(0.57*FS)+(0.14*FN)-(0.46*FO)
FMD = 182.39

EXCESS AIR IN EXHAUST, dimensionless fraction

EAF = (O2D-(0.00005*COD))/(20.9-(O2D-(0.00005*COD)))
EAF = 19.56

STOICHIOMETRIC AIR REQUIRED, scf/min

QS = MF*FMD*KC_2
QS = 1,596

EXHAUST DRY STANDARD FLOWRATE, dscf/min

QFE_1 = QS*(1+EAF)
QFE_1 = 32,817

EXHAUST WET STANDARD FLOWRATE, wscf/min

QWE_1 = QFE_1/(1-BWE/100)
QWE_1 = 33,487

NITROGEN IN EXHAUST, % dry basis

ND = 100-(O2D+C2D+(COD*KC_1)+(TCE*KC_1*(1-(BWE/100))))
ND = 79.29

INLET DRY STANDARD VOLUMETRIC FLOW, dscf/min

QFI_1 = QFE_1*((ND/100)/(1-(20.9/100)))
QFI_1 = 32,895

INLET WET STANDARD VOLUMETRIC FLOW, wscf/min

QWI_1 = QFI_1/(1-BWI/100)
QWI_1 = 33,104

F-FACTOR METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Slipstream
Test Run No.:	2	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Outlet Conc. THC, wet ppm	TCE	35.5617981
Outlet Conc. O2, dry percent	O2D	20.6584326
Outlet Conc. CO2, dry percent	C2D	0.23069959
Outlet Conc. CO, dry ppm	COD	186.894804
Outlet Moisture, percent	BWE	2
Carbon Content of Fuel, wt fraction	FC	0.8552
Hydrogen Content of Fuel, % by wt	FH	14.18
Sulfur Content of Fuel, % by wt	FS	0.0496
Nitrogen Content of Fuel, % by wt	FN	0.0007
Oxygen Content of Fuel, % by wt	FO	0.2199
Conversion Constant, %/ppm	KC_1	0.0001
Calc. Constant min/hour	KC_2	0.01666667
Mass rate Fuel Burn, LB/HR	MF	525
Inlet Moisture	BWI	0.8335

Calculations

F FACTOR FOR FUEL, scf/lb Fuel

$FMD = (3.64*FH)+(1.53*FC*100)+(0.57*FS)+(0.14*FN)-(0.46*FO)$
$FMD = 182.39$

EXCESS AIR IN EXHAUST, dimensionless fraction

$EAF = (O2D-(0.00005*COD))/(20.9-(O2D-(0.00005*COD)))$
$EAF = 82.30$

STOICHIOMETRIC AIR REQUIRED, scf/min

$QS = MF*FMD*KC_2$
$QS = 1,596$

EXHAUST DRY STANDARD FLOWRATE, dscf/min

$QFE_1 = QS*(1+EAF)$
$QFE_1 = 132,932$

EXHAUST WET STANDARD FLOWRATE, wscf/min

$QWE_1 = QFE_1/(1-BWE/100)$
$QWE_1 = 136,645$

NITROGEN IN EXHAUST, % dry basis

$ND = 100-(O2D+C2D+(COD*KC_1)+(TCE*KC_1*(1-(BWE/100))))$
$ND = 79.09$

INLET DRY STANDARD VOLUMETRIC FLOW, dscf/min

$QFI_1 = QFE_1*((ND/100)/(1-(20.9/100)))$
$QFI_1 = 132,912$

INLET WET STANDARD VOLUMETRIC FLOW, wscf/min

$QWI_1 = QFI_1/(1-BWI/100)$
$QWI_1 = 133,760$

F-FACTOR METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Engine
Test Run No.:	3	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Outlet Conc. THC, wet ppm	TCE	141.55
Outlet Conc. O2, dry percent	O2D	19.91144
Outlet Conc. CO2, dry percent	C2D	0.746357
Outlet Conc. CO, dry ppm	COD	888.438
Outlet Moisture, percent	BWE	2
Carbon Content of Fuel, wt fraction	FC	0.8552
Hydrogen Content of Fuel, % by wt	FH	14.18
Sulfur Content of Fuel, % by wt	FS	0.0496
Nitrogen Content of Fuel, % by wt	FN	0.0007
Oxygen Content of Fuel, % by wt	FO	0.2199
Conversion Constant, %/ppm	KC_1	0.0001
Calc. Constant min/hour	KC_2	0.016667
Mass rate Fuel Burn, LB/HR	MF	525
Inlet Moisture	BWI	0.6335

Calculations

F FACTOR FOR FUEL, scf/lb Fuel

FMD = (3.64*FH)+(1.53*FC*100)+(0.57*FS)+(0.14*FN)-(0.46*FO)
FMD = 182.39

EXCESS AIR IN EXHAUST, dimensionless fraction

EAF = (O2D-(0.00005*COD))/(20.9-(O2D-(0.00005*COD)))
EAF = 19.43

STOICHIOMETRIC AIR REQUIRED, scf/min

$QS = MF*FMD*KC_2$
QS = 1,596

EXHAUST DRY STANDARD FLOWRATE, dscf/min

$QFE_1 = QS*(1+EAF)$
QFE_1 = 32,805

EXHAUST WET STANDARD FLOWRATE, wscf/min

$QWE_1 = QFE_1/(1-BWE/100)$
QWE_1 = 33,270

NITROGEN IN EXHAUST, % dry basis

$ND = 100-(O2D+C2D+(COD*KC_1)+(TCE*KC_1*(1-(BWE/100))))$
ND = 79.26

INLET DRY STANDARD VOLUMETRIC FLOW, dscf/min

$QFI_1 = QFE_1*((ND/100)/(1-(20.9/100)))$
QFI_1 = 32,671

INLET WET STANDARD VOLUMETRIC FLOW, wscf/min

$QWI_1 = QFI_1/(1-BWI/100)$
QWI_1 = 32,679

F-FACTOR METHOD
EXAMPLE CALCULATIONS

Client:	Moody AFB	Location:	Slipstream
Test Run No.:	3	Test Date:	4/24/02
Engine Type:	T38		
Test Condition:	Idle		

Inputs

Outlet Conc. THC, wet ppm	TCE	28.30816667
Outlet Conc. O2, dry percent	O2D	20.41541837
Outlet Conc. CO2, dry percent	C2D	0.205796016
Outlet Conc. CO, dry ppm	COD	166.6190633
Outlet Moisture, percent	BWE	2
Carbon Content of Fuel, wt fraction	FC	0.8552
Hydrogen Content of Fuel, % by wt	FH	14.18
Sulfur Content of Fuel, % by wt	FS	0.0496
Nitrogen Content of Fuel, % by wt	FN	0.0007
Oxygen Content of Fuel, % by wt	FO	0.2199
Conversion Constant, %/ppm	KC_1	0.0001
Calc. Constant min/hour	KC_2	0.016666667
Mass rate Fuel Burn, LB/HR	MF	525
Inlet Moisture	BWI	0.6335

Calculations

F FACTOR FOR FUEL, scf/lb Fuel

$FMD = (3.64*FH)+(1.53*FC*100)+(0.57*FS)+(0.14*FN)-(0.46*FO)$

$FMD = 182.39$

EXCESS AIR IN EXHAUST, dimensionless fraction

$EAF = (O2D-(0.00005*COD))/(20.9-(O2D-(0.00005*COD)))$

$EAF = 41.40$

STOICHIOMETRIC AIR REQUIRED, scf/min

$QS = MF*FMD*KC_2$

$QS = 1,596$

EXHAUST DRY STANDARD FLOWRATE, dscf/min

$QFE_1 = QS*(1+EAF)$

$QFE_1 = 67,668$

EXHAUST WET STANDARD FLOWRATE, wscf/min

$QWE_1 = QFE_1/(1-BWE/100)$

$QWE_1 = 69,049$

NITROGEN IN EXHAUST, % dry basis

$ND = 100-(O2D+C2D+(COD*KC_1)+(TCE*KC_1*(1-(BWE/100))))$

$ND = 79.36$

INLET DRY STANDARD VOLUMETRIC FLOW, dscf/min

$QFI_1 = QFE_1*((ND/100)/(1-(20.9/100)))$

$QFI_1 = 67,889$

INLET WET STANDARD VOLUMETRIC FLOW, wscf/min

$QWI_1 = QFI_1/(1-BWI/100)$

$QWI_1 = 68,322$

Summary of Stack Gas Parameters and Test Results
030197.0002.5
Moody AFB - Valdosta, Georgia
US EPA Test Method 5 - Particulate Matter
Slipstream - T38 Idle
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	RUN NUMBER	*M5-ID-1*	*M5-ID-2*	*M5-ID-3*	*M5-ID-Comp*	
	RUN DATE	*04/24/2002*	*04/24/2002*	*04/24/2002*	*04/24/2002*	*Average*
	RUN TIME	*0751-1052*	*1110-1413*	*1455-1757*	*0751-1653*	
	MEASURED DATA					
P_{static}	Stack Static Pressure, inches H_2O	0.00	0.00	0.00	0.00	0.00
y	Meter Box Correction Factor	1.001	1.001	1.001	1.021	1.006
P_{bar}	Barometric Pressure, inches Hg	30.70	30.70	30.70	30.70	30.70
V_m	Sample Volume, ft^3	114.002	131.350	134.675	308.945	172.243
$Dp^{1/2}$	Average Square Root Dp, $(in. H_2O)^{1/2}$	0.0190	0.0224	0.0224	0.0212	0.0213
DH	Avg Meter Orifice Pressure, in. H_2O	1.23	1.69	1.70	0.95	1.39
T_m	Average Meter Temperature, °F	77	91	101	89	90
T_s	Average Stack Temperature, °F	130	148	150	139	142
V_{lc}	Condensate Collected, ml	36.5	35.5	38.1	95.1	51.3
CO_2	Carbon Dioxide content, % by volume	0.0	0.0	0.0	0.0	0.0
O_2	Oxygen content, % by volume	21.0	21.0	21.0	21.0	21.0
N_2	Nitrogen content, % by volume	79.0	79.0	79.0	79.0	79.0
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84	0.84
	Circular Stack? 1=Y,0=N:	0	0	0	0	
As	Diameter or Dimensions, inches:	576.00	576.00	576.00	576.00	576.00
Q	Sample Run Duration, minutes	180	180	180	540	270
D_n	Nozzle Diameter, inches	1.370	1.370	1.370	1.230	1.335
	CALCULATED DATA					
A_n	Nozzle Area, ft^2	0.010236	0.010236	0.010236	0.008251	0.009740
$V_{m(std)}$	Standard Meter Volume, ft^3	115.422	129.749	130.665	311.859	171.924
$V_{m(std)}$	Standard Meter Volume, m^3	3.268	3.674	3.700	8.831	4.868
Q_m	Average Sampling Rate, dscfm	0.641	0.721	0.726	0.578	0.666
P_s	Stack Pressure, inches Hg	30.70	30.70	30.70	30.70	30.70
B_{ws}	Moisture, % by volume	1.5	1.3	1.4	1.4	1.4
$B_{ws(sat)}$	Moisture (at saturation), % by volume	14.7	23.4	24.6	18.6	20.3
V_{wstd}	Standard Water Vapor Volume, ft^3	1.718	1.671	1.793	4.476	2.415
$1-B_{ws}$	Dry Mole Fraction	0.985	0.987	0.986	0.986	0.986
M_d	Molecular Weight (d.b.), lb/lb•mole	28.84	28.84	28.84	28.84	28.84
M_s	Molecular Weight (w.b.), lb/lb•mole	28.68	28.70	28.69	28.69	28.69
V_s	Stack Gas Velocity, ft/s	1.1	1.3	1.3	1.3	1.3
A	Stack Area, ft^2	4.0	4.0	4.0	4.0	4.00
Q_a	Stack Gas Volumetric flow, acfm	268	321	321	301	303
Q_s	Stack Gas Volumetric flow, dscfm	118,704	118,704	118,704	118,704	118,704
Q_s	Stack Gas Volumetric flow, dscmm	3,361	3,361	3,361	3,361	3,361
I	Isokinetic Sampling Ratio, %	103.4	99.9	100.8	104.3	102.1

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	RUN NUMBER	*M5-ID-1*	*M5-ID-2*	*M5-ID-3*	*M5-ID-Comp*	
	RUN DATE	*04/24/2002*	*04/24/2002*	*04/24/2002*	*04/24/2002*	*Average*
	RUN TIME	*0751-1052*	*1110-1413*	*1455-1757*	*0751-1653*	
	EMISSIONS DATA					
	Particulate Matter					
PM	Filter Weight Gain, mg	4.7	2.35	4.45	8.2	
PM	Beaker Weight Gain, mg	7.1	4.75	6	6.3	
PM	Total Catch, g	0.0118	0.0071	0.0105	0.0145	0.0110
C_{PM}	**Concentration, gr/dscf**	**1.58E-03**	**8.44E-04**	**1.23E-03**	**7.18E-04**	**1.09E-03**
C_{PM}	**Concentration, lb/dscf**	**2.25E-07**	**1.21E-07**	**1.76E-07**	**1.03E-07**	**1.56E-07**
E_{PM}	**Emission Rate, lb/hr**	**1.61E+00**	**8.59E-01**	**1.26E+00**	**7.30E-01**	**1.11E+00**
E_{PM}	**Emission Rate, lb/1000 lb Fuel**	**3.06E+00**	**1.64E+00**	**2.39E+00**	**1.39E+00**	**2.12E+00**
	Condensible Matter					
PM	Organic Gain, mg					
PM	Aqueous Gain, mg	23.6	19.5	18.4	49.9	
PM	Total Catch, g	0.0236	0.0195	0.0184	0.0499	0.0279
C_{PM}	**Concentration, gr/dscf**	**3.16E-03**	**2.32E-03**	**2.17E-03**	**2.47E-03**	**2.53E-03**
C_{PM}	**Concentration, lb/dscf**	**4.51E-07**	**3.31E-07**	**3.10E-07**	**3.53E-07**	**3.61E-07**
E_{PM}	**Emission Rate, lb/hr**	**3.21E+00**	**2.36E+00**	**2.21E+00**	**2.51E+00**	**2.57E+00**
E_{PM}	**Emission Rate, lb/1000 lb Fuel**	**6.12E+00**	**4.49E+00**	**4.21E+00**	**4.79E+00**	**4.90E+00**
	Total Particulate Matter					
PM	Total Catch, g	3.54E-02	2.66E-02	2.89E-02	6.44E-02	3.88E-02
C_{PM}	**Concentration, gr/dscf**	**4.73E-03**	**3.16E-03**	**3.41E-03**	**3.19E-03**	**3.62E-03**
C_{PM}	**Concentration, lb/dscf**	**6.76E-07**	**4.52E-07**	**4.87E-07**	**4.55E-07**	**5.18E-07**
E_{PM}	**Emission Rate, lb/hr**	**4.82E+00**	**3.22E+00**	**3.47E+00**	**3.24E+00**	**3.69E+00**
E_{PM}	**Emission Rate, lb/1000 lb Fuel**	**9.17E+00**	**6.13E+00**	**6.60E+00**	**6.18E+00**	**7.02E+00**
F	Fuel Flow, lb/hr	525.000	525.000	525.000	525.000	

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	RUN NUMBER *RUN DATE* *RUN TIME*	*M5-INT-1* *04/25/2002* *0830-1030*	*M5-INT-2* *04/25/2002* *1105-1205*	*M5-INT-3* *04/25/2002* *1230-1430*	*M5-INT-Comp* *04/25/2002* *0830-1434*	*Average*
	MEASURED DATA					
P_{static}	Stack Static Pressure, Inches H_2O	0.00	0.00	0.00	0.00	0.00
y	Meter Box Correction Factor	1.001	1.001	1.001	1.021	1.006
P_{bar}	Barometric Pressure, inches Hg	30.70	30.70	30.70	30.70	30.70
V_m	Sample Volume, ft^3	118.244	56.792	120.297	347.322	160.664
$Dp^{1/2}$	Average Square Root Dp, $(in.\ H_2O)^{1/2}$	0.1000	0.1000	0.1000	0.1000	0.1000
DH	Avg Meter Orifice Pressure, in. H_2O	3.10	3.10	3.10	2.90	3.05
T_m	Average Meter Temperature, °F	88	97	102	101	97
T_s	Average Stack Temperature, °F	121	126	130	125	126
V_{lc}	Condensate Collected, ml	54.5	21.9	41.3	131.5	62.3
CO_2	Carbon Dioxide content, % by volume	0.0	0.0	0.0	0.0	0.0
O_2	Oxygen content, % by volume	21.0	21.0	21.0	21.0	21.0
N_2	Nitrogen content, % by volume	79.0	79.0	79.0	79.0	79.0
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84	0.84
	Circular Stack? 1=Y,0=N:	0	0	0	0	
As	Diameter or Dimensions, inches:	576.00	576.00	576.00	576.00	576.00
Q	Sample Run Duration, minutes	120	60	120	360	165
D_n	Nozzle Diameter, inches	0.750	0.750	0.750	0.745	0.749
	CALCULATED DATA					
A_n	Nozzle Area, ft^2	0.003068	0.003068	0.003068	0.003027	0.003058
$V_{m(std)}$	Standard Meter Volume, ft^3	117.837	55.682	116.897	344.698	158.778
$V_{m(std)}$	Standard Meter Volume, m^3	3.337	1.577	3.310	9.761	4.496
Q_m	Average Sampling Rate, dscfm	0.982	0.928	0.974	0.957	0.960
P_s	Stack Pressure, inches Hg	30.70	30.70	30.70	30.70	30.70
B_{ws}	Moisture, % by volume	2.1	1.8	1.6	1.8	1.8
$B_{ws(sat)}$	Moisture (at saturation), % by volume	11.5	13.2	14.7	12.9	13.1
V_{wstd}	Standard Water Vapor Volume, ft^3	2.565	1.031	1.944	6.190	2.932
$1-B_{ws}$	Dry Mole Fraction	0.979	0.982	0.984	0.982	0.982
M_d	Molecular Weight (d.b.), lb/lb•mole	28.84	28.84	28.84	28.84	28.84
M_s	Molecular Weight (w.b.), lb/lb•mole	28.61	28.64	28.66	28.65	28.64
V_s	Stack Gas Velocity, ft/s	5.8	5.9	5.9	5.9	5.9
A	Stack Area, ft^2	4.0	4.0	4.0	4.0	4.00
Q_a	Stack Gas Volumetric flow, acfm	1,402	1,407	1,411	1,406	1,406
Q_s	Stack Gas Volumetric flow, dscfm	293,150	293,150	293,150	293,150	293,150
Q_s	Stack Gas Volumetric flow, dscmm	8,301	8,301	8,301	8,301	8,301
I	Isokinetic Sampling Ratio, %	100.1	94.8	99.7	99.0	98.4

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	RUN NUMBER	***M5-INT-1***	***M5-INT-2***	***M5-INT-3***	***M5-INT-Comp***	
	RUN DATE	***04/25/2002***	***04/25/2002***	***04/25/2002***	***04/25/2002***	***Average***
	RUN TIME	***0830-1030***	***1105-1205***	***1230-1430***	***0830-1434***	
	EMISSIONS DATA					
	Particulate Matter					
PM	Filter Weight Gain, mg	2.75	0.35	2.2	5.25	
PM	Beaker Weight Gain, mg	8	4.25	7.2	6.25	
PM	Total Catch, g	0.0108	0.0046	0.0094	0.0115	0.0091
C_{PM}	**Concentration, gr/dscf**	**1.41E-03**	**1.27E-03**	**1.24E-03**	**5.15E-04**	**1.11E-03**
C_{PM}	**Concentration, lb/dscf**	**2.01E-07**	**1.82E-07**	**1.77E-07**	**7.36E-08**	**1.59E-07**
E_{PM}	**Emission Rate, lb/hr**	**3.54E+00**	**3.20E+00**	**3.12E+00**	**1.29E+00**	**2.79E+00**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**3.39E+00**	**3.07E+00**	**2.98E+00**	**1.24E+00**	**2.67E+00**
	Condensible Matter					
PM	Organic Gain, mg					
PM	Aqueous Gain, mg	23.7	20.9	31.3	66.5	
PM	Total Catch, g	0.0237	0.0209	0.0313	0.0665	0.0356
C_{PM}	**Concentration, gr/dscf**	**3.10E-03**	**5.79E-03**	**4.13E-03**	**2.98E-03**	**4.00E-03**
C_{PM}	**Concentration, lb/dscf**	**4.43E-07**	**8.27E-07**	**5.90E-07**	**4.25E-07**	**5.72E-07**
E_{PM}	**Emission Rate, lb/hr**	**7.80E+00**	**1.46E+01**	**1.04E+01**	**7.48E+00**	**1.01E+01**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**7.46E+00**	**1.39E+01**	**9.94E+00**	**7.16E+00**	**9.62E+00**
	Total Particulate Matter					
PM	Total Catch, g	3.45E-02	2.55E-02	4.07E-02	7.80E-02	4.47E-02
C_{PM}	**Concentration, gr/dscf**	**4.51E-03**	**7.07E-03**	**5.37E-03**	**3.49E-03**	**5.11E-03**
C_{PM}	**Concentration, lb/dscf**	**6.45E-07**	**1.01E-06**	**7.68E-07**	**4.99E-07**	**7.30E-07**
E_{PM}	**Emission Rate, lb/hr**	**1.13E+01**	**1.78E+01**	**1.35E+01**	**8.77E+00**	**1.28E+01**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**1.08E+01**	**1.70E+01**	**1.29E+01**	**8.40E+00**	**1.23E+01**
F	Fuel Flow, lb/hr	1045	1045	1045	1045	

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	RUN NUMBER *RUN DATE* *RUN TIME*	*M5-MIL-1* *04/26/2002* *0753-1008*	*M5-MIL-2* *04/26/2002* *1033-1159*	*M5-MIL-3* *04/26/2002* *1222-1450*	*M5-MIL-Comp* *04/26/2002* *0753-1450*	*Average*
	MEASURED DATA					
P_{static}	Stack Static Pressure, inches H_2O	0.00	0.00	0.00	0.00	0.00
y	Meter Box Correction Factor	1.001	1.001	1.001	1.021	1.006
P_{bar}	Barometric Pressure, inches Hg	30.72	30.72	30.72	30.72	30.72
V_m	Sample Volume, ft^3	82.937	52.751	63.251	234.937	108.469
$Dp^{1/2}$	Average Square Root Dp, $(in.\ H_2O)^{1/2}$	0.2236	0.2236	0.2236	0.2236	0.2236
DH	Avg Meter Orifice Pressure, in. H_2O	1.50	1.50	1.50	1.50	1.50
T_m	Average Meter Temperature, °F	74	81	87	83	81
T_s	Average Stack Temperature, °F	130	138	142	137	137
V_{lc}	Condensate Collected, ml	15.9	8.1	20.5	61.2	26.4
CO_2	Carbon Dioxide content, % by volume	0.0	0.0	0.0	0.0	0.0
O_2	Oxygen content, % by volume	21.0	21.0	21.0	21.0	21.0
N_2	Nitrogen content, % by volume	79.0	79.0	79.0	79.0	79.0
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84	0.84
	Circular Stack? 1=Y,0=N:	0	0	0	0	
As	Diameter or Dimensions, inches:	576.00	576.00	576.00	576.00	576.00
Q	Sample Run Duration, minutes	120	80	90	330	155
D_n	Nozzle Diameter, inches	0.420	0.420	0.420	0.430	0.423
	CALCULATED DATA					
A_n	Nozzle Area, ft^2	0.000962	0.000962	0.000962	0.001008	0.000974
$V_{m(std)}$	Standard Meter Volume, ft^3	84.551	53.082	62.949	240.245	110.207
$V_{m(std)}$	Standard Meter Volume, m^3	2.394	1.503	1.783	6.803	3.121
Q_m	Average Sampling Rate, dscfm	0.705	0.664	0.699	0.728	0.699
P_s	Stack Pressure, Inches Hg	30.72	30.72	30.72	30.72	30.72
B_{ws}	Moisture, % by volume	0.9	0.7	1.5	1.2	1.1
$B_{ws(sat)}$	Moisture (at saturation), % by volume	14.7	18.1	20.1	17.7	17.7
V_{wstd}	Standard Water Vapor Volume, ft^3	0.748	0.381	0.965	2.881	1.244
$1-B_{ws}$	Dry Mole Fraction	0.991	0.993	0.985	0.988	0.989
M_d	Molecular Weight (d.b.), lb/lb•mole	28.84	28.84	28.84	28.84	28.84
M_s	Molecular Weight (w.b.), lb/lb•mole	28.74	28.76	28.68	28.71	28.72
V_s	Stack Gas Velocity, ft/s	13.1	13.2	13.3	13.2	13.2
A	Stack Area, ft^2	4.0	4.0	4.0	4.0	4.00
Q_a	Stack Gas Volumetric flow, acfm	3,150	3,170	3,186	3,170	3,169
Q_s	Stack Gas Volumetric flow, dscfm	544,313	544,313	544,313	544,313	544,313
Q_s	Stack Gas Volumetric flow, dscmm	15,413	15,413	15,413	15,413	15,413
I	Isokinetic Sampling Ratio, %	102.2	96.7	103.0	101.6	100.9

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	RUN NUMBER	***M5-MIL-1***	***M5-MIL-2***	***M5-MIL-3***	***M5-MIL-Comp***	
	RUN DATE	***04/26/2002***	***04/26/2002***	***04/26/2002***	***04/26/2002***	***Average***
	RUN TIME	***0753-1008***	***1033-1159***	***1222-1450***	***0753-1450***	
	EMISSIONS DATA					
	Particulate Matter					
PM	Filter Weight Gain, mg	3.45	1.05	2.6	8.65	
PM	Beaker Weight Gain, mg	7.25	5.7	4.55	6.6	
PM	Total Catch, g	0.0107	0.0068	0.0072	0.0153	0.0100
C_{PM}	**Concentration, gr/dscf**	**1.95E-03**	**1.96E-03**	**1.75E-03**	**9.80E-04**	**1.66E-03**
C_{PM}	**Concentration, lb/dscf**	**2.79E-07**	**2.80E-07**	**2.50E-07**	**1.40E-07**	**2.37E-07**
E_{PM}	**Emission Rate, lb/hr**	**9.11E+00**	**9.16E+00**	**8.18E+00**	**4.57E+00**	**7.75E+00**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**3.57E+00**	**3.59E+00**	**3.21E+00**	**1.79E+00**	**3.04E+00**
	Condensible Matter					
PM	Organic Gain, mg					
PM	Aqueous Gain, mg	7.4	0	0	20.3	
PM	Total Catch, g	0.0074	0.0000	0.0000	0.0203	0.0069
C_{PM}	**Concentration, gr/dscf**	**1.35E-03**	**0.00E+00**	**0.00E+00**	**1.30E-03**	**6.64E-04**
C_{PM}	**Concentration, lb/dscf**	**1.93E-07**	**0.00E+00**	**0.00E+00**	**1.86E-07**	**9.48E-08**
E_{PM}	**Emission Rate, lb/hr**	**6.30E+00**	**0.00E+00**	**0.00E+00**	**6.08E+00**	**3.10E+00**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**2.47E+00**	**0.00E+00**	**0.00E+00**	**2.39E+00**	**1.21E+00**
	Total Particulate Matter					
PM	Total Catch, g	1.81E-02	6.75E-03	7.15E-03	3.56E-02	1.69E-02
C_{PM}	**Concentration, gr/dscf**	**3.30E-03**	**1.96E-03**	**1.75E-03**	**2.28E-03**	**2.33E-03**
C_{PM}	**Concentration, lb/dscf**	**4.72E-07**	**2.80E-07**	**2.50E-07**	**3.26E-07**	**3.32E-07**
E_{PM}	**Emission Rate, lb/hr**	**1.54E+01**	**9.16E+00**	**8.18E+00**	**1.07E+01**	**1.09E+01**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**6.04E+00**	**3.59E+00**	**3.21E+00**	**4.18E+00**	**4.25E+00**
F	Fuel Flow, lb/hr	2550	2550	2550	2550	

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	RUN NUMBER	*0011-ID*	*0011-INT*	*0011-MIL*	
	RUN DATE	*04/24/2002*	*04/25/2002*	*04/26/2002*	*Average*
	RUN TIME	*0751-1154*	*0830-1433*	*0753-1450*	
	MEASURED DATA				
P_{static}	Stack Static Pressure, inches H_2O	0.00	0.00	0.00	0.00
y	Meter Box Correction Factor	1.000	1.000	1.000	1.000
P_{bar}	Barometric Pressure, inches Hg	30.70	30.70	30.72	30.71
V_m	Sample Volume, ft^3	171.250	163.722	236.070	190.347
$Dp^{1/2}$	Average Square Root Dp, $(in.\ H_2O)^{1/2}$	0.0198	0.1000	0.2236	0.1145
DH	Avg Meter Orifice Pressure, in. H_2O	1.60	0.56	1.60	1.25
T_m	Average Meter Temperature, °F	83	97	84	88
T_s	Average Stack Temperature, °F	126	125	134	128
V_{lc}	Condensate Collected, ml	58.8	70.9	68.9	66.2
CO_2	Carbon Dioxide content, % by volume	0.0	0.0	0.0	0.0
O_2	Oxygen content, % by volume	21.0	21.0	21.0	21.0
N_2	Nitrogen content, % by volume	79.0	79.0	79.0	79.0
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84
	Circular Stack? 1=Y,0=N:	0	0	0	
As	Diameter or Dimensions, inches:	576.00	576.00	576.00	576.00
F	Fuel Flow, lb/hr	525	1045	2550	
Q	Sample Run Duration, minutes	240	360	330	310
D_n	Nozzle Diameter, inches	1.450	0.495	0.435	0.793
	CALCULATED DATA				
A_n	Nozzle Area, ft^2	0.011467	0.001336	0.001032	0.004612
$V_{m(std)}$	Standard Meter Volume, ft^3	171.447	159.394	236.060	188.967
$V_{m(std)}$	Standard Meter Volume, m^3	4.855	4.514	6.684	5.351
Q_m	Average Sampling Rate, dscfm	0.714	0.443	0.715	0.624
P_s	Stack Pressure, inches Hg	30.70	30.70	30.72	30.71
B_{ws}	Moisture, % by volume	1.6	2.1	1.4	1.7
$B_{ws(sat)}$	Moisture (at saturation), % by volume	13.2	12.9	16.3	14.1
V_{wstd}	Standard Water Vapor Volume, ft^3	2.768	3.337	3.243	3.116
$1-B_{ws}$	Dry Mole Fraction	0.984	0.979	0.986	0.983
M_d	Molecular Weight (d.b.), lb/lb•mole	28.84	28.84	28.84	28.84
M_s	Molecular Weight (w.b.), lb/lb•mole	28.67	28.62	28.69	28.66
V_s	Stack Gas Velocity, ft/s	1.2	5.9	13.2	6.7
A	Stack Area, ft^2	4.0	4.0	4.0	4.00
Q_a	Stack Gas Volumetric flow, acfm	279	1,406	3,164	1,616
Q_s	Stack Gas Volumetric flow, dscfm	118,704	293,150	544,313	318,722
Q_s	Stack Gas Volumetric flow, dscmm	3,361	8,301	15,413	9,025
I	Isokinetic Sampling Ratio, %	98.2	103.9	97.4	99.9

Summary of Stack Gas Parameters and Test Results
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Test Method 0011 - Aldehyde/Keytones
Slipstream - T38 - All Conditions
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	RUN NUMBER	***0011-ID***	***0011-INT***	***0011-MIL***	
	RUN DATE	***04/24/2002***	***04/25/2002***	***04/26/2002***	***Average***
	RUN TIME	***0751-1450***	***0830-1433***	***0753-1450***	
	EMISSIONS DATA				
HCHO	Formaldehyde				
	Target Catch, µg	13000.0	1500.0	200.0	4900.0
	Concentration, µg/dscm	2677.75	332.33	29.92	1013.33
	Emission Rate, lb/hr	1.188	0.364	0.061	0.538
	Emission Rate, lb/1000 lb fuel	2.26E+00	3.48E-01	2.39E-02	8.78E-01
CH_3CHO	Acetaldehyde				
	Target Catch, µg	1400.0	83.0	13.0	498.7
	Concentration, µg/dscm	288.37	18.39	1.94	102.90
	Emission Rate, lb/hr	0.128	0.020	0.004	0.051
	Emission Rate, lb/1000 lb fuel	2.44E-01	1.93E-02	1.55E-03	8.82E-02
CH_2CHCHO	Acrolein				
	Target Catch, µg	1800.00	55.00	11.00	622.00
	Concentration, µg/dscm	370.77	12.19	1.65	128.20
	Emission Rate, lb/hr	0.165	0.013	0.003	0.0604
	Emission Rate, lb/1000 lb fuel	3.13E-01	1.28E-02	1.31E-03	1.09E-01
$CH_3CH_2CH_2OH$	Propanol				
	Target Catch, µg	450.0	55.0	11.0	172.0
	Concentration, µg/dscm	92.7	12.2	1.6	35.5
	Emission Rate, lb/hr	0.041	0.013	0.003	0.019
	Emission Rate, lb/1000 lb fuel	7.83E-02	1.28E-02	1.31E-03	3.08E-02
$CH_3CHCHCHO$	Crotonaldehyde				
	Target Catch, µg	680.00	55.0	11.00	248.67
	Concentration, µg/dscm	140.07	12.19	1.65	51.30
	Emission Rate, lb/hr	0.062	0.013	0.003	0.0263
	Emission Rate, lb/1000 lb fuel	1.18E-01	1.28E-02	1.31E-03	4.42E-02
$CH_3COC_5H_{11}$	Methyl Ethyl Ketone/Butyraldehydes				
	Target Catch, µg	450.0	55.0	11.0	172.0
	Concentration, µg/dscm	92.7	12.2	1.65	35.5
	Emission Rate, lb/hr	0.041	0.013	0.003	0.019
	Emission Rate, lb/1000 lb fuel	7.83E-02	1.28E-02	1.31E-03	3.08E-02
C_6H_5CHO	Benzaldehyde				
	Target Catch, µg	450.0	55.0	11.0	172.0
	Concentration, µg/dscm	92.7	12.2	1.65	35.5
	Emission Rate, lb/hr	0.041	0.013	0.003	0.019
	Emission Rate, lb/1000 lb fuel	7.83E-02	1.28E-02	1.31E-03	3.08E-02
$(CH_3)_2CHCH_2CHC$	Isopentanal				
	Target Catch, µg	450.0	55.0	11.0	172.0
	Concentration, µg/dscm	92.7	12.2	1.65	35.5
	Emission Rate, lb/hr	0.041	0.013	0.003	0.019
	Emission Rate, lb/1000 lb fuel	7.83E-02	1.28E-02	1.31E-03	3.08E-02

Summary of Stack Gas Parameters and Test Results
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	RUN NUMBER	*0011-ID*	*0011-INT*	*0011-MIL*	
	RUN DATE	*04/24/2002*	*04/25/2002*	*04/26/2002*	*Average*
	RUN TIME	*0751-1154*	*0830-1433*	*0753-1450*	
	EMISSIONS DATA - Continued				
$CH_3(CH_2)_3CHO$	Pentanal				
	Target Catch, µg	1400.0	55.0	11.0	488.7
	Concentration, µg/dscm	288.4	12.2	1.6	100.7
	Emission Rate, lb/hr	0.128	0.013	0.003	0.048
	Emission Rate, lb/1000 lb fuel	2.44E-01	1.28E-02	1.31E-03	8.59E-02
$C_6H_4CH_3CHO$	o-Tolualdehyde				
	Target Catch, µg	540.0	55	11.0	202.0
	Concentration, µg/dscm	111.2	12.2	1.6	41.7
	Emission Rate, lb/hr	0.049	0.013	0.003	0.022
	Emission Rate, lb/1000 lb fuel	9.40E-02	1.28E-02	1.31E-03	3.60E-02
$CH_3(CH_2)_4CHO$	Hexanal				
	Target Catch, µg	450.0	55	11.0	172
	Concentration, µg/dscm	92.7	12.2	1.6	35.5
	Emission Rate, lb/hr	0.041	0.013	0.003	0.02
	Emission Rate, lb/1000 lb fuel	7.83E-02	1.28E-02	1.31E-03	3.08E-02

Run #0011-ID had a Rpt. Limit of 450
Run #0011-INT had a Rpt. Limit of 55
Run #0011-MIL had a Rpt. Limit of 11

Summary of Stack Gas Parameters and Test Results
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Moody AFB - Valdosta, Georgia
PAH
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	RUN NUMBER	*PAH-ID*	*PAH-INT*	*PAH-MIL*	
	RUN DATE	*04/24/2002*	*04/25/2002*	*04/26/2002*	*Average*
	RUN TIME	*0856-1156*	*0833-1440*	*0753-1447*	
	MEASURED DATA				
P_{static}	Stack Static Pressure, inches H_2O	0.00	0.00	0.00	0.00
y	Meter Box Correction Factor	1.038	1.038	1.038	1.038
P_{bar}	Barometric Pressure, inches Hg	30.70	30.70	30.72	30.71
V_m	Sample Volume, L^3	180.130	353.980	332.250	288.787
$Dp^{1/2}$	Average Square Root Dp, $(in.\ H_2O)^{1/2}$	0.0207	0.1000	0.2236	0.1148
T_m	Average Meter Temperature, °F	84	94	80	86
T_s	Average Stack Temperature, °F	139	126	137	134
CO_2	Carbon Dioxide content, % by volume	0.0	0.0	0.0	0.0
O_2	Oxygen content, % by volume	21.0	21.0	21.0	21.0
N_2	Nitrogen content, % by volume	79.0	79.0	79.0	79.0
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84
	Circular Stack? 1=Y,0=N:	0	0	0	
As	Diameter or Dimensions, inches:	576.00	576.00	576.00	576.00
F	Fuel Flow, lb/hr	525.00	1045.00	2550.00	
Q	Sample Run Duration, minutes	180	360	325	288
	CALCULATED DATA				
$V_{m(std)}$	Standard Meter Volume,L^3	186.134	359.177	346.093	297.135
$V_{m(std)}$	Standard Meter Volume,ft^3	6.573	12.683	12.221	10.492
P_s	Stack Pressure, inches Hg	30.70	30.70	30.72	30.71
B_{ws}	Moisture, % by volume	1.4	1.9	1.1	1.5
$1-B_{ws}$	Dry Mole Fraction	0.986	0.981	0.989	0.985
M_d	Molecular Weight (d.b.), lb/lb•mole	28.84	28.84	28.84	28.84
M_s	Molecular Weight (w.b.), lb/lb•mole	28.69	28.63	28.72	28.68
V_s	Stack Gas Velocity, ft/s	1.2	5.9	13.2	6.8
A	Stack Area, ft^2	4.0	4.0	4.0	4.00
Q_a	Stack Gas Volumetric flow, acfm	294	1,407	3,170	1,624
Q_s	Stack Gas Volumetric flow, dscfm	118,704	293,150	544,313	318,722
Q_s	Stack Gas Volumetric flow, dscmm	3,361	8,301	15,413	9,025
	Napthalene				
	Analysis, *ug*/sample	18.0	*2.0*	*2.0*	**7.3**
	Molecular Weight, MW	128.2	128.2	128.2	**128.2**
	Concentration, lb/dscf	**6.03E-09**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**1.81E-02**	**1.04E-03**	**1.08E-03**	**6.74E-03**
	Parts Per Million, Dry Basis	**1.84E-02**	**1.06E-03**	**1.09E-03**	**6.84E-03**
	Emission Rate, lb/hr	**4.35E-02**	**6.22E-03**	**1.19E-02**	**2.05E-02**
	Emission Rate, lb/1000 lb fuel	8.29E-02	5.95E-03	4.66E-03	**3.12E-02**

	2-Methylnapthalene				
	Analysis, *ug*/sample	28.0	*2.0*	*2.0*	**10.7**
	Molecular Weight, MW	142.2	142.2	142.2	**142.2**
	Concentration, lb/dscf	**9.37E-09**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**2.54E-02**	**9.40E-04**	**9.76E-04**	**9.10E-03**
	Parts Per Million, Dry Basis	**2.58E-02**	**9.58E-04**	**9.86E-04**	**9.23E-03**
	Emission Rate, lb/hr	**6.77E-02**	**6.22E-03**	**1.19E-02**	**2.86E-02**
	Emission Rate, lb/1000 lb fuel	1.29E-01	5.95E-03	4.66E-03	**4.65E-02**
	2-Chloronapthalene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	162.6	162.6	162.6	**162.6**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**1.59E-03**	**8.22E-04**	**8.53E-04**	**1.09E-03**
	Parts Per Million, Dry Basis	**1.61E-03**	**8.38E-04**	**8.63E-04**	**1.10E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Acenapthene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	154.2	154.2	154.2	**154.2**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.67E-03**	**8.67E-04**	**9.00E-04**	**1.15E-03**
	Parts Per Million, Dry Basis	**1.70E-03**	**8.84E-04**	**9.10E-04**	**1.16E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Acenapthylene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	152.2	152.2	152.2	**152.2**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**1.69E-03**	**8.78E-04**	**9.11E-04**	**1.16E-03**
	Parts Per Million, Dry Basis	**1.72E-03**	**8.95E-04**	**9.22E-04**	**1.18E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Fluorene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	166.2	166.2	166.2	**166.2**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.55E-03**	**8.04E-04**	**8.35E-04**	**1.06E-03**
	Parts Per Million, Dry Basis	**1.57E-03**	**8.20E-04**	**8.44E-04**	**1.08E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Phenanthrene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	178.0	178.0	178.0	**178.0**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.45E-03**	**7.51E-04**	**7.79E-04**	**9.93E-04**
	Parts Per Million, Dry Basis	**1.47E-03**	**7.66E-04**	**7.88E-04**	**1.01E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**

	2-Methylnapthalene				
	Analysis, *ug*/sample	28.0	*2.0*	*2.0*	10.7
	Molecular Weight, MW	142.2	142.2	142.2	142.2
	Concentration, lb/dscf	**9.37E-09**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**2.54E-02**	**9.40E-04**	**9.76E-04**	**9.10E-03**
	Parts Per Million, Dry Basis	**2.58E-02**	**9.58E-04**	**9.86E-04**	**9.23E-03**
	Emission Rate, lb/hr	**6.77E-02**	**6.22E-03**	**1.19E-02**	**2.86E-02**
	Emission Rate, lb/1000 lb fuel	1.29E-01	5.95E-03	4.66E-03	**4.65E-02**
	2-Chloronapthalene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	162.6	162.6	162.6	**162.6**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**1.59E-03**	**8.22E-04**	**8.53E-04**	**1.09E-03**
	Parts Per Million, Dry Basis	**1.61E-03**	**8.38E-04**	**8.63E-04**	**1.10E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Acenapthene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	154.2	154.2	154.2	**154.2**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.67E-03**	**8.67E-04**	**9.00E-04**	**1.15E-03**
	Parts Per Million, Dry Basis	**1.70E-03**	**8.84E-04**	**9.10E-04**	**1.16E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Acenapthylene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	152.2	152.2	152.2	**152.2**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**1.69E-03**	**8.78E-04**	**9.11E-04**	**1.16E-03**
	Parts Per Million, Dry Basis	**1.72E-03**	**8.95E-04**	**9.22E-04**	**1.18E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Fluorene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	166.2	166.2	166.2	**166.2**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.55E-03**	**8.04E-04**	**8.35E-04**	**1.06E-03**
	Parts Per Million, Dry Basis	**1.57E-03**	**8.20E-04**	**8.44E-04**	**1.08E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Phenanthrene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	178.0	178.0	178.0	**178.0**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.45E-03**	**7.51E-04**	**7.79E-04**	**9.93E-04**
	Parts Per Million, Dry Basis	**1.47E-03**	**7.66E-04**	**7.88E-04**	**1.01E-03**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**

	Benzo(k)fluoranthene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	252.3	252.3	252.3	**252.3**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.02E-03**	**5.30E-04**	**5.50E-04**	**7.01E-04**
	Parts Per Million, Dry Basis	**1.04E-03**	**5.40E-04**	**5.56E-04**	**7.11E-04**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Benzo(a)pyrene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	252.3	252.3	252.3	**252.3**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**1.02E-03**	**5.30E-04**	**5.50E-04**	**7.01E-04**
	Parts Per Million, Dry Basis	**1.04E-03**	**5.40E-04**	**5.56E-04**	**7.11E-04**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Indeno(1,2,3-c,d)pyrene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	276.3	276.3	276.3	**276.3**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**9.34E-04**	**4.84E-04**	**5.02E-04**	**6.40E-04**
	Parts Per Million, Dry Basis	**9.47E-04**	**4.93E-04**	**5.08E-04**	**6.49E-04**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Dibenz(a,h)anthracene				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	278.4	278.4	278.4	**278.4**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**9.27E-04**	**4.80E-04**	**4.98E-04**	**6.35E-04**
	Parts Per Million, Dry Basis	**9.40E-04**	**4.89E-04**	**5.04E-04**	**6.44E-04**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**
	Benzo(g,h,I,perylene)				
	Analysis, *ug*/sample	*2.0*	*2.0*	*2.0*	**2.0**
	Molecular Weight, MW	276.3	276.3	276.3	**276.3**
	Concentration, lb/dscf	**6.69E-10**	**3.47E-10**	**3.60E-10**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**9.34E-04**	**4.84E-04**	**5.02E-04**	**6.40E-04**
	Parts Per Million, Dry Basis	**9.47E-04**	**4.93E-04**	**5.08E-04**	**6.49E-04**
	Emission Rate, lb/hr	**4.84E-03**	**6.22E-03**	**1.19E-02**	**7.65E-03**
	Emission Rate, lb/1000 lb fuel	9.21E-03	5.95E-03	4.66E-03	**6.61E-03**

APPENDIX B

EMISSION SAMPLING METHODS

EPA METHOD 5 AND EPA METHOD 202

Particulate

The test train utilized to perform the particulate and condensable particulate sampling will conform to U.S. EPA Methods 5 and 202 (M5/M202).

The impingers will be charged as indicated below (Figure 1):

- Impingers 1 through 3: 100 ml deionized water.
- Impinger 4: 300 g of silica gel.

The particulate train will consist of the following compounds:

- A borosilicate or stainless-steel nozzle with an inside diameter sized to sample the amount of exhaust specified in Method 5.
- A heated, borosilicate-lined probe equipped with a calibrated thermocouple to measure flue gas temperature and an S-type pitot tube to measure the flue gas velocity pressure.
- A heated oven containing a borosilicate connector and filter holder with a Soxhlet-extracted glass-fiber filter.
- A rigid borosilicate connector to join the outlet of the filter holder to the inlet of the impinger train.
- Greenburg-Smith impingers plus a thermocouple to detect sample gas exit temperature.
- A vacuum line (umbilical cord) with adapter to connect the outlet of the impinger train to a control module.
- A control module containing a 3-cfm carbon-vane vacuum pump (sample gas mover), a calibrated dry gas meter (sample gas volume measurement device), a calibrated orifice (sample gas flow rate monitor), and inclined manometers (orifice and gas stream pressure indicators).

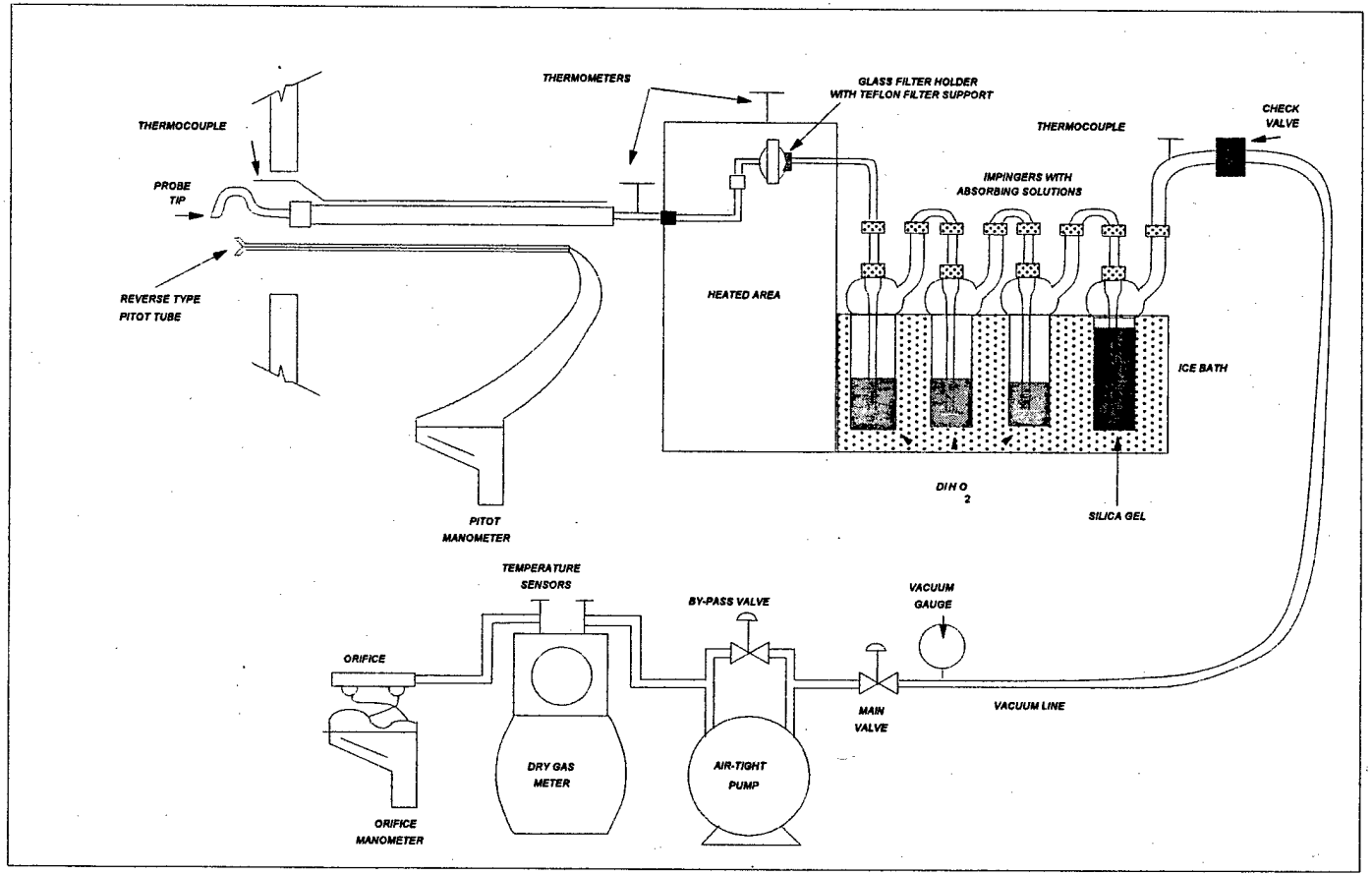

FIGURE 1
PARTICULATE (front and backhalf) SAMPLING TRAIN
EPA METHOD 5 AND METHOD 202

- A switchable, calibrated, digital pyrometer to monitor flue and sample gas temperatures.

The M5/M202 train will be calibrated to satisfy U.S. EPA requirements. Sample collection will follow U.S. EPA M5/M202 procedures. Prior to sampling, the number of traverse points and their locations will be calculated using U.S. EPA Method 1.

Figures 2, 3, and 4 illustrate the procedures that will be used to prepare the particulate sampling trains prior to each test, the procedures used to sample the stack flue gases, and the procedures used to recover the samples from the train, respectively. Each test will be ^{3} 60 minutes in length, ^{3} 50 ft^3 in sample volume, and isokinetic ± 10%.

Particulate Matter Analysis (M5/M202)

The M5 probe/front-half acetone wash and filter fractions and back-half condensate from all test runs will be analyzed gravimetrically for particulates according to U.S. EPA M5/M202. The front-half particulate analysis will be performed according to the procedures established in U.S. EPA Reference Method 5 (40 CFR 60, Appendix A). As specified by the method, quartz filters exhibiting >99.5 % efficiency on 0.3-micron dioctyl phthalate smoke particles will be used. Particulate analysis of the filter will be performed by oven-drying the filter. The filter will be oven-dried for 2 to 3 hours at 105°C (220°F) and cooled in a desiccator. The filter will be weighed to a constant weight.

Constant weight means a difference of no more than 0.5 mg or 1% of total weight less tare weight, whichever is greater, between two consecutive weighings.

The acetone probe rinse will be checked for any leakage during transport. The liquid will be measured volumetrically to the nearest ±1 ml. The contents will be transferred to a tared 250-ml beaker. The probe rinse will be evaporated to dryness at ambient temperature and pressure. The beaker will be weighed to a constant weight and the results reported to the nearest 0.1 mg.

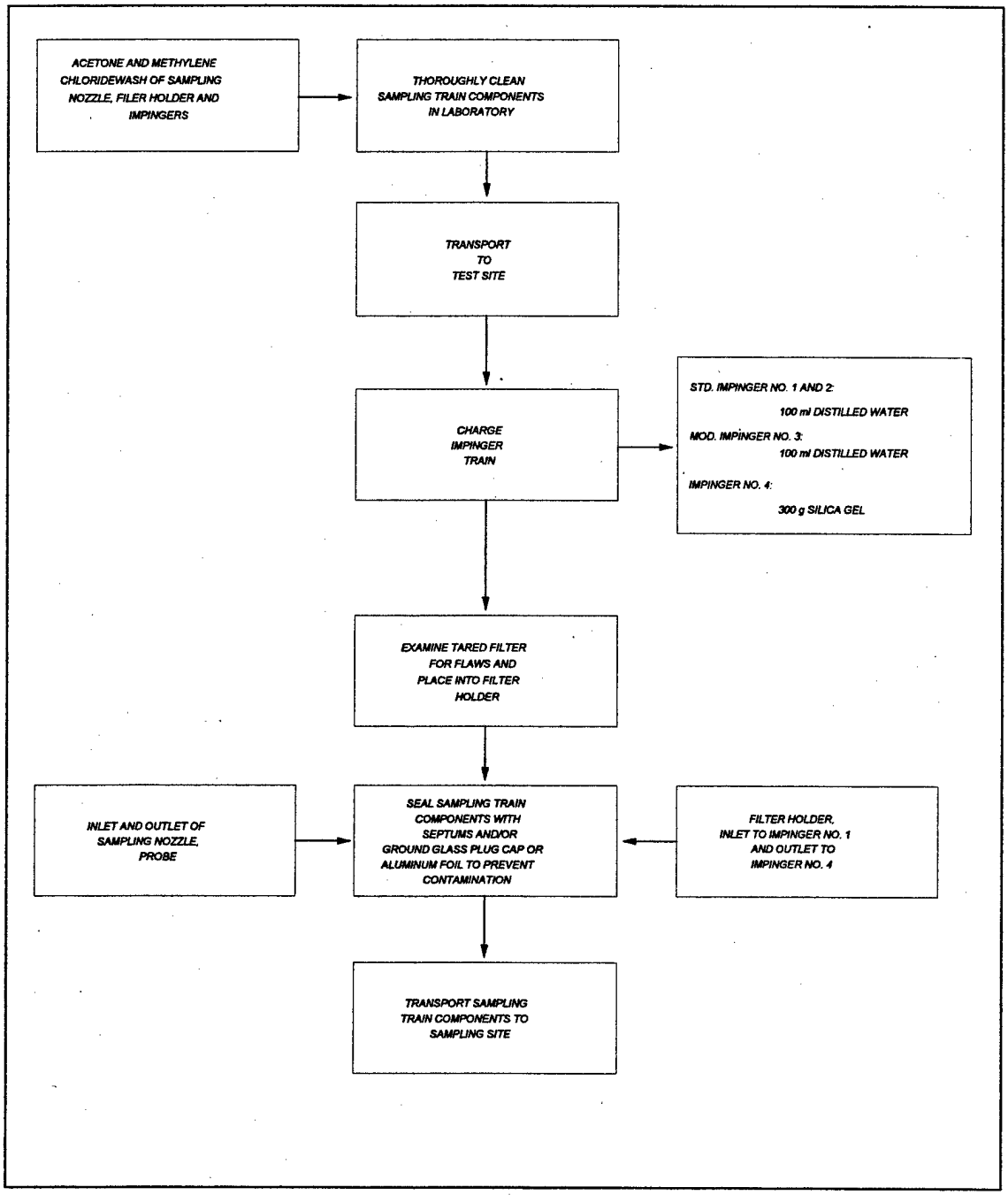

FIGURE 2
PREPARATION PROCEDURES FOR PARTICULATE (M5/M202) SAMPLING TRAIN

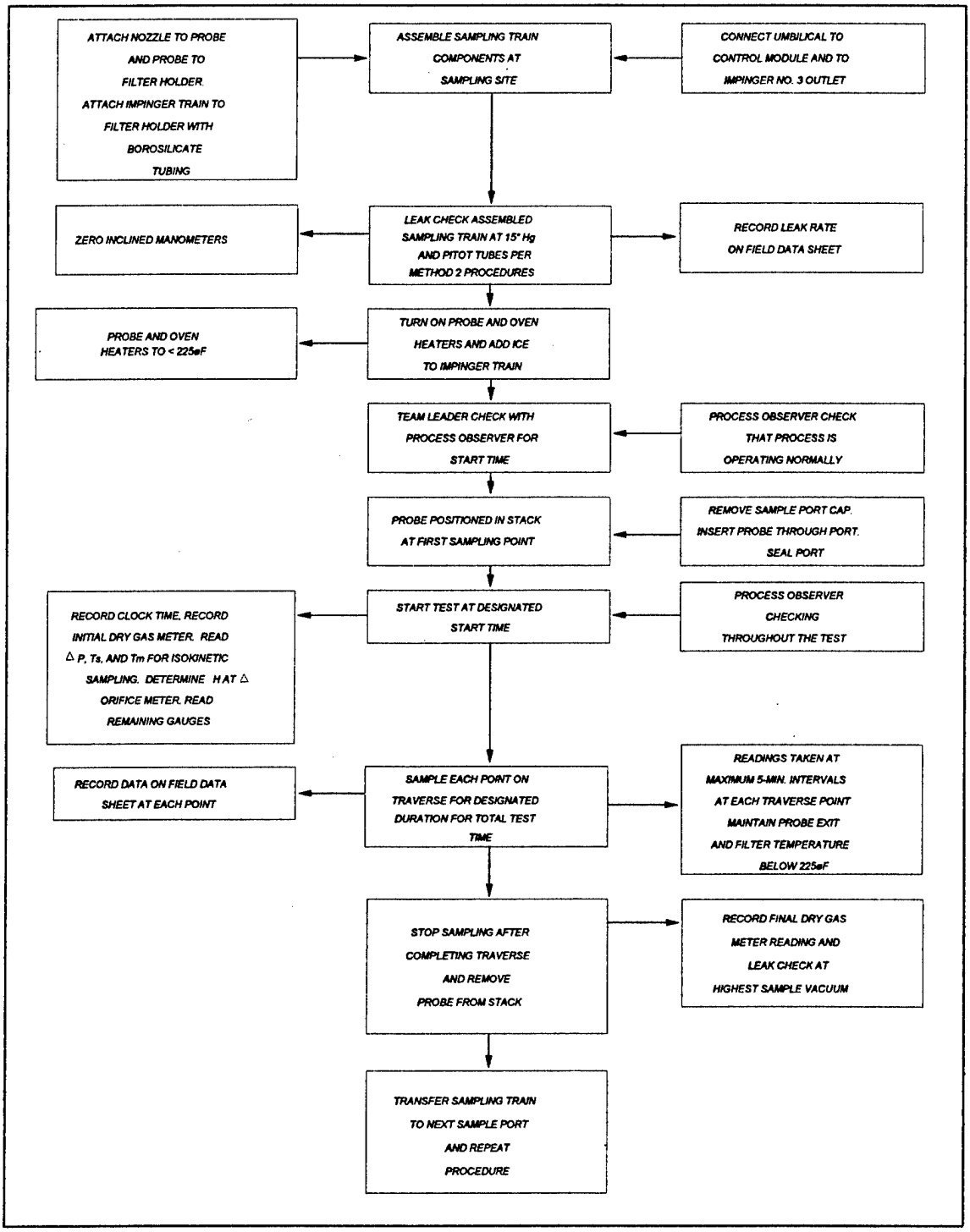

FIGURE 3
TEST PROCEDURES FOR PARTICULATES (M5/M202)

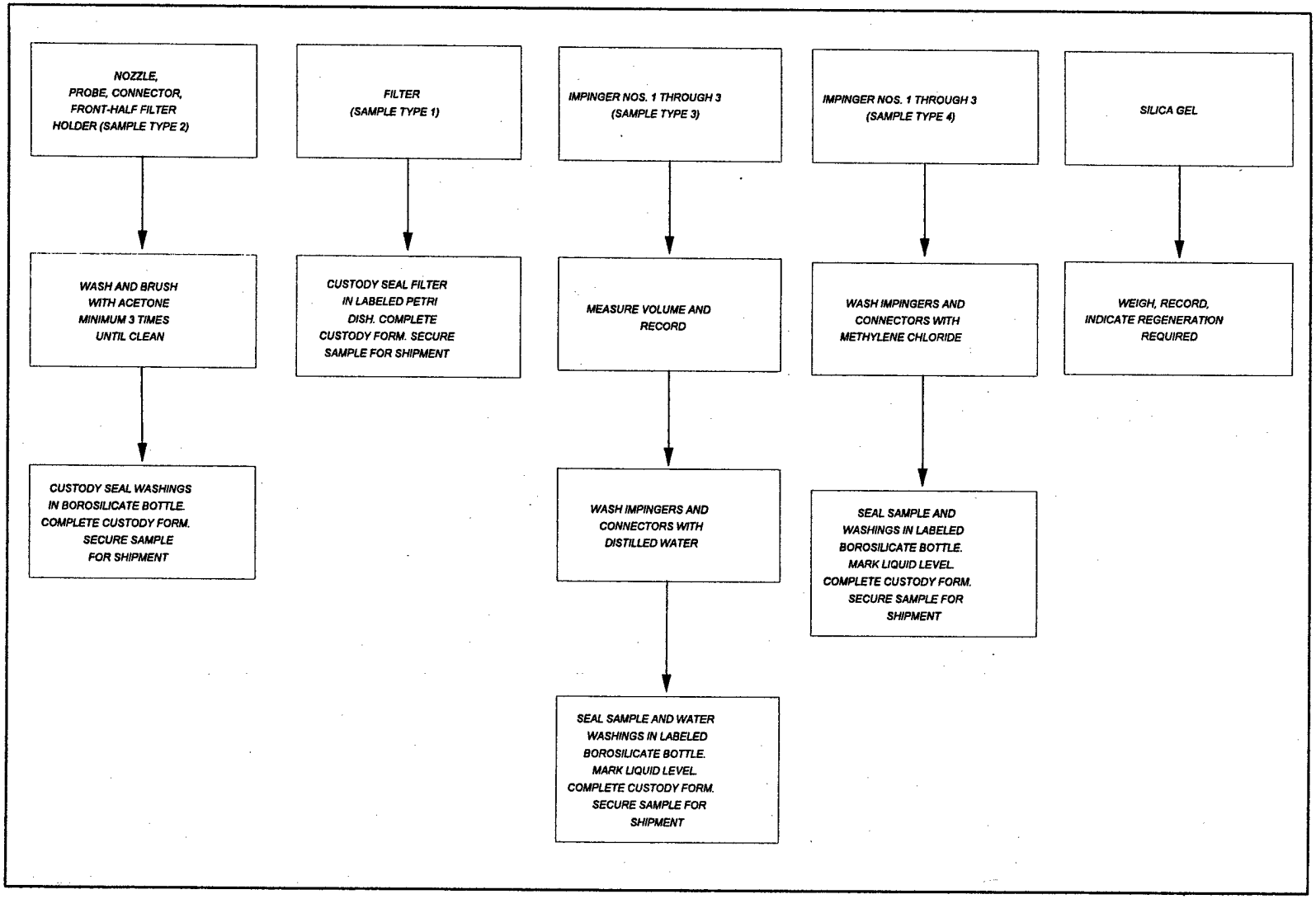

FIGURE 4
SAMPLE RECOVERY PROCEDURES FOR PARTICULATE (M5/M202) SAMPLING TRAIN

The back-half condensable particulate fraction analysis will be performed according to procedures established in U.S. EPA Reference Method 202 (40 CFR 60, Appendix A). The back-half water and wash samples will be combined in a separator funnel to separate aqueous and organic phases. The organic-phase extract will be placed in a tared beaker and evaporated to dryness at ambient temperature and pressure, then desiccated to a constant 0.1-mg weight. A methylene chloride extraction will be performed on the distilled water blank sampling to obtain a blank correction value.

The extracted water sample and extracted distilled water sample blank will be poured into tared beakers, evaporated to dryness at 220 to 230°F, then desiccated at ambient temperature and pressure to a constant 0.1-mg weight. The residue weight of the dried distilled water samples will be adjusted based on the water blank sample correction factor.

Particulate QC Sampling Procedures

The sampling QC procedures that will be used to ensure representative measurements of particulates are the following:

- The sample rate must be within 10 % of the true isokinetic (100 %) rate.
- All sampling nozzles will be manufactured and calibrated according to U.S. EPA standards.
- Particulate filters will be pre-test and post-test weighed (following 24 hours of desiccation) to the nearest 0.1 mg to a constant (± 0.5 mg) value.
- Recovery procedures will be completed in a clean environment.
- Sample containers for liquids will be constructed of borosilicate with Teflon®-lined lids. Filters will be stored in plastic or borosilicate petri dishes.

EPA METHOD 0011-FORMALDEHYDE SAMPLING TRAIN

The formaldehyde in the stack gas emission stream will be determined by U.S. EPA Method 0011. The sampling train (see Figure 1) will consist of the following components connected in a series:

- A calibrated borosilicate nozzle attached to a heated borosilicate probe.
- A rigid borosilicate connector to join the outlet of the sampling probe to the inlet of the impinger train.
- An impinger train consisting of four impingers. The first, second, and third impingers will each contain 100 ml of cleaned 2,4-dinitrophenylhydrazine (DNPH) solution. The fourth impinger will contain 300 grams of dry preweighed silica gel. The second impinger will be a Greenburg-Smith type; all other impingers will be of a modified design. All impingers will be maintained in a crushed ice bath.
- A vacuum line (umbilical cord with adapter) to connect the outlet of the fourth impinger train to a control module.
- A control module containing a 3-cfm carbon-vane vacuum pump (sample gas mover), a calibrated dry gas meter (sample gas volume measurement device), a calibrated orifice (sample gas flow rate monitor), and inclined manometers (orifice and gas stream pressure indicators).

Figures 2, 3, and 4 outline the preparation, sampling, and recovery procedures that will be used to determine the formaldehyde at the stack location.

Formaldehyde Analysis Procedures

The analytical procedures for the quantification of formaldehyde will be performed as specified in U.S. EPA Methods 0011 and 0011A utilizing high-performance liquid chromatography (HPLC).

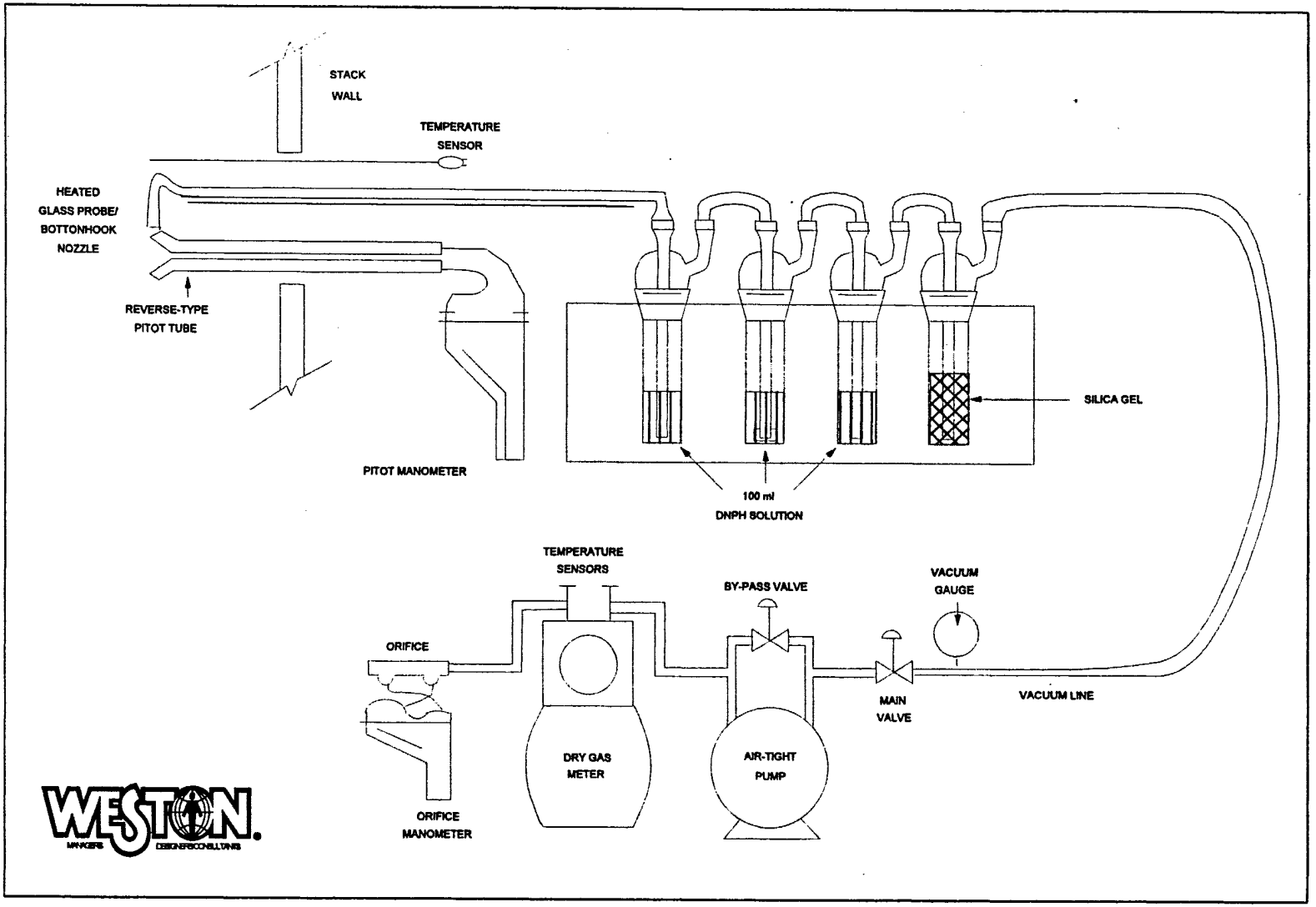

FIGURE 1
EPA METHOD 0011 - FORMALDEHYDE SAMPLING TRAIN

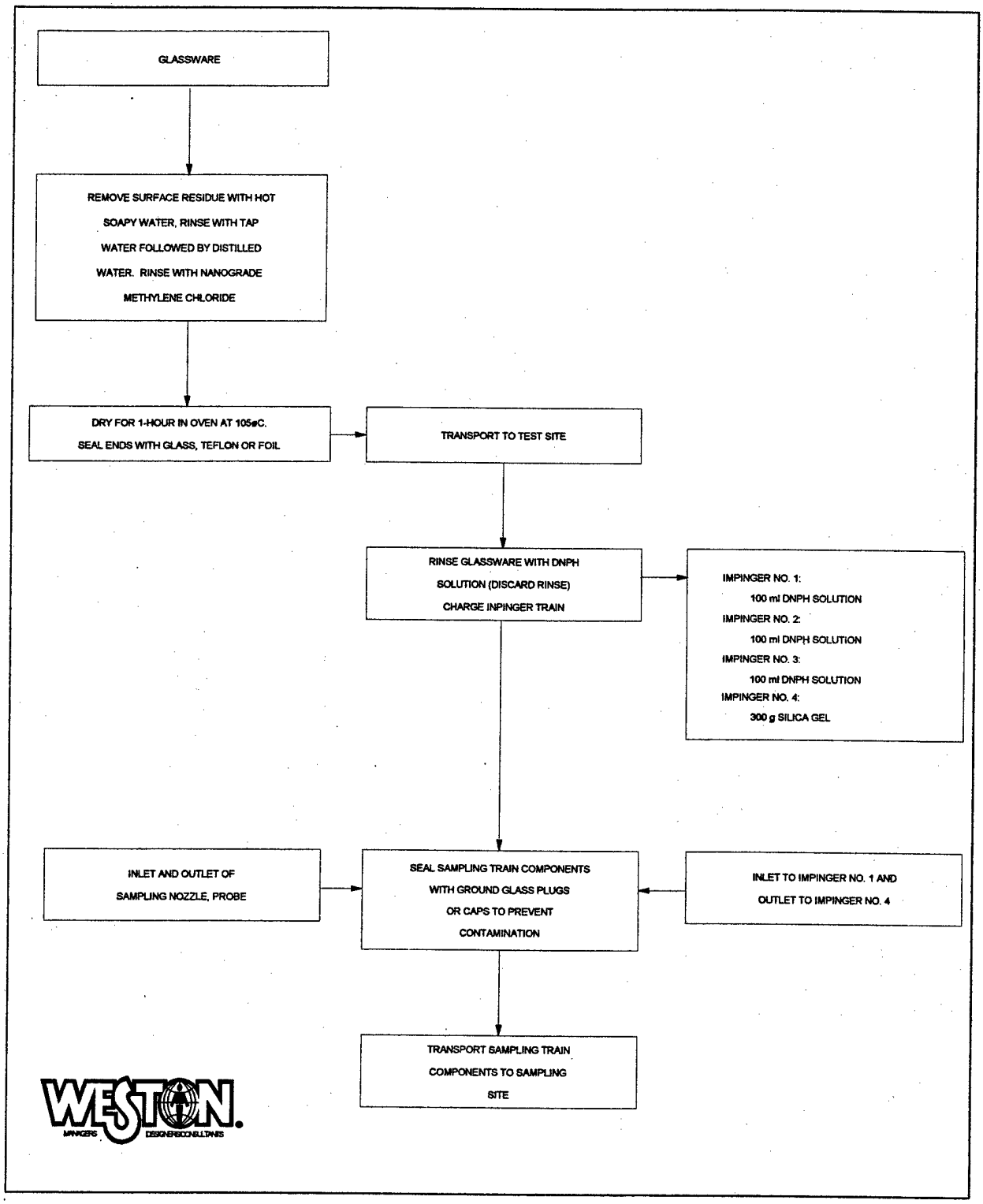

FIGURE 2
PREPARATION PROCEDURES FOR FORMALDEHYDE SAMPLING TRAIN

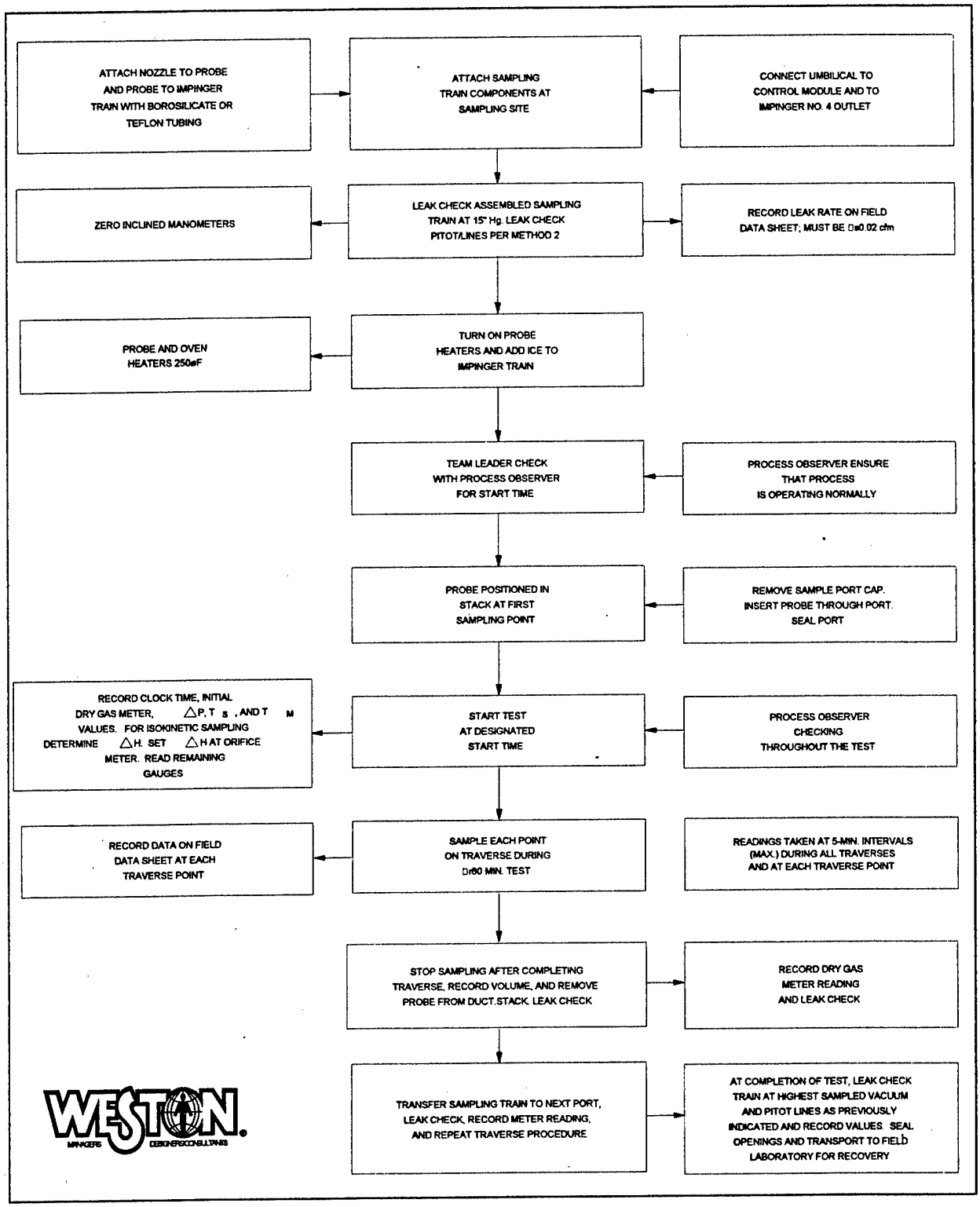

FIGURE 3
SAMPLING PROCEDURES FOR FORMALDEHYDE

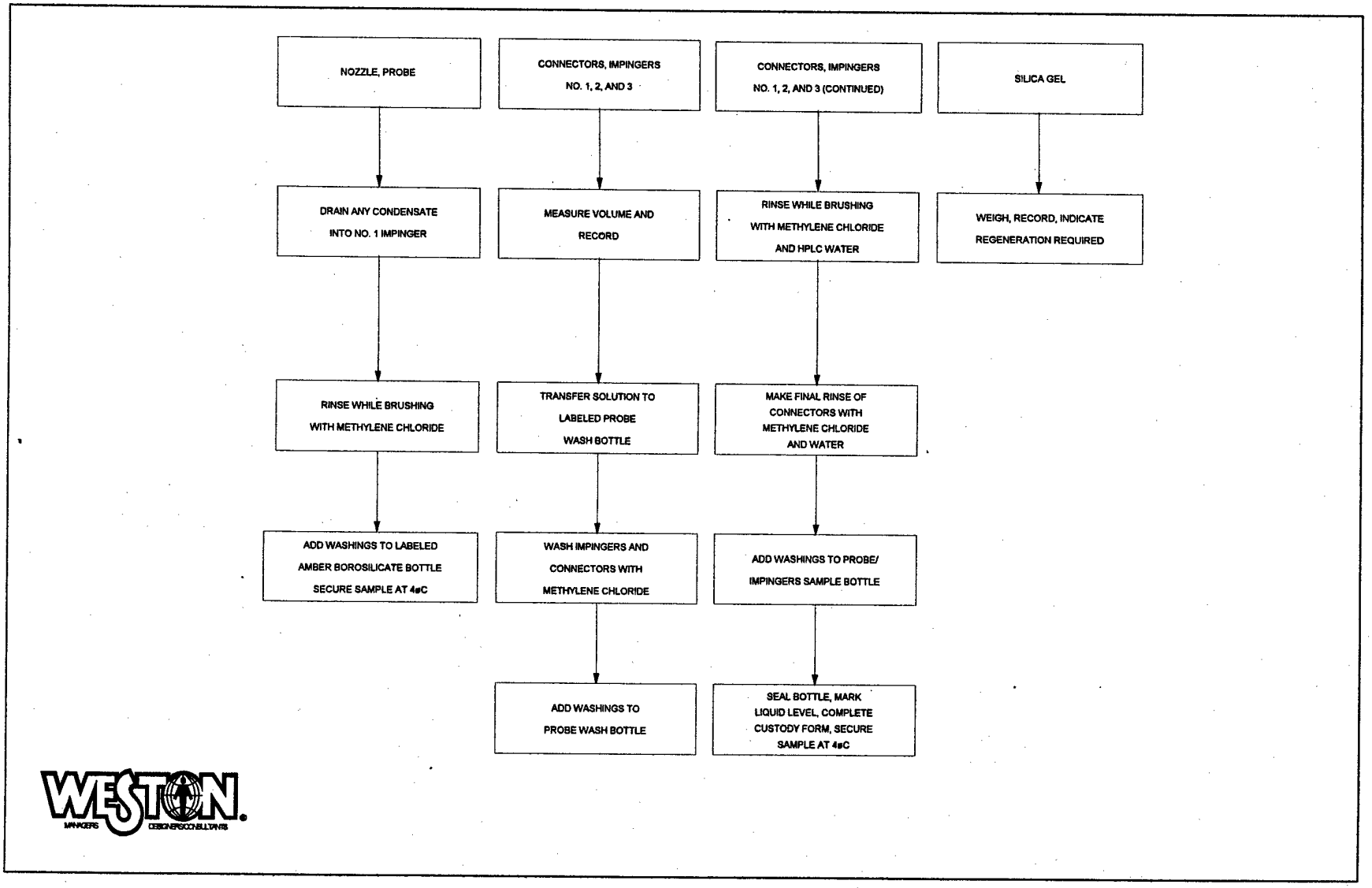

FIGURE 4
SAMPLE RECOVERY PROCEDURES FOR FORMALDEHYDE SAMPLING TRAIN

Each of the three DNPH impingers will be recovered, composited, and analyzed as one sample. The samples must be chilled immediately to stabilize the DNPH-carbonyl derivatives.

The HPLC will be calibrated prior to use each day. Calibration standard mixtures will be prepared from appropriate reference materials and will contain analytes appropriate for the method of analysis.

If a correlation of 0.996 cannot be obtained, additional standards must be analyzed to define the calibration curve. A midpoint calibration check standard will be analyzed each shift to confirm the validity of the initial calibration curve. The check standard must be within 20% of the initial response curve to demonstrate that the initial calibration curve is still valid.

Calibration data, including the correlation coefficient, will be retained in laboratory notebooks to maintain a permanent record of instrument performance.

At least one method blank and two method spikes will be included in each laboratory lot of samples. The method spikes and blanks will be in aqueous media. Method spikes will be examined to determine if contamination is being introduced in the laboratory.

The spikes will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery of the spikes; precision will be measured by the reproducibility of both method spikes.

Formaldehyde QC Sampling Procedures

The following QC procedures will ensure representative formaldehyde data are taken:

- Reagents will be used that meet method criteria. A supply of the DNPH reagent will be extracted the day before shipping to the test site. Two aliquots from each lot of DNPH prepared will be reserved for blank analysis per U.S. EPA Method 0011.

- The formaldehyde trains will be assembled and recovered in an environment free from uncontrolled dust and contaminated organics, and will be performed in an area away from other test train recovery activities to minimize contamination. The train will be prerinsed with DNPH to eliminate any acetone residue prior to charging.

- DNPH will be stored in a cool environment and away from other solvents.

EPA METHOD 0030 (VOST)

Volatile Organic Compounds

The volatile organics in the stack gas emission stream will be determined by U.S. EPA Method 0030 (VOST). This sampling train (see Figure 1) will consist of the following components connected in series:

- A heated borosilicate or quartz probe containing a glass wool particulate filter.
- An ice-water-cooled condenser connected to the probe, followed by a temperature sensor, an adsorption cartridge containing 1.6 grams of Tenax, and a condensate trap.
- A section of Teflon tubing used to connect the outlet of the condensate trap to a second condenser, which will be followed by a backup sorbent trap containing 1 gram of Tenax and 1 gram of activated charcoal, a second condensate collector, and a borosilicate tube containing an unweighed amount of dry silica gel.
- A tube of silica gel connected via an umbilical cable to a control console containing flow controllers, a calibrated 1-liter-per-minute dry gas meter, a sample pump, a temperature indicator, and other components.

A total of one VOST tube pairs will be collected during each test period. The volatile organics will be determined by analyzing the tube pairs by purge-trap-desorb GC/MS.

Figures 2, 3 and 4 outline the preparation, sampling, and recovery procedures that will be used to determine the volatile organics at the stack location.

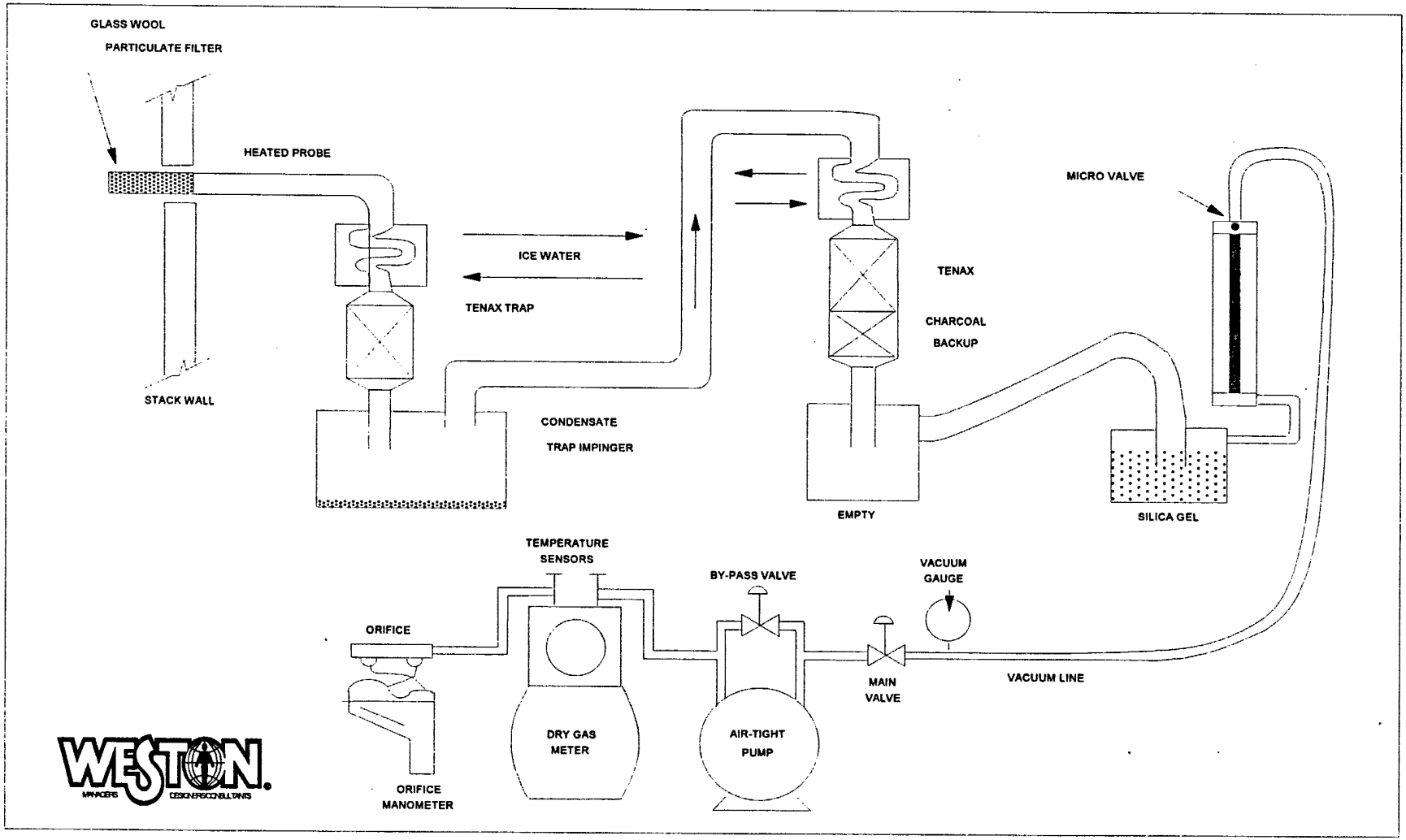

FIGURE 1
EPA METHOD 0030 - VOLATILE ORGANIC SAMPLING TRAIN (VOST)

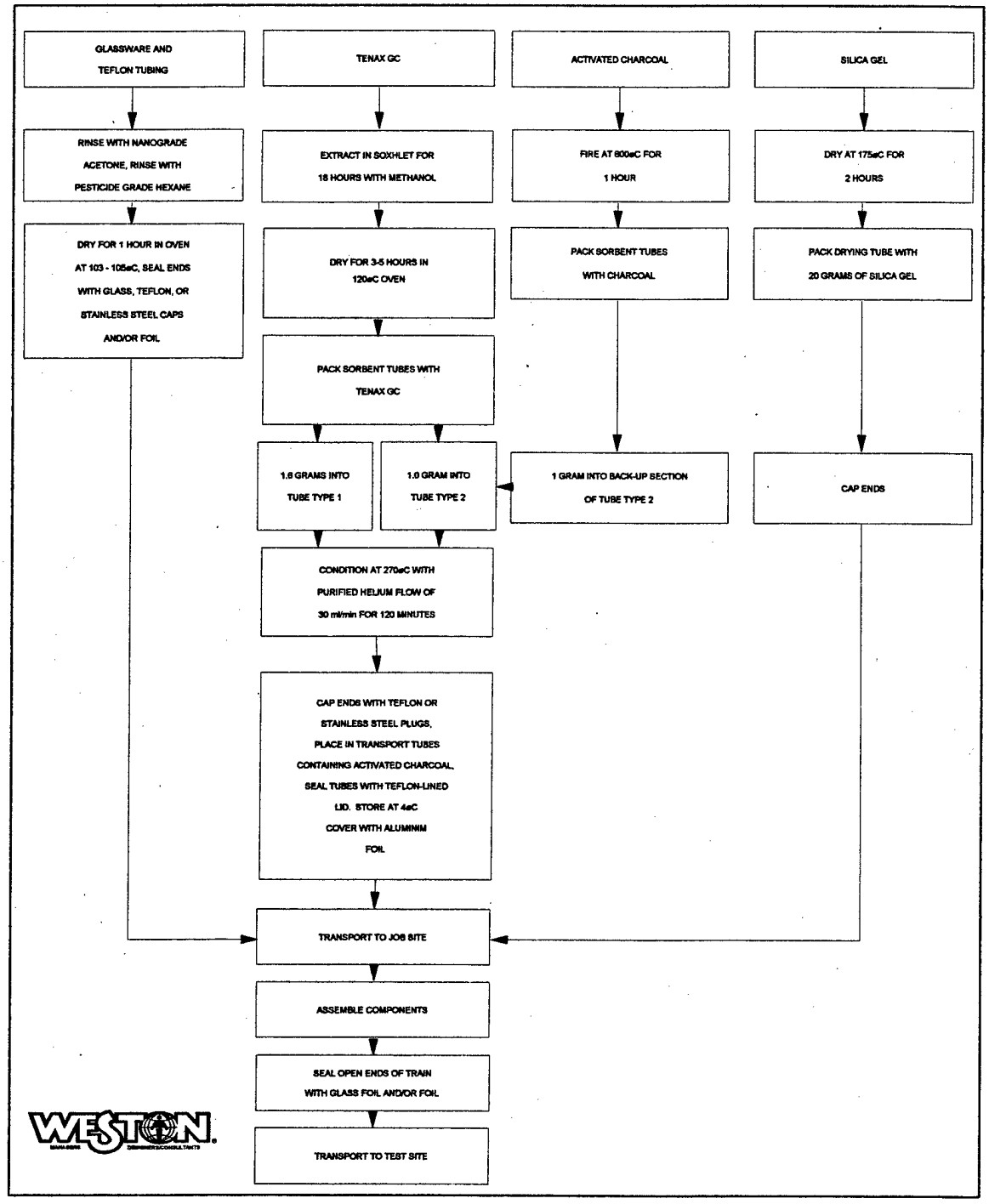

FIGURE 2
PREPARATION PROCEDURES FOR VOLATILE ORGANICS SAMPLING TRAIN

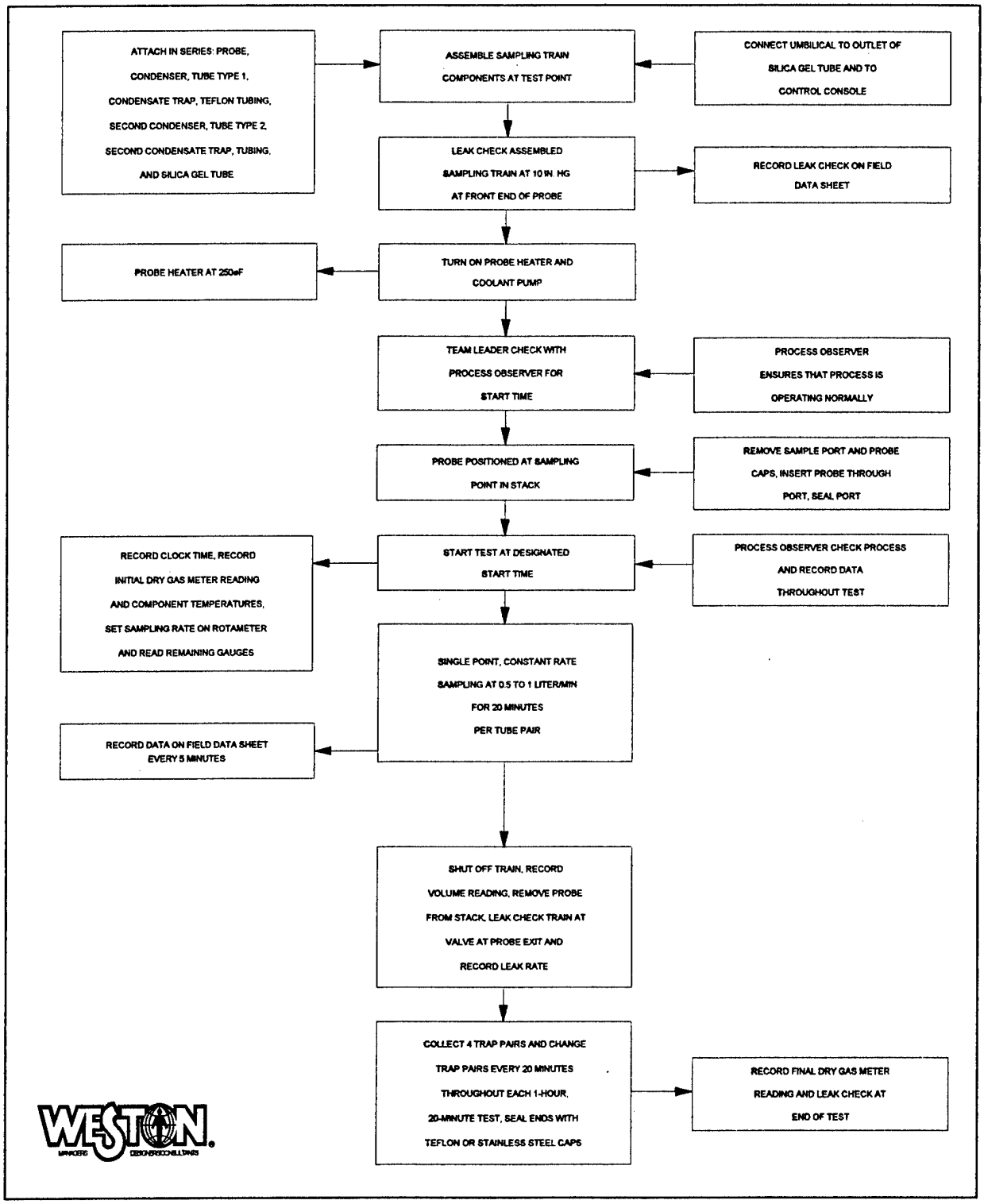

FIGURE 3
SAMPLING PROCEDURES FOR VOLATILE ORGANICS

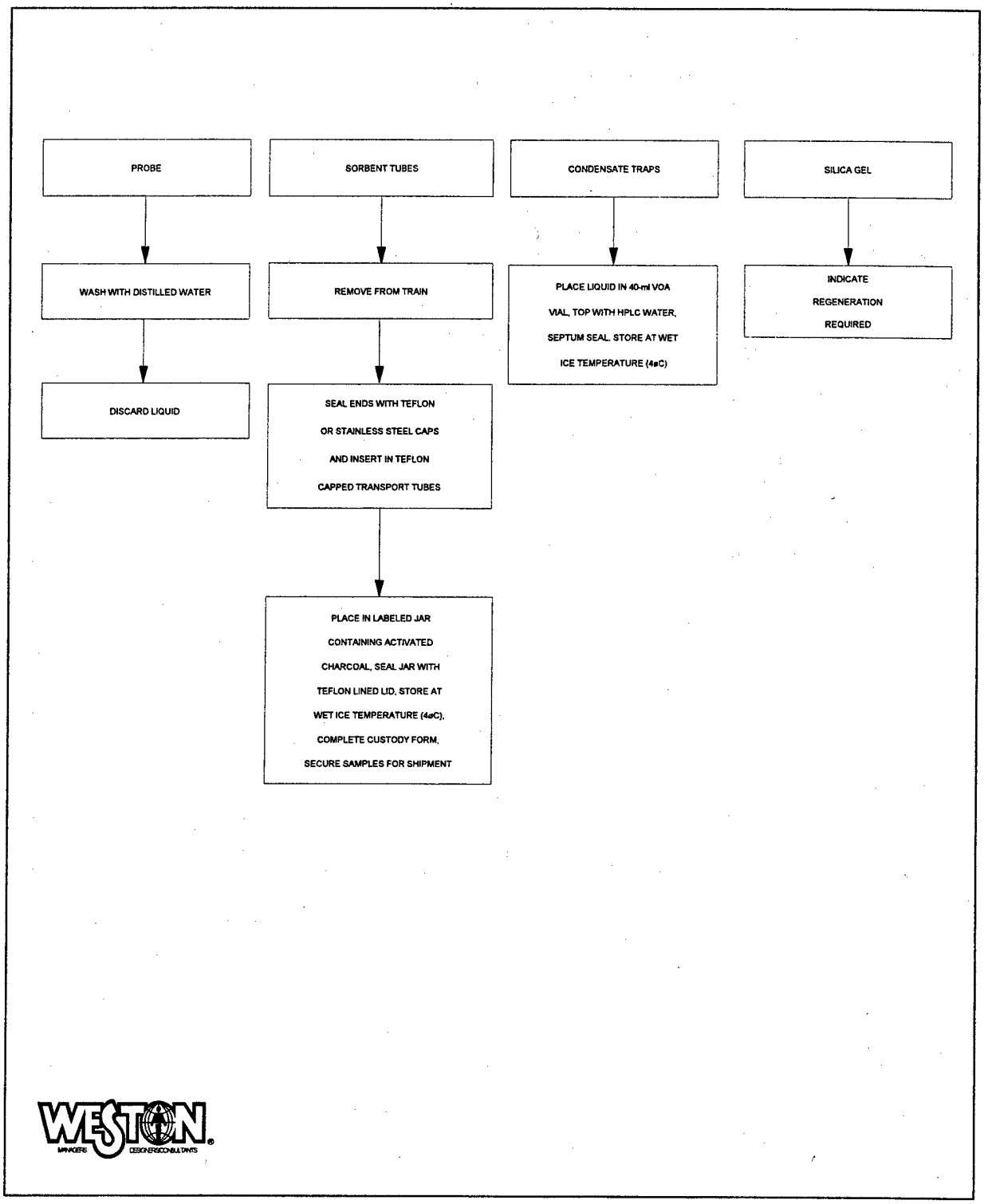

FIGURE 4
RECOVERY PROCEDURES FOR VOLATILE ORGANICS

Volatile Organics Analysis

The VOST samples will be placed in cold storage (<4°C) upon receipt in the laboratory. The samples have a recommended 14-day holding time from collection to analysis. The samples will require no additional preparation for analysis, except additions of the internal standard and the surrogate (D_8-toluene).

Volatile organics present in stack gases will be collected on Tenax and Tenax/charcoal sorbent cartridges using a VOST. Method 5040 (SW-846, third edition) describes in detail the procedural steps required to desorb VOST cartridges and analyze the effluent gas stream for VOCs. Additionally, if peaks of other compounds appear in the total ionization chromatogram (up to 10), they will be tentatively identified using a forward library search against the U.S. EPA/National Institutes of Health (NIH) mass spectral library and semiquantified relative to an internal standard spiked into the traps prior to analysis.

Methanolic solutions of internal standards compounds will be spiked onto each set of tubes prior to thermal desorption and analysis.

After spiking, the contents of the sorbent cartridges will be desorbed thermally for approximately 10 minutes at 180°C with organic-free nitrogen or helium gas, and bubbled through a tower to impinge water desorbed from the cartridges. Target analytes will be trapped on an analytical adsorbent trap. After the 10-minute desorption, the analytical adsorbent trap will be heated rapidly to 180°C with the carrier gas flow reversed. VOCs will be desorbed from the analytical trap and vented directly to a megabore column in the GC. The VOCs will be separated by temperature-programmed GC and detected by low-resolution MS. Concentrations of VOCs will be calculated using the internal standard technique.

VOST QC

The QC procedures that will ensure representative volatile organics data are the following:

- All sample and recovery glassware will be precleaned as per the procedure outlined in U.S. EPA Method 0030.
- The distilled water used for recovery of the condensate sample will be HPLC grade.
- Blanks of distilled water and unused tube pairs will be retained for blank analysis.

- All condensate and tube pair samples will be maintained at 4°C following collection and prior to analysis.

- VOST train preparation and recovery will be conducted in an area away from other test train recovery activities to avoid solvent contamination.

CONTINUOUS EMISSION MONITORING METHODS

The continuous emission monitoring system (CEMS) will be utilized to monitor gaseous emissions from stationary sources. The CEMS will monitor one or more of the following analytes: oxygen (O_2), carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and total hydrocarbons (THCs). These measurements will satisfy the requirements of the following U.S. EPA Reference Methods:

- Method 3A — Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources.
- Method 6C — Determination of Sulfur Dioxide Emissions from Stationary Sources.
- Method 7E — Determination of Nitrogen Oxide Emissions from Stationary Sources.
- Method 10 — Determination of Carbon Monoxide Emissions from Stationary Sources.
- Method 25A — Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer.

The CEMS consists of the sampling interface, the analyzers, and the data collection system. The sample interface will begin at the sample probe and extract the sample from the source, transport the samples to the analyzers, and filter the samples. For most of the analytes the moisture in the sample will be removed in the sample interface prior to analysis. Only the flame ionization analyzer sample will be analyzed on a wet basis. The sample interface will allow calibration gas to be introduced at the analyzer and at the sample probe. The analyzers will provide the next component of the CEMS. The analyzers must meet specific calibration requirements. The data collection system will record the raw voltage signal output from the analyzers, convert the signal to represent the analyte concentration, and store these concentrations as discrete averages (usually 1-minute averages). At the end of any test run, the data collection system will correct the test results for calibration drift and bias as required in the EPA methods.

The CEMS can be operated to monitor one or all of the analytes. The sampling interface will be modified to suit the source characteristics and the desired analytes.

Sample Interface

The hot, wet sample interface (see Figure 1) must be used if THCs are being measured. The sample will be extracted through a heated probe, filter, and sample line to prevent condensation. The sample interface components that are outside the stack will be maintained at or above 250 °F. The hot, wet sample interface will consist of the following components:

- An unheated inner stainless-steel probe extension, which will be maintained at stack temperature.
- A heated probe section (at least 250 °F) which penetrates the stack wall and connects the inner probe to the heated filter box.
- A heated filter box (at least 250 °F) which contains calibration gas injection ports and an in-line stainless-steel filter.
- A heated sample line (at least 250 °F) to transport the sample from the filter box to the analyzer manifold.
- A heated manifold, which will split the sample between the heated and unheated analyzers.
- A VIA MAK II low contact refrigerated condenser to remove water.
- A flow distribution manifold to maintain the required sample flow to each analyzer.

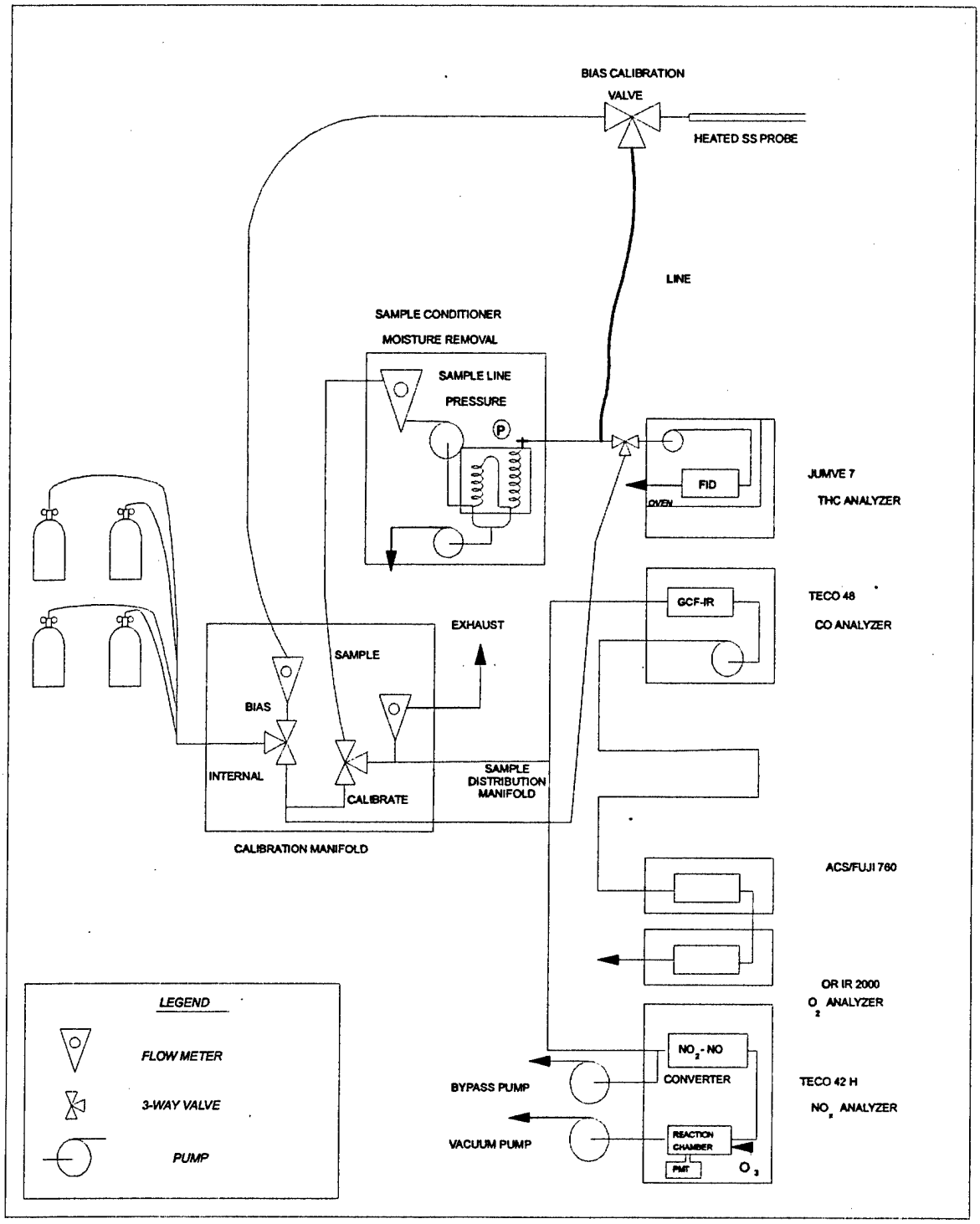

Figure 1

Continuous Emissions Monitoring System

One fraction of the sample will be transported by a short heated line to the hydrocarbon analyzer. The remaining sample will be sent to a VIA MAK II low-contact refrigerated condenser to remove water. The condenser will be maintained at 38 °F, and condensed moisture will be removed continuously from the bottom of the condenser through a peristaltic pump. The dried sample will pass through a pump and control valve, and will be distributed to the various analyzers by a distribution manifold. The critical flow parameter for each analyzer will be monitored with a rotameter as described below. The sample control valve will be adjusted to ensure that the sample gas always will be provided in excess, and that the excess sample will be released to the atmosphere.

Calibration

Calibration of the CEMS is always conducted in two steps: internal (direct to the instrument) and bias (direct to the probe end in the heated filter box). The internal calibration always is conducted first to verify instrument response. The internal calibration is conducted by introducing a calibration standard through the flow distribution manifold.

The instrument response will be adjusted initially by observing the front display of the analyzer. All final calibration response data **must be collected from the datalogger display.** Typically, there will be a slight difference between the analyzer front panel display and the data logger display, and the calibration data must be consistent with the recorded test data.

The bias calibration will be conducted prior to the start of the test run. This calibration will be conducted by introducing the calibration gas standard to a tee on the end of the probe in the heated filter box. The calibration gas will be supplied in excess and the surplus gas will flow out of the open end of the probe into the stack. This will ensure that bias calibrations are conducted at stack pressure.

The calibration drift will be measured at the end of the test run by repeating the bias calibration for zero and one or more calibration standards. The difference between the pretest and posttest CEMS response will be the calibration drift.

Analyzers

The following analyzers may be used in the CEMS:

- Total hydrocarbons:

  JUM Model VE- 7
  Flame ionization analyzer
  Range: 0 to 100, 0 to 10,000 ppm as carbon equivalent.

- Sulfur dioxide:

  Bovar Corporation Model 721, version AT or M
  Nondispersive infrared adsorption
  Range: 0 to 500, 0 to 5000 ppm as SO_2.

- Nitrogen oxides:

  Thermo Environmental Company (TECO) Model 42H
  Chemiluminescence
  Range: Between 0 to 25 and 0 to 5000 ppm as NO or as NO_X ; NO_2 by difference.

  API Model 200
  Chemiluminescence
  Range: Between 0 to 100 and 0 to 10,000 ppm as NO or NO_X; NO_2 by difference.

- Carbon monoxide:

  TECO Model 48 or 48H
  Gas correlation nondispersive infrared
  Range: 0 to 10 and 0 to 1,000 ppm (Model 48) and 0 to 10,000 ppm (Model 48H).

  API Model 100
  Gas correlation nondispersive infrared
  Range: 0 to 100 and 0 to 1,000 ppm.

- Carbon dioxide:

  Fugi/ACS Model 760
  Nondispersive infrared
  Range: 0 to 1000 ppm, 0 to 1%, and 0 to 5%.

- Oxygen:

  Siemens Oxymat 5E
  Paramagnetic
  Range: 0 to 25 %.

  Servomex 1400
  Paramagnetic
  Range: 0 to 25 %.

EPA Reference Methods

The performance parameters for the EPA Reference Methods are presented in Table 1.

The universal WESTON calibration performance requirements, applicable to all parameters, are the following:

- Calibration error: ± 2%
- Calibration bias: ± 2%
- Calibration drift: ± 3%

All parameters will be calibrated using zero plus three upscale gas standards. All sample data will be corrected using the EPA method 6C bias correction.

$$C_{corrected} = \frac{(C_{raw} - Z_b)}{(S_b - Z_b)} \times S_{std}$$

Where:

$C_{corrected}$ = Run average concentration corrected for instrument bias and drift.
C_{raw} = Raw run average concentration before correction.
Z_b = Average pre- and posttest zero bias response.
S_b = Average pre and posttest upscale bias response.
S_{std} = True value of upscale bias standard.

TABLE 1. PERFORMANCE PARAMETERS FOR EPA REFERENCE METHODS

Parameter	Method	Calibration Gas (% F_s)[a]	Calibration Error (% F_s)[b]	Calibration Bias (% F_s)[c]	Calibration Drift (% F_s)	Interference Check	Calibration Bias Drift Correction	Other Requirements
O_2	3A	Zero - 0 Low - N/R Mid - 40 to 60 High - 80 to 100	± 2 % F_s	± 5 % F_s	± 3 % F_s/run	Per Method 20[d]	Per Method 6C	
CO_2	3A	Zero - 0 Low - N/R Mid - 40 to 60 High - 80 to 100	± 2 % F_s	± 5 % F_s	± 3 % F_s/run	Per Method 20[d]	Per Method 6C	
SO_2	6C	Zero - 0 Low - N/R Mid - 40 to 60 High - 80 to 100	± 2 % F_s	± 5 % F_s	± 3 % F_s/run	7% of Method 6C[e]	Linear correction for average bias response	
CO	10	Zero - 0 Low - N/R Mid - Approx. 30 High - Approx. 60	± 2 % F_s[f]	± 2 % F_s[f]	± 10 % F_s/8 hrs	For CO_2 and H_2O	Per Method 6C[g]	
NO_X	7E	Zero - 0 Low - N/R Mid - 40 to 60 High - 80 to 100	± 2 % F_s	± 5 % F_s	± 3 % F_s/run	Per Method 20	Per Method 6C	NO_2/NO converter efficiency 98% minimum.
THC	25A	Zero - 0 Low 25 to 35 Mid - 40 to 60 High - 80 to 90	± 5 % C_g[g]	± 5 % C_g[h]	± 3 % F_s/run	N/R	Per Method 6C[g]	Pretest calibration required within 2 hours of start of test run.

N/R = Not required by method.
F_s = Instrument full scale or span value.
C_g = Calibration gas value
a % F_s = Percent full scale of calibration range.
b Calibration error = difference between known calibration value and instrument response when injected directly into instrument.
c Calibration bias = difference between instrument response when calibration gas is injected directly into the instrument and when calibration gas is injected at the sample probe.
d Substitute 500-ppm NO for oxygen or carbon dioxide during interference check.
e Required for first use at a source category only.
f Difference between calibration error and calibration bias is not specified in method; CO accuracy requirement is applied to both.
g Not specific method, but required as WESTON basic operating procedure.
h According to method, all calibrations are conducted from probe.

Stack CEM QC Sampling Procedures

The following QC procedures will be applied to ensure collection of representative CEM data.

- CEMs (probe to sample conditioner) will be leak-checked prior to the testing.

- All CEMs will be calibrated prior to testing to ensure precise and accurate data. Cylinder gases with a certified accuracy of ±2 % or Protocol One standards will be used to calibrate each of the analyzers. Each analyzer will be calibrated at four points (zero, low, mid, and high range). Nitrogen or hydrocarbon-free air will be used to set the instrument zero. The three calibration standards will be approximately 20 to 30, 45 to 55, and 80 to 100 % of span.

- Pre- and posttest calibration bias tests will be performed for each test run. The bias check will be performed with the calibration standard that is closest to the observed concentration in the sample gas. The average pretest/posttest bias drift will not exceed 3 % of full scale.

- A permanent data record of CEM analyzer responses will be made on a strip chart data logger and on the sampling data sheets.

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APPENDIX C

FIELD DATA

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Source Information		Calibration Corrected	Mass Emission	Mass Emission
	Start-Stop	Raw Data	Calibration Data			Stack Flow	Fuel Flow	Data	Rate	Rate
Run No.	Time	(ppm)	Cma	Co	Cm	(dscfm)	(lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	08:27-10:46	688.6	902.8	-0.3	890.0	32,899	525	698.6	100.25	190.9433
2	12:00-14:19	674.3	447.8	0.5	436.5	30,116	525	692.0	90.90	173.1428
3	15:55-16:54	668.3	447.8	-0.6	434.5	28,868	525	688.4	86.69	165.1155
							Average	693.0	92.61	176.4006

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
E(lb/hr)(Run 1) = 698.6*28.01*32,699*60/385300000 = 100.3
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Source Information		Calibration Corrected	Mass Emission	Mass Emission
	Start-Stop	Raw Data	Calibration Data			Stack Flow	Fuel Flow	Data	Rate	Rate
Run No.	Time	(ppm)	Cma	Co	Cm	(dscfm)	(lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	07:52-10:48	202.6	300.9	-4.0	289.0	93,842	525	212.2	86.85	165.4257
2	11:26-14:21	179.9	300.9	-4.0	292.0	94,610	525	186.9	77.13	146.9060
3	15:55-16:54	161.8	300.9	-4.0	295.5	105,541	525	166.6	76.70	146.1005
							Average	188.6	80.23	152.8107

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	0

						Calibration Corrected
	Start-Stop	Raw Data	Calibration Data			Data
Run No.	Time	(ppm)	Cma	Co	Cm	(% or ppm)
1	07:52-08:21	-0.3	902.8	-0.3	890.0	0.00
2	11:26-11:55	-0.3	447.8	0.5	436.5	0.00
3	15:20-15:49	-0.5	447.8	-0.6	434.5	0.10
					Averag	0.03

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	08:27-10:46	0.6	9.9	0.0	9.8	0.6
2	12:00-14:19	0.6	9.9	-0.1	9.9	0.7
3	15:55-16:54	0.6	9.9	-0.2	9.9	0.7
					Average	0.7

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:52-10:48	0.204	1.01	-0.03	0.99	0.231
2	11:26-14:21	0.203	1.01	-0.03	0.98	0.231
3	15:55-16:54	0.181	1.01	-0.02	0.98	0.207
					Average	0.223

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:52-08:21	-0.03	9.94	0.00	9.80	0.000
2	11:26-11:55	-0.06	9.94	-0.10	9.85	0.040
3	15:20-15:49	-0.09	9.94	-0.15	9.90	0.059
					Average	0.033

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:27-10:46	19.9	20.0	0.1	19.9	20.0
2	12:00-14:19	19.8	20.0	0.1	19.9	19.9
3	15:55-16:54	19.7	20.0	0.1	19.8	19.9
					Average	19.9

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	07:52-10:48	20.8	20.0	-0.3	20.1	20.7
2	11:26-14:21	20.8	20.0	-0.4	20.1	20.7
3	15:55-16:54	20.2	20.0	-0.5	19.8	20.4
					Average	20.6

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	07:52-08:21	20.9	20.0	0.1	19.9	21.0
2	11:26-11:55	20.9	20.0	0.1	19.9	21.0
3	15:20-15:49	20.8	20.0	0.1	19.8	21.0
					Average	21.0

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
			Stack	Stack	Data	Emission	Emission
Run No.	Start-Stop Time	Raw Data (ppm)	Flow (dscfm)	Moisture (%)	Dry Basis (ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	08:27-10:46	179.8	34,326	2.00	183.5	15.69	29.8881
2	12:00-14:19	155.5	32,817	2.00	158.7	12.98	24.7153
3	15:55-16:54	141.6	32,605	2.00	144.4	11.73	22.3502
				Average	162.2	13.47	25.65

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
			Stack	Stack	Data	Emission	Emission
Run No.	Start-Stop Time	Raw Data (ppm)	Flow (dscfm)	Moisture (%)	Dry Basis (ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	07:52-10:48	41.4	155,513	2.00	42.2	16.35	31.1497
2	11:26-14:21	35.6	132,932	2.00	36.3	12.02	22.8928
3	15:55-16:54	28.3	67,668	2.00	28.9	4.87	9.2764
				Average	35.8	11.08	21.11

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	0
Sampling Location:	0
Date:	4/24/02
Project Number:	0
CEM Operator:	0
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	0000	0.00
2	0000	0.00
3	0000	0.00

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information				
						Stack	Fuel	Calibration	Mass	Mass
	Start-Stop	Raw Data	Calibration Data			Flow	Flow	Corrected	Emission	Emission
Run No.	Time	(% or ppm)	Cma	Co	Cm	(dscfm)	(lb/hr)	Data (% or ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	08:27-10:46	3.5	19.9	0.2	19.9	32,899	525	3.4	0.80	1.5198
2	12:00-14:19	3.8	19.9	0.3	19.4	30,116	525	3.7	0.79	1.5076
3	15:55-16:54	3.7	19.9	0.2	18.8	28,868	525	3.7	0.77	1.4751
							Average	3.6	0.79	1.5009

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information				
						Stack	Fuel	Calibration	Mass	Mass
	Start-Stop	Raw Data	Calibration Data			Flow	Flow	Corrected	Emission	Emission
Run No.	Time	(% or ppm)	Cma	Co	Cm	(dscfm)	(lb/hr)	Data (% or ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	07:52-10:48	0.40	10.1	-0.2	9.6	93,735	525	0.6	0.38	0.7252
2	11:26-14:21	0.40	10.1	-0.1	9.8	94,495	525	0.5	0.31	0.5921
3	15:55-16:54	0.40	10.1	0.1	9.8	105,389	525	0.4	0.27	0.5216
							Average	0.5	0.32	0.6130

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	#REF!

						Calibration Corrected
	Start-Stop	Raw Data	Calibration Data			Data
Run No.	Time	(% or ppm)	Cma	Co	Cm	(% or ppm)
1	07:52-08:21	-0.05	19.9	0.2	19.9	0.00
2	11:26-11:55	0.00	19.9	0.3	19.4	0.00
3	15:20-15:49	-0.04	19.9	0.2	18.8	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Source Information		Calibration	Mass	Mass
						Stack	Fuel	Corrected	Emission	Emission
Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Flow (dscfm)	Flow (lb/hr)	Data (% or ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	09:10-10:29	202.4	447.8	-4.0	420.5	61,513	1,045	217.7	58.42	55.9077
2	11:35-13:04	194.5	447.8	-4.0	418.5	55,855	1,045	210.4	51.06	48.8648
3	13:25-14:24	190.7	447.8	-4.5	418.5	53,421	1,045	206.7	48.16	46.0849
							Average	211.6	52.55	50.2858

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Source Information		Calibration	Mass	Mass
						Stack	Fuel	Corrected	Emission	Emission
Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Flow (dscfm)	Flow (lb/hr)	Data (% or ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	08:36-10:32	39.0	59.4	-1.2	57.0	292,603	1,045	41.0	52.36	50.1013
2	11:10-13:07	37.0	59.4	-1.2	55.9	292,063	1,045	39.7	50.62	48.4428
3	13:25-14:24	35.7	59.4	-1.3	54.8	294,783	1,045	39.1	50.34	48.1688
							Average	40.0	51.11	48.9043

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	0

						Calibration Corrected
						Data
Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	(% or ppm)
1	08:36-09:05	-4.1	447.8	-4.0	420.5	0.00
2	11:01-11:30	-4.1	447.8	-4.0	418.5	0.00
3	14:30-14:59	-4.5	447.8	-4.5	418.5	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	09:10-10:29	0.6	9.9	-0.2	10.1	0.8
2	11:35-13:04	0.6	9.9	-0.3	10.0	0.8
3	13:25-14:24	0.6	9.9	-0.3	10.0	0.9
					Average	0.8

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-10:32	0.132	1.01	-0.03	0.98	0.159
2	11:10-13:07	0.134	1.01	-0.02	0.97	0.159
3	13:25-14:24	0.135	1.01	-0.02	0.97	0.158
					Average	0.159

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-09:05	-0.03	9.94	-0.15	10.05	0.112
2	11:01-11:30	-0.07	9.94	-0.25	10.00	0.179
3	14:30-14:59	-0.09	9.94	-0.30	10.00	0.203
					Average	0.165

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	09:10-10:29	19.9	20.0	0.1	19.8	20.1
2	11:35-13:04	19.8	20.0	0.1	19.8	20.0
3	13:25-14:24	19.8	20.0	0.1	19.8	20.0
					Average	20.0

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-10:32	21.1	20.0	-0.5	21.0	20.1
2	11:10-13:07	20.8	20.0	-0.5	20.8	20.0
3	13:25-14:24	20.6	20.0	-0.5	20.5	20.2
					Average	20.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-09:05	20.9	20.0	0.1	19.8	21.1
2	11:01-11:30	20.9	20.0	0.1	19.8	21.1
3	14:30-14:59	20.8	20.0	0.1	19.8	21.0
					Average	21.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Data Dry Basis (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	09:10-10:29	12.1	61,513	1.50	12.3	1.89	1.8070
2	11:35-13:04	9.1	55,655	1.50	9.2	1.28	1.2242
3	13:25-14:24	7.6	53,421	1.50	7.7	1.02	0.9795
				Average	9.7	1.40	1.34

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Data Dry Basis (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	08:36-10:32	3.1	292,603	1.50	3.1	2.29	2.1904
2	11:10-13:07	2.2	292,083	1.50	2.2	1.62	1.5549
3	13:25-14:24	1.5	294,783	1.50	1.6	1.16	1.1031
				Average	2.3	1.69	1.62

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	08:36-09:05	-0.45
2	11:01-11:30	-0.48
3	14:30-14:59	-0.20

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	09:10-10:29	5.5	19.9	0.2	19.5	61,513	1,045	5.5	2.44	2.3380
2	11:35-13:04	5.6	19.9	0.5	18.9	55,855	1,045	5.6	2.22	2.1263
3	13:25-14:24	5.7	19.9	0.3	18.3	53,421	1,045	6.0	2.29	2.1887
							Average	5.7	2.32	2.2177

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	08:36-10:32	0.80	10.1	-0.2	10.2	292,603	1,045	1.0	2.03	1.9386
2	11:10-13:07	0.80	10.1	-0.2	10.3	292,063	1,045	0.9	1.91	1.8295
3	13:25-14:24	0.80	10.1	-0.1	10.9	294,783	1,045	0.8	1.74	1.6695
							Average	0.9	1.89	1.8126

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	#REF!

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	08:36-09:05	-0.04	19.9	0.2	19.5	0.00
2	11:01-11:30	-0.04	19.9	0.5	18.9	0.00
3	14:30-14:59	-0.08	19.9	0.3	18.3	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	08:30-09:54	177.4	300.9	-4.0	282.5	87,364	2,550	190.5	72.59	28.4857
2	11:02-12:27	170.9	300.9	-4.0	282.5	83,385	2,550	183.7	66.80	26.1955
3	12:41-12:57	172.0	300.9	-4.0	279.5	82,049	2,550	186.8	66.86	26.2187
							Average	187.0	68.75	26.9600
A/B	15:35-15:38	156.7	300.9	-4.0	279.5	21,314	2,230	170.5	15.85	7.1085

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	07:54-09:54	26.9	59.4	-1.1	57.4	554,869	2,550	28.4	68.85	26.9227
2	10:33-12:27	25.0	59.4	-1.0	57.3	547,724	2,550	26.5	63.26	24.8067
3	12:41-14:18	24.9	59.4	-1.1	56.6	530,345	2,550	26.8	61.99	24.3085
							Average	27.2	64.63	25.3459
A/B	15:35-15:38	27.4	59.4	-1.1	56.6	177,277	2,230	29.4	22.71	10.1850

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	0

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:53-08:22	-4.1	300.9	-4.0	282.5	0.00
2	10:25-10:54	-4.1	300.9	-4.0	282.5	0.00
3	14:25-14:54	-4.1	300.9	-4.0	279.5	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	08:30-09:54	1.3	9.9	0.0	9.9	1.3
2	11:02-12:27	1.3	9.9	-0.1	10.0	1.4
3	12:41-12:57	1.3	9.9	-0.1	9.8	1.4
				Average		1.4
A/B	15:35-15:38	4.6	9.9	-0.1	9.8	4.8

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:54-09:54	0.187	1.01	-0.02	1.00	0.207
2	10:33-12:27	0.187	1.01	-0.02	0.99	0.210
3	12:41-14:18	0.191	1.01	-0.02	0.98	0.217
				Average		0.212
A/B	15:35-15:38	0.5	1.0	0.0	1.0	0.6

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:53-08:22	0.00	9.94	0.00	9.85	0.000
2	10:25-10:54	0.00	9.94	-0.10	9.95	0.101
3	14:25-14:54	-0.03	9.94	-0.10	9.80	0.066
				Average		0.055

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	08:30-09:54	19.2	20.0	0.1	20.0	19.2
2	11:02-12:27	19.2	20.0	0.1	20.0	19.2
3	12:41-12:57	19.1	20.0	0.6	20.0	19.2
				Average		19.2
A/B	15:35-15:38	14.4	20.0	0.6	20.0	14.3

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:54-09:54	20.8	20.0	-0.5	20.4	20.6
2	10:33-12:27	20.8	20.0	-0.5	20.4	20.5
3	12:41-14:18	20.7	20.0	-0.5	20.0	20.8
				Average		20.6
A/B	15:35-15:38	20.0	20.0	-0.5	20.0	20.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:53-08:22	20.9	20.0	0.1	20.0	21.0
2	10:25-10:54	20.9	20.0	0.1	20.0	20.9
3	14:25-14:54	20.9	20.0	0.6	20.0	21.0
				Average		21.0

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Eagine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Data Dry Basis (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	08:30-09:54	2.0	87,364	1.50	2.0	0.44	0.1733
2	11:02-12:27	2.0	83,385	1.50	2.0	0.42	0.1654
3	12:41-12:57	2.0	82,049	1.50	2.0	0.42	0.1628
				Average	2.0	0.43	0.17
A/B	15:35-15:38	9.1	21,314	1.50	9.2	0.49	0.2190

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Data Dry Basis (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	07:54-09:54	1.3	554,869	1.50	1.3	1.79	0.7009
2	10:33-12:27	0.7	547,724	1.50	0.7	0.96	0.3769
3	12:41-14:18	0.5	530,345	1.50	0.5	0.72	0.2835
				Average	0.8	1.16	0.45
A/B	14:25-14:54	3.2	177,277	1.50	3.3	1.45	0.6520

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	07:53-08:22	0.68
2	10:25-10:54	0.64
3	14:25-14:54	0.79

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information		Calibration Corrected	Mass Emission	Mass Emission
	Start-Stop	Raw Data	Calibration Data			Stack Flow	Fuel Flow	Data	Rate	Rate
Run No.	Time	(% or ppm)	Cma	Co	Cm	(dscfm)	(lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	08:30-09:54	15.6	19.9	0.2	18.8	87,364	2,550	16.6	10.36	4.0633
2	11:02-12:27	15.3	19.9	0.3	19.1	83,385	2,550	15.9	9.49	3.7198
3	12:41-12:57	15.6	19.9	0.1	20.1	82,049	2,550	15.5	9.12	3.5765
							Average	16.0	9.66	3.7865
A/B	15:35-15:38	41.2	19.9	0.1	20.1	21,314	2,230	41.0	6.26	2.8090

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information		Calibration Corrected	Mass Emission	Mass Emission
	Start-Stop	Raw Data	Calibration Data			Stack Flow	Fuel Flow	Data	Rate	Rate
Run No.	Time	(% or ppm)	Cma	Co	Cm	(dscfm)	(lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	07:54-09:54	0.97	10.1	-0.1	10.2	554,869	2,550	1.1	4.31	1.6919
2	10:33-12:27	0.92	10.1	-0.1	9.6	547,724	2,550	1.1	4.25	1.6670
3	12:41-14:18	0.88	10.1	-0.1	9.2	530,345	2,550	1.1	4.09	1.6055
							Average	1.1	4.22	1.6548
A/B	15:35-15:38	1.9	10.1	-0.1	9.2	177,277	2,230	2.1	2.70	1.2120

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	#REF!

						Calibration Corrected
	Start-Stop	Raw Data	Calibration Data			Data
Run No.	Time	(% or ppm)	Cma	Co	Cm	(% or ppm)
1	07:53-08:22	-0.09	19.9	0.2	18.8	0.00
2	10:25-10:54	-0.09	19.9	0.3	19.1	0.00
3	14:25-14:54	-0.12	19.9	0.1	20.1	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data			Source Information		Calibration Corrected Data	Mass Emission Rate	Mass Emission Rate
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	08:27-10:46	688.6	902.8	-0.3	890.0	34,326	525	698.6	104.59	199.2232
2	12:00-14:19	674.3	447.8	0.5	436.5	32,817	525	692.0	99.05	188.6746
3	15:55-16:54	668.3	447.8	-0.6	434.5	32,605	525	688.4	97.91	186.4898
							Average	693.0	100.52	191.4626

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data			Source Information		Calibration Corrected Data	Mass Emission Rate	Mass Emission Rate
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	07:52-10:48	202.6	300.9	-4.0	289.0	155,513	525	212.2	143.92	274.1393
2	11:26-14:21	179.9	300.9	-4.0	292.0	132,932	525	186.9	108.37	206.4187
3	15:55-16:54	161.8	300.9	-4.0	295.5	67,668	525	166.6	49.18	93.6726
							Average	188.6	100.49	191.4075

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	0
Sampling Location:	0
Date:	4/24/02
Project Number:	0
CEM Operator:	0
Pollutant:	CO
Molecular Weight:	0

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data			Calibration Corrected Data
			Cma	Co	Cm	(% or ppm)
1	0000	0.0	902.8	-0.3	890.0	0.30
2	0000	0.0	447.8	0.5	436.5	0.00
3	0000	0.0	447.8	-0.6	434.5	0.62
					Averag	0.31

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:27-10:46	0.6	9.9	0.0	9.8	0.6
2	12:00-14:19	0.6	9.9	-0.1	9.9	0.7
3	15:55-16:54	0.6	9.9	-0.2	9.9	0.7
				Average		0.7

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	07:52-10:48	0.204	1.01	-0.03	0.99	0.231
2	11:26-14:21	0.203	1.01	-0.03	0.98	0.231
3	15:55-16:54	0.181	1.01	-0.02	0.98	0.207
				Average		0.223

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	0
Sampling Location:	0
Date:	4/24/02
Project Number:	0
CEM Operator:	0
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	0000	0.00	9.94	0.00	9.80	0.000
2	0000	0.00	9.94	-0.10	9.85	0.100
3	0000	0.00	9.94	-0.15	9.90	0.148
				Average		0.083

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:27-10:46	19.9	20.0	0.1	19.9	20.0
2	12:00-14:19	19.8	20.0	0.1	19.9	19.9
3	15:55-16:54	19.7	20.0	0.1	19.8	19.9
					Average	19.9

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	07:52-10:48	20.8	20.0	-0.3	20.1	20.7
2	11:26-14:21	20.8	20.0	-0.4	20.1	20.7
3	15:55-16:54	20.2	20.0	-0.5	19.8	20.4
					Average	20.6

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	0
Sampling Location:	0
Date:	4/24/02
Project Number:	0
CEM Operator:	0
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	0000	0.0	20.0	0.1	19.9	0.0
2	0000	0.0	20.0	0.1	19.9	0.0
3	0000	0.0	20.0	0.1	19.8	0.0
					Average	0.0

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)	Source Information: Stack Flow (dscfm)	Source Information: Stack Moisture (%)	Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	08:27-10:46	179.8	32,899	1.50	182.5	14.96	28.5006
2	12:00-14:19	155.5	30,116	1.50	157.9	11.85	22.5656
3	15:55-16:54	141.6	28,868	1.50	143.7	10.34	19.6881
				Average	161.4	12.38	23.58

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)	Source Information: Stack Flow (dscfm)	Source Information: Stack Moisture (%)	Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	07:52-10:48	41.4	93,842	1.50	42.0	9.82	18.7015
2	11:26-14:21	35.8	94,610	1.50	36.1	8.51	16.2105
3	15:55-16:54	28.3	105,541	1.50	28.7	7.56	14.3949
				Average	35.6	8.63	16.44

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	07:52-08:21	1.78
2	11:26-11:55	-4.72
3	15:20-15:49	-9.91

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	08:27-10:46	3.5	19.9	0.2	19.9	34,326	525	3.4	0.83	1.5858
2	12:00-14:19	3.8	19.9	0.3	19.4	32,817	525	3.7	0.86	1.6428
3	15:55-16:54	3.7	19.9	0.2	18.8	32,605	525	3.7	0.87	1.6661
							Average	3.6	0.86	1.6315

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Idle
Date:	4/24/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	07:52-10:48	0.40	10.1	-0.2	9.6	155,513	525	0.6	0.63	1.2032
2	11:26-14:21	0.40	10.1	-0.1	9.8	132,932	525	0.5	0.44	0.8329
3	15:55-16:54	0.40	10.1	0.1	9.8	67,668	525	0.4	0.18	0.3349
							Average	0.5	0.41	0.7903

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	0
Sampling Location:	0
Date:	4/24/02
Project Number:	0
CEM Operator:	0
Pollutant:	NOx
Molecular Weight:	#REF!

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	0000	0.00	19.9	0.2	19.9	0.00
2	0000	0.00	19.9	0.3	19.4	0.00
3	0000	0.00	19.9	0.2	18.8	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	09:10-10:29	202.4	447.8	-4.0	420.5	78,902	1,045	217.7	74.94	71.7121
2	11:35-13:04	194.5	447.8	-4.0	418.5	76,060	1,045	210.4	69.79	66.7804
3	13:25-14:24	190.7	447.8	-4.5	418.5	74,072	1,045	206.7	66.77	63.8993
							Average	211.6	70.50	67.4640

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	08:36-10:32	39.0	59.4	-1.2	57.0	328,584	1,045	41.0	58.79	56.2623
2	11:10-13:07	37.0	59.4	-1.2	55.9	328,688	1,045	39.7	56.97	54.5176
3	13:25-14:24	35.7	59.4	-1.3	54.8	328,736	1,045	39.1	56.13	53.7170
							Average	40.0	57.30	54.8323

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	0

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	08:36-09:05	-4.1	447.8	-4.0	420.5	0.00
2	11:01-11:30	-4.1	447.8	-4.0	418.5	0.00
3	14:30-14:59	-4.5	447.8	-4.5	418.5	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	09:10-10:29	0.6	9.9	-0.2	10.1	0.8
2	11:35-13:04	0.6	9.9	-0.3	10.0	0.8
3	13:25-14:24	0.6	9.9	-0.3	10.0	0.9
					Average	0.8

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-10:32	0.132	1.01	-0.03	0.98	0.159
2	11:10-13:07	0.134	1.01	-0.02	0.97	0.159
3	13:25-14:24	0.135	1.01	-0.02	0.97	0.158
					Average	0.159

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-09:05	-0.03	9.94	-0.15	10.05	0.112
2	11:01-11:30	-0.07	9.94	-0.25	10.00	0.179
3	14:30-14:59	-0.09	9.94	-0.30	10.00	0.203
					Average	0.165

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	09:10-10:29	19.9	20.0	0.1	19.8	20.1
2	11:35-13:04	19.8	20.0	0.1	19.8	20.0
3	13:25-14:24	19.8	20.0	0.1	19.8	20.0
					Average	20.0

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-10:32	21.1	20.0	-0.5	21.0	20.1
2	11:10-13:07	20.8	20.0	-0.5	20.8	20.0
3	13:25-14:24	20.6	20.0	-0.5	20.5	20.2
					Average	20.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:36-09:05	20.9	20.0	0.1	19.8	21.1
2	11:01-11:30	20.9	20.0	0.1	19.8	21.1
3	14:30-14:59	20.8	20.0	0.1	19.8	21.0
					Average	21.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
			Stack	Stack	Data	Emission	Emission
Run No.	Start-Stop Time	Raw Data (ppm)	Flow (dscfm)	Moisture (%)	Dry Basis (ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	09:10-10:29	12.1	78,902	2.00	12.4	2.43	2.3297
2	11:35-13:04	9.1	76,060	2.00	9.3	1.76	1.6816
3	13:25-14:24	7.6	74,072	2.00	7.7	1.43	1.3651
				Average	9.8	1.87	1.79

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
			Stack	Stack	Data	Emission	Emission
Run No.	Start-Stop Time	Raw Data (ppm)	Flow (dscfm)	Moisture (%)	Dry Basis (ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
1	08:36-10:32	3.1	328,584	2.00	3.2	2.58	2.4723
2	11:10-13:07	2.2	328,688	2.00	2.2	1.84	1.7588
3	13:25-14:24	1.5	328,736	2.00	1.6	1.29	1.2365
				Average	2.3	1.90	1.82

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	08:36-09:05	-0.45
2	11:01-11:30	-0.48
3	14:30-14:59	-0.20

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information		Calibration	Mass	Mass
Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	Corrected Data (% or ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	09:10-10:29	5.5	19.9	0.2	19.5	78,902	1,045	5.5	3.13	2.9989
2	11:35-13:04	5.6	19.9	0.5	18.9	76,060	1,045	5.6	3.04	2.9059
3	13:25-14:24	5.7	19.9	0.3	18.3	74,072	1,045	6.0	3.17	3.0348
							Average	5.7	3.11	2.9798

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Intermediate
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information		Calibration	Mass	Mass
Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	Corrected Data (% or ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	08:36-10:32	0.80	10.1	-0.2	10.2	328,584	1,045	1.0	2.28	2.1770
2	11:10-13:07	0.80	10.1	-0.2	10.3	328,688	1,045	0.9	2.15	2.0590
3	13:25-14:24	0.80	10.1	-0.1	10.9	328,736	1,045	0.8	1.95	1.8618
							Average	0.9	2.12	2.0326

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/25/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Calibration Corrected
Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Data (% or ppm)
1	08:36-09:05	-0.04	19.9	0.2	19.5	0.00
2	11:01-11:30	-0.04	19.9	0.5	18.9	0.00
3	14:30-14:59	-0.08	19.9	0.3	18.3	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	08:30-09:54	177.4	300.9	-4.0	282.5	94,623	2,550	190.5	78.62	30.8311
2	11:02-12:27	170.9	300.9	-4.0	282.5	92,198	2,550	183.7	73.86	28.9641
3	12:41-12:57	172.0	300.9	-4.0	279.5	92,391	2,550	186.8	75.28	29.5233
							Average	187.0	75.92	29.7728
A/B	15:35-15:38	156.7	300.9	-4.0	279.5	24,493	2,230	170.5	18.22	8.1667

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	07:54-09:54	26.9	59.4	-1.1	57.4	364,726	2,550	28.4	45.13	17.6968
2	10:33-12:27	25.0	59.4	-1.0	57.3	389,257	2,550	26.5	44.96	17.6296
3	12:41-14:18	24.9	59.4	-1.1	56.6	1,151,554	2,550	26.8	134.59	52.7817
							Average	27.2	74.89	29.3894
A/B	15:35-15:38	27.4	59.4	-1.1	56.6	193,402	2,230	29.4	24.78	11.1113

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	0

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:53-08:22	-4.1	300.9	-4.0	282.5	0.00
2	10:25-10:54	-4.1	300.9	-4.0	282.5	0.00
3	14:25-14:54	-4.1	300.9	-4.0	279.5	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	08:30-09:54	1.3	9.9	0.0	9.9	1.3
2	11:02-12:27	1.3	9.9	-0.1	10.0	1.4
3	12:41-12:57	1.3	9.9	-0.1	9.8	1.4
					Average	1.4
A/B	15:35-15:38	4.6	9.9	-0.1	9.8	4.8

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:54-09:54	0.187	1.01	-0.02	1.00	0.207
2	10:33-12:27	0.187	1.01	-0.02	0.99	0.210
3	12:41-14:18	0.191	1.01	-0.02	0.98	0.217
					Average	0.212
A/B	15:35-15:38	0.5	1.0	0.0	1.0	0.6

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:53-08:22	0.00	9.94	0.00	9.85	0.000
2	10:25-10:54	0.00	9.94	-0.10	9.95	0.101
3	14:25-14:54	-0.03	9.94	-0.10	9.80	0.066
					Average	0.055

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	08:30-09:54	19.2	20.0	0.1	20.0	19.2
2	11:02-12:27	19.2	20.0	0.1	20.0	19.2
3	12:41-12:57	19.1	20.0	0.6	20.0	19.2
				Average		19.2
A/B	15:35-15:38	14.4	20.0	0.6	20.0	14.3

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:54-09:54	20.8	20.0	-0.5	20.4	20.5
2	10:33-12:27	20.9	20.0	-0.5	20.4	20.5
3	12:41-14:18	20.7	20.0	-0.5	20.0	20.8
				Average		20.6
A/B	15:35-15:38	20.0	20.0	-0.5	20.0	20.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:53-08:22	20.9	20.0	0.1	20.0	21.0
2	10:25-10:54	20.9	20.0	0.1	20.0	20.9
3	14:25-14:54	20.9	20.0	0.6	20.0	21.0
				Average		21.0

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Data Dry Basis (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	08:30-09:54	2.0	94,623	4.96	2.1	0.50	0.1946
2	11:02-12:27	2.0	92,198	4.96	2.1	0.48	0.1898
3	12:41-12:57	2.0	92,391	4.96	2.1	0.48	0.1900
				Average	2.1	0.49	0.19
A/B	15:35-15:38	9.1	24,493	2.00	9.2	0.56	0.2529

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Data Dry Basis (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	07:54-09:54	1.3	384,726	4.96	1.3	1.22	0.4775
2	10:33-12:27	0.7	389,257	4.96	0.7	0.71	0.2776
3	12:41-14:18	0.5	1,151,554	4.96	0.6	1.63	0.6380
				Average	0.9	1.18	0.46
A/B	15:35-15:38	3.2	193,402	2.00	3.3	1.59	0.7150

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	07:53-08:22	0.68
2	10:25-10:54	0.84
3	14:25-14:54	0.79

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Engine - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	08:30-09:54	15.6	19.9	0.2	18.8	94,623	2,550	16.6	11.22	4.4009
2	11:02-12:27	15.3	19.9	0.3	19.1	92,198	2,550	15.9	10.49	4.1130
3	12:41-12:57	15.6	19.9	0.1	20.1	92,391	2,550	15.5	10.27	4.0273
							Average	16.0	10.66	4.1804
A/B	15:35-15:38	41.2	19.9	0.1	20.1	24,493	2,230	41.0	7.20	3.2280

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Slipstream - Military
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	07:54-09:54	0.97	10.1	-0.1	10.2	364,726	2,550	1.1	2.84	1.1121
2	10:33-12:27	0.92	10.1	-0.1	9.6	389,257	2,550	1.1	3.02	1.1847
3	12:41-14:18	0.88	10.1	-0.1	9.2	1,151,554	2,550	1.1	8.89	3.4860
							Average	1.1	4.92	1.9276
A/B	15:35-15:38	1.9	10.1	-0.1	9.2	193,402	2,230	2.1	2.95	1.3222

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Moody AFB
Sampling Location:	Ambient
Date:	4/26/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	#REF!

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	07:53-08:22	-0.09	19.9	0.2	18.8	0.00
2	10:25-10:54	-0.09	19.9	0.3	19.1	0.00
3	14:25-14:54	-0.12	19.9	0.1	20.1	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Condition	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
Idle	14:18-14:27	1650.0	447.8	-1.2	437.5	24,956	1,040	1685.6	183.48	176.4244
Intermediate	14:35-14:43	384.9	447.8	-1.2	437.5	82,241	2,060	373.7	134.04	65.0702
Military	14:46-14:53	255.2	447.8	-1.2	437.5	120,532	4,440	261.7	137.60	30.9904
Afterburner	1455-1456	1300.0	447.8	-1.2	437.5	17,130	4,460	1328.3	99.25	22.2523
							Average	912.3	138.59	73.6843

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Condition	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
Ambient	1345-1352	-1.1	447.8	-1.2	437.5	0.03
					Averag	0.01

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Idle	14:18-14:27	1.7	2.0	0.0	2.0	1.7
Intermediate	14:35-14:43	1.1	2.0	0.0	2.0	1.1
Military	14:46-14:53	1.6	2.0	0.0	2.0	1.7
Afterburner	1455-1456	11.5	2.0	0.0	2.0	11.7
					Average	4.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Ambient	1345-1352	0.02	2.00	0.00	1.96	0.015
					Average	0.004

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Idle	14:18-14:27	18.2	10.6	-0.1	10.5	18.4
Intermediate	14:35-14:43	19.5	10.6	-0.1	10.5	19.6
Military	14:46-14:53	18.8	10.6	-0.1	10.5	18.9
Afterburner	1455-1456	5.5	10.6	-0.1	10.5	5.6
					Average	15.6

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Ambient	1345-1352	20.8	10.6	-0.1	10.5	21.0
					Average	5.2

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
Condition	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Data Dry Basis (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
Idle	14:18-14:27	208.4	24,956	1.50	211.6	13.16	12.6519
Intermediate	14:35-14:43	24.0	82,241	1.50	24.3	4.99	2.4200
Military	14:46-14:53	9.5	120,532	1.50	9.7	2.91	0.6548
Afterburner	1455-1456	260.0	17,130	1.50	264.0	11.27	2.5260
				Average	127.4	8.08	4.56

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Condition	Start-Stop Time	Raw Data (ppm)
Ambient	1345-1352	2.51

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Source Information Stack Flow (dscfm)	Fuel Flow (lb/hr)	Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
Idle	14:18-14:27	7.0	19.9	0.4	21.5	24,956	1,040	6.3	1.12	1.0750
Intermediate	14:35-14:43	3.0	19.9	0.4	21.5	82,241	2,060	2.4	1.44	0.7006
Military	14:46-14:53	10.8	19.9	0.4	21.5	120,532	4,440	9.9	8.53	1.9207
Afterburner	1455-1456	100.0	19.9	0.4	21.5	17,130	4,460	94.3	11.58	2.5963
							Average	28.2	5.67	1.5731

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16 00
NOx	46 01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
Ambient	1345-1352	-0.04	19.9	0.4	21.5	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Source Information		Calibration	Mass	Mass
						Stack	Fuel	Corrected	Emission	Emission
	Start-Stop	Raw Data	Calibration Data			Flow	Flow	Data	Rate	Rate
Condition	Time	(ppm)	Cma	Co	Cm	(dscfm)	(lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
Idle	14:18-14:27	1650.0	447.8	-1.2	437.5	25,101	1,040	1685.6	184.55	177.4490
Intermediate	14:35-14:43	364.9	447.8	-1.2	437.5	97,837	2,060	373.7	159.46	77.4091
Military	14:46-14:53	255.2	447.8	-1.2	437.5	138,865	4,440	261.7	158.53	35.7041
Afterburner	1455-1456	1300.0	447.8	-1.2	437.5	18,446	4,460	1328.3	106.87	23.9622
							Average	912.3	152.35	78.6311

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Calibration Corrected
	Start-Stop	Raw Data	Calibration Data			Data
Condition	Time	(ppm)	Cma	Co	Cm	(% or ppm)
Ambient	1345-1352	-1.1	447.8	-1.2	437.5	0.03
					Averag	0.01

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Idle	14:18-14:27	1.7	2.0	0.0	2.0	1.7
Intermediate	14:35-14:43	1.1	2.0	0.0	2.0	1.1
Military	14:46-14:53	1.6	2.0	0.0	2.0	1.7
Afterburner	1455-1456	11.5	2.0	0.0	2.0	11.7
					Average	4.1

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	CO2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Ambient	1345-1352	0.02	2.00	0.00	1.96	0.015
					Average	0.004

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Idle	14:18-14:27	18.2	10.6	-0.1	10.5	18.4
Intermediate	14:35-14:43	19.5	10.6	-0.1	10.5	19.6
Military	14:46-14:53	18.8	10.6	-0.1	10.5	18.9
Afterburner	1455-1456	5.5	10.6	-0.1	10.5	5.6
					Average	15.6

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Ambient	1345-1352	20.8	10.6	-0.1	10.5	21.0
					Average	5.2

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

Total Hydrocarbon Data Correction

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected	Mass	Mass
			Stack	Stack	Data	Emission	Emission
Condition	Start-Stop Time	Raw Data (ppm)	Flow (dscfm)	Moisture (%)	Dry Basis (ppm)	Rate (lb/hr)	Rate (lb/1000 lb fuel)
Idle	14:18-14:27	208.4	25,101	14.18	242.9	15.19	14.6056
Intermediate	14:35-14:43	24.0	97,837	14.18	27.9	6.81	3.3042
Military	14:46-14:53	9.5	138,865	14.18	11.1	3.84	0.8659
Afterburner	1455-1456	260.0	18,446	14.18	303.0	13.92	3.1219
				Average	146.2	9.94	5.47

Moisture Correction
Cgas(dry)=Cgas(wet)/(1-(% moisture/100))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas(dry)*MWgas*Qs(dscfm)*60/385300000

Total Hydrocarbon Data Correction

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Condition	Start-Stop Time	Raw Data (ppm)
Ambient	1345-1352	2.51

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Source Information		Calibration Corrected Data (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
Idle	14:18-14:27	7.0	19.9	0.4	21.5	25,101	1,040	6.3	1.12	1.0813
Intermediate	14:35-14:43	3.0	19.9	0.4	21.5	97,837	2,060	2.4	1.72	0.8334
Military	14:46-14:53	10.8	19.9	0.4	21.5	138,865	4,440	9.9	9.82	2.2128
Afterburner	1455-1456	100.0	19.9	0.4	21.5	18,446	4,460	94.3	12.47	2.7958
							Average	28.2	6.28	1.7308

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
Mass Emission Rate (lb/hr)
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
Mass Emission Rate (lb/1000 lb fuel)
E(lb/MMBtu)=E(lb/hr)/Fuel flow * 1000

Pollutant	MWgas
CO	28.01
Methane	16 00
NOx	46.01
SO2	64.06

CEM Data Correction Data Sheet

Plant Name:	Randolph AFB
Sampling Location:	Engine
Date:	5/1/02
Project Number:	030197.0002.5
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Condition	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
Ambient	1345-1352	-0.04	19.9	0.4	21.5	0.00
					Averag	0.00

Calibration Error Correction
Cgas=(Cobs-Co)*(Cma/(Cm-Co))

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APPENDIX D

QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

D.1 QUALITY CONTROL PROCEDURES

As part of the engine testing program, EQ will implement a quality assurance (QA) and quality control (QC) program. QA/QC are defined as follows:

- Quality Control - The overall system of activities whose purpose is to provide a quality product or service (e.g., the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process).

- Quality Assurance - A system of activities whose purpose is to provide assurance that the overall QC is being conducted effectively.

The Field Team Leaders for stack sampling will be responsible for implementation of field QA/QC procedures. Individual laboratory managers will be responsible for implementation of analytical QA/QC procedures. The overall Project Manager oversees all QA/QC procedures to ensure that sampling and analyses meet the QA/QC requirements and that accurate data results from the test program are obtained.

D.1.1 Field QC Sample Collection/Preparation Procedures

Table B-1 provides a summary of the numbers and types of field and analytical QA/QC samples by parameter. General field QC procedures are the following:

- Collect only the number of samples needed to represent the media being sampled.

- To the extent possible, determine the quantities and types of samples and sample locations prior to the actual field work.

- As few people as possible should handle samples.

TABLE D-1. SUMMARY OF ANALYTICAL QA/QC SAMPLES

SAMPLE LOCATION	PARAMETER	NUMBER OF SAMPLES	TYPES OF QA/QC SAMPLES		
			FB	TB	MS
STACK GAS[1]:					
	Particulate Volatile organics[2] Aldehydes and Ketones	48 48 4	-- 1 pair 1	1 1 pair 1	-- 12 pair --
AMBIENT (BACKGROUND)					
	Particulate Volatile organics	4 5	1 1	-- --	-- --

[1] Trip blanks for stack gas samples will consist of reagent blanks. See Subsection 6.1.2 for a description of stack gas blank samples.

[2] Four VOST tubes per test run.

FB = Field Blank
TB = Trip Blank
MB = Method Blank or Preparation Blank
MS = Matrix Spike

- The field sampler is personally responsible for the care and control of the samples collected until they are property transferred or dispatched.

- Sample records must be completed for each sample, using black waterproof ink or other measures to ensure the legibility and integrity of sample identification.

- The Field Team Leader ensures that proper preservation, storage, and security procedures are followed during the field work and decides if additional samples are needed.

- Storage conditions of samples must be documented on the sample forms or project records.

D.1.1.1 QC Procedures for Stack Gas Sample Collection

This subsection provides a list of QC procedures to be employed during the field sampling effort. Method-specific QC procedures are detailed in the method descriptions contained in Appendix A. General QC checks that will apply to all methods include the following:

- Leak checks.
- Use of standardized forms, labels, and checklists.
- Ensure sample traceability.
- Collection of appropriate blanks.
- Use of calibrated instrumentation.
- Use of Protocol 1 and/or NIST-traceable calibration gases.
- Review of data sheets in the field to verify completeness.
- Use of validated spreadsheets for calculating results.

D.1.1.2 Velocity/Volumetric Flow Rate QC Procedures

Volumetric flow rates will be determined during the isokinetic stack gas tests. The following QC procedures will be followed during these tests:

- The S-type pitot tube will be inspected visually before sampling.

- Both legs of the pitot tube will be leak-checked before sampling.

- Proper orientation of the S-type pitot tube will be maintained while making measurements. The yaw and pitch axes of the S-type pitot tube will be maintained at 90° to the flow.

- The manometer oil will be leveled and zeroed before each run.
- Cyclonic or turbulent flow checks will be performed prior to testing the source.
- Pitot tube coefficients will be determined based on physical measurement techniques as delineated in EPA Method 2.

D.1.1.3 Moisture Content and Sample Volume QC Procedures

Gas stream moisture will be determined by EPA Method 4 as part of the isokinetic stack gas tests. The following QC procedures will be followed in determining the volume of moisture collected:

- The balance zero will be checked and rezeroed if necessary before each weighing.
- The balance will be leveled and placed in a clean, motionless environment for weighings.
- The indicating silica gel will be fresh for each run and will be inspected periodically and replaced during runs, if needed.

The QC procedures that will be followed to ensure accurate sample gas volume determination are the following:

- The dry gas meter will be fully calibrated annually using an EPA-approved intermediate standard device.
- Pretest, port-change, and posttest leakchecks will be completed (must be less than 0.02 cfm or 4 % of the average sample rate).
- The gas meter will be read to the thousandth of a cubic foot for all initial and final readings.
- Readings of the dry gas meter, meter orifice pressure **(Delta H)**, and meter temperatures will be taken at every sampling point.
- Accurate barometric pressures will be recorded at least once per day.
- Pre- and posttest program dry gas meter checks will be completed to verify the accuracy of the meter calibration constant (Y).

The most critical operating parameter for ambient air-sampling equipment is the airflow rate during sampling, which determines the total volume of air sampled. Calibrations of the ambient air-sampling equipment will be performed to accurately determine the operating flow rates of the samplers, and to verify that all method-based flow-rate requirements are met.

All ambient air samplers will be calibrated upon installation to establish the means for determining operating flow rates, and as required throughout the monitoring program whenever field calibration checks or repairs require recalibration. All calibrations will be conducted according to standard operating procedures (SOP), using materials traceable to NIST reference materials. Calibrations will be conducted by qualified personnel thoroughly familiar with the sampling equipment. All calibration and audit results will be recorded in a field logbook and/or the calibration/audit data sheets. Other specific QA/QC for particulate, VOST, aldehydes and ketones, and CEMS are in Appendix B.

D.1.2 Exhaust Gas Blank Samples

Stack gas blank samples will consist primarily of reagent blanks collected in the on-site sample recovery area during the test program. Reagent blanks will include solvents used to recover stack samples, absorbing solutions, filters, and resins (Tenax, Tenax/charcoal). All reagent blanks will be collected by transferring directly from storage containers to sample jars, or labeling filters and resins as blank samples.

For the VOST Method 0030* sampling trains, additional blank samples will be taken in the field according to the following procedures. Blank Tenax and Tenax/charcoal cartridges will be taken to the sampling location and the end caps removed for a period of time equal to the time required to exchange one pair of VOST tubes on the VOST train. After this time period, the end caps will be replaced on the blank tubes and these tubes will be handled in a manner similar to the other VOST tube samples. This procedure is consistent with the *EPA Quality Assurance/Quality Control (QA/QC) Procedures for Hazardous Waste Incineration* (January 1990).

* 40 CFR 60 Appendix A

A blank Method 0011* (aldehydes and ketones) sample train will be taken to the stack sample location, leak checked, and then recovered in the same manner as the Method 0011* stack samples.

The sampling media may contain small amounts of the target compounds emitted from naturally occurring or anthropogenic emission sources. Contamination may be introduced to the sampling media during handling of the media in the laboratory, in the field, or during shipping. Blank samples will be used to quantify these sources of contamination. A blank sample consists of a complete set of sampling media (e.g., a PUF cartridge and a glass fiber filter, or a complete ADS sampling train) that has had no air drawn through it by the sampling equipment. Field blank samples will be collected during the monitoring program.

The field blanks will be used to identify contamination resulting from field sample handling procedures. A field blank will be handled in the same manner as an actual sample, undergoing the same preparation, installation in the sampler module, and recovery procedures.

The following stack sample blank corrections will be performed.

- Particulate — Acetone and methylene chloride blank.
- VOST — Field and trip blanks.
- Aldehydes and Ketones — Reagent blanks.

D.2 SAMPLING CONTAINERS, PRESERVATIVES, AND VOLUME REQUIREMENTS

Table B-2 lists the holding times, storage containers and preservation requirements to be used for routine storage and handling of samples.

D.3 DECONTAMINATION PROCEDURES

Stack-gas sampling equipment will be precleaned following standard source test method procedures. All stack-gas sampling equipment will be cleaned on site as part of individual sample recovery procedures.

Sample containers will be purchased from a vendor with a certificate indicating that each lot of bottles is free of contaminants.

All personnel associated with sample collection will use designated personal protective equipment (PPE). Personnel will follow standard PPE decontamination procedures for each level of PPE required.

All personnel have received the proper hazardous materials training as specified in 29 CFR 1910.

D.4 SAMPLING PACKAGING AND SHIPMENT

All samples will be packaged and shipped according to the specifications detailed in the Hazardous Materials Transportation Regulations published by the U.S. Department of Transportation (DOT) (49 CFR 171-180) for ground transportation and the International Air Transport Association (IATA) regulations for air shipment. These regulations contain detailed instructions on how hazardous materials must be identified, packaged, marked, labeled, documented, and placarded. All personnel involved with sample shipment are trained and certified for shipment of hazardous materials.

When transferring possession of samples, the individuals relinquishing and receiving those samples will sign, date, and note the time on the sample chain-of-custody record. This record documents sample transfer from the sampler, often through another person or commercial carrier, to the sample custodian or analyst.

The procedure for shipping samples will be as follows:

- A complete sample inventory form (chain-of-custody) will be enclosed with the samples being shipped, and a copy retained by the Field Team Leader.
- DOT and IATA regulations will be followed for shipping container requirements. The regulations require that the shipper make a reasonable determination whether the sample is classified as a hazardous material and, if so, that it is appropriately identified.
- Each package will be designed and constructed, and its contents limited, so that under normal transportation conditions there will be no significant release of materials to the environment and no potentially hazardous conditions.

TABLE D-2. RECOMMENDED SAMPLE CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

SAMPLE LOCATION	ANALYTE	MATRIX	CONTAINER TYPE AND SIZE	PRESERVATION	HOLDING TIME
STACK GAS	Particulate Condensable particulate Volatile organics Aldehydes and Ketones	Liquids, filters, and resins Liquid	AG/500 mL AG/1.0 L G/40 mL AG/1L AG/1.0 L	NA NA ≤4 °C ≤4 °C ≤4 °C	NA NA 14 days 14 days to exit/40 days to analysis 14 days
AMBIENT	Particulate Volatile organics	Filter Whole air Filter/PUF	E S G/A	NA NA 4 ± 2°C	NA 30 days 7 days to exit/40 days to analysis

Key:

A= Aluminum Foil
AG = Amberglass
D = Denuder Tube
E = Envelope/Folder
G = Glass
NA = Not Applicable
P = Plastic
S = Stainless Steel Canister.

- Samples will be placed inside a shipping container for transport back to the laboratory.

- Preservation of the samples (e.g., refrigerant packs, ice, chemical preservatives, etc.) will be performed as required by the test plan or analytical requirements and documented on the sample inventory record.

- All freight bills and shipping records will be retained as part of the permanent records by the Project Manager.

D.5 CUSTODY PROCEDURES

An overriding consideration for environmental measurement data is the ability to demonstrate that samples have been obtained from the locations stated using the prescribed methods and that they have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal will be documented to accomplish this objective. Documentation will be accomplished through a chain-of-custody record that documents each sample and the individuals responsible for sample collection, shipment, and receipt. A sample will be considered "in custody " under the following conditions:

- It is in a person's actual possession.

- It is in view after being in physical possession.

- It is secured in a locked compartment so that no one can tamper with it after it has been in physical custody.

- It is in a secured area, restricted to authorized personnel.

D.5.1 Field Custody Procedures

Sample custody will be initiated by EQ during collection of the samples. Preformatted labels will be used at the time of collection. Documents prepared specifically for monitoring field sample collection and recovery will be used for recording pertinent information about the types and numbers of samples collected and shipped for analysis. The samples collected first will be assembled at an on-site location for batching and paperwork checks. This task includes matching similar sample types (e.g., solids, liquids) from all sampling locations. Sample packaging procedures will comply with all DOT and IATA requirements for shipment of environmental

samples. Establishing or maintaining sample integrity involves numerous steps or considerations in addition to custody documentation. For example, major concerns in programs of this nature are contamination, cross-contamination, and/or degradation of sample containers; absorbing and filtration media; recovery materials; and actual samples, as applicable. These problems will be avoided or minimized at all times by using the following procedure:

- The lid of each labeled jar will be secured with a strip of custody tape.
- Individual sample jars will then be sealed in plastic bags and placed in appropriate shipping containers.
- Volatile materials will be stored, handled, and transported apart from sorbent materials (e.g., store, handle, and ship VOST tubes apart from solvents [methylene chloride, acetone, toluene, etc.] used to recover the other sample trains).
- Volatile, organic, and aldehyde and ketone samples will be sealed and kept away from sources of solvents, gasoline, etc., during recovery, transportation, storage, and analysis (e.g., recovery of particulate samples where acetone is used will be performed remote from preparation, recovery, and storage of VOST and aldehyde and ketone samples).
- Vermiculite will be placed around the bags in the shipping container for protection from damage, if needed. Ice will be placed in the shipping container, if required.
- One chain-of-custody form will be completed for each shipping container, placed in a large plastic bag, and the bag taped to the inside lid of the shipping container.
- The container will be taped closed with tape and sealed with custody tape on two sides such that opening the container will break the custody tape.

Collected samples will be kept under lock and key or within sight at all times until their shipment to the laboratory. The field sampler will act as the sample custodian and the document control officer in order to monitor the location of collected samples and to record vital sample information in field logbooks.

A unique system for individual sample identification will be used and included on each sample label.

This naming convention allows every sample to be completely and consistently identified on the field data sheets, sample media labels, chain-of-custody forms, and laboratory reports. The naming convention is designed to provide redundant information that can be used in conjunction with laboratory media identification numbers to verify sample identity.

The final evidence file will include at a minimum the following:

- Field logbooks.
- Field data and data deliverables.
- Photographs.
- Drawings.
- Laboratory data deliverables.
- Data validation reports.
- Data assessment reports.
- Progress reports, QA reports, interim project reports, etc.
- All custody documentation (i.e., tags, forms, airbills, etc.).

D.6 DATA REDUCTION, VALIDATION, AND REPORTING

Data will be produced primarily from three sources, specifically the following:

- Engine operations during the test program.
- Field measurements data, including sampling records (volumes and duration), and observations.
- Sample analysis and characterization data.

All data generated by field activities or by the laboratory will be reduced and validated prior to reporting. Specific data reduction, validation and reporting procedures are described in the following subsections.

D.6.1 Data Reduction

D.6.1.1 Field Data Reduction Procedures

The stages of data confirmation will begin with an initial series of calculations completed on the same day as the sampling effort to establish that the pretest assumptions were correct and

that the test procedures completed to that point were performed in an acceptable manner. This enables the on-site test team to correct any faulty procedures, and provides a greater understanding of any immediate problems. The on-site data reduction and confirmation activities will be performed by an experienced data management specialist.

D.6.1.2 Office Calculations

All data averages will be "double-checked" to verify numerical accuracy by an experienced technician. Prior to utilization of the analytical data for calculation of test results, a check will be applied to ascertain any obvious "out-of-line" results for reanalysis.

All results of calculations will be examined by another individual as assigned by the Field Team Leader. Depending on the complexity of the work, this person will either spot-check certain calculations or repeat the entire effort as assigned by the Field Team Leader. When all data are summarized, a check will be made for test result correctness by the Field Team Leader and by the EQ Program Manager. The EQ QA Manager will conduct routine audits to document that the checks are being performed and documented (with checker's initials and date).

The initial field test data and resulting calculations will be performed on a portable PC at the end of each test day. In the office, final results and result tables will be developed on a microcomputer. Standard EPA method programs have been developed and validated for the computational systems to ensure that correct equations are utilized to generate results. The programs will list all entry items (for proofing purposes) and produce calculated results in hard copy form. Reference method equations will be used to calculate the concentration and/or mass rate of each measured parameter.

D.6.2 Analytical Data Validation Evaluation

All data will be compared to the acceptance criteria of the reference method. For example, particulate tests must be 100% isokinetic, ±10%, to be acceptable. Laboratory data will be acceptable only if calibration standards fall within the established control limits.

TABLE D-3. ACTIVITY MATRIX FOR CALIBRATION OF EQUIPMENT[a]

APPARATUS	ACCEPTANCE LIMITS	FREQUENCY AND METHOD OF MEASUREMENT	ACTION IF REQUIREMENTS ARE NOT MET
Wet test meter	Capacity 3.4 m^3/hr (120 ft/hr); accuracy within ±1.0%	Calibrate initially, and then yearly by liquid displacement.	Adjust until specifications are met, or return to manufacturer.
Dry gas meter	$Y_1 = Y \pm 0.02\ Y$	Calibrate vs. wet test meter initially, and when posttest check exceeds Y ±0.05 Y	Repair, or replace and then recalibrate.
Thermometers	Impinger thermometer ±1°C (2°F); dry gas meter thermometer ±3°C (5.4°F) over range; stack temperature sensor ±1.5% of absolute temperature	Calibrate each initially as a separate component against a mercury-in-glass thermometer. Then before each field trip compare each as part of the train with the mercury-in-glass thermometer.	Adjust to determine a constant correction factor, or reject.
Probe heating system	Capable of maintaining 120° ± 14°C (248° ± 25°F) at a flow rate of 20 l/min (0.71 ft^3/ min)	Calibrate component initially by APTD-0576(11) if constructed by APTD-0581(10), or use published calibration curves.	Repair or replace and then reverify the calibration.
Barometer	±2.5 mm (0.1 in.) Hg of mercury-in-glass barometer	Calibrate initially vs. mercury-in-glass barometer; check before and after each field test.	Adjust to agree with a certified barometer.
Probe nozzle	Average of three ID measurements of nozzle; difference between high and low 0.1 mm (0.004 in.)	Use a micrometer to measure to nearest 0.025 mm (0.001 in.); check before field test.	Recalibrate, reshape, and sharpen when nozzle becomes nicked, dented, or corroded.
Type S pitot tube and/or probe assembly	All dimension specifications met, or calibrate according to Subsection 3.1.2, and mount in an interference-free manner	When purchased, use method in Subsections 3.1.1 and 3.1.2; visually inspect after each field test.	Do not use pitot tubes that do not meet face opening specifications; repair or replace as required.
Stack gas temperature measurement system	Capable of measuring within 1.5% of minimum absolute stack temperature	When purchased and after each field test, calibrate against ASTM thermometer.	Adjust to agree with Hg bulb thermometer, or construct a calibration curve to correct the readings.
Analytical balance	±1 mg of Class-S weights	Check with Class-S weights upon receipt.	Adjust or repair.

(continued)

TABLE D-3 (continued)

APPARATUS	ACCEPTANCE LIMITS	FREQUENCY AND METHOD OF MEASUREMENT	ACTION IF REQUIREMENTS ARE NOT MET
Differential pressure gauge (does not include inclined manometers)	Agree within ±5% of incline manometers	Initially and after each field use.	Adjust to agree with inclined manometer or construct calibration curve to correct the readings.
Orsat analyzer	Average of three replicates should be 20.9 ± 0.5% (absolute) or known concentration ±0.5 (absolute)	Upon receipt and before any test in which the analyzer has not been checked during the previous 3 mo; determine % O_2 in ambient air, or use a calibration gas with known CO, CO_2, and O_2 concentrations	Check Orsat analyzer for leaking valves, spent absorbing reagent, and/or operator techniques. Repair or replace parts or absorbing solutions, and/or modify operator techniques.
Rotameter or rate meter	Smooth curve of rotameter actual flow rates with no evidence of error. ±5% of known flow rate.	Check with wet test meter or volume meter at 6-month intervals or at indication of erratic behavior.	Repeat calibration steps until limits are attained.

[a] EPA-600/9-76-005, *Quality Assurance Handbook for Air Pollution Measurement Systems - Volume III,* U. S. EPA, Office of Research and Development, Environmental Monitoring and Support Laboratory, Research Triangle Park, NC, January 1976, as revised.

Outliers will be treated on a case-by-case basis. All questionable data will be reviewed in an attempt to find a reason for rejection. All questionable data will be outlined in the scientific and technical report.

Unacceptable data will be appropriately qualified in the scientific and technical report. Case narratives will be prepared, which will include information concerning data that fell outside acceptance limits, and any other anomalous conditions encountered during sample analysis. After the Laboratory QA Officer approves these data, they will be considered ready for data validation.

D.6.2.1 Procedures Used To Evaluate Field Data

Procedures used to evaluate field data include posttest field instrument calibration checks, acceptable isokinetic sampling rates, and demonstration of acceptable posttest leak checks.

D.6.3 Data Reporting

Data reporting procedures will be performed for field operations as indicated in the following subsections.

D.6.3.1 Field Data Reporting

Field data reporting will be conducted principally through the generation of test data tables containing tabulated results of all measurements made in the field, and documentation of all field calibration activities.

D.7 PREVENTIVE MAINTENANCE REVIEW

Well-maintained equipment is an essential ingredient in ensuring the quality, completeness, and timeliness of the field and analytical data. This subsection reviews the schedules of preventive maintenance that must be performed to minimize the downtime for critical measurement systems for each contracting company. Also, lists of critical spare parts that must be available at the individual field and laboratory sites must be developed and reviewed. This subsection represents a review of the preventive maintenance items that are required for the field operations.

D.7.1 Field Instrument Preventative Maintenance

Field source testing equipment and instrumentation that require maintenance and/or calibration will be serviced immediately prior to conducting the test program.

Normal spare parts (e.g., control consoles, sample boxes, probes, glassware, sample bottles, etc.) as well as extra materials/supplies (e.g., filters, solutions, solvents, XAD traps, etc.) are scheduled to be available at the field site during testing.

Extra spare parts and equipment for process sample collection and compositing equipment, glassware, sample containers, etc. are scheduled to be available at the field site during testing. Extra materials/supplies (e.g., filters, solvents, etc.) required for the process sample collection will also be available at the field site during testing.

Sufficient volumes of protocol and calibration gases for the CEM monitoring, extra fittings, sample lines, pumps, heating tapes, and analyzer cells, along with sufficient materials/supplies (e.g., pump oil, filters, etc.) will be available at the field site during testing.

D.8 CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or procedures out of QC performance that can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation, and data assessment. All corrective actions proposed and implemented should be documented in the regular QA reports to management. Corrective action should be implemented only after approval by the EQ Project Manager or his designee. If immediate corrective action is required, approvals secured from the EQ Project Manager should be documented in an additional memorandum.

Depending on the nature of the problem, the corrective action may be formal or informal. In either case, occurrence of the problem, the corrective action performed, and verification that the problem has been resolved will be documented. Whenever a corrective action is required, documentation will be completed by the individual noting the problem and a copy will be filed with the EQ Project Manager.

The shared effort for implementing the corrective action will be the responsibility of the EQ Project Manager, the EQ QA Managers, and the Field Team Leaders.

Corrective actions will be initiated when data quality problems are determined during the program. These data quality problems will be flagged "out of control" if they are outside the predetermined limits specified above for internal, performance, system, and data audits. When discovered, prompt action toward a solution will be undertaken by the generator of the data. The corrective action will be conducted through the following six activities:

- Define the quality problem.
- Notify the designated individuals listed in the work plan.
- Determine the cause of the problem.
- Determine the corrective action.
- Implement the corrective action.
- Verify the solution to the problem.

Corrective action will be instituted immediately by the individual noting a problem in a measurement system. An unresolved problem will be reported to the EQ Project Manager and the EQ QA Managers for further action.

APPENDIX E

QA/QC – CALIBRATION DATA

CALIBRATION PROCEDURES AND RESULTS

All of the equipment used is calibrated in accordance with the procedures outlined in the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III (*EPA 600/4-77-027b). The following pages describe these procedures and include the data sheets.

CALIBRATION PROCEDURES AND FREQUENCY

This subsection describes the calibration procedures and the frequency at which these procedures will be performed for both field and laboratory instruments.

B.6.1 Field Instrument Calibration

The following equipment items will be calibrated before and after field usage:

- Velocity measurement devices.
- Gas flow rate metering systems.
- Gas volume metering equipment.
- Gas composition measuring apparatus (Orsat).

The calibration records will include device numbers, calibration dates, methods, and data and results, and will be maintained on file at the EQ laboratory. Copies of applicable calibration records also will be available at the job site for review.

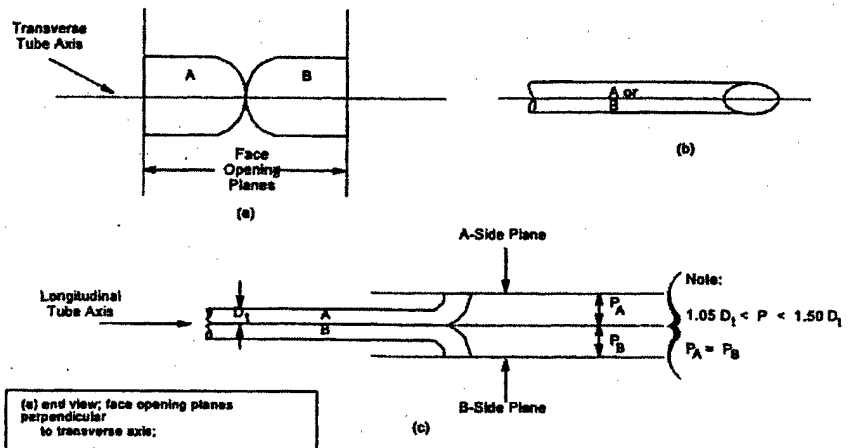
Acceptance limits are shown for each equipment item in Table B-4.

DRY GAS METER AND ORIFICE METER

Dry gas meters and orifices are calibrated in accordance with Section 3.3.2 of the QA Handbook. This procedure involves direct comparison of the dry gas meter to a reference dry test meter. The reference dry test meter is routinely calibrated using a liquid displacement technique. Before its initial use in the field, the metering system is calibrated over the entire range of operation. After each field use, the metering system is calibrated at a single intermediate setting based on the previous field test. Acceptable tolerances for the initial and final gas meter factors and orifice calibration factors are ∀0.02 and ∀0.20 from average, respectively.

Pitot Tube Calibration

Each pitot tube used in sampling meets all requirements of EPA Method 2, Section 4.1.[**] Therefore, a baseline coefficient of 0.84 is assigned to each pitot tube. The following pages show the alignment requirements of Method 2 and the Pitot Tube Inspection Data Sheet(s) for each pitot tube used during the test program.



(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

[**] 40 CFR 60, Appendix A, July 1995

ENVIRONMENTAL QUALITY MANAGEMENT

PITOT TUBE CALIBRATIONS

Pitot ID	Date Calibrated	α_1	B_1	α_2	B_2	Y	θ	A	z	w	P_α	P_β	D_t	A/2/D_t	Accept/Reject
P2-1P	12/18/01	1.8	1.6	3.7	2.8	2	0.3	0.951	0.033	0.005	0.476	0.478	0.375	1.268	ACCEPT
P2-2P	12/18/01	1.3	0.4	3.0	0	0.4	0.2	0.945	0.007	0.003	0.473	0.473	0.375	1.260	ACCEPT
P2-3	12/21/01	3.1	1.2	3.9	0.9	2.1	1.8	0.947	0.035	0.030	0.474	0.477	0.375	1.263	ACCEPT
P3-1	12/21/01	1.3	2.6	1.8	2.8	1.6	1.3	0.941	0.026	0.021	0.475	0.475	0.375	1.255	ACCEPT
P3-2	12/21/01	3.7	1.8	2.8	2.6	3.4	1.9	0.940	0.056	0.031	0.477	0.478	0.375	1.253	ACCEPT
P3-3P	12/18/01	1.7	1.2	0.2	1.7	0.8	1.2	0.941	0.013	0.020	0.538	0.539	0.375	1.256	ACCEPT
P3-4P	12/18/01	1.7	0.3	4.5	0.4	1.3	0.4	0.943	0.021	0.007	0.474	0.474	0.375	1.257	ACCEPT
P4-1	12/21/01	0.6	1.4	1.6	1.5	2.3	1.3	0.955	0.038	0.022	0.477	0.477	0.375	1.273	ACCEPT
P4-2	12/18/01	0.2	1.8	1.5	1.4	0.3	1.2	0.943	0.005	0.020	0.473	0.472	0.375	1.257	ACCEPT
P4-3P	12/21/01	1.1	1.2	0.8	0.4	1.8	0.5	0.895	0.028	0.008	0.472	0.473	0.375	1.193	ACCEPT
P4-4P	12/21/01	0.7	2.2	1.2	1.3	1.6	0.7	0.940	0.026	0.011	0.472	0.472	0.375	1.253	ACCEPT
P4-5P	12/21/01	3.6	2.1	3.6	1.2	0.8	0.5	0.930	0.013	0.008	0.472	0.472	0.375	1.240	ACCEPT
T5-1	12/21/01	0.4	0.3	1.5	1.2	0.6	1.2	0.930	0.010	0.019	0.465	0.472	0.375	1.240	ACCEPT
T5-2P	12/21/01	0.3	2.0	0.4	1.0	0.8	1.2	0.975	0.014	0.020	0.488	0.472	0.375	1.300	ACCEPT
T5-3	12/21/01	5.5	1.6	6.4	1.5	1.5	1.5	0.935	0.024	0.024	0.468	0.472	0.375	1.247	ACCEPT
P6-1P	12/21/01	4.2	0.8	3.2	0.5	0.2	0.9	0.955	0.003	0.015	0.478	0.472	0.375	1.273	ACCEPT
P6-2	12/26/01	0.3	0.9	0.7	1.4	1.1	1.4	0.941	0.018	0.023	0.475	0.475	0.375	1.256	ACCEPT
P6-3P	12/26/01	3.0	1.2	2.9	0.7	1.1	0.4	0.910	0.017	0.006	0.461	0.461	0.375	1.213	ACCEPT
P6-4P	12/26/01	0.9	1.9	1.6	1.6	1.2	0.3	0.943	0.020	0.005	0.474	0.475	0.375	1.257	ACCEPT
T7-1P	12/26/01	0.1	0.5	2.3	0.8	0.4	0.2	0.928	0.006	0.003	0.474	0.475	0.375	1.237	ACCEPT
P8-1	12/26/01	2.7	0.6	1.4	0.1	0.6	0.4	0.945	0.010	0.007	0.465	0.468	0.375	1.260	ACCEPT
P8-2	12/26/01	0.8	1.5	2.6	0.8	0.9	0.3	0.939	0.015	0.005	0.486	0.486	0.375	1.252	ACCEPT
P8-3P	12/27/01	0.8	0.9	0.6	1.2	1.1	0.8	0.941	0.018	0.013	0.477	0.478	0.375	1.255	ACCEPT
P8-4P	12/27/01	0.3	0.6	0.7	0.1	0.7	0.5	0.941	0.011	0.008	0.473	0.473	0.375	1.255	ACCEPT
P8-5	12/26/01	0.7	0.7	0.4	0.3	1.0	1.0	0.950	0.017	0.017	0.472	0.472	0.375	1.267	ACCEPT
P9-1	12/26/01	1.2	0.5	1.2	0.3	0.4	0.6	0.939	0.007	0.010	0.472	0.472	0.375	1.252	ACCEPT
P10-1P	12/26/01	2.7	0.3	3.0	0.6	1.4	1.2	0.929	0.023	0.019	0.472	0.472	0.375	1.239	ACCEPT
T11-1P	12/26/01	1.0	0.3	0.1	0.3	1.1	0.5	0.965	0.019	0.008	0.472	0.472	0.375	1.287	ACCEPT

- 1 = Pitot Alone

- 1P = Full Probe Assembly

DIGITAL INDICATORS FOR THERMOCOUPLE READOUT

A digital indicator is calibrated by feeding a series of millivolt signals to the input and comparing the indicator reading with the reading the signal should have generated. Errors did not exceed 0.5 percent when the temperatures were expressed in degrees Rankine. Calibration data are included in the following Thermocouple Digital Indicator Calibration Data Sheet(s).

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-1	Bar. Press.(Pb):	29.60	in. Hg	
Date:	December 26, 2001	Calibrated By :	AH		

		RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
DH	Delta H	0.50	0.75	1.00	1.50	2.00	4.00
in Hg	Vacuum	10	10	10	10	10	10
Vw_1	Initial RTM	604.553	615.440	628.959	640.862	654.016	665.387
Vw_2	Final RTM	615.285	628.753	640.691	653.386	665.040	675.449
Vd_1	Initial DGM	726.766	737.820	751.557	763.679	777.103	788.723
Vd_2	Final DGM	737.552	751.344	763.494	776.465	788.354	798.958
Tw	Ave. Temp RTM °F	67	67	68	68	69	72
Td	Ave. Temp DGM °F	71	75	77	78	80	83
t	Time (min.)	25.0	26.0	20.0	18.0	14.0	9.0
$Vw_2 - Vw_1$	Net Volume RTM	10.732	13.313	11.732	12.524	11.024	10.062
$Vd_2 - Vd_1$	Net Volume DGM	10.786	13.524	11.937	12.786	11.251	10.235
	Y	1.001	0.997	0.997	0.994	0.995	0.994
	dH@	1.520	1.590	1.616	1.720	1.790	1.786

AVERAGE Y =	**1.000**	(Reference meter correction factor of 1.004)			
Average Y Range =		0.980	TO	1.020	**ACCEPT**
AVERAGE dH@ =	**1.670**				
Average dH@ Range =		1.470	TO	1.870	**ACCEPT**

Calculations

$Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw + 460))$

$dH@ = 0.0317 * dHd / (Pb (Td + 460)) * ((Tw + 460) * t) / Vw)^2$

Initial Dry Gas Meter Calibration Form (English Units) **2002 Yearly Calibration**

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-1	Bar. Press.(Pb):	29.05	in. Hg
Date:	April 30, 2002	Pretest Gamma:	1.000	
Calibrated By	JK	Pretest dH@:	1.670	
Plant:	Moody AFB GA			

		RUN 1	RUN 2	RUN 3
DH	Delta H	2.00	2.00	2.00
in Hg	Vacuum	1.00	1.00	1.00
Vw_1	Initial RTM	38.009	51.510	64.220
Vw_2	Final RTM	51.510	64.220	76.562
Vd_1	Initial DGM	286.005	299.485	312.335
Vd_2	Final DGM	299.485	312.335	324.901
Tw	Ave. Temp RTM °F	71.0	72.0	73.0
Td	Ave. Temp DGM °F	78.0	81.0	83.0
t	Time (min.)	16.0	16.0	16.0
$Vw_2 - Vw_1$	Net Volume RTM	13.501	12.710	12.342
$Vd_2 - Vd_1$	Net Volume DGM	13.480	12.850	12.566
	Y	1.010	1.001	0.996
	dH@	1.606	1.809	1.919

AVERAGE Y = **0.993**

% Difference from Yearly Y = **-0.677** **ACCEPT**

AVERAGE dH@ = **1.778**

Calculations

Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw +460))

dH@ = 0.0317 * dHd / (Pb (Td + 460)) * (((Tw +460) * time) / Vw)^2

Posttest Dry Gas Meter Calibration Form (English Units)

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE: 26-Dec-01 INDICATOR NO.: MB-1

OPERATOR: AH SERIAL NO.:

CALIBRATION DEVIC Thermocouple Simulator MANUFACTURER: Omega

TEST POINT NO.	MILLIVOLT SIGINAL	EQUIVALENT TEMP, °F	DIGITAL INDICATOR TEMP READING, °F	DIFFERENCE, %
1	-0.692	0	-1	0.2
2	1.520	100	98	0.4
3	3.819	200	200	0.0
4	6.092	300	299	0.1
5	8.314	400	398	0.2
6	10.560	500	499	0.1
7	22.251	1000	1000	0.0
8	29.315	1300	1299	0.1
9	36.166	1600	1600	0.0
10	42.732	1900	1900	0.0

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{\text{(Equivalent Temp,.°R - Digital Indicator Temp., °R) * (1C}}{\text{(Equivalent Temp., °R)}}$

Where °R = °F + 460

ACCEPT

DIGITAL INDICATOR 2002 Yearly Calibratiion

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-7	Bar. Press.(Pb):	29.33	in. Hg	
Date: 3/13/02		Calibrated By :	JK		

		RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
DH	Delta H	0.50	0.75	1.00	1.50	2.00	4.00
in Hg	Vacuum	10	10	10	10	10	10
Vw_1	Initial RTM	396.544	408.914	420.547	431.672	442.252	453.255
Vw_2	Final RTM	406.545	418.455	430.645	441.720	452.315	463.235
Vd_1	Initial DGM	51.398	63.784	75.535	86.782	97.489	108.599
Vd_2	Final DGM	61.398	73.885	85.675	96.815	107.525	118.627
Tw	Ave. Temp RTM °F	74	74	74	75	75	76
Td	Ave. Temp DGM °F	76	78	80	82	84	84
t	Time (min.)	24.0	20.0	17.5	14.5	12.5	9.0
$Vw_2 - Vw_1$	Net Volume RTM	10.001	9.541	10.098	10.048	10.063	9.980
$Vd_2 - Vd_1$	Net Volume DGM	10.000	10.101	10.140	10.033	10.036	10.028
	Y	1.003	0.950	1.005	1.011	1.014	1.000
	dH@	1.656	1.888	1.710	1.783	1.755	1.857

AVERAGE Y =	**1.001**	(Reference meter correction factor of 1.004)			
Average Y Range =		0.981	TO	1.021	**ACCEPT**
AVERAGE dH@ =	**1.775**				
Average dH@ Range =		1.575	TO	1.975	**ACCEPT**

Calculations

$Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw + 460))$

$dH@ = 0.0317 * dHd / (Pb (Td + 460)) * (((Tw + 460) * t) / Vw)^2$

Initial Dry Gas Meter Calibration Form (English Units) **2001 Yearly Calibration**

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE: 13-Mar-02 INDICATOR NO.: MB-7

OPERATOR: JK SERIAL NO.: 10285505

CALIBRATION DEVIC Thermocouple Simulator MANUFACTURER: Omega

TEST POINT NO.	MILLIVOLT SIGINAL	EQUIVALENT TEMP, °F	DIGITAL INDICATOR TEMP READING, °F	DIFFERENCE, %
1	-0.692	0	0	0.0
2	1.520	200	200	0.0
3	3.819	400	396	0.5
4	6.092	600	600	0.0
5	8.314	800	801	0.1
6	10.560	1000	1000	0.0
7	22.251	1200	1199	0.1
8	29.315	1400	1397	0.2
9	36.166	1600	1601	0.0
10	42.732	1800	1800	0.0

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{\text{(Equivalent Temp.,°R - Digital Indicator Temp., °R) * (1C}}{\text{(Equivalent Temp., °R)}}$

Where °R = °F + 460

ACCEPT

DIGITAL INDICATOR 2001 Yearly Calibratiion

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB7	Bar. Press.(Pb):	29.05	in. Hg
Date:	April 30, 2002	Pretest Gamma:	1.001	
Calibrated By	JK	Pretest dH@:	1.775	
Plant:	Moody AFB GA			

		RUN 1	RUN 2	RUN 3
DH	Delta H	3.00	3.00	3.00
in Hg	Vacuum	13.00	13.00	13.00
Vw_1	Initial RTM	144.665	159.910	174.225
Vw_2	Final RTM	159.910	174.225	190.064
Vd_1	Initial DGM	177.622	192.520	206.950
Vd_2	Final DGM	192.520	206.950	222.715
Tw	Ave. Temp RTM °F	71.0	72.0	73.0
Td	Ave. Temp DGM °F	77.0	79.0	81.0
t	Time (min.)	15.0	15.0	16.0
$Vw_2 - Vw_1$	Net Volume RTM	15.245	14.315	15.839
$Vd_2 - Vd_1$	Net Volume DGM	14.898	14.430	15.765
	Y	1.027	0.998	1.012
	dH@	1.664	1.887	1.754

AVERAGE Y = **1.003**

% Difference from Yearly Y = **0.236** **ACCEPT**

AVERAGE dH@ = **1.769**

Calculations

Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw +460))

dH@ = 0.0317 * dHd / (Pb (Td + 460)) * (((Tw +460) * time) / Vw)^2

Posttest Dry Gas Meter Calibration Form (English Units)

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-8	Bar. Press.(Pb):	29.33	in. Hg
Date: 3/14/02		Calibrated By :	JK	

		RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
DH	Delta H	0.50	0.75	1.00	1.50	2.00	4.00
in Hg	Vacuum	10	10	10	10	10	10
Vw_1	Initial RTM	473.842	484.796	496.125	507.315	518.706	530.618
Vw_2	Final RTM	483.975	495.235	506.445	517.490	529.335	540.815
Vd_1	Initial DGM	45.775	56.689	68.015	79.181	90.554	102.419
Vd_2	Final DGM	55.810	67.075	78.175	89.235	101.080	112.445
Tw	Ave. Temp RTM °F	76	77	77	77	76	76
Td	Ave. Temp DGM °F	79	81	82	82	82	83
t	Time (min.)	23.8	20.5	17.5	14.5	13.0	9.0
$Vw_2 - Vw_1$	Net Volume RTM	10.133	10.439	10.320	10.175	10.629	10.197
$Vd_2 - Vd_1$	Net Volume DGM	10.035	10.386	10.160	10.054	10.526	10.026
	Y	1.014	1.011	1.023	1.018	1.016	1.020
	dH@	1.582	1.666	1.650	1.752	1.714	1.782

AVERAGE Y =	**1.021**	(Reference meter correction factor of 1.004)			
Average Y Range =		1.001	TO	1.041	**ACCEPT**
AVERAGE dH@ =	**1.691**				
Average dH@ Range =		1.491	TO	1.891	**ACCEPT**

Calculations

$Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw + 460))$

$dH@ = 0.0317 * dHd / (Pb (Td + 460)) * (((Tw + 460) * t) / Vw)^2$

Initial Dry Gas Meter Calibration Form (English Units) **2001 Yearly Calibration**

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE: 13-Mar-02 INDICATOR NO.: MB-8

OPERATOR: JK SERIAL NO.: 10285505

CALIBRATION DEVIC Thermocouple Simulator MANUFACTURER: Omega

TEST POINT NO.	MILLIVOLT SIGINAL	EQUIVALENT TEMP, °F	DIGITAL INDICATOR TEMP READING, °F	DIFFERENCE, %
1		0	0	0.0
2		200	200	0.0
3		400	397	0.3
4		600	600	0.0
5		800	801	0.1
6		1000	1001	0.1
7		1200	1199	0.1
8		1400	1398	0.1
9		1600	1602	0.1
10		1800	1800	0.0

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{\text{(Equivalent Temp,.°R - Digital Indicator Temp., °R) * (1C}}{\text{(Equivalent Temp., °R)}}$

Where °R = °F + 460

ACCEPT

DIGITAL INDICATOR 2001 Yearly Calibratiion

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB 8	Bar. Press.(Pb):	29.05	in. Hg
Date:	April 30, 2002	Pretest Gamma:	1.021	
Calibrated By	JK	Pretest dH@:	1.691	
Plant:	Moody AFB GA			

		RUN 1	RUN 2	RUN 3
DH	Delta H	3.00	3.00	3.00
in Hg	Vacuum	5.00	5.00	5.00
Vw_1	Initial RTM	76.662	96.385	115.125
Vw_2	Final RTM	96.385	115.125	128.935
Vd_1	Initial DGM	523.826	543.115	561.825
Vd_2	Final DGM	543.115	561.825	575.785
Tw	Ave. Temp RTM °F	71.0	71.0	72.0
Td	Ave. Temp DGM °F	78.0	82.0	85.0
t	Time (min.)	19.0	19.0	14.0
$Vw_2 - Vw_1$	Net Volume RTM	19.723	18.740	13.810
$Vd_2 - Vd_1$	Net Volume DGM	19.289	18.710	13.960
	Y	1.028	1.015	1.006
	dH@	1.592	1.751	1.747

AVERAGE Y = **1.007**

% Difference from Yearly Y = **-1.340** **ACCEPT**

AVERAGE dH@ = **1.697**

Calculations

Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw +460))

dH@ = 0.0317 * dHd / (Pb (Td + 460)) * (((Tw +460) * time) / Vw)^2

Posttest Dry Gas Meter Calibration Form (English Units)

ENVIRONMENTAL QUALITY MANAGEMENT

Date:	1/7/02	Flow Rate:	0.25 l/min
Vost Box Number:	VB-1	Rotameter Setting:	0.3
		Bubble Meter Temp. :	72

Run 1			
Bubble Meter		Meter Box	
1	256.2	Initial Volume	4579.00
2	256.3	Final Volume	4596.35
3	256.4	Initial Temp.	88
4	256.4	Final Temp.	90
5	256.8	Average Temp.	89
6	256.2	Time:	64
7	256.5	QDGM=	262.699
Average:	256.38	Y=	0.9760

Run 2			
Bubble Meter		Meter Box	
1	256.1	Initial Volume	4560.00
2	256.5	Final Volume	4577.48
3	256.3	Initial Temp.	85
4	256.5	Final Temp.	88
5	256.3	Average Temp.	86.5
6	256.6	Time:	64
7	256.3	QDGM=	265.878
Average:	256.37	Y=	0.9642

Run 3			
Bubble Meter		Meter Box	
1	256.4	Initial Volume	4597.00
2	256	Final Volume	4614.39
3	255.8	Initial Temp.	90
4	256.0	Final Temp.	88
5	256.4	Average Temp.	89
6	256.6	Time:	64
7	256.5	QDGM=	263.305
Average:	256.24	Y=	0.9732

$QDGM = (((Vm_2 - Vm_1) * TBm°R) / (Tm°R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y=	0.9711

VOST Box Calibration Sheet 2002 Yearly Calibration

ENVIRONMENTAL QUALITY MANAGEMENT

Date:	1/2/02	Flow Rate:	**0.5 l/min**
Vost Box Number:	VB-1	Rotameter Setting:	0.55
		Bubble Meter Temp. :	69

Run 1			
Bubble Meter		Meter Box	
1	488.9	Initial Volume	4281.00
2	488.8	Final Volume	4288.00
3	488.6	Initial Temp.	88
4	488	Final Temp.	89
5	488.1	Average Temp.	88.5
6	488.1	Time:	13.33
7	487.9	QDGM=	506.462
Average:	**488.34**	Y=	**0.9642**

Run 2			
Bubble Meter		Meter Box	
1	485.6	Initial Volume	4289.00
2	486.0	Final Volume	4295.00
3	485.8	Initial Temp.	89
4	486.3	Final Temp.	88
5	486	Average Temp.	88.5
6	486.1	Time:	11.54
7	486	QDGM=	501.446
Average:	**485.97**	Y=	**0.9691**

Run 3			
Bubble Meter		Meter Box	
1	484.9	Initial Volume	4296.00
2	484.9	Final Volume	4302.00
3	484.7	Initial Temp.	88
4	484.7	Final Temp.	88
5	486	Average Temp.	88
6	485.4	Time:	11.52
7	485.3	QDGM=	502.775
Average:	**485.13**	Y=	**0.9649**

$QDGM = (((Vm_2 - Vm_1) * TBm°R) / (Tm°R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y=	**0.9661**

VOST Box Calibration Sheet 2002 Yearly Calibration

ENVIRONMENTAL QUALITY MANAGEMENT

Date:	1/2/02	Flow Rate:	**1.0 l/min**
Vost Box Number:	VB-1	Rotameter Setting:	1
		Bubble Meter Temp. :	68

Run 1			
Bubble Meter		Meter Box	
1	951.5	Initial Volume	4314.00
2	950.6	Final Volume	4326.00
3	948.9	Initial Temp.	88
4	949.4	Final Temp.	89
5	948.6	Average Temp.	88.5
6	948.9	Time:	11.51
7	949.1	QDGM=	1003.606
Average:	**949.57**	Y=	**0.9462**

Run 2			
Bubble Meter		Meter Box	
1	947.4	Initial Volume	4327.00
2	946.2	Final Volume	4337.00
3	947.7	Initial Temp.	89
4	946.5	Final Temp.	88
5	946.2	Average Temp.	88.5
6	947.1	Time:	9.54
7	945.9	QDGM=	880.897
Average:	**946.71**	Y=	**1.0747**

Run 3			
Bubble Meter		Meter Box	
1	949.7	Initial Volume	4338.00
2	948.6	Final Volume	4348.00
3	946.5	Initial Temp.	89
4	943.6	Final Temp.	89
5	944.2	Average Temp.	89
6	944.8	Time:	10
7	944.2	QDGM=	839.845
Average:	**945.94**	Y=	**1.1263**

$QDGM = (((Vm_2 - Vm_1) * TBm°R) / (Tm°R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y=	**1.0491**

VOST Box Calibration Sheet 2002 Yearly Calibration

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE: 2-Jan-02 INDICATOR NO.: VB-1

OPERATOR: AH SERIAL NO.:

CALIBRATION DEVICE Thermocouple Simulator MANUFACTURER: Omega

TEST POINT NO.	MILLIVOLT SIGINAL	EQUIVALENT TEMP, °F	DIGITAL INDICATOR TEMP READING, °F	DIFFERENCE, %
1	-0.692	0	0	0.0
2	1.520	100	100	0.0
3	3.819	200	202	0.3
4	6.092	300	301	0.1
5	8.314	400	400	0.0
6	10.560	500	501	0.1
7	22.251	1000	1002	0.1
8	29.315	1300	1302	0.1
9	36.166	1600	1603	0.1
10	42.732	1900	1903	0.1

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{\text{(Equivalent Temp.,°R - Digital Indicator Temp., °R) * (100%)}}{\text{(Equivalent Temp., °R)}}$

Where °R = °F + 460

ACCEPT

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE: 2-Jan-02 INDICATOR NO.: VB-1

OPERATOR: AH SERIAL NO.:

CALIBRATION DEVICE Thermocouple Simulator MANUFACTURER: Omega

TEST POINT NO.	MILLIVOLT SIGINAL	EQUIVALENT TEMP. °F	DIGITAL INDICATOR TEMP READING, °F	DIFFERENCE, %
1	-0.692	0	0	0.0
2	1.520	100	100	0.0
3	3.819	200	202	0.3
4	6.092	300	301	0.1
5	8.314	400	400	0.0
6	10.560	500	501	0.1
7	22.251	1000	1002	0.1
8	29.315	1300	1302	0.1
9	36.166	1600	1603	0.1
10	42.732	1900	1903	0.1

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{\text{(Equivalent Temp.,°R - Digital Indicator Temp., °R) * (100%)}}{\text{(Equivalent Temp., °R)}}$

Where °R = °F + 460

ACCEPT

ENVIRONMENTAL QUALITY MANAGEMENT

Date:	3/20/01	Flow Rate:	**0.5 l/min**
Vost Box Number:	VB-2	Rotameter Setting:	0.6
		Bubble Meter Temp. :	72

Run 1			
Bubble Meter		Meter Box	
1	530.5	Initial Volume	4069.00
2	530.7	Final Volume	4074.00
3	511.4	Initial Temp.	84
4	512.2	Final Temp.	85
5	530.3	Average Temp.	84.5
6	527.3	Time:	10.07
7	530.3	QDGM=	485.126
Average:	**524.67**	Y=	**1.0815**

Run 2			
Bubble Meter		Meter Box	
1	520.1	Initial Volume	4075.00
2	526.7	Final Volume	4080.00
3	527.6	Initial Temp.	85
4	528.7	Final Temp.	86
5	537.7	Average Temp.	85.5
6	527.5	Time:	10.15
7	530.2	QDGM=	480.420
Average:	**528.36**	Y=	**1.0998**

Run 3			
Bubble Meter		Meter Box	
1	523.1	Initial Volume	4081.00
2	534	Final Volume	4086.00
3	507	Initial Temp.	86
4	533.8	Final Temp.	86
5	530.7	Average Temp.	86
6	504.1	Time:	10.1
7	502.7	QDGM=	482.356
Average:	**519.34**	Y=	**1.0767**

$QDGM = (((Vm_2 - Vm_1) * TBm°R) / (Tm°R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y=	**1.0860**

VOST Box Calibration Sheet 2002 Yearly Calibration

ENVIRONMENTAL QUALTIY MANAGEMENT

Date: 3/20/01
Vost Box Number: VB-2

Flow Rate: 1.0 l/min
Rotameter Setting: 1.1
Bubble Meter Temp. : 73

Run 1			
Bubble Meter		Meter Box	
1	998	Initial Volume	4087.00
2	1012.0	Final Volume	4097.00
3	1023	Initial Temp.	86
4	1013	Final Temp.	87
5	999	Average Temp.	86.5
6	1001	Time:	10.17
7	1011	QDGM=	958.994
Average:	**1008.14**	Y=	**1.0512**

Run 2			
Bubble Meter		Meter Box	
1	1030.0	Initial Volume	4100.00
2	996.0	Final Volume	4110.00
3	1009	Initial Temp.	87
4	1021	Final Temp.	87
5	1011	Average Temp.	87
6	1007	Time:	10.28
7	1008	QDGM=	947.866
Average:	**1011.71**	Y=	**1.0674**

Run 3			
Bubble Meter		Meter Box	
1	998.6	Initial Volume	4111.00
2	1017	Final Volume	4121.00
3	1015	Initial Temp.	87
4	1010.0	Final Temp.	88
5	1008	Average Temp.	87.5
6	1009	Time:	10.27
7	1012.0	QDGM=	947.922
Average:	**1009.94**	Y=	**1.0654**

$QDGM = (((Vm_2 - Vm_1) * TBm°R) / (Tm°R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y=	1.0613

VOST Box Calibration Sheet 2002 Yearly Calibration

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE: 2-Jan-02 INDICATOR NO.: VB-2

OPERATOR: AH SERIAL NO.:

CALIBRATION DEVICE: Thermocouple Simulator MANUFACTURER: Omega

TEST POINT NO.	MILLIVOLT SIGINAL	EQUIVALENT TEMP, °F	DIGITAL INDICATOR TEMP READING, °F	DIFFERENCE, %
1	-0.692	0	0	0.0
2	1.520	100	100	0.0
3	3.819	200	202	0.3
4	6.092	300	300	0.0
5	8.314	400	399	0.1
6	10.560	500	500	0.0
7	22.251	1000	1001	0.1
8	29.315	1300	1301	0.1
9	36.166	1600	1602	0.1
10	42.732	1900	1901	0.0

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{(\text{Equivalent Temp.,°R} - \text{Digital Indicator Temp., °R}) * (100\%)}{(\text{Equivalent Temp., °R})}$

Where °R = °F + 460

ACCEPT

DIGITAL INDICATOR 2002 Yearly Calibration

DRY GAS THERMOCOUPLES AND IMPINGER THERMOCOUPLES

The dry gas thermocouples are calibrated by comparing them with an ASTM-3 thermometer at approximately 32°F, ambient temperature, and a higher temperature between approximately 100°F and 200°F. The thermocouples agreed within 5°F of the reference thermometer. The impinger thermocouples are checked in a similar manner at approximately 32°F and ambient temperature, and they agreed within 2°F. The thermocouples may be checked at ambient temperature prior to the test series to verify calibration. Calibration data are included in the following Dry Gas Thermometer and Impinger Thermocouple Calibration Data Sheet(s).

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR SAMPLE HEADS

DATE: 26-Dec-01

Reference point number	Source[a] (Specify)	Reference Thermometer Temperature,°F	Thermocouple Potentiometer Temperature,°F	Temperature Difference,[b] °F	
Sample Head No. 1					
1	Ambient Air	68	69	1	**ACCEPT**
2	Cold Bath	37	37	0	
Sample Head No. 2					
1	Ambient Air	68	68	0	**ACCEPT**
2	Cold Bath	37	38	1	
Sample Head No. 3					
1	Ambient Air	68	69	1	**ACCEPT**
2	Cold Bath	36	36	0	
Sample Head No. 4					
1	Ambient Air	68	68	0	**ACCEPT**
2	Cold Bath	37	38	1	
Sample Head No. 5					
1	Ambient Air	68	69	1	**ACCEPT**
2	Cold Bath	37	37	0	
Sample Head No. 6					
1	Ambient Air	68	69	1	**ACCEPT**
2	Cold Bath	37	37	0	
Sample Head No. 7					
1	Ambient Air	68	68	0	**ACCEPT**
2	Cold Bath	37	38	1	
Sample Head No. 8					
1	Ambient Air	68	68	0	**ACCEPT**
2	Cold Bath	37	37	0	

[a]Type of calibration used.

Calibrated By: AH

[b]Allowable tolerance $\pm 2^{\circ}F$

SAMPLE HEAD

2002 Yearly Calibration

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 26-Dec-01 **THERMOCOUPLE NUMBER:** MB-1

AMBIENT TEMPERATURE: 68 °F **BAROMETRIC PRES.(In.Hg):** 29.60

CALIBRATOR: AH

Reference point number	Source[a] (Specify)	Reference Thermometer Temperature,°F	Thermocouple Potentiometer Temperature,°F	Temperature Difference,[b] °F
Inlet				
1	Ambient Air	68	69	1
2	Cold Bath	36	36	0
3	Hot Bath	180	179	1
Outlet				
1	Ambient Air	68	69	1
2	Cold Bath	36	35	1
3	Hot Bath	180	178	2

ACCEPT

[a]Type of calibration used.

[b]Allowable tolerance ±5°F

Comments:

METER BOX
THERMOCOUPLES

2002 Yearly Calibration

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 13-Mar-02 **THERMOCOUPLE NUMBER:** MB-7

AMBIENT TEMPERATURE: 74 °F **BAROMETRIC PRES.(In.Hg):** 29.33

CALIBRATOR: JK

Reference point number	Source[a] (Specify)	Reference Thermometer Temperature,°F	Thermocouple Potentiometer Temperature,°F	Temperature Difference,[b] °F
Inlet				
1	Ambient Air	74	72	2
2	Cold Bath	40	39	1
3	Hot Bath	138	134	4
Outlet				
1	Ambient Air	74	72	2
2	Cold Bath	40	39	1
3	Hot Bath	138	134	4

ACCEPT

[a]Type of calibration used.

[b]Allowable tolerance ±5°F

Comments:

METER BOX
THERMOCOUPLES

2001 Yearly Calibration

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 13-Mar-02 **THERMOCOUPLE NUMBER:** MB-8

AMBIENT TEMPERATURE: 74 °F **BAROMETRIC PRES.(In.Hg):** 29.33

CALIBRATOR: JK

Reference point number	Source[a] (Specify)	Reference Thermometer Temperature,°F	Thermocouple Potentiometer Temperature,°F	Temperature Difference,[b] °F
Inlet				
1	Ambient Air	74	71	3
2	Cold Bath	41	41	0
3	Hot Bath	138	134	4
Outlet				
1	Ambient Air	74	71	3
2	Cold Bath	41	40	1
3	Hot Bath	138	136	2

[a]Type of calibration used.

ACCEPT

[b]Allowable tolerance ±5°F

Comments:

METER BOX
THERMOCOUPLES

2001 Yearly Calibration

ENVIRONMENTAL QUALTIY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 2-Jan-02 **THERMOCOUPLE NUMBER:** VB-1

AMBIENT TEMPERATURE: 67 °F **BAROMETRIC PRES.(In.Hg):** 29.60

CALIBRATOR: AH

Reference point number	Source[a] (Specify)	Reference Thermometer Temperature,°F	Thermocouple Potentiometer Temperature,°F	Temperature Difference,[b] °F
Inlet				
1	Ambient Air	67	67	0
2	Cold Bath	36	36	0
3	Hot Bath	138	136	2
Outlet				
1	Ambient Air	67	67	0
2	Cold Bath	37	37	0
3	Hot Bath	148	148	0

[a]Type of calibration used.

[b]Allowable tolerance ±5°F

ACCEPT

Comments:

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 2-Jan-02 **THERMOCOUPLE NUMBER:** VB-2

AMBIENT TEMPERATURE: 67 °F **BAROMETRIC PRES.(In.Hg):** 29.60

CALIBRATOR: AH

Reference point number	Source[a] (Specify)	Reference Thermometer Temperature,°F	Thermocouple Potentiometer Temperature,°F	Temperature Difference,[b] °F
Inlet				
1	Ambient Air	67	66	1
2	Cold Bath	38	38	0
3	Hot Bath	130	130	0
Outlet				
1	Ambient Air	67	67	0
2	Cold Bath	38	38	0
3	Hot Bath	132	131	1

[a]Type of calibration used.

[b]Allowable tolerance ±5°F

ACCEPT

Comments:

STACK THERMOCOUPLES

Each thermocouple is calibrated by comparing it with an ASTM-3F thermometer at approximately 32°F, ambient temperature, 212°F, and 500°F. The thermocouple reads within 1.5 percent of the reference thermometer throughout the entire range when expressed in degrees Rankine. The thermocouples may be checked at ambient temperature at the test site to verify the calibration. Calibration data are included in the following Thermocouple Calibration Data Sheet(s).

ENVIRONMENTAL QUALITY MANAGEMENT
STACK THERMOCOUPLES

Thermo. ID	Therm.	Date Calibrated	Ambient Air	Diff., %	Cold Bath	Diff., %	Hot Bath	Diff., %	Hot Oil	Diff., %	Accept/Reject
T2-1	Reference	12/27/01	67	0.19	38	0.40	162	0.48	442	0.22	ACCEPT
	Pitot		68		40		159		440		
T2-2	Reference	12/27/01	67	0.00	38	0.20	172	0.95	460	0.22	ACCEPT
	Pitot		67		39		166		459		
T2-3	Reference	12/27/01	67	0.19	38	0.20	180	0.78	460	0.65	ACCEPT
	Pitot		68		39		175		454		
T2-4	Reference	1/4/01	72	0.19	33	0.00	200	0.00	437	0.45	ACCEPT
	Pitot		71		33		200		433		
T2-5	Reference			0.00		0.00		0.00		0.00	ACCEPT
	Pitot										
T2-6	Reference	12/26/01	68	0.00	36	0.20	184	0.31	456	0.98	ACCEPT
	Pitot		68		37		182		449		
T2-7	Reference	3/27/02	73	0.19	38	0.40	165	0.16	368	0.36	ACCEPT
	Pitot		72		36		164		365		
T3-1	Reference	12/27/01	67	0.19	39	0.00	156	0.49	460	0.76	ACCEPT
	Pitot		68		39		153		453		
T3-2	Reference	12/27/01	67	0.19	38	0.40	168	0.16	442	0.44	ACCEPT
	Pitot		68		40		167		438		
T3-3P	Reference	12/28/01	68	0.19	40	0.40	172	0.63	460	0.43	ACCEPT
	Pitot		67		42		168		456		
T3-4P	Reference	12/28/01	68	0.19	38	0.20	162	0.16	460	0.65	ACCEPT
	Pitot		67		37		161		454		
T3-5	Reference	12/26/01	69	0.19	38	0.20	188	0.62	456	0.11	ACCEPT
	Pitot		67		37		184		455		
T3-6	Reference	12/26/01	68	0.00	38	0.20	187	0.48	456	0.11	ACCEPT
	Pitot		68		39		184		455		
T4-1	Reference	12/28/01	68	0.19	39	0.20	177	0.16	460	0.22	ACCEPT
	Pitot		67		40		176		458		
T4-2	Reference	12/28/01	68	0.00	39	0.20	178	0.31	460	0.54	ACCEPT
	Pitot		68		40		176		455		
T4-3P	Reference	12/28/01	68	0.00	36	0.00	184	0.31	436	0.00	ACCEPT
	Pitot		68		36		185		436		
T4-4P	Reference	12/28/01	68	0.00	36	0.20	180	0.16	440	0.67	ACCEPT
	Pitot		68		37		179		434		
T4-5	Reference	12/28/01	68	0.00	35	0.81	152	0.16	460	0.65	ACCEPT
	Pitot		68		38		151		454		
T4-6	Reference	12/26/01	68	0.00	35	0.00	179	0.63	458	0.00	ACCEPT
	Pitot		68		35		178		458		
T4-7	Reference	12/26/01	68	0.00	38	0.40	178	0.47	456	0.11	ACCEPT
	Pitot		68		39		175		457		
T4-8	Reference	3/27/02	73	0.19	37	0.20	165	0.16	400	0.35	ACCEPT
	Pitot		72		36		164		397		
T5-1	Reference	12/28/01	68	0.00	36	0.20	181	0.00	450	0.11	ACCEPT
	Pitot		68		37		181		449		
T5-2P	Reference	12/28/02	68	0.00	37	0.00	186	0.31	458	0.22	ACCEPT
	Pitot		68		37		184		456		
T5-3	Reference	12/28/01	68	0.00	38	0.20	178	0.16	450	0.22	ACCEPT
	Pitot		68		37		177		448		
T5-4	Reference	3/27/02	73	0.19	36	0.20	170	0.32	390	0.24	ACCEPT
	Pitot		72		35		168		388		
T5-5	Reference	3/27/02	73	0.19	35	0.20	170	0.32	402	0.35	ACCEPT
	Pitot		72		35		188		399		
T6-1	Reference	12/28/01	68	0.00	38	0.20	198	0.30	451	0.33	ACCEPT
	Pitot		68		39		196		448		
T6-2	Reference	12/28/01	68	0.00	38	0.20	199	0.15	451	0.11	ACCEPT
	Pitot		68		39		199		450		
T6-3P	Reference	12/28/01	68	0.00	38	0.00	198	0.15	453	0.22	ACCEPT
	Pitot		68		38		197		451		
T6-4P	Reference	12/28/01	68	0.00	37	0.00	200	0.15	454	0.11	ACCEPT
	Pitot		68		37		199		453		
T6-5	Reference	12/28/01	68	0.19	38	0.00	198	0.30	451	0.11	ACCEPT
	Pitot		67		38		196		450		
T7-1	Reference	12/28/01	68	0.19	37	0.40	180	0.31	450	0.55	ACCEPT
	Pitot		69		39		178		445		
T8-1	Reference	12/28/01	68	0.00	37	0.40	199	0.62	456	0.44	ACCEPT
	Pitot		68		39		196		452		
T8-2	Reference	12/28/01	68	0.19	37	0.20	200	0.30	440	0.11	ACCEPT
	Pitot		69		38		198		439		
T8-3P	Reference	12/28/01	68	0.19	37	0.20	181	0.16	440	0.33	ACCEPT
	Pitot		69		38		180		437		
T8-4P	Reference	12/28/01	68	0.00	37	0.00	181	0.16	440	0.44	ACCEPT
	Pitot		68		37		180		436		
T8-5	Reference	12/28/01	68	0.00	37	0.40	202	0.45	460	0.65	ACCEPT
	Pitot		68		39		199		454		
T9-1	Reference	12/28/01	68	0.00	38	0.20	183	0.16	440	0.00	ACCEPT
	Pitot		68		39		182		440		
10-1	Reference	12/28/01	68	0.00	38	0.20	181	0.16	448	0.22	ACCEPT
	Pitot		68		38		182		446		
T11-1	Reference	12/28/01	68	0.00	39	0.00	180	0.31	448	0.55	ACCEPT
	Pitot		68		39		178		443		

AFIERA/DOBP (STINFO)
2513 KENNEDY CIRCLE
BROOKS CITY-BASE TX 78235-5116

OFFICIAL BUSINESS