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PT6A-68 Emissions Measurement Program Summary

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September 2002

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The Report is the product of a five year emissions testing program designed to document, characterize, and evaluate emissions from aircraft engines, auxiliary power units (APU's) burning JP-8. The purpose of the emissions testing program was to develop emission factors for the tested engines under representative load conditions. This addendum is for the PT6A-68 aircraft engine test program. 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
PPM	part per million
PPMVD	part per million by volume dry
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

TEST METHOD REFERENCES

- Air Force Institute for Environment, Safety and Occupational Risk Analysis (AFIERA), *Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations*, January 2002.
- American Society of Testing Materials (ASTM), http://www.astm.org/cgi-bin/SoftCart.exe/STORE/standardsearch.shtml?E+mystore
- NIOSH Manual of Analytical Methods (NMAM), http://www.cdc.gov/niosh/nmam/nmammenu.html
- Pratt and Whitney, http://www.afms.mil/AFIERA/ead_div.htm
- United States Environmental Protection Agency (USEPA), Title 40, Code of Federal Regulations, Part 60, Appendix A http://www.epa.gov/ttn/emc/tmethods.html
- USEPA SW846 http://www.epa.gov/epaoswer/hazwaste/test/methdev.htm

EXECUTIVE SUMMARY

The PT6A-68 aircraft engine powers the T-6A Texan II aircraft. The results of this test program will be used to evaluate the potential environmental impacts that may be created by the bed down of the T-6A Texan II Aircraft at various Air Force Bases. Two PT6A-68 engines were tested individually in a test cell at Pratt & Whitney Canada to measure criteria and select hazardous air pollutants.

I. OBJECTIVES

The objective of this program was to determine emission factors for the PT6A-68 engines under representative aircraft load conditions while burning JP-8+100 fuel. These data will be used for conformity analysis and aircraft bed down evaluation. Testing was conducted for particulate matter, nitrogen oxides, carbon monoxide, total non-methane hydrocarbons, and select hazardous air pollutants (volatiles, polynuclear aromatic hydrocarbons, and aldehydes and ketones).

Gaseous emissions, benzene, and formaldehyde were measured directly behind the engine to note differences between the measurements made at the test cell exhaust stacks and directly behind the engine.

II. SAMPLING METHODOLOGY

Sampling was performed for criteria pollutants and those HAPs that are products of incomplete combustion (PICs) from the two PT6A-68 engines at the Pratt & Whitney Canada facility. Environmental Protection Agency (EPA) emissions test methods (Title 40, Code of Federal Regulations, Part 60, Appendix A) were followed during this test program. The following is a list of the constituents of the exhaust stream that were measured at Pratt & Whitney along with the corresponding EPA test methods used:

- Filterable and condensible particulate (EPA Methods 5 and 202).
- Aldehydes and ketones (EPA 0011[1] 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)
- Benzene (TO-14)
- Formaldehyde (TO-11)

Sampling was not performed for sulfur dioxide and metals in the engine exhaust. Historic testing of metals provided random results with a number of interferences. Sulfur dioxide emissions are reported based on the procedure documented by AFIERA. 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 be expected to be emitted in detectable quantities. 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, carbon balance, and oxygen flow models. Historic ambient air monitoring programs have shown that ambient air concentrations of pollutants play an insignificant role in total engine emissions.

A. Engine Testing Conditions

The engines were tested at five flight settings. Nominal flight settings for emissions sampling are provided below:

- Ground Idle (GI)
- Flight Idle (FI)
- Descend (D)
- Approach (A)
- Max Continuous (MC)

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[1] From EPA SW-846.

Each flight setting emissions test was comprised of three 2-hour sampling runs 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 and polynuclear aromatic hydrocarbons were collected over the 6-hour sampling period. The first engine was tested at the ground idle, approach, and max. continuous flight settings for all target pollutants. In addition, gaseous emissions were measured at flight idle. The second engine was tested at the flight idle, descend, and max. continuous flight settings for all target pollutants. Gaseous emissions were measured at ground idle and approach also.

III. RESULTS

A. Criteria Pollutants

Test results of the criteria pollutants are presented in Tables ES-1 and ES-2. The summary of the data collected during this program represents an average of the test results for both engines at the engine tailpipe and test cell exhaust stacks. The data are very comparable between the two data sets. These tables present the test results for nitrogen oxides (NO_x), carbon monoxide (CO), total particulate, total non-methane hydrocarbons (TNMHC), sulfur dioxide (SO_2), and carbon dioxide (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 sampling runs are presented in Section 5, Tables 5-3 through 5-7, of this report. Table ES-3 contains a comparison of the historic emission test results obtained by Pratt & Whitney and a summary of the data collected during this program.

Particulate emissions are presented in Tables ES-4 and ES-5. The particulate emissions were consistent between each engine and setting. The condensable particulate fraction contained approximately 40% of organics at the ground idle and flight idle settings, 12% at approach, and <2% at max continuous and descend. 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.

B. Hazardous Air Pollutants

Table ES-6 summarizes average HAP emissions (volatile and aldehyde and ketone compounds) for each engine. The 11 HAPs shown in Table ES-6 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.

IV. CONCLUSIONS

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

- At ground idle, flight idle, and descend, there was a discoloration in the Method 5 sampling train impingers. The discoloration was heaviest at ground idle and decreased as power increased. The discoloration was a heavy yellow at the ground idle setting and was slightly cloudy at max. continuous (See Figure 5-3). The yellow material appeared to be unburned JP-8+100 fuel. Therefore, the condensible particulate fraction contained unburned fuel. The organic fraction (primarily unburned fuel) of the condensible particulate was approximately 40% at the ground idle and flight idle settings, approximately 12% at approach, and 2% at max continuous and descend. The condensible particulate fraction presented in Tables ES-4 and ES-5 includes only the aqueous fraction.

- Emissions measured directly behind the engine and at the test cell exhaust stack were comparable. A minimal number of data points showed only a slight variance.

- The test results between engines are comparable, which indicates good data reproducibility and validates the test 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. During previous test programs, 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 89% - 94% of the total particles). The larger particles, 2.5 to 10 microns, were found to be agglomerates of smaller combustion particles. These agglomerates accounted for 6% to 11% 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 1.5% of the particles were greater than 7.5 microns. Particles were only identified at the approach setting for each engine. At the remaining power settings, the particles were bound together. The analytical laboratory was unable to count the particles in each "bundle." Therefore, "not analyzed" was reported for the remaining settings. A possible explanation for this agglomeration is that the particles are bound together by the organics in the high temperature exhaust stream.

- The TNMHC was found to be higher at the test cell exhaust stack than at the engine exhaust at ground and flight idle. This could be attributed to the engine "misting" fuel. It was noted in the field that the sample line at the engine was loaded with fuel. A portion of the TNMHC may have passed the probe in an atomized form and volatilized in the exhaust stack where it was measured as TNMHC at the test cell exhaust.

- Ambient measurements were made in order to complete the theoretical exhaust flow calculations. Ambient measurements were not made to correct the target pollutants measured in the test cell. The contribution of any ambient pollutants was negligible because the test cell intake was located away from any source of pollutants.

- The distribution of pollutants within the two test cell exhaust stacks was determined to be the same. The continuous emission analyzer sample probe was moved between each stack during testing to validate this point. The gaseous pollution concentrations were very similar.

TABLE ES-1
PT6A-68
CRITERIA POLLUTANT
EMISSION FACTOR SUMMARY
lbs/1000 lbs fuel
Engine A - Serial No. RA0154

	Ground Idle	Flight Idle	Approach	Max. Continuous
Exhaust Flow, dscfm	14,436	16,727	30,833	37,728
Fuel Flow, lbs/hr	155	179	448	612
Pollutant				
Nitrogen Oxides (NOx)	1.83	1.92	6.28	8.44
Carbon Monoxide (CO)	135.67	103.06	11.19	4.75
Total Non Methane Hydrocarbons	41.69	30.07	0.32	0.07
Carbon Dioxide (CO_2)	4,467	4,354	3,678	4,393
Sulfur Dioxide (SO_2)[(a)]	0.66	0.66	0.66	0.66
Total Particulate	3.95	NA[(b)]	3.35	3.78

(a) - Sulfur dioxide emissions based on sulfur content in fuel (0.033%).

As noted in "Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, January 2002".

(b) - Particulate was not measured during the Flight Idle Condition.

TABLE ES-2
PT6A-68
CRITERIA POLLUTANT
EMISSION FACTOR SUMMARY
lbs/1000 lbs fuel
Engine B - Serial No. RA0156

	Ground Idle	Flight Idle	Descend	Approach	Max. Continuous
Exhaust Flow, dscfm	14,436	16,647	26,967	30,833	36,649
Fuel Flow, lbs/hr	155	179	328	448	624
Pollutant					
Nitrogen Oxides (NOx)	2.32	2.25	5.03	6.59	7.53
Carbon Monoxide (CO)	122.24	103.82	35.24	13.96	4.75
Total Non Methane Hydrocarbons	41.16	32.21	3.40	0.23	0.07
Carbon Dioxide (CO_2)	4,403	4,588	4,732	4,150	4,427
Sulfur Dioxide (SO_2) [(a)]	0.66	0.66	0.66	0.66	0.66
Total Particulate	NA[(b)]	4.18	3.35	NA[(b)]	3.80

(a) - Sulfur dioxide emissions based on sulfur content in fuel (0.033%).

As noted in "Air Emissions Inventory Guidance Document for Mobile Sources at Air Force Installations, January 2002".

(b) - Particulate was not measured during the Ground Idle and Approach Conditions.

TABLE ES-3
PT6A-68 EMISSION FACTOR COMPARISON
EQ PROGRAM VS. PRATT & WHITNEY PROGRAM

Flight Setting	**Ground Idle**	**Flight Idle**		**Descend**		**Approach**		**Max. Continuous**	
Fuel Flow, lbs/hr	155	179	191	328	334	448	587	618	651
Test Group	EQ	EQ	P&W	EQ	P&W	EQ	P&W	EQ	P&W
Pollutant									
NO_X	2.08	2.08	2.70	3.46	4.40	6.43	6.40	8.07	8.80
CO	125.37	102.19	73.40	22.91	23.70	11.71	6.90	4.09	5.20
TNMHC	39.24	28.85	25.20	2.94	4.20	0.20	0.30	0.07	0.20

EQ data represents the average of both engines.

Pratt & Whitney data was obtained from https: www.afms.mil\afiera\ead_div.htm

TABLE ES-4
ENGINE A (SERIAL No. RA0154)
PT6A-68
EMISSIONS FACTOR SUMMARY
PARTICULATE

	Run Number									
	1		2		3		Composite		Average	
	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
Ground Idle										
Flow Rate, dscfm	14,724		14,160		14,423		16,610		14,979	
Fuel Flow, lbs/hr	155		155		155		155		155	
Filterable	0.28	1.83	0.27	1.71	0.32	2.08	0.24	1.55	0.28	1.79
Condensible[A]	0.46	2.97	0.14	0.91	0.20	1.30	0.54	3.45	0.33	2.16
Total Particulate	0.74	4.80	0.41	2.62	0.52	3.38	0.78	5.00	0.61	3.95
Approach										
Flow Rate, dscfm	29,039		31,585		31,876		35,067		31,892	
Fuel Flow, lbs/hr	453		453		453		453		453	
Filterable	1.13	2.49	1.74	3.38	1.47	3.25	1.09	2.42	1.36	3.00
Condensible[A]	0.28	0.69	ND	ND	ND	ND	0.35	0.77	0.16	0.35
Total Particulate	1.41	3.12	1.74	3.83	1.47	3.25	1.44	3.18	1.52	3.35
Max. Continuous										
Flow Rate, dscfm	36,909		38,474		37,800		40,130		38,329	
Fuel Flow, lbs/hr	612		612		612		612		612	
Filterable	4.84	7.91	2.33	3.81	2.50	4.09	1.80	2.94	2.87	3.61
Condensible[A]	ND	ND	ND	ND	ND	ND	0.30	0.50	0.76	0.12
Total Particulate	4.84	7.91[B]	2.33	3.81	2.50	4.09	2.10	3.43	2.95	3.78

(A) – Aqueous fraction only. The organic condensible fraction accounted for approximately 40% of the condensible fraction at Ground Idle, 12% at Approach, and <2% at Max. Continuous.

(B) – Not included in average.

ND – Not detected

TABLE ES-5
ENGINE B (SERIAL No. RA0156)
PT6A-68
EMISSIONS FACTOR SUMMARY
PARTICULATE

	Run Number									
	1		2		3		Composite		Average	
	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
Flight Idle										
Flow Rate, dscfm	16,981		16,664		16,296		17,583		16,881	
Fuel Flow, lbs/hr	180		180		180		180		180	
Filterable	0.37	2.03	0.57	3.16	0.39	2.16	0.28	1.55	0.40	2.23
Condensible^A	0.36	1.98	0.36	1.99	0.32	1.78	0.37	2.08	0.35	1.96
Total Particulate	0.72	4.01	0.93	5.15	0.71	3.94	0.65	3.63	0.75	4.18
Descend										
Flow Rate, dscfm	26,452		27,948		26,500		27,896		27,199	
Fuel Flow, lbs/hr	328		328		328		328		328	
Filterable	0.73	2.23	1.90	5.80	0.68	2.08	0.52	1.60	0.64	1.97
Condensible^A	0.41	1.25	0.25	0.76	0.48	1.47	0.47	1.42	0.45	1.38
Total Particulate	1.14	3.48	2.15	6.56^b	1.16	3.54	0.99	3.02	1.10	3.35
Max. Continuous										
Flow Rate, dscfm	36,211		37,594		36,143		37,942		36,972	
Fuel Flow, lbs/hr	611		611		611		611		611	
Filterable	1.83	3.00	3.43	5.62	1.89	3.09	1.25	2.04	2.10	3.44
Condensible^A	0.28	0.47	ND	ND	ND	ND	0.60	0.99	0.22	0.36
Total Particulate	2.12	3.46	3.43	5.62	1.89	3.09	1.85	3.03	2.32	3.80

(A) – Aqueous fraction only. The organic condensible fraction accounted for approximately 38% at Flight Idle, <2% at Descend, and <2% at Max. Continuous.

(B) – Not included in average.

ND - Not detected.

TABLE ES-6
PT6A-68
HAZARDOUS AIR POLLUTANTS (HAPs)
EMISSION FACTOR SUMMARY
lbs/1000 lbs fuel

	ENGINE A (Serial No. RA0154)			ENGINE B (Serial No. RA0156)		
	GROUND IDLE	APPROACH	MAX. CONTINUOUS	FLIGHT IDLE	DESCEND	MAX. CONTINUOUS
Exhaust Flow, dscfm	14,436	30,833	37,728	16,647	26,967	36,649
Fuel Flow, lbs/hr	155	448	612	179	328	624
Pollutant						
Formaldehyde	4.80E+00	6.73E-01	2.40E-02	5.27E+00	2.93E+00	2.00E-03
Acetaldehyde	2.99E-01	1.04E-01	2.76E-03	3.47E-01	8.79E-02	1.58E-03
Acrolein	7.16E-01	ND	ND	6.01E-01	5.05E-02	ND
Isobutraldehyde/MEK	7.29E-01	ND	ND	ND	ND	ND
Naphthalene	7.24E-03	6.28E-03	2.68E-02	1.16E-02	1.40E-02	1.27E-01
Benzene	2.83E-01	1.43E-03	4.84E-04	5.21E-01	8.48E-02	1.24E-03
Toluene	1.65E-01	2.37E-03	4.28E-04	2.42E-01	2.46E-02	6.07E-04
Ethylbenzene	4.76E-02	2.36E-04	1.16E-04	4.94E-02	2.52E-03	1.41E-04
m,p-Xylene	1.13E-01	6.27E-04	4.55E-04	1.31E-01	6.03E-03	3.45E-04
o-Xylene	5.98E-02	2.86E-04	1.61E-04	6.59E-02	2.92E-03	1.72E-04
Styrene	4.68E-02	ND	ND	4.68E-02	2.21E-03	ND
Total HAPs	7.27E+00	7.88E-01	5.52E-02	7.29E+00	3.21E+00	1.33E-01

SECTION 1

INTRODUCTION

This Emission Summary Scientific and Technical Report has been prepared by Environmental Quality Management, Inc. (EQ) under Delivery Order 0008, Modification 13, of the Occupational and Environmental Health Assessments Contract (Contract Number F41624-95-D-9019) 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 March 2002, A004).
- Preparation of the Site Survey Report (A011).
- Preparation of monthly progress, status, and management reports (A001).
- Preparation of conference agenda and minutes (A008).
- Preparation of a summary Scientific and Technical Report (this document, A003).

A description of the project background and objectives is provided in this section.

1.1 PREVIOUS STUDIES

The USAF began to develop a database of known engine emissions data in the 1970s. The purpose of developing the database was to produce a catalog of smoke plume opacity and gaseous emissions from engine test facilities. Environmental managers could use data from the catalog to meet regulatory reporting requirements. Subsequently, the USAF and the U.S. Navy (USN) have attempted to amass and review existing engine emissions data, validate the data, and identify data gaps. The USAF's Engineering and Services Laboratory and Engineering Services Center, and the USN's Environmental Support Office have been the lead organizations for this effort.

Available aircraft emissions technical references were compiled and reviewed by the U.S. Environmental Protection Agency (U.S. EPA) in 1993. The current effort is being undertaken by the USAF's AFIERA/RSEQ located at Brooks AFB, TX.

1.2 PROJECT OBJECTIVES

As part of the broader engine-testing program, the USAF, through the Human Systems Center (HSC) (now AFIERA/RSEQ) at Brooks Air Force Base, TX, has contracted to have the emissions characterized from the PT6A-68 engine operating at a variety of settings utilizing JP-8+100 fuel. Specifically, the objectives of the PT6A-86 emission measurement program were as follows:

1) To determine emission factors from the test facility (lbs of pollutant per 1000 lb of fuel burned) for carbon monoxide (CO), oxides of nitrogen (NO_x), total non-methane hydrocarbons (TNMHC), particulate matter (PM10), and speciated hazardous air pollutants (volatile compounds and aldehydes and ketones). Measure all target pollutants for two engines in order to provide a larger database.

2) 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.

3) Compare emission results between each engine.

Testing of the PT6A-68 engines was conducted during the week of 20 May, 2002 at the Pratt & Whitney facility located in Montreal, Canada. This testing is the focus of the sampling effort described within this document.

1.2.1 PT6A-68

The T-6A Texan II Trainer Aircraft is powered by the PT6A-68 engine, rated at approximately 1,100 horsepower. The PT6A-68 is a turbo shaft propulsion engine. Pratt & Whitney manufactures these engines at the Montreal, Canada and West Virginia, USA facilities.

1.2.2 Test Facility

The PT6A-68 engine emission tests were conducted at the Pratt & Whitney facility located in Montreal, Canada. This manufacturing facility develops and tests a variety of military and commercial engines. Testing was conducted within Test Cell 18.

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SECTION 2

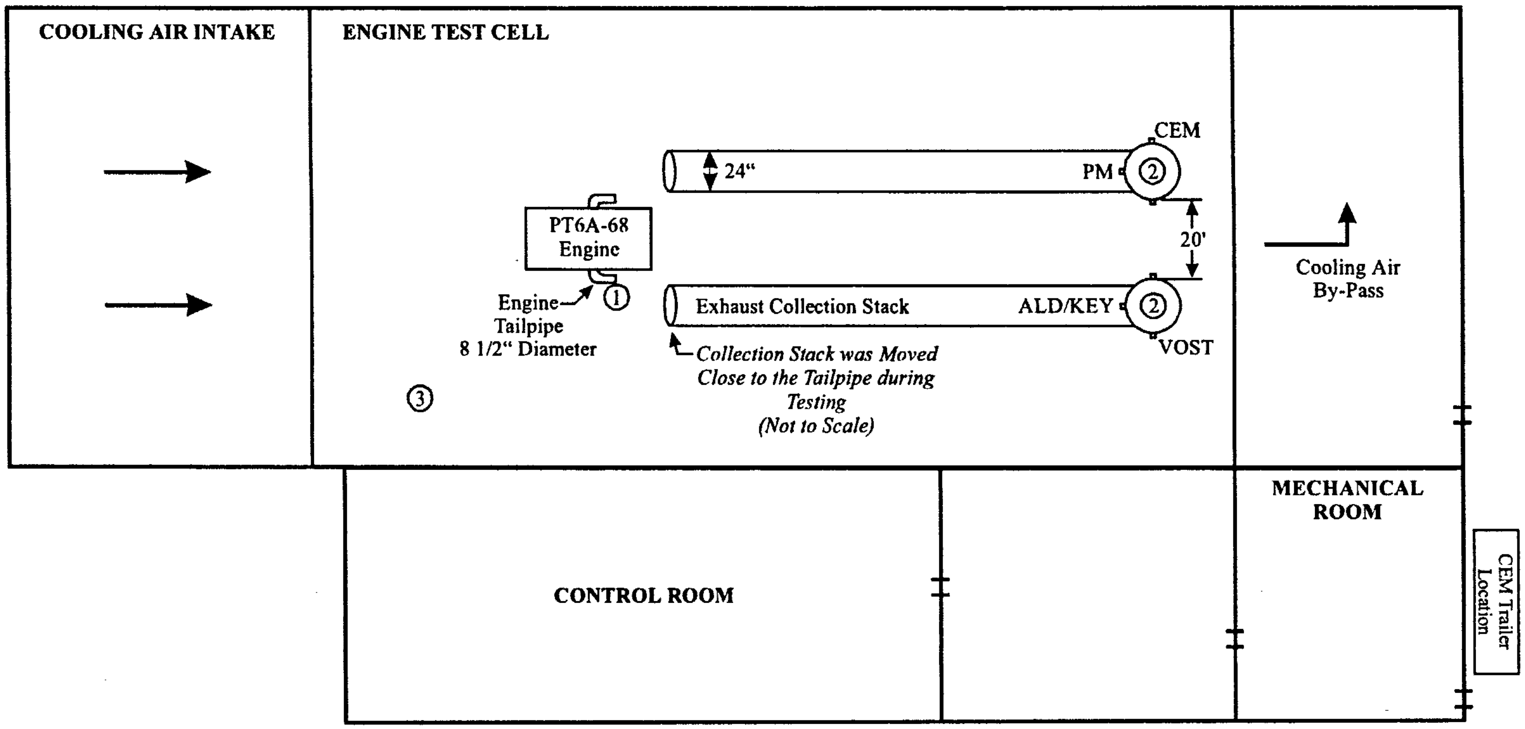
TEST FACILITY DESCRIPTION

Two PT6A-68 engines were tested at the Pratt & Whitney Canada facility utilizing JP-8+100 jet fuel. The physical layout of the test cell allowed the engine exhaust to be sampled using traditional EPA-recommended emission testing methodologies (U.S. EPA 40 CFR 60, Appendix A), and the dilution created by the engine propeller was determined through mathematical methodology. A description of Test Cell 18 and the sampling system apparatus is provided in this section. A detailed description of the sampling methodology is provided in Sections 3 and 4.

2.1 PRATT & WHITNEY TEST CELL 18 OVERVIEW

The aircraft engines were tested in an indoor enclosure, known as a test cell, which is designed to restrain the engine and provide remote electronic control for operation and testing. The test cell functions include: supply air filtration, noise suppression, and exhaust diversion. During the test, the engine was mounted on a stand near the center of the cell and exhausted through two horizontal circular ducts that discharged into two vertical stacks. An approximate layout of Test Cell 18 is illustrated in Figures 2-1and 2-2.

The test team collected samples from the test cell exhaust stacks and at the engine exhaust. Additional details of the test cell and sampling locations are included in Figures 2-3 through 2-9.

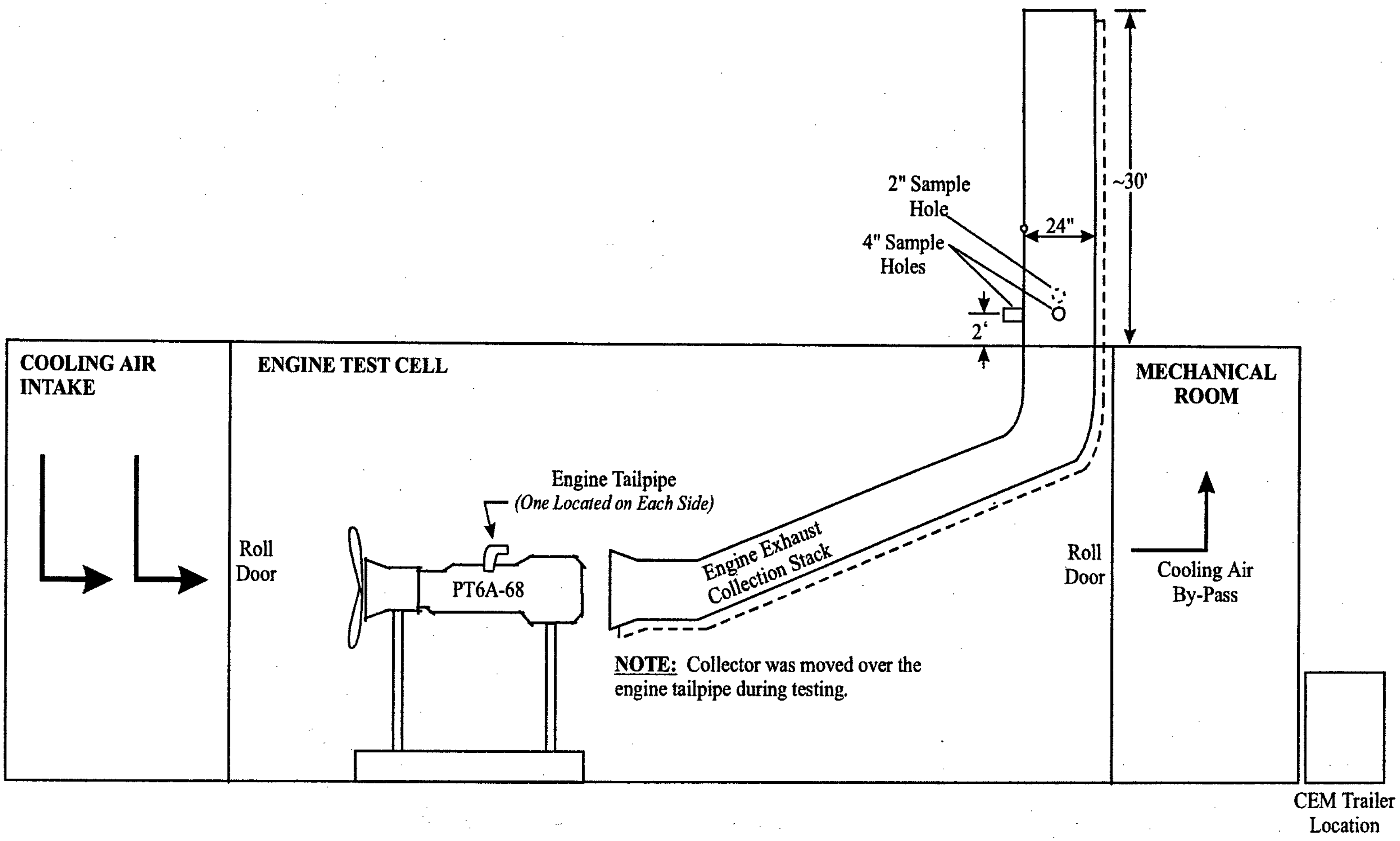


① - Engine Tailpipe Sample Location (CO, NO$_x$, TNMHC, O$_2$, CO$_2$, Temp., Benzene, Formaldehyde)

② - Engine Exhaust Sample Location (CO, NO$_x$, TNMHC, O$_2$, CO$_2$, Temp., PM, VOST, ALD/KEY, PAH)

③ - Test Cell Oxygen and Temperature Measurement Location

Figure 2-1. Test Cell 18 - Top View



NOTE: Collector was moved over the engine tailpipe during testing.

Figure 2-2. Test Cell 18 - Side View

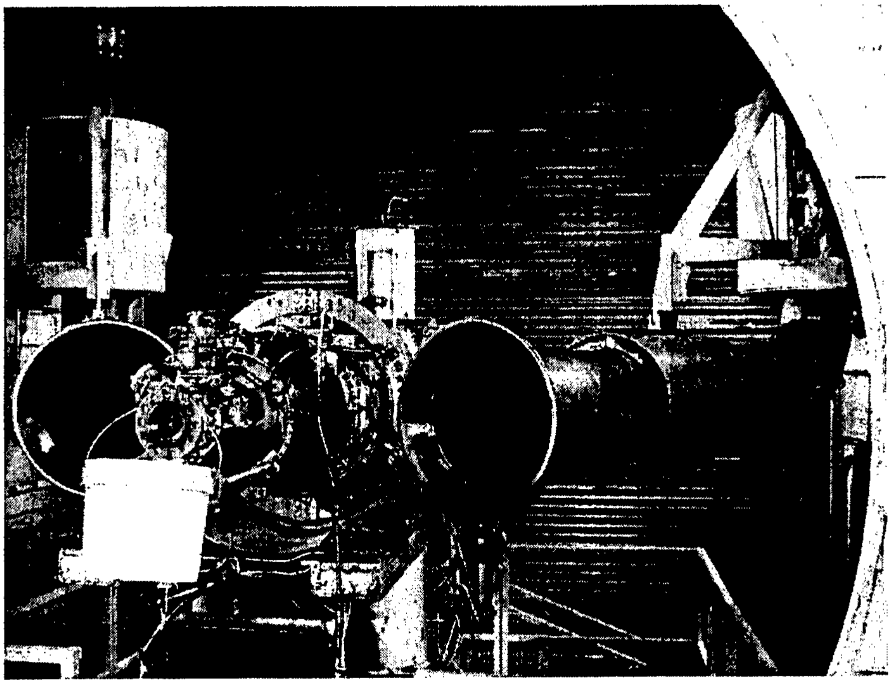


Figure 2-3. Engine Stand and Exhaust Stack

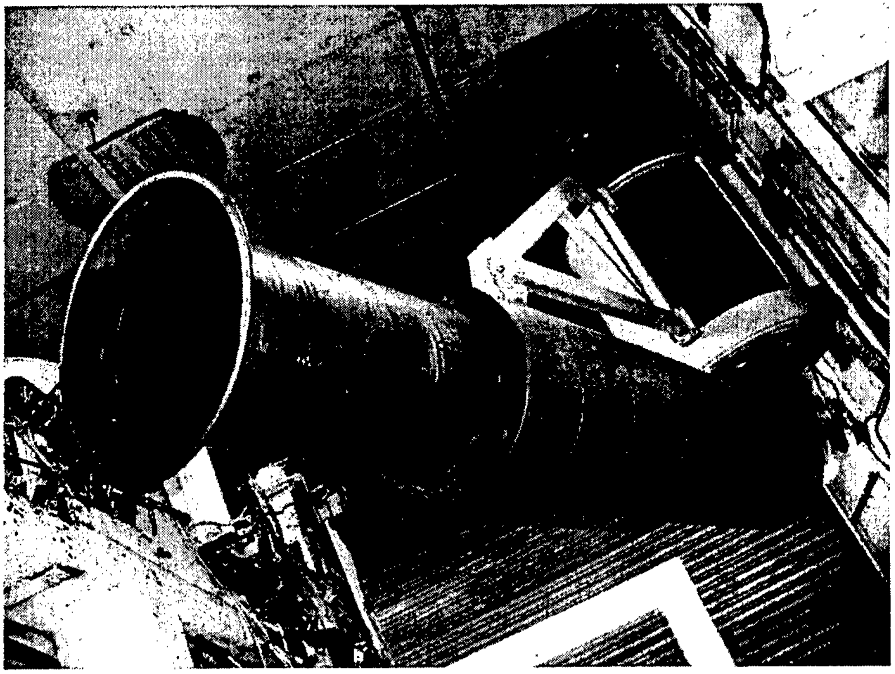


Figure 2-4. Exhaust Stack Exiting from Test Cell 18

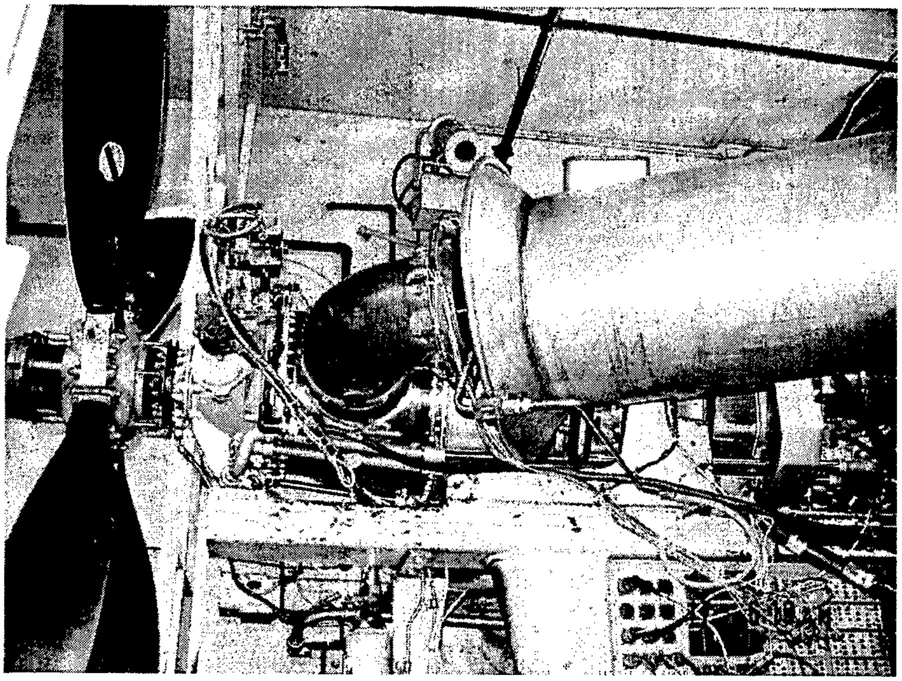


Figure 2-5. Engine Exhaust to Stack (Side View)

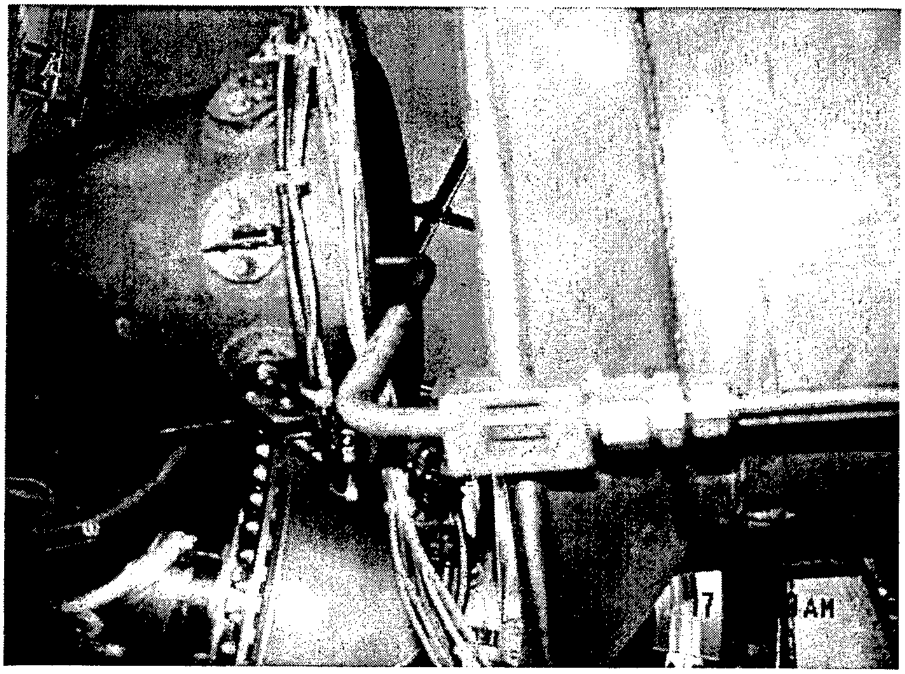


Figure 2-6. Sample Probe at Engine Exhaust

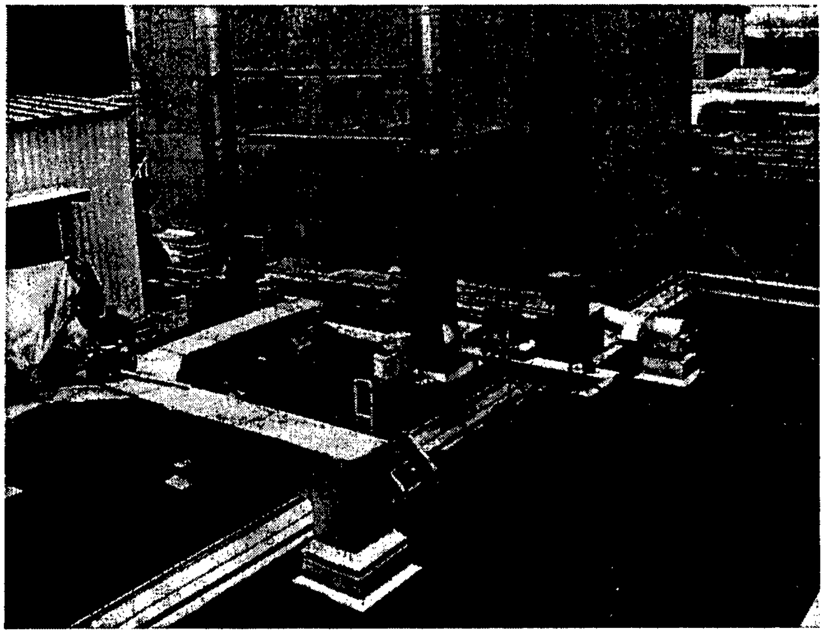


Figure 2-7. Engine Exhaust Stacks - Front View

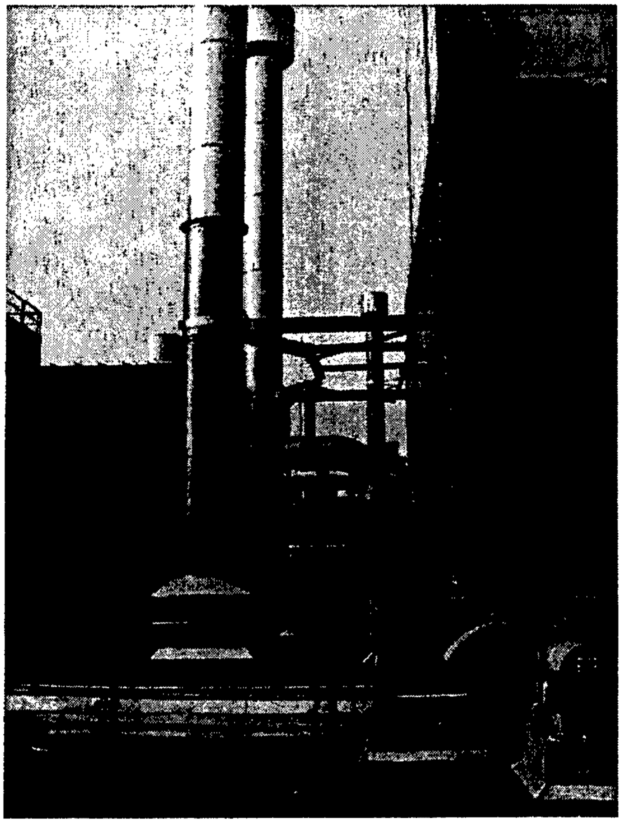


Figure 2-8. Engine Exhaust Stacks - Side View

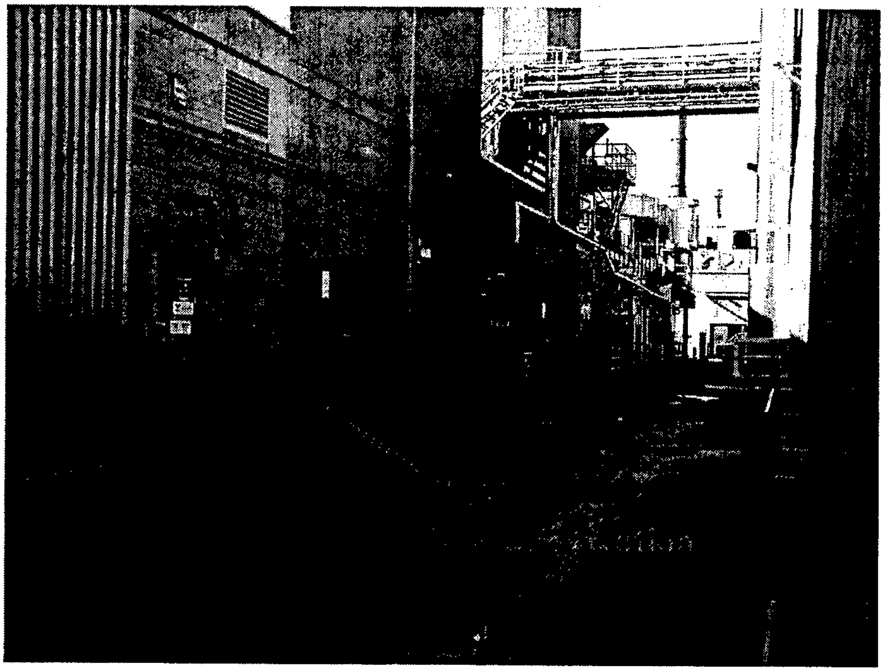


Figure 2-9. Exterior Rear of Test Cell 18

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SECTION 3

SAMPLING APROACH AND METHODS

The sampling program involved sample collection at the two Test Cell 18 exhaust stacks and directly behind the engine exhaust pipe to characterize emissions from two PT6A-68 aircraft engines operated in succession. The test program involved emission sampling at seven engine test settings: ground idle, flight idle, descend, approach, climb, cruise and maximum continuous. At the Climb and Cruise settings, only gaseous pollutants were measured. Two PT6A-68 engines (serial numbers RA0154 and RA0156) were operated in succession and fueled by JP8+100. A breakdown of the target pollutants for each engine setting is provided in Table 3-1. The entire target list of pollutants were monitored at three settings for each engine.

Due to the complexity of the test program, several items were considered prior to sample collection. Each item is discussed in more detail in the following sections.

- A portion of cooling air drawn by the propeller across the engine was carried into the engine exhaust stacks. The engine exhaust emission measurements made at the exhaust stack are diluted by the cooling air.
- Particulate measurements at the engine exhaust stacks were sampled at an isokinetic sampling rate[1] while attempting to maximize sample volume and retain filter integrity as well as particle catch.
- One composite particulate sample was collected at each setting. This sample was collected in conjunction with the remaining samples for six hours 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.

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[1] Isokinetic sampling is sampling the exhaust gas at the same rate it is moving through the stack to obtain a distribution of particle sizes in the samples that is representative of those in the exhaust gas itself.

TABLE 3-1. TARGET EXHAUST POLLUTANTS FOR EACH ENGINE SETTING

	Sampling Duration	Particulate Matter	HAPs (VOC, ALD/KEY)	NO_X	TNMHC	CO	CO_2	O_2
Engine A								
Ground Idle	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X
Flight Idle	30 minutes			X	X	X	X	X
Approach	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X
Max Continuous	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X
Engine B								
Ground Idle	30 minutes			X	X	X	X	X
Flight Idle	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X
Descend	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X
Approach	30 minutes			X	X	X	X	X
Max Continuous	6 hours (Three 2-hour test runs)	X	X	X	X	X	X	X

3.1 EMISSION MEASUREMENT APPROACH

Sampling at the two exhaust stacks of test cell 18 was performed for criteria pollutants and select HAPs. Emissions were monitored using traditional EPA point source sampling methodologies (U.S. EPA 40 CFR 60, Appendix A, www.epa.gov/ttn/cmc/tmethods.html) at each exhaust stack and directly behind the engine tailpipe (Figure 2-1). One particulate sample at each setting was analyzed via scanning electron microscopy for particle size distribution and morphology. The following compounds were monitored:

- Filterable and condensable particulate (EPA Methods 5 and 202).
- 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 will be reported as total non-methane hydrocarbons.
- Methane (EPA Method 25A).
- Polynuclear Aromatic Hydrocarbons (NIOSH Method 5506)

Gaseous emissions, formaldehyde (Method TO-14), and benzene (Method TO-11) were measured at the engine tailpipe. These data were compared to the test cell exhaust stack emissions.

The engine exhaust was not sampled for sulfur dioxide, metals or semi-volatiles. Fuel samples were collected and analyzed for the presence of metals. Historic sampling has not indicated the presence of metals. Sulfur dioxide emissions were calculated using the sulfur content in the fuel (AFIERA, 2002). Dioxins, furans, and semi-volatile emissions were not measured in this test program. Previous aircraft engine tests have shown that semi-volatile emissions from aircraft are predominantly less than method detection limits.

Cooling air is drawn into the test cell by the propeller and is either by-passed at the rear of the test cell or exits through the engine exhaust ducts. The volume of gas in the exhaust stacks was measured directly utilizing USEPA Methods and traditional isokinetic sampling methodologies (U.S. EPA 40 CFR 60, Appendix A Methods 1-5). Due to the introduction of cooling air, the air dilution ratio in the exhaust ducts was determined indirectly through carbon balance, F-factor, and oxygen balance calculations.

3.1.1 Exhaust Flow Determination

As indicated in Figure 2-2, cooling (ambient) air is drawn by the propeller into the test cell to cool the engine. A portion of the cooling air enters the engine exhaust collection stack, where it mixes uniformly with the actual engine exhaust and dilutes the exhaust pollutant concentrations. Therefore, to calculate actual emissions from the engine, the contribution of dilution air must be calculated and subtracted from the total test cell exhaust stack flow.

The combined exhaust was measured at the engine exhaust collection stack via traditional EPA Method 2 (pitot tube) procedures. The portion of cooling air that enters the engine exhaust collection stack was calculated using three methods. An oxygen ratio was used to determine the flow of cooling air into the exhaust duct. Also, F-factor and carbon balance were used to estimate the quantity of airflow generated by the engine. Because the total exhaust flow was measured directly, the net difference, total less the quantity determined using F-factor, would theoretically be the quantity of cooling air entering the collection stack. The calculated engine exhaust flow was used to determine the pollutant mass rate from the engine tailpipe.

Section 4 discusses in detail the methodologies that were applied to calculate air flow from the engine.

3.1.2 Pretest Measurements

Preliminary test data was obtained during the shakedown runs. Preliminary exhaust flow rate data and gas composition data was collected. Inlet and exhaust geometry measurements were obtained and recorded, and sampling point distances verified. A preliminary velocity traverse was performed utilizing a calibrated S-type pitot tube and a Dwyer inclined manometer to determine velocity profiles. Exhaust gas temperatures were observed with a calibrated thermocouple.

A check for the presence or absence of cyclonic flow ("swirling" stack gas flow that is not flowing parallel to the stack) was conducted in each stack. 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.

3.1.3 Gaseous Emission Measurement

Continuous emission analyzers were utilized to measure gaseous pollutants at several locations during the test program. 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, a Siemens Ultramat SE analyzer was used. This analyzer meets the specifications established by Pratt & Whitney Engineers.

Two complete sets of continuous emission analyzers were used to monitor emissions. One set of analyzers was dedicated to the engine exhaust stacks (Figure 2-1, Point 3). The sample probe was moved between the two stacks periodically during testing to note even mixing of engine exhaust between the stacks. The second complete set of continuous emission analyzers monitored the engine tailpipe exhaust and ambient parameters (Figure 2-1, Point 2). A single 3/8-inch-diameter stainless steel sample probe was positioned into the exhaust plane to measure the engine tailpipe emissions.

3.1.4 Particulate Measurement

The collection of particulate matter from aircraft engines is difficult due to the lack of particulate present in the exhaust stream. Aircraft engines are highly efficient and thus produce minimal particulate matter in a diluted exhaust stream. Due to the difficulty in obtaining a measurable quantity of particulate matter from the engine exhaust using EPA test methodologies, the method has been adapted to provide the best opportunity for particle collection. U.S. EPA Method 5 was utilized, but the sample run times were extended to two hours in length. 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 that resulted in filter material adhering to the support frit gasket. This resulted in a loss of mass 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 two hours while maintaining a steady sample flow rate so the filter material was not pulled to the impinger solution.

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 2-hour sample runs. The composite sample run followed EPA Method 5 procedures for a 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 only 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, a 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 one sample to accommodate the SEM analysis. A silver membrane filter media was used based on the intent of gaining the highest possible quantity of measurable particulate matter.

3.1.5 Direct Engine Exhaust Measurement

During each sample run, a single sample was collected directly behind the engine for gaseous pollutant analysis. A single stainless steel sample line was attached to one of the PT6A-68 exhausts. These data were compared to the gaseous emissions data collected at the test cell exhaust stacks to note dilution ratios and possible secondary chemistry with the dilution air.

3.1.6 Inlet Air Sampling

Since a portion of the cooling air pulled across the engine by the propeller is drawn into the exhaust stack, ambient levels of pollutants were taken into account in determining the emissions from the engine exhaust stacks. However, it was determined during the testing that ambient levels of pollutants were insignificant as no fuel handling or solvent operations, vehicles, heavy machinery operating in the area, or engine emissions from operation in adjacent test cells were present at test time. Ambient measurements of TNMHC, CO_2, O_2, CO, and NO_x were made to verify that no sources were contributing to the exhaust measurements and to gather information to complete the carbon balance, F-Factor, and oxygen balance calculations.

3.1.7 Emission Test Methods

The following paragraphs discuss methods that were utilized for emissions testing. Furthermore, Appendix A of this document 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.

3.1.7.1 Particulate Sampling

EPA Method 5 was used for particulate sampling at the test cell exhaust. 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 condensable particulate. The method was modified as noted in Section 3.1.4 to allow for larger sample volumes and particle size determination. Three 2-hour sample runs were conducted at three engine settings along with one 6-hour composite sample.

3.1.7.2 Aldehyde and Ketones

The sampling train utilized to perform aldehyde and ketone sampling conformed to EPA Method 0011. A single 4-hour sample run was conducted at the flight engine settings.

3.1.7.3 Volatile Organic Compounds

The sampling train utilized to perform VOC sampling conformed to EPA Reference Method 0030. Three 2-hour sample runs were conducted at the flight engine settings. Table 3-2 lists the VOCs that were analyzed in each sample.

3.1.7.4 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). Due to the expected low concentration of CO_2 in the exhaust stream, Siemens Ultramat 5E was used. The analyzer has the ability to measure the concentration in several ranges: 0-2%, 0-5% and 0-10% CO_2 with accuracy to three decimal places.

TABLE 3-2. SUMMARY OF SOURCE TARGET COMPOUNDS FOR VOLATILE ORGANIC COMPOUNDS

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

3.1.7.5 Total Non-Methane Hydrocarbons (TNMHC)

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

The NMTHC analyzer was calibrated with a zero and span gas at the beginning and end of each sample day to assess the instrument's performance.

3.1.7.6 Polynuclear Aromatic Hydrocarbons

National Institute of Occupational Safety and Health (NIOSH) Method 5506 was used to collect a representative sample for the target pollutants. A sample was drawn through an in-stack filter across an XAD-2 resin trap at approximately 1 lpm. A single 3-hour sample was collected at each flight engine setting.

3.2 ENGINE TESTING MATRIX

3.2.1 Engine Shakedown Runs

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

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

3.2.2 Engine Test Settings

Emissions testing was performed on two PT6A-68 engines (A and B) at seven aircraft flight settings. These settings are the following:

- Ground Idle
- Flight Idle
- Descend
- Approach
- Climb (Shakedown testing only)
- Cruise (Shakedown testing only)
- Maximum Continuous.

Gaseous emissions were measured for trend curve analysis at the Climb and Cruise settings only. The first engine was tested at the ground idle, approach, and max continuous flight settings for all target pollutants. In addition, gaseous emissions were measured at flight idle. The second engine was tested at the flight idle, descend, and max continuous flight settings for all target pollutants. Gaseous emissions were measured at the ground idle and approach flight settings also. All flight engine settings were defined by Pratt & Whitney so that the engine could run continuously (or as long as practical) at each setting. Table 3-3 lists engine type, number of power settings, and the number and types of samples that were collected.

3.2.3 Engine Emission Trend Development

In addition to the settings listed above, a sample run from ground idle to max continuous was conducted. The purpose of the run was to sample for gaseous pollutants throughout the engine power band. The engine throttle position was increased in small increments at 10-minute intervals so that gaseous emission data could be collected. These sampling runs were conducted during the shake-down procedure.

3.3 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 this test stand constantly monitored a variety of engine parameters during engine testing. For the purpose of emissions sampling, a select number of these parameters were provided to EQ for emission factor development. These parameters assisted in noting the effect of a specific pollutant for a specific engine load condition. The following data were compiled by facility personnel:

- Fuel flow at each load.
- Engine rpm at each load.
- Shaft horsepower at each load.
- Humidity and temperature.

TABLE 3-3. ENGINE EMISSION SAMPLING MATRIX

Pollutant/ Method	Sample Location		Sample Duration (Minutes)	Number of Samples per Setting	Total Number of Samples	Engine Setting			
	Engine Exhaust	Ambient				Flight Idle	Ground Idle	Approach	Max Continuous
Particulate/EPA Method 5/202	X		120	3	9	X	X	X	X
Aldehydes and Ketones/EPA Method 0011	X		240	1	3	X	X	X	X
VOST/EPA Method 0030	X		120	3	9	X	X	X	X
Carbon Monoxide/EPA Method 10	X	X	120	3	12	X	X	X	X
Carbon Dioxide and Oxygen/ EPA Method 3A	X	X	120	3	12	X	X	X	X
Oxides of Nitrogen/EPA Method 7E	X	X	120	3	12	X	X	X	X
Total Hydrocarbons/ EPA Method 25A	X	X	120	3	12	X	X	X	X
Methane/EPA Method 25A	X		120	3	12	X	X	X	X
Polynuclear Aromatic Hydrocarbons/NIOSH Method 5506	X		360	3	9	X	X	X	X

*Please note that the complete pollutant target list will be acquired at three engine settings. The fourth setting will be monitored for gaseous emissions only. The gaseous emission setting will be alternated between the engines so that a complete pollutant emission rate is obtained at each setting. (See Figure 3-1)

Please note that fuel flow and shaft horsepower were the most important data items in the above list. The remaining data were important for documentation of engine conditions during sample collection.

3.4 FUEL SAMPLING AND ANALYSIS

The JP-8+100 fuel analysis was determined in order to develop a custom F-factor and to document fuel characteristics during emissions testing. Table 3-4 lists the fuel analysis requirements.

TABLE 3-4. FUEL ANALYSIS REQUIREMENTS

Parameter	Method
Sulfur %	ASTM D 5453
Carbon %	ASTM D 5291
Nitrogen %	ASTM 4629
Hydrogen %	ASTM D 5291
Ash %	ASTM D 482
Aromatics %	PONA Analysis
Parafins %	PONA Analysis
Olefins %	PONA Analysis
Naphthalene %	PONA Analysis
Btu per pound	ASTM D 240

Two fuel samples were collected over the period of testing. EQ collected these samples and shipped them to the appropriate laboratory for analysis.

EQ collected duplicate fuel samples for metals analysis. The analytical procedure involves the combustion of JP-8+100 fuel in an evaporative dish. The combustion residue is ashed in a muffle furnace. Ash product is treated with an aqua regia to digest any residual carbon. The solution is diluted then analyzed via Inductively Coupled Plasma Spectroscopy, Cold Vapor Atomic Absorption Spectroscopy (Hg), or treated with chelating agent and analyzed via colorimetric methodology (P). Concentrations were determined for the metals listed in Table 3-5.

TABLE 3-5. SUMMARY OF SOURCE TARGET METALS FROM FUEL ANALYSIS

Antimony	Arsenic
Barium	Beryllium
Cadmium	Cobalt
Chromium	Copper
Lead	Manganese
Mercury	Nickel
Phosphorus	Selenium
Silver	Thallium
Zinc	

3.5 TEST SCHEDULE AND RESPONSIBILITIES

Figure 3-1 shows the time-line for engine testing. The time-lines depict completed activities and the time each activity required.

The following is a breakout of the general tasks that were conducted during each of the four phases of testing:

- **Equipment setup** - Setup and calibration of sampling equipment took one day. The first day was reserved for clearing and parking the test trailers, setting up the sampling equipment, the flow measurement system, and the mobile laboratory. EQ worked with Pratt & Whitney personnel so that the facility test schedule was not interrupted.

- **Shakedown** - During this important period, both the test team and engine test stand operators became familiar with the operational procedures of the test program. The test team needed to gather 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 2-hour test runs at two engine settings in one sample day. It took approximately 15 hours to complete the six runs.

- **Teardown** - Teardown of the equipment was accomplished at the completion of testing

3.5.1 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 3-6 lists the personnel categories and the required qualifications and tasks.

DAY No.	1	2	3	4	5
Engine Setting:	S	Engine A: SD[3]		Engine B: SD[3]	D
Ground Idle		T[1]			T[2]
Flight Idle		T[2]		T[1]	
Approach			T[1]		T[2]
Max. Continuous			T[1]		T[1]
Descend				T[1]	

[1] Particulate Matter, CEM Runs 3, 2-hour sample runs

[2] CEM Run Only. Approximately 30-minute run time

[3] Shakedown Run included engine trend curve development for gaseous pollutants only.

Activity Code:	
Mobilize	M
Setup	S
Shakedown	SD
Test	T
Teardown	D

Figure 3-1. Time-Line for PT6A-68 Engine Testing at the Pratt & Whitney, Montreal, Canada Facility

TABLE 3-6. EXAMPLE BREAKOUT OF FIELD TEAM PERSONNEL AND RESPONSIBILITIES

Personnel	Responsibilities/Qualifications
Project Manager	Act as liaison between PW personnel, sample team, and AFIERA/RSEQ. Coordinate engine operation with testing. Assist in equipment preparation and sample recovery. Collect fuel samples. Set up and construct sampling equipment.
Team Leader	Assume technical responsibility for overall sampling effort, sample recovery, and ambient air monitoring. Set up and calibrate equipment. Collect samples and operate CEM and manual sampling system.
CEM Operator	Operate and calibrate CEM system.
VOST Sample Train Operator	Operate VOST sampling train and assist other sampling personnel as needed.
Particulate Matter Train Operator	Operate particulate matter sampling trains and assist in sample recovery.
Aldehyde and Ketone Train Operator	Operate aldehyde and ketone sampling train; supervise IATA/DOT certification of shipment of hazardous materials (hazardous sample media, i.e., acetone); and act as field sample custodian.
Ambient Monitoring Equipment Operator and Sample Recovery	Calibrate and operate all ambient sampling equipment and perform sample recovery.
Sampling Technician	Provide sampling support to the above personnel.

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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 cooling air). The total exhaust flow was required to quantify mass emission rates for the parameters being measured.

Standard EPA flow measurement methods (U.S. EPA 40 CFR 60, Appendix A) were used to quantify airflow to the test cell exhaust stacks; however, three alternate flow measurement techniques were also employed to determine the flow at the engine exhaust. These measurement techniques are the following:

- F-factor for the calculation of the engine exhaust flow and measurement of the flow in the exhaust duct.
- Oxygen balance for the calculation of the cooling airflow entering the exhaust.
- Carbon balance for the calculation of the engine exhaust flow.

Each method has 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.

4.1 CALCULATION OF AIRFLOW USING F-FACTOR AND EXHAUST DUCT MEASUREMENT

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 could be easily determined and the volumetric flow of combustion air is difficult to measure. The

F-factor relationship was used to calculate the airflow from the engine (shown as A in Figure 4-1) based on the fuel firing rate. The total exhaust duct flow (shown as B in Figure 4-1) was measured using EPA Methodology. The cooling airflow (shown as C in Figure 4-1) will be calculated in the following manner:

- Cooling Air Entering the Exhaust Duct (calculated) = Total Exhaust Duct Flow (measured) – Exhaust from Engine (calculated by F-factor)

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 will be 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 will be 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, can be 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) can be determined by simply multiplying the measured fuel firing rate by the F-factors.

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

$$= \text{dry combustion air flow, } \frac{\text{scf}}{\text{min}}$$

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

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

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:

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

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:

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

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. It is estimated that the oxygen content in the exhaust stream is less than 18.5%.

4.2 CALCULATION OF AIRFLOW USING OXYGEN BALANCE

The oxygen content in the cooling air intake will be measured at the engine exhaust and at the exhaust collection duct terminus. If the oxygen content is known at each location, the quantity of cooling air entering the exhaust duct (shown as C in Figure 4-1) can be calculated. The cooling airflow entering the exhaust duct and the concentration of pollutants in the stream will result in the mass of ambient pollutants that contribute to the pollutant measurements made at the exhaust duct exit (shown as B in Figure 4-1).

The theory of the oxygen balance is as follows and is demonstrated in the example calculation. The cooling air that enters the test cell from the draw of the engine propeller has an oxygen content of approximately 21%. The exhaust duct flow rate and associated oxygen content, which is less than 21%, will be measured during each test run. The oxygen content at the engine exhaust tip will also be measured during each test run. The quantity of air required to increase the oxygen content from the engine exhaust tip from a relatively low value to the value measured at the exhaust duct terminus can then be determined.

In the example provided, the theoretical measured test cell exhaust conditions are provided. These are the measurements made at the two test cell exhausts and the associated mass of airflow. The second section of the example is the calculated volume of cooling air that enters the exhaust duct. This is the airflow that will be used with the ambient pollutant concentrations to determine the mass of pollutants entering the test cell exhaust stack. The third example table provides the conditions measured at the tip of the engine exhaust. Again, the measured oxygen content at the engine exhaust, test cell exhaust, and test cell cooling air inlet can be utilized to determine the quantity of cooling air that enters the test cell exhaust and dilutes the engine exhaust stream.

4.3 CALCULATION OF ENGINE EXHAUST FLOW USING 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:

$MI = ME - MF$ *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, $\frac{\text{wscf}}{\text{min}}$.

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

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

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

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:

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

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.

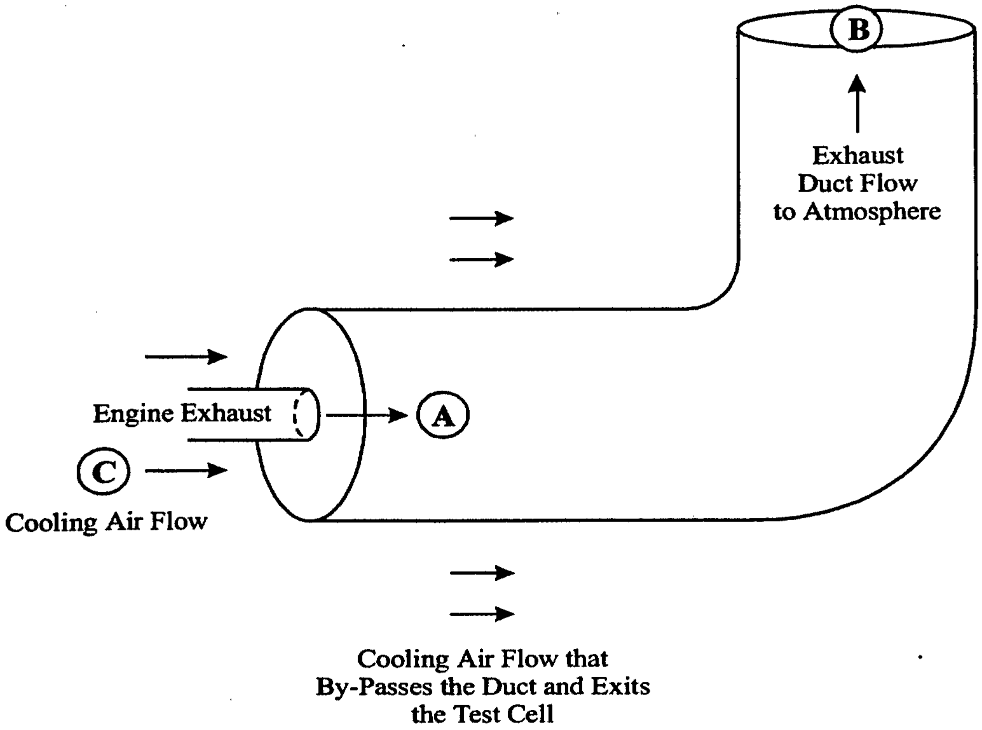

Figure 4-1. Calculation of Dilution/Cooling Air Flow

OXYGEN MASS BALANCE EXAMPLE

MEASURED TEST CELL EXHAUST CONDITIONS

FLOW	16108.74 ACFM
	10526.32 WSCFM
	10000 DSCFM
TEMPERATURE	350 oF
MOISTURE	5 %
PRESSURE	1 IN H2O
	0.073529 IN Hg
BAROMETRIC	29.92 IN Hg
STACK PRESSURE	29.99353 IN Hg

	%	ppm	g/MOLE	SV SCF/LB
CO2	1.20		44.009	8.76
O2	15.00		31.998	12.05
N2	83.80		28.014	13.77
CO	0.0005	500	28.01	13.77
SO2	0.0001	100	64.062	6.02
NO2	0.0004	400	46.005	8.38
THC	1.5E-06	1.5	42.081	9.17
TOTAL	100.00			
H2O	5.00		18.015	21.41

STACK MASS FLOW

Calculated based on the measurements using EPA sampling methods

SPECIES	LB/MIN	SCFM	% WET	% DRY
CO2	13.692	120.000	1.140	1.200
O2	124.441	1500.000	14.250	15.000
N2	608.644	8379.900	79.609	83.799
CO	0.004	0.050	0.000	0.001
SO2	0.002	0.010	0.000	0.000
NO2	0.005	0.040	0.000	0.000
THC	0.000	0.000	0.000	0.000
TOTAL DRY	746.787	10000.000		100.000
H2O	24.58271	526.316	5.000	
TOTAL WET	771.369	10526.316	100.000	

CALCULATED INDUCED COOLING AIR VOLUME

The mass of oxygen is calculated using the "Goal Seek" function in Excel to set the oxygen content at the engine exhaust to the target oxygen that was measured at the engine exhaust tip.

SPECIES	LB/MIN	SCFM	% DRY	% WET
O2	25.166	303.347	20.890	20.638
N2	83.437	1148.771	79.110	78.154
TOTAL DRY	108.603	1452.118	100.000	
H2O	0.830	17.760		1.208
TOTAL WET	109.432	1469.878		100.000

PERCENT STACK FLOW	13.96	%
AMBIENT TEMPERATURE	70	oF
SATURATION MOISTURE	0.022	LB/LB DA
RELATIVE HUMIDITY	35	%
ACTUAL MOISTURE	0.008	LB/LB DA

CONDITIONS AT ENGINE EXHAUST TIP

SPECIES	LB/MIN	SCFM	% WET	% DRY	TARGET O2	
CO2	13.692	120.000	1.325	1.404		
O2	99.275	1196.653	13.213	13.999	14	Mesured value
N2	525.207	7231.129	79.845	84.596		
CO	0.004	0.050	0.001	0.001		
SO2	0.002	0.010	0.000	0.000		
NO2	0.005	0.040	0.000	0.000		
THC	0.000	0.000	0.000	0.000		
TOTAL DRY	638.184	8547.882		100.000		
H2O	23.753	508.556	5.615			
TOTAL WET	661.937	9056.438	100.000			

SECTION 5

RESULTS

PT6A-68 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. Two PT6A-68 engines were tested independently on a test stand in a test cell at the Pratt & Whitney Facility in Montreal, Canada. Sampling was performed at the test cell exhaust for nitrogen oxides (NO_X), carbon monoxide (CO), carbon dioxide (CO_2), total non-methane hydrocarbons (TNMHC), particulate matter (PM), particle size characterization, aldehyde and ketones, polynuclear aromatic hydrocarbons, and volatile organic compounds. In addition, measurements were made directly behind the engine at the exhaust tip for gaseous emissions, formaldehyde, and benzene. 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 (AFIERA, 2002). This procedure estimates that sulfur 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, f-factor, and oxygen balance calculations. Emission rates were not corrected for ambient pollutants due to the lack of contributing sources in the vicinity of the test facility.

5.1 GASEOUS POLLUTANTS

Gaseous emissions were collected directly at the engine tailpipe and at the test cell exhaust for each engine. 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, a series of shakedown runs were performed to note gaseous pollutant concentrations and the fluctuation with power settings. Data was collected at the ground idle, flight idle, descend, approach, climb, cruise, and max continuous power settings to note the variation of NO_X, CO, CO_2, O_2, and TNMHC.

Tables 5-1 and 5-2 and Figures 5-1 and 5-2 present the gaseous emissions data collected at various power settings during the shakedown runs.

TABLE 5-1
PT6A-68
GASEOUS EMISSION TREND SUMMARY
ENGINE A (SERIAL NUMBER RA0154)

Power Setting (%)	O_2 Dry %	CO_2 Dry %	NO_x Dry ppm	TNMHC Wet ppm (as CH_4)	CO Dry ppm
Ground Idle (2.4)	16.91	2.35	18.9	610	1367
Flight Idle (3.6)	17.04	2.31	18.7	481	1086
Descend (22)	17.84	2.48	28.5	40.6	292
Approach (53)	16.27	3.62	67	7.6	160
Climb (89)	15.65	4.07	75.4	7.3	77.9
Cruise (94)	15.54	4.16	78.7	(A)	73.1
Max. Continuous (100)	15.51	4.18	79.9	4.1	67.2

[a] Sample line was contaminated with fuel during cruise setting resulting in biased TNMHC data.
Note: Samples collected at engine exhaust.

TABLE 5-2
PT6A-68
GASEOUS EMISSION TREND SUMMARY
ENGINE B (SERIAL No. RA0156)

Power Setting (%)	O_2 Dry %	CO_2 Dry %	NO_x Dry ppm	TNMHC Wet ppm (as CH_4)	CO Dry ppm
Ground Idle (2.4)	16.7	2.75	17.2	664	1334
Flight Idle (3.6)	16.8	2.78	21.8	504	1040
Descend (22)	16.4	3.02	45.7	96	367
Approach (53)	15.9	3.43	66.7	24	134
Climb (89)	15.2	3.88	88.4	10.9	49.7
Cruise (94)	15.2	3.92	89.0	6.1	48.1
Max. Continuous (100)	15.3	3.94	90.3	4.5	42.0

Tables 5-3 through 5-6 contain the gaseous emission summary for the emission samples collected at the engine tailpipe and at the test cell exhaust stacks. As can be seen in Table 5-7, the CO, TNMHC, and CO_2 emission rates compare well, while the NO_X data tended to be higher directly behind the engine at the lower engine settings. 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 test cell exhaust and little NO_2. The NO_X variation decreases as power increases. At the lower settings, the NO_X emission factor was approximately 0.9 lb/1000 lb fuel at the test cell exhaust stack and approximately 2.8 lb/1000 lbs fuel at the engine tailpipe.

The comparison of emission factors between each engine is very similar. The same NO_X trend exists between each engine. At the lower power settings, the NO_X was higher at the engine than at the test cell exhaust. At ground idle and flight idle, the TNMHC emissions were calculated higher at the stack than at the engine. For engine A, the TNMHC was 52.2 lbs/1000 lbs fuel at the test cell exhaust and 31.2 lbs/1000 lb fuel at the engine tailpipe. As the power increased, the emission rates were comparable. The difference in hydrocarbon emissions can be attributed to fuel misting

Figure 5-1
PT6A-68 Emission Trend
Engine A - Serial No. RA0154
Gaseous Pollutants vs. Power Setting

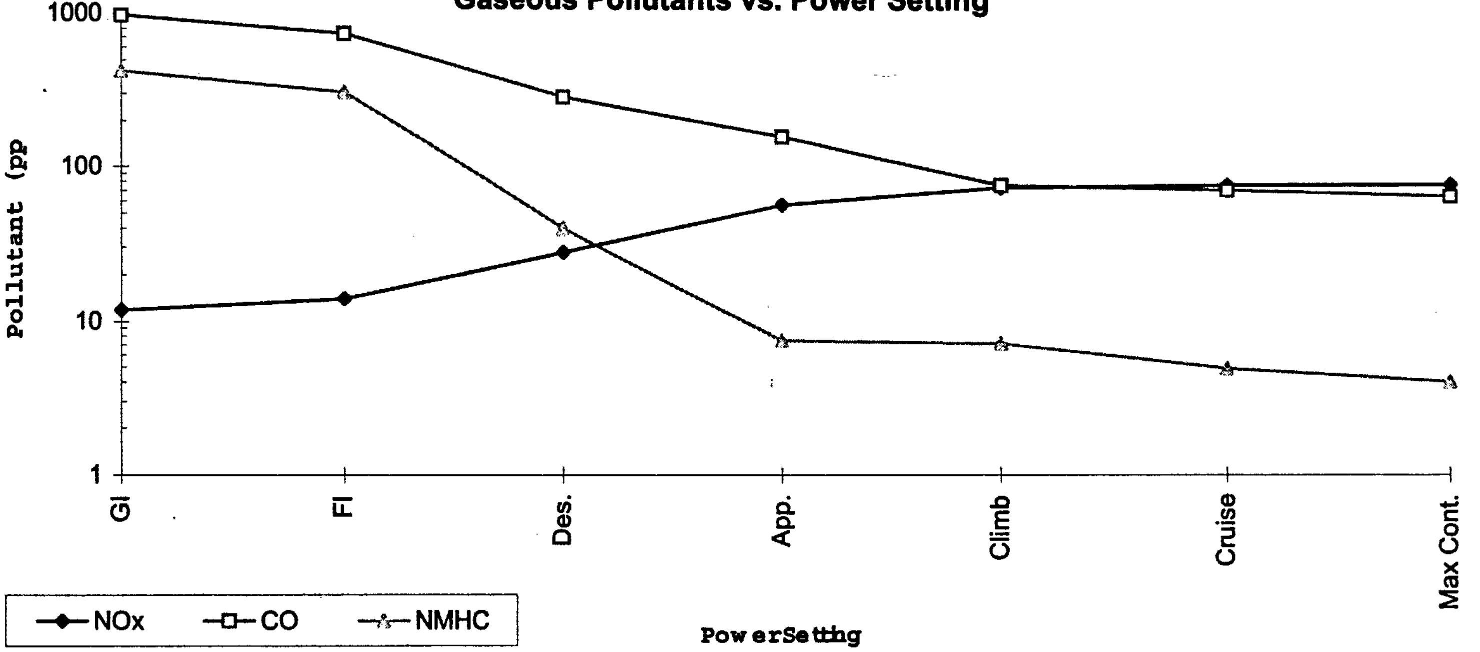

Figure 5-2
PT6A-68 Emission Trend
Engine B - Serial No. RA0156
Gaseous Pollutants vs. Power Setting

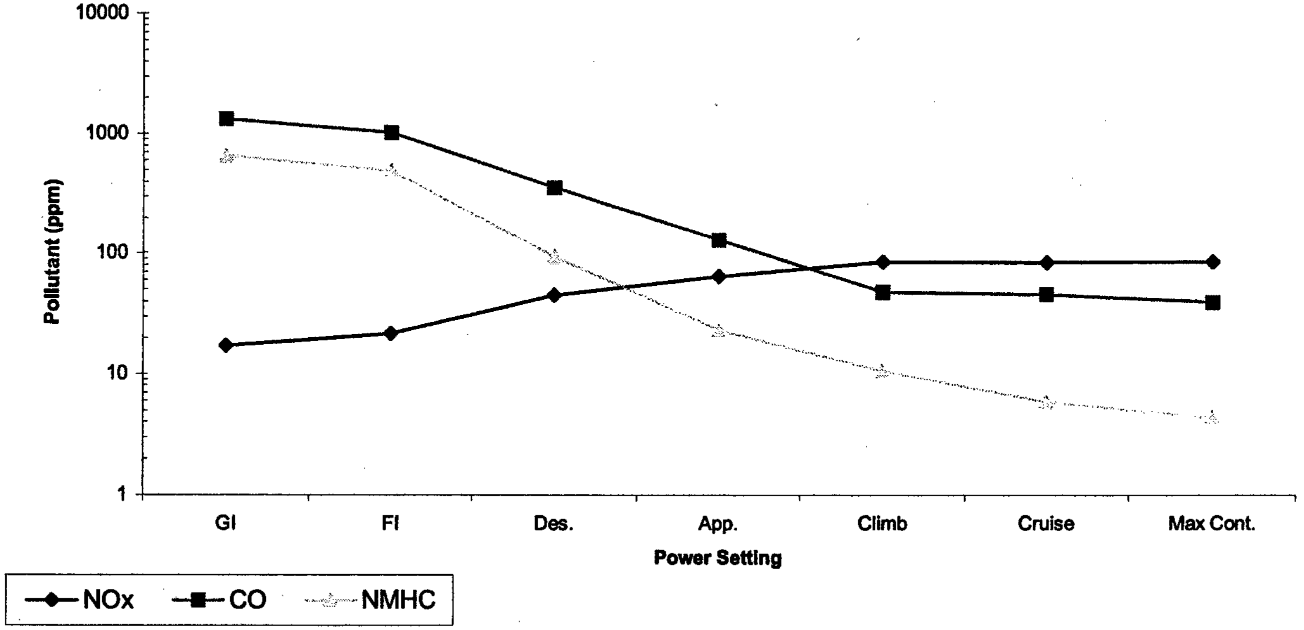

TABLE 5-3
PT6A-68
ENGINE EXHAUST
EMISSION FACTOR SUMMARY
Engine A – Serial No. RA0154

	Ground Idle			Flight Idle			Approach			Max. Continuous		
Flow Rate dscfm	3,185			3,867			7,149			7,583		
Fuel Flow lbs/hr	155			179			448			612		
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)	18.9	0.3	2.78	18.7	0.4	2.90	67.2	2.5	7.69	93.3	5.1	8.3
Carbon Monoxide (CO)	1366.9	14.5	122.51	1086.1	13.3	102.33	157.3	3.5	10.94	56.9	1.9	3.1
TNMHC (as CH4)	609.5	3.7	31.21	481.3	3.4	25.90	3.7	0.1	0.15	2.0	0.0	0.1
Carbon Dioxide (CO2)	29000	632.9	4403.21	28000	821.2	4587.97	36000	1763.4	3936.18	40000	2078.3	3395.90

TABLE 5-4
PT6A-68
TEST CELL EXHAUST STACK
EMISSION FACTOR SUMMARY
Engine A – Serial No. RA0154

	Ground Idle			Flight Idle			Approach			Max. Continuous		
Flow Rate dscfm	14,436			16,727			30,833			37,728		
Fuel Flow lbs/hr	155			179			448			612		
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)	1.3	0.1	0.87	1.4	0.2	0.93	3.7	0.1	4.87	19.1	5.2	8.44
Carbon Monoxide (CO)	334.0	21.0	135.67	252.8	18.5	103.06	37.3	5.0	11.19	16.3	2.7	4.75
TNMHC (as CH4)	224.8	8.1	52.17	129.1	5.4	30.07	1.9	0.1	0.32	0.5	0.1	0.07
Carbon Dioxide (CO2)	7000	692.4	4467.02	6800	779.3	4353.90	7800	1647.8	3678.22	10400	2688.5	4392.89
Particulate Matter (PM)	-	-	3.95	-	-	NA	-	-	3.35	-	-	3.78

PM sampling not performed at flight idle.

TABLE 5-5
PT6A-68
ENGINE EXHAUST
EMISSION FACTOR SUMMARY
Engine B – Serial No. RA0156

	Ground Idle			Flight Idle			Descend			Approach			Max. Continuous		
Flow Rate dscfm	3,165			3,870			6,416			7,140			7,573		
Fuel Flow lbs/hr	155			179			328			448			624		
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	ppmvd	lbs/hr	lbs/ 1000 lbs fuel
Nitrogen Oxides (NOx)	21.0	0.5	3.07	21.8	0.6	3.39	47.0	2.2	6.59	68.2	3.5	7.79	92.0	5.0	8.00
Carbon Monoxide (CO)	1359.1	18.8	121.04	1056.5	17.8	99.56	123.9	3.5	10.57	154.5	4.8	10.74	57.5	1.9	3.84
TNMHC (as CH4)	637.1	5.0	32.41	505.9	4.9	27.23	51.1	0.8	2.47	2.7	0.1	0.11	2.0	0.0	0.08
Carbon Dioxide (CO2)	30000	650.6	4197.28	29000	769.0	4295.97	33000	1450.7	4422.92	36000	1761.2	3931.22	40000	2075.5	3326.20

TABLE 5-6
PT6A-68
TEST CELL EXHAUST STACK
EMISSION FACTOR SUMMARY
Engine B – Serial No. RA0156

	Ground Idle			Flight Idle			Descend			Approach			Max. Continuous		
Flow Rate dscfm	14,436			16,647			26,967			30,833			36,649		
Fuel Flow lbs/hr	155			179			328			448			624		
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	ppmvd	lbs/hr	lbs/ 1000 lbs fuel
Nitrogen Oxides (NOx)	2.4	0.2	1.58	1.7	0.2	1.11	5.9	1.1	3.46	10.9	2.4	5.39	17.9	4.7	7.53
Carbon Monoxide (CO)	300.9	19.0	122.24	256.0	18.6	103.82	98.3	11.6	35.24	46.5	6.3	13.96	18.6	3.0	4.75
TNMHC (as CH4)	177.4	6.4	41.16	139.0	5.8	32.21	16.6	1.1	3.40	1.3	0.1	0.23	0.5	0.1	0.07
Carbon Dioxide (CO2)	6900	682.5	4403.21	7200	821.2	4587.97	8300	1552.1	4731.98	8800	1859.1	4149.78	11000	2762.2	4426.65
Particulate Matter (PM)	-	-	NA	-	-	4.18	-	-	3.35	-	-	NA	-	-	3.80

PM sampling not performed at ground idle or approach.

TABLE 5-7
PT6A-68
ENGINE A VS. ENGINE B
EMISSION FACTOR COMPARISON

Pollutant	Engine	Location	Ground Idle	Flight Idle	Descend	Approach	Max Continuous
Exhaust Flow Rate, dscfm	A	Engine	3185	3867		7149	7583
	A	Stack	14436	16727		30833	37728
NOx, lb/1000 lb fuel	A	Engine	2.78	2.90		7.69	8.29
	A	Stack	0.87	0.93		4.87	8.44
CO, lb/1000 lb fuel	A	Engine	122.51	102.33		10.94	3.04
	A	Stack	135.67	103.06		11.19	4.75
TNMHC, lb/1000 lb fuel	A	Engine	31.21	25.90		0.15	0.06
	A	Stack	52.17	30.07		0.32	0.07
CO_2, %	A	Engine	2.91	2.75		3.57	4.01
	A	Stack	0.70	0.68		0.78	1.04
O_2, %	A	Engine	16.91	17.04		16.19	15.78
	A	Stack	20.23	20.24		20.11	19.65
Fuel Flow, lb/hr	A	N/A	155	179		448	612
Exhaust Flow Rate, dscfm	B	Engine	3165	3870	6416	7140	7573
	B	Stack	14436	16647	26967	30833	36649
NOx, lb/1000 lb fuel	B	Engine	3.07	3.39	6.59	7.79	8.00
	B	Stack	1.58	1.11	3.46	5.39	7.53
CO, lb/1000 lb fuel	B	Engine	121.04	99.56	10.57	10.74	3.84
	B	Stack	122.24	103.82	35.24	13.96	4.75
TNMHC, lb/1000 lb fuel	B	Engine	32.41	27.23	2.47	0.11	0.08
	B	Stack	41.16	32.21	3.40	0.23	0.07
CO_2, %	B	Engine	2.99	2.92	3.32	3.63	4.05
	B	Stack	0.69	0.72	0.84	0.88	1.10
O_2, %	B	Engine	16.94	16.94	16.51	16.19	15.61
	B	Stack	20.02	19.97	19.85	19.80	19.52
Fuel Flow, lb/hr	B	N/A	155	179	328	448	624

1) All Stack flows measured using EPA Methods 1-4.

2) All Engine flows based upon Oxygen Balance calculations except for the Max Continuous data, which is based upon F-factor calculation.

3) "Engine" indicates measurements made directly at the engine tailpipe. "Stack" indicates measurements made at the test cell exhaust stacks.

Engine A - Serial No. RA0154

Engine B - Serial No. RA0156

at the engine exhaust and vaporizing in the test cell exhaust stack. The measured concentration at the engine exhaust may have been biased low. The atomized fuel evaporated in the test cell exhaust stack and was measured as TNMHC at the test cell exhaust.

At the test cell exhaust stack and engine exhaust, the NO_X concentrations were relatively low, approximately 2 to 20 ppm. Slight variations in the concentrations impacted the engine emission factor. For example, the NO_X concentration at the test cell exhaust at ground idle was approximately 2 ppm. If the concentration increased to 4 ppm, which is within the EPA method allowable variance, the emission factor would increase to 1.6 lbs/1000 lbs fuel which is comparable to the 2.8 lbs/1000 lbs fuel measured at the test cell exhaust stack. Therefore, the difference between the test cell exhaust and engine exhaust would be minimal.

Table 5-8 contains a comparison of the historic emission test results obtained by Pratt & Whitney and a summary of the data collected during this program. The summary of the data collected during this program represents an average of the test results for both engines at the engine tailpipe and test cell exhaust stacks. The data are very comparable between the two data sets. The CO data collected by EQ at the approach flight setting was higher than the Pratt & Whitney data set. The difference could be attributed to the variance in fuel rates at the setting.

5.2 VOLATILE ORGANIC COMPOUNDS

Speciation of volatile organic compounds was performed at the test cell exhaust for each engine and each engine setting. The highest emission rate of volatiles was at the ground idle and flight idle setting. This has been the typical trend in historic engine emission testing. Due to the inefficiencies in engine operation at the lower power settings, unburned hydrocarbons tend to be present in the exhaust stream resulting in higher organic emissions. The VOC HAP total at ground idle was 0.93 lb/1000 lbs fuel for engine A and 1.32 lb/1000 lbs fuel at flight idle for engine B. 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

TABLE 5-8
PT6A-68 EMISSION FACTOR COMPARISON
EQ PROGRAM VS. PRATT & WHITNEY PROGRAM

Flight Setting	Ground Idle	Flight Idle		Descend		Approach		Max. Continuous	
Fuel Flow, lbs/hr	155	179	191	328	334	448	587	618	651
Test Group	EQ	EQ	P&W	EQ	P&W	EQ	P&W	EQ	P&W
Pollutant									
NO_x	2.08	2.08	2.70	3.46	4.40	6.43	6.40	8.07	8.80
CO	125.37	102.19	73.40	22.91	23.70	11.71	6.90	4.09	5.20
TNMHC	39.24	28.85	25.20	2.94	4.20	0.20	0.30	0.07	0.20

EQ data represents the average of both engines tested.

Pratt & Whitney data was obtained from https: www.afms.mil\afiera\ead_div.htm in the exhaust stream. A summary of the volatile emissions is provided in Tables 5-9 through 5-14.

5.2.1 Speciated Pollutant Comparison

Samples for benzene and formaldehyde were collected at the tailpipe exhaust and at the test cell exhaust to note the variation in emissions at the various settings. For engine A, the benzene emissions determined directly behind the engine are summarized in Table 5-15. These data were very similar to the benzene emissions measured at the test cell exhaust which are also shown in Table 5-15. At ground idle, the emission factor for benzene behind the engine was 0.55 lb/1000 lbs fuel and 0.28 lb/1000 lbs fuel at the test cell exhaust. At the approach engine setting, the benzene emission factor was 0.012 lb/1000 lbs fuel at the engine and 0.014 lb/1000 lbs fuel at the test cell exhaust. This was the same trend for max continuous. For engine B, the benzene emissions followed a similar trend between the engine and the test cell exhaust. Formaldehyde samples collected at each setting behind each engine were compared to the formaldehyde data collected at the test cell exhaust. These data are presented in Table 5-15. The formaldehyde data collected behind each engine was not comparable to the formaldehyde emissions measured at the test cell exhaust. The formaldehyde data at the engine was at least an order of magnitude lower than the emission factor at the test cell exhaust. A different test method will be used in the future for measurement behind the engine.

5.3 ALDEHYDE AND KETONES

Aldehyde and ketone data were collected at the test cell exhaust for the ground idle, approach, and max continuous settings for engine A and flight idle, and descend and max continuous for engine B. These data are summarized in Tables 5-16 and 5-17. The emission rates were highest at the ground idle and flight idle, which is consistent with the data trends seen in this program. Formaldehyde was the pollutant emitted in the highest quantity at 4.80 lbs/1000 lbs fuel at ground idle and 5.27 lbs/1000 lbs fuel at flight idle. As the engine moved to the higher engine settings, the emissions

TABLE 5-9
PT6A-68
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
GROUND IDLE (ENGINE A – SERIAL No. RA0154)

		Run Number													
		1(A)				2				3					
Flow Rate, dscfm		14,128				13,862				13,908					
Fuel Flow, lbs/hr		155				155				155				Average	
		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	2.40E-05		1.55E-04			4.40E-07		2.84E-06		1.39E-03		8.97E-03	4.72E-04	3.04E-03
Bromomethane*	74-83-9		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Chloroethane*	75-00-3		2.18E-05		1.41E-04		3.14E-05		2.03E-04		1.39E-03		8.97E-03	4.81E-04	3.10E-03
Freon 11 (Trichlorofluoromethane)	75-69-4		2.18E-05		1.41E-04	3.92E-05		2.53E-04			1.39E-03		8.97E-03	4.84E-04	3.12E-03
1,1-Dichloroethane*	75-34-3		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Carbon Disulfide*	75-15-0		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Acetone	67-64-1		1.09E-04		7.04E-04	5.49E-03		3.54E-02			6.96E-03		4.49E-02	4.19E-03	2.70E-02
Methylene Chloride*	75-09-2		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
trans-1,2-Dichloroethene	156-60-5		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
1,1-Dichloroethene*	75-35-4		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Vinyl Acetate*	108-05-4		1.09E-04		7.04E-04		1.31E-04		8.44E-04	6.96E-03		4.49E-02		2.40E-03	1.55E-02
cis-1,2-Dichloroethene*	156-59-2		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3		1.09E-04		7.04E-04	2.59E-03		1.67E-02			6.95E-03		4.49E-02	3.22E-03	2.08E-02
Chloroform*	67-66-3		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
1,1,1-Trichloroethane*	71-55-6		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Carbon Tetrachloride*	56-23-5		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Benzene*	71-43-2		2.18E-05		1.41E-04	2.38E-02		1.54E-01			1.08E-01		6.94E-01	4.38E-01	2.83E-01
1,2-Dichloroethane*	107-06-2		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Bromodichloromethane	75-27-4		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
4-Methyl-2-pentanone*	108-10-1		1.09E-04		7.04E-04		1.31E-04		8.44E-04	6.96E-03		4.49E-02		2.40E-03	1.55E-02
Toluene*	108-88-3		2.18E-05		1.41E-04	2.62E-02		1.69E-01		5.07E-02		3.27E-01		2.56E-02	1.65E-01
1,1,2-Trichloroethane*	79-00-5		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Tetrachloroethene*	127-18-4		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
2-Hexanone	591-78-6		1.09E-04		7.04E-04		1.31E-04		8.44E-04	6.96E-03		4.49E-02		2.40E-03	1.55E-02
Dibromochloromethane	124-48-1		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Chlorobenzene*	108-90-7		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
~ Ethyl Benzene*	100-41-4		2.18E-05		1.41E-04	1.15E-02		7.43E-02		1.06E-02		6.84E-02		7.38E-03	4.78E-02
m,p-Xylene*	108-38-3		2.18E-05		1.41E-04	2.41E-02		1.55E-01		2.85E-02		1.84E-01		1.75E-02	1.13E-01
o-Xylene*	95-47-6		2.18E-05		1.41E-04	1.36E-02		8.78E-02		1.42E-02		9.16E-02		9.28E-03	5.98E-02
Styrene*	100-42-5		2.18E-05		1.41E-04	1.28E-02		8.27E-02		8.94E-03		5.77E-02		7.26E-03	4.68E-02
Bromoform*	75-25-2		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
1,3-Butadiene*	106-99-0		1.09E-04		7.04E-04		1.31E-04		8.44E-04	6.92E-02		4.46E-01		2.31E-02	1.49E-01
1,2-Dichloropropane	78-87-5		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND
Trichloroethene	79-01-6		2.18E-05		1.41E-04		2.62E-05		1.69E-04		1.39E-03		8.97E-03	ND	ND

* Hazardous air pollutant (HAP)
(A) Run 1 was voided due to poor laboratory response.

TABLE 5-10
PT6A-68
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
APPROACH (ENGINE A – SERIAL No. RA0154)

		Run Number													
		1				2				3					
Flow Rate, dscfm		28,664				31,042				31,230					
Fuel Flow, lbs/hr		453				453				453				Average	
		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	1.28E-04		2.82E-04		4.40E-07		9.71E-07			7.13E-05		1.57E-04	6.65E-05	1.47E-04
Bromomethane*	74-83-9		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Chloroethane*	75-00-3		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Freon 11 (Trichlorofluoromethane)	75-69-4	6.97E-05		1.54E-04		8.13E-05		1.80E-04		7.84E-05		1.73E-04		7.65E-05	1.69E-04
1,1-Dichloroethane*	75-34-3		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Carbon Disulfide*	75-15-0		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Acetone	67-64-1	3.60E-04		7.95E-04		6.73E-04		1.48E-03		6.84E-04		1.51E-03		5.72E-04	1.26E-03
Methylene Chloride*	75-09-2	1.12E-04		2.48E-04		1.18E-04		2.61E-04		2.35E-04		5.19E-04		1.55E-04	3.43E-04
trans-1,2-Dichloroethene	156-60-5		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
1,1-Dichloroethene*	75-35-4		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Vinyl Acetate*	108-05-4		1.94E-04		4.28E-04		3.70E-04		8.16E-04		3.56E-04		7.87E-04	ND	ND
cis-1,2-Dichloroethene*	156-59-2		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3		1.94E-04		4.28E-04		3.70E-04		8.16E-04		3.56E-04		7.87E-04	ND	ND
Chloroform*	67-66-3		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
1,1,1-Trichloroethane*	71-55-6		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Carbon Tetrachloride*	56-23-5		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Benzene*	71-43-2	6.82E-03		1.51E-02		6.65E-03		1.47E-02		5.99E-03		1.32E-02		6.49E-03	1.43E-02
1,2-Dichloroethane*	107-06-2		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Bromodichloromethane	75-27-4		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
4-Methyl-2-pentanone*	108-10-1		1.94E-04		4.28E-04		3.70E-04		8.16E-04		3.56E-04		7.87E-04	ND	ND
Toluene*	108-88-3	1.33E-03		2.94E-03		1.33E-03		2.94E-03		5.63E-04		1.24E-03		1.08E-03	2.37E-03
1,1,2-Trichloroethane*	79-00-5		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Tetrachloroethene*	127-18-4		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
2-Hexanone	591-78-6		1.94E-04		4.28E-04		3.70E-04		8.16E-04		3.56E-04		7.87E-04	ND	ND
Dibromochloromethane	124-48-1		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Chlorobenzene*	108-90-7		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Ethyl Benzene*	100-41-4	1.08E-04		2.39E-04		1.40E-04		3.10E-04			7.13E-05		1.57E-04	1.07E-04	2.36E-04
m,p-Xylene*	108-38-3	3.45E-04		7.61E-04		4.36E-04		9.63E-04			7.13E-05		1.57E-04	2.84E-04	6.27E-04
o-Xylene*	95-47-6	1.47E-04		3.25E-04		1.70E-04		3.75E-04			7.13E-05		1.57E-05	1.30E-04	2.86E-04
Styrene*	100-42-5		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Bromoform*	75-25-2		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
1,3-Butadiene*	106-99-0		1.94E-04		4.28E-04		3.70E-04		8.16E-04		3.56E-04		7.87E-04	ND	ND
1,2-Dichloropropane	78-87-5		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND
Trichloroethene	79-01-6		3.87E-05		8.55E-05		7.39E-05		1.63E-03		7.13E-05		1.57E-04	ND	ND

* Hazardous air pollutant (HAP)

TABLE 5-11
PT6A-68
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
MAX. CONTINUOUS (ENGINE A – SERIAL No. RA0154)

		Run Number													
		1				2				3					
Flow Rate, dscfm		36,812				36,384				37,792					
Fuel Flow, lbs/hr		612				612				612				Average	
Analyte	CAS number	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
		Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit		
Chloromethane*	74-87-3	3.44E-04		5.61E-04		4.40E-07		7.19E-07		8.96E-05		1.46E-04		1.45E-04	2.36E-04
Bromomethane*	74-83-9	1.10E-04		1.80E-04		7.72E-05		1.26E-04		7.46E-05		1.22E-04		8.74E-05	1.43E-04
Chloroethane*	75-00-3		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Freon 11 (Trichlorofluoromethane)	75-69-4		6.13E-05		1.00E-04	6.53E-05		1.07E-04		1.12E-04		1.83E-04		7.96E-05	1.30E-04
1,1-Dichloroethane*	75-34-3		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Carbon Disulfide*	75-15-0		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Acetone	67-64-1	1.16E-03		1.89E-03		3.80E-04		6.21E-04		3.81E-04		6.22E-04		6.40E-04	1.05E-03
Methylene Chloride*	75-09-2		6.13E-05		1.00E-04		5.94E-05		9.70E-05	8.96E-05		1.46E-04		7.01E-05	1.15E-04
trans-1,2-Dichloroethene	156-60-5		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
1,1-Dichloroethene*	75-35-4		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Vinyl Acetate*	108-05-4		3.07E-04		5.01E-04		2.97E-04		4.85E-04		2.69E-04		6.10E-04	ND	ND
cis-1,2-Dichloroethene*	156-59-2		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3		3.07E-04		5.01E-04		2.97E-04		4.85E-04		2.69E-04		6.10E-04	ND	ND
Chloroform*	67-66-3		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
1,1,1-Trichloroethane*	71-55-6		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Carbon Tetrachloride*	56-23-5		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Benzene*	71-43-2	3.13E-04		5.11E-04		2.85E-04		4.66E-04		2.91E-04		4.76E-04		2.96E-04	4.84E-04
1,2-Dichloroethane*	107-06-2		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Bromodichloromethane	75-27-4		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
4-Methyl-2-pentanone*	108-10-1		3.07E-04		5.01E-04		2.97E-04		4.85E-04		2.69E-04		6.10E-04	ND	ND
Toluene*	108-88-3	3.19E-04		5.21E-04		2.14E-04		3.49E-04		2.54E-04		4.15E-04		2.62E-04	4.28E-04
1,1,2-Trichloroethane*	79-00-5		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Tetrachloroethene*	127-18-4		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
2-Hexanone	591-78-6		3.07E-04		5.01E-04		2.97E-04		4.85E-04		2.69E-04		6.10E-04	ND	ND
Dibromochloromethane	124-48-1		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Chlorobenzene*	108-90-7		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Ethyl Benzene*	100-41-4	7.36E-05		1.20E-04		6.53E-05		1.07E-04			7.46E-05		1.22E-04	7.12E-05	1.16E-04
m,p-Xylene*	108-38-3	2.94E-04		4.81E-04		2.73E-04		4.46E-04		2.69E-04		4.39E-04		2.79E-04	4.55E-04
o-Xylene*	95-47-6	1.10E-04		1.80E-04		9.50E-05		1.56E-04		8.96E-05		1.46E-04		9.83E-05	1.61E-04
Styrene*	100-42-5		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Bromoform*	75-25-2		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
1,3-Butadiene*	106-99-0		3.07E-04		5.01E-04		2.97E-04		4.85E-04		2.69E-04		6.10E-04	ND	ND
1,2-Dichloropropane	78-87-5		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND
Trichloroethene	79-01-6		6.13E-05		1.00E-04		5.94E-05		9.70E-05		7.46E-05		1.22E-04	ND	ND

* Hazardous air pollutant (HAP)

TABLE 5-12
PT6A-68
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
FLIGHT IDLE (ENGINE B – SERIAL No. RA0156)

		Run Number													
		1				2				3					
Flow Rate, dscfm		16,686				16,464				16,050					
Fuel Flow, lbs/hr														Average	
		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		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Bromomethane*	74-83-9		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Chloroethane*	75-00-3		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Freon 11 (Trichlorofluoromethane)	75-69-4		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
1,1-Dichloroethane*	75-34-3		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Carbon Disulfide*	75-15-0		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Acetone	67-64-1		8.82E-03		4.90E-02		6.22E-03		3.46E-02		5.82E-03		3.23E-02	ND	ND
Methylene Chloride*	75-09-2		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
trans-1,2-Dichloroethene	156-60-5		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
1,1-Dichloroethene*	75-35-4		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Vinyl Acetate*	108-05-4		8.82E-03		4.90E-02		6.22E-03		3.46E-02		5.82E-03		3.23E-02	ND	ND
cis-1,2-Dichloroethene*	156-59-2		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3		8.82E-03		4.90E-02		6.22E-03		3.46E-02		5.82E-03		3.23E-02	ND	ND
Chloroform*	67-66-3		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
1,1,1-Trichloroethane*	71-55-6		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Carbon Tetrachloride*	56-23-5		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Benzene*	71-43-2	9.91E-02		5.50E-01		9.96E-02		5.53E-01		8.30E-02		4.61E-01		9.39E-02	5.21E-01
1,2-Dichloroethane*	107-06-2		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Bromodichloromethane	75-27-4		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
4-Methyl-2-pentanone*	108-10-1		8.82E-03		4.90E-02		6.22E-03		3.46E-02		5.82E-03		3.23E-02	ND	ND
Toluene*	108-88-3	4.81E-02		2.67E-01		4.69E-02		2.60E-01		3.57E-02		1.98E-01		4.36E-02	2.42E-01
1,1,2-Trichloroethane*	79-00-5		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Tetrachloroethene*	127-18-4		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
2-Hexanone	591-78-6		8.82E-03		4.90E-02		6.22E-03		3.46E-02		5.82E-03		3.23E-02	ND	ND
Dibromochloromethane	124-48-1		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Chlorobenzene*	108-90-7		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Ethyl Benzene*	100-41-4	9.58E-03		5.32E-02		9.48E-03		5.27E-02		7.64E-03		4.25E-02		8.90E-03	4.94E-02
m,p-Xylene*	108-38-3	2.50E-02		1.39E-01		2.68E-02		1.49E-01		1.89E-02		1.05E-01		2.35E-02	1.31E-01
o-Xylene*	95-47-6	1.24E-02		6.86E-01		1.38E-02		7.65E-02		9.48E-03		5.26E-02		1.19E-02	6.59E-02
Styrene*	100-42-5	9.58E-03		5.32E-02			9.48E-03		5.27E-02	6.19E-03		3.44E-02		8.42E-03	4.68E-02
Bromoform*	75-25-2		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
1,3-Butadiene*	106-99-0	3.65E-02		2.03E-01		6.84E-02		3.80E-01		3.93E-02		2.18E-01		4.81E-02	2.67E-01
1,2-Dichloropropane	78-87-5		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND
Trichloroethene	79-01-6		1.76E-03		9.80E-03		4.40E-07		2.44E-06		1.16E-03		6.47E-03	ND	ND

* Hazardous air pollutant (HAP)

TABLE 5-13
PT6A-68
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
DESCEND (ENGINE B – SERIAL No. RA0156)

		Run Number													
		1				2				3					
Flow Rate, dscfm		25,804				27,296				25,520					
Fuel Flow, lbs/hr		328				328				328				Average	
Analyte	CAS number	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
		Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit		
Chloromethane*	74-87-3	2.32E-04		7.09E-04		9.89E-04		3.01E-03			4.58E-04		1.40E-03	2.30E-04	7.02E-04
Bromomethane*	74-83-9		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Chloroethane*	75-00-3		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Freon 11 (Trichlorofluoromethane)	75-69-4		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
1,1-Dichloroethane*	75-34-3		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Carbon Disulfide*	75-15-0		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Acetone	67-64-1	2.97E-03		9.04E-03			2.44E-03		7.44E-03	3.08E-03		9.38E-03		2.83E-03	8.62E-03
Methylene Chloride*	75-09-2	1.43E-04		4.37E-04			4.88E-04		1.49E-03		4.58E-04		1.40E-03	3.63E-04	1.11E-03
trans-1,2-Dichloroethene	156-60-5		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
1,1-Dichloroethene*	75-35-4		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Vinyl Acetate*	108-05-4		2.47E-04		7.54E-04		2.44E-03		7.44E-03		2.29E-03		6.98E-03	ND	ND
cis-1,2-Dichloroethene*	156-59-2		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3	2.47E-04		7.54E-03			2.44E-03		7.44E-03		2.29E-03		6.98E-03	1.66E-03	5.06E-03
Chloroform*	67-66-3		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
1,1,1-Trichloroethane*	71-55-6		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Carbon Tetrachloride*	56-23-5		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Benzene*	71-43-2	6.92E-03		2.11E-02		3.90E-02		1.19E-01		3.78E-02		1.15E-01		2.78E-02	8.48E-02
1,2-Dichloroethane*	107-06-2		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Bromodichloromethane	75-27-4		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
4-Methyl-2-pentanone*	108-10-1		2.47E-04		7.54E-04		2.44E-03		7.44E-03		2.29E-03		6.98E-03	ND	ND
Toluene*	108-88-3	1.09E-03		3.32E-03		1.13E-02		3.46E-02		1.18E-02		3.59E-02		8.07E-03	2.46E-02
1,1,2-Trichloroethane*	79-00-5		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Tetrachloroethene*	127-18-4		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
2-Hexanone	591-78-6		2.47E-04		7.54E-04		2.44E-03		7.44E-03		2.29E-03		6.98E-03	ND	ND
Dibromochloromethane	124-48-1		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Chlorobenzene*	108-90-7		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Ethyl Benzene*	100-41-4	7.91E-05		2.41E-04		1.22E-03		3.72E-03		1.18E-03		3.59E-03		8.26E-04	2.52E-03
m,p-Xylene*	108-38-3	2.08E-04		6.33E-04		2.85E-03		8.68E-03		2.88E-03		8.78E-03		1.98E-03	6.03E-03
o-Xylene*	95-47-6	1.63E-04		4.97E-04		1.34E-03		4.07E-03		1.37E-03		4.19E-03		9.58E-04	2.92E-03
Styrene*	100-42-5	1.63E-04		4.97E-04		6.39E-04		1.95E-03		1.37E-03		4.19E-03		7.28E-04	2.21E-03
Bromoform*	75-25-2		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
1,3-Butadiene*	106-99-0	4.40E-03		1.34E-02		2.67E-03		8.15E-03		3.88E-03		1.18E-02		3.64E-03	1.11E-02
1,2-Dichloropropane	78-87-5		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND
Trichloroethene	79-01-6		4.94E-05		1.51E-04		4.88E-04		1.49E-03		4.58E-04		1.40E-03	ND	ND

* Hazardous air pollutant (HAP)

TABLE 5-14
PT6A-68
EMISSION FACTOR SUMMARY
VOLATILE ORGANIC COMPOUNDS (VOCs)
MAX CONTINUOUS (ENGINE B – SERIAL No. RA0156)

		Run Number													
		1				2				3					
Flow Rate, dscfm		35,684				37,516				35,850					
Fuel Flow, lbs/hr		611				611				611				Average	
		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	1.39E-03		2.28E-03		1.30E-04		2.13E-04		1.43E-04		2.34E-04		5.56E-04	9.10E-04
Bromomethane*	74-83-9	1.58E-04		2.59E-04			7.20E-05		1.18E-04	1.05E-04		1.72E-04		1.12E-04	1.83E-04
Chloroethane*	75-00-3		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Freon 11 (Trichlorofluoromethane)	75-69-4	9.30E-05		1.52E-05		8.64E-05		1.41E-04		1.05E-04		1.72E-04		9.49E-05	1.55E-04
1,1-Dichloroethane*	75-34-3		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Carbon Disulfide*	75-15-0		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Acetone	67-64-1	5.58E-04		9.13E-04		5.61E-04		9.19E-04			3.76E-04		6.16E-04	4.98E-04	8.16E-04
Methylene Chloride*	75-09-2	1.58E-04		2.59E-04		1.73E-04		2.83E-04		1.50E-04		2.46E-04		1.60E-04	2.63E-04
trans-1,2-Dichloroethene	156-60-5		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
1,1-Dichloroethene*	75-35-4		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Vinyl Acetate*	108-05-4		4.65E-04		7.61E-04		3.60E-04		5.89E-04		3.76E-04		6.16E-04	ND	ND
cis-1,2-Dichloroethene*	156-59-2		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
2-Butanone (Methyl Ethyl Ketone)*	78-93-3		4.65E-04		7.61E-04		3.60E-04		5.89E-04		3.76E-04		6.16E-04	ND	ND
Chloroform*	67-66-3		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
1,1,1-Trichloroethane*	71-55-6		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Carbon Tetrachloride*	56-23-5		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Benzene*	71-43-2	1.18E-03		1.93E-03		5.25E-04		8.60E-04		5.72E-04		9.36E-04		7.59E-04	1.24E-03
1,2-Dichloroethane*	107-06-2		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Bromodichloromethane	75-27-4		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
cis-1,3-Dichloropropene*	10061-01-5		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
trans-1,3-Dichloropropene*	10061-02-6		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
4-Methyl-2-pentanone*	108-10-1		4.65E-04		7.61E-04		3.60E-04		5.89E-04		3.76E-04		6.16E-04	ND	ND
Toluene*	108-88-3	6.14E-04		1.00E-03		2.74E-04		4.48E-04		2.26E-04		3.69E-04		3.71E-04	6.07E-04
1,1,2-Trichloroethane*	79-00-5		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Tetrachloroethene*	127-18-4		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
2-Hexanone	591-78-6		4.65E-04		7.61E-04		3.60E-04		5.89E-04		3.76E-04		6.16E-04	ND	ND
Dibromochloromethane	124-48-1		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Chlorobenzene*	108-90-7		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Ethyl Benzene*	100-41-4	1.12E-04		1.83E-04			1.01E-04		1.65E-04		1.05E-04		1.72E-04	8.63E-05	1.41E-04
m,p-Xylene*	108-38-3	3.63E-04		5.94E-04		1.87E-04		3.06E-04		8.28E-05		1.35E-04		2.11E-04	3.45E-04
o-Xylene*	95-47-6	1.67E-04		2.74E-04			1.01E-04		1.65E-04		1.05E-04		1.72E-04	1.05E-04	1.72E-04
Styrene*	100-42-5		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Bromoform*	75-25-2		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
1,1,2,2-Tetrachloroethane*	79-34-5		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
1,3-Butadiene*	106-99-0		4.65E-04		7.61E-04		3.60E-04		5.89E-04		3.76E-04		6.16E-04	ND	ND
1,2-Dichloropropane	78-87-5		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND
Trichloroethene	79-01-6		1.30E-04		2.13E-04		1.01E-04		1.65E-04		1.05E-04		1.72E-04	ND	ND

* Hazardous air pollutant (HAP)

TABLE 5-15
PT6A-68 SPECIATED HAP COMPARISON
DATA PROVIDED IN LBS/1000 LBS FUEL

	Ground Idle	Flight Idle	Descend	Approach	Max. Continuous
Fuel Flow, lbs/hr	155	180	328	453	611
Pollutant/Test Location					
Benzene					
Engine A	5.50E-01	NA	NA	1.19E-02	1.81E-04
Engine B	NA	3.87E-01	1.01E-01	NA	2.86E-04
Test Cell Exhaust Stack	2.85E-01	5.21E-01	8.48E-02	1.43E-02	8.62E-04
Formaldehyde					
Engine A	1.92E-02	NA	NA	8.15E-03	1.12E-03
Engine B	NA	7.12E-02	3.10E-02	NA	1.08E-03
Test Cell Exhaust Stack	4.80E+00	5.27E+00	2.93E+00	6.73E-01	2.20E-02

NA – Not tested at this setting.

TABLE 5-16
PT6A-68 ENGINE
EMISSION FACTOR SUMMARY
ADELHYDE/KETONES
Engine A – SERIAL No. RA0154

	Ground Idle		Approach		Max. Continuous	
Flow Rate Dscfm	15,322		35,440		40,018	
Fuel Flow lbs/hr	155		453		612	
Analyte	lbs/hr	lbs/ 1000 lbs fuel	lbs/hr	lbs/ 1000 lbs fuel	lbs/hr	lbs/ 1000 lbs fuel
Formaldehyde*	7.45E-01	4.80E+00	3.05E-01	6.73E-01	1.47E-02	2.40E-02
Acetaldehyde*	4.64E-02	2.99E-01	4.71E-03	1.04E-02	1.69E-03	2.76E-03
Acrolein*	1.11E-01	7.16E-01	ND	ND	ND	ND
Propanal*	2.02E-02	1.30E-01	ND	ND	ND	ND
Crotonaldehyde	3.23E-02	2.08E-01	ND	ND	ND	ND
Isobutraldehyde / Methyl Ethyl Ketone*	1.13E-01	7.29E-01	ND	ND	ND	ND
Benzaldehyde	3.63E-02	2.34E-01	3.63E-03	8.00E-03	ND	ND
Isopentanal (Isovaleraldehyde)	ND	ND	ND	ND	ND	ND
Pentanal (Valeraldehyde)	1.49E-02	9.63E-02	ND	ND	ND	ND
o-Tolualdehyde	ND	ND	ND	ND	ND	ND
Hexanal (Hexaldehyde)	2.42E-02	1.56E-01	ND	ND	ND	ND
m, p-Tolualdehyde	2.42E-02	1.56E-01	3.26E-03.	7.20E-03	ND	ND

*-Hazardous Air Pollutant (HAP)
Run A-GI-0011 had a reporting Limit of 420ug
Run A-APP-0011 had a reporting limit of 82ug
Run A-MAX-0011 had a reporting limit of 5.7ug
Note: ND = No Detection

TABLE 5-17
PT6A-68 ENGINE
EMISSION FACTOR SUMMARY
ADLEHYDE/KETONES
Engine B – SERIAL No. RA0156

	Flight Idle		**Descend**		**Max. Continuous**	
Flow Rate Dscfm	18,136		28,560		41,486	
Fuel Flow lbs/hr	180		328		611	
Analyte	lbs/hr	lbs/ 1000 lbs fuel	lbs/hr	lbs/ 1000 lbs fuel	lbs/hr	lbs/ 1000 lbs fuel
Formaldehyde*	9.49E-01	5.27E+00	9.61E-01	2.93E+00	1.23E-02	2.00E-02
Acetaldehyde*	6.25E-02	3.47E-01	2.88E-02	8.79E-02	9.64E-04	1.58E-03
Acrolein*	1.08E-01	6.01E-01	1.66E-02	5.05E-02	ND	ND
Propanal*	1.95E-02	1.08E-01	ND	ND	ND	ND
Crotonaldehyde	3.12E-02	1.73E-01	ND	ND	ND	ND
Isobutraldehyde / Methyl Ethyl Ketone*	ND	ND	ND	ND	ND	ND
Benzaldehyde	3.12E-02	1.73E-01	1.46E-02	4.45E-02	ND	ND
Isopentanal (Isovaleraldehyde)	ND	ND	ND	ND	ND	ND
Pentanal (Valeraldehyde)	1.23E-02	6.81E-02	1.09E-02	3.34E-02	ND	ND
o-Tolualdehyde	ND	ND	ND	ND	ND	ND
Hexanal (Hexaldehyde)	ND	ND	ND	ND	ND	ND
m,p-Tolualdehyde	1.59E-02	8.81E-02	ND	ND	ND	ND

*-Hazardous Air Pollutant (HAP)
Run B-FI-0011 had a reporting limit of 490ug
Run B-D-0011 had a reporting limit of 310ug
Run B-MAX-0011 had a reporting limit of 6.9ug
Note: ND = No Detection

decreased accordingly. Formaldehyde emissions were 0.02 lb/1000 lbs fuel at max continuous. The data was very comparable between the two engines.

5.4 POLYNUCLEAR AROMATIC HYDROCARBONS

Samples for polynuclear aromatic hydrocarbons were collected at the test cell exhaust for the PT6A-68 engines. A summary of the results for each setting is provided in Tables 5-18 and 5-19. Naphthalene and 2-methylnaphthalene were detected at the flight idle and max continuous settings. All other compounds at the remaining power settings were not detected.

5.5 PARTICULATE MATTER

The total particulate emissions are presented in Tables 5-20 and 5-21. The results represent the total particulate, condensable (aqueous fraction only), and filterable exiting the test cell.

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. The sample times were reduced where possible when the particle loading was high.
- 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 particulate emission index was 3.95 lbs/1000 lbs fuel at ground idle, 3.35 lbs/1000 lbs fuel at approach, and 3.78 lbs/1000 lbs fuel at max continuous for engine A. For engine B, the particulate emission index was 4.18 lbs/1000 lbs fuel at flight idle, 3.35

TABLE 5-18
PT6A-68 ENGINE EXHAUST STACK
EMISSION FACTOR SUMMARY
POLYNUCLEAR AROMATIC HYDROCARBONS
ENGINE A (SERIAL No. RA0154)

		Ground Idle				Approach				Max. Continuous				Average	
Flow Rate, dscfm		16,160				34,288				39,760					
Fuel Flow, lbs/hr		155				453				612					
		lb/hr		lbs/1000lbs fuel		lb/hr		lbs/1000lbs fuel		lb/hr		lbs/1000lbs fuel			lbs/1000lb
Analyte	CAS Number	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	lb/hr	fuel
Naphthalene*	91-20-3		1.12E-03		7.24E-03		2.84E-03		6.28E-03	1.64E-02		2.68E-02		6.79E-03	1.34E-02
2-Methylnapthlene	91-57-6		1.12E-03		7.24E-03		2.84E-03		6.28E-03	1.45E-02		2.38E-02		6.17E-03	1.24E-02
2-Chloronapthalene	91-58-7		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Acenaphthene*	83-32-9		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Acenaphthylene*	208-96-8		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Fluorene*	86-73-7		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Phenanthrene*	85-01-8		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Anthracene*	120-12-7		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Fluoranthene*	206-44-0		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Pyrene*	129-00-0		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Chrysene*	218-01-9		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Benzo(a)anthracene*	56-55-3		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Benzo(b)fluoranthene*	205-99-2		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Benzo(k)fluoranthene*	207-08-9		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Benzo(a)pyrene*	50-32-8		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Indeno(1,2,3-c,d)pyrene*	193-3-5		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Dibenzo(a,h)anthracene*	53-70-3		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND
Benzo(g,h,I)perylene*	191-24-2		1.12E-03		7.24E-03		2.84E-03		6.28E-03		3.09E-03		5.06E-03	ND	ND

* - Hazardous Air Pollutant (HAP)

TABLE 5-19
PT6A-68 ENGINE EXHAUST STACK
EMISSION FACTOR SUMMARY
POLYNUCLEAR AROMATIC HYDROCARBONS
ENGINE B (SERIAL No. RA0156)

		Flight Idle				Descend				Max. Continuous				Average	
Flow Rate, dscfm		17,248				26,386				37,622				13,543	
Fuel Flow, lbs/hr		180				328				611				373	
		lb/hr		lbs/1000lbs fuel		lb/hr		lbs/1000lbs fuel		lb/hr		lbs/1000lbs fuel			lbs/1000lb
Analyte	CAS Number	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	Detected	Detection Limit	lb/hr	fuel
Naphthalene*	91-20-3	2.09E-03		1.16E-02			4.60E-03		1.40E-02	7.75E-02		1.27E-01		2.81E-02	5.08E-02
2-Methylnapthlene	91-57-6		1.49E-03		8.27E-03		4.60E-03		1.40E-02	9.61E-02		1.57E-01		3.41E-02	5.99E-02
2-Chloronapthalene	91-58-7		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Acenaphthene*	83-32-9		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Acenaphthylene*	208-96-8		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Fluorene*	86-73-7		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Phenanthrene*	85-01-8		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Anthracene*	120-12-7		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Fluoranthene*	206-44-0		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Pyrene*	129-00-0		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Chrysene*	218-01-9		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Benzo(a)anthracene*	56-55-3		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Benzo(b)fluoranthene*	205-99-2		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Benzo(k)fluoranthene*	207-08-9		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Benzo(a)pyrene*	50-32-8		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Indeno(1,2,3-c,d)pyrene*	193-3-5		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Dibenzo(a,h)anthracene*	53-70-3		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND
Benzo(g,h,I)perylene*	191-24-2		1.49E-03		8.27E-03		4.60E-03		1.40E-02		3.10E-03		5.07E-03	ND	ND

* - Hazardous Air Pollutant (HAP)

TABLE 5-20
ENGINE A (SERIAL No. RA0154)
PT6A-68
EMISSIONS FACTOR SUMMARY
PARTICULATE

	Run Number									
	1		2		3		Composite		Average	
	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
Ground Idle										
Flow Rate, dscfm	14,724		14,160		14,423		16,610		14,979	
Fuel Flow, lbs/hr	155		155		155		155		155	
Filterable	0.28	1.83	0.27	1.71	0.32	2.08	0.24	1.55	0.28	1.79
Condensible[A]	0.46	2.97	0.14	0.91	0.20	1.30	0.54	3.45	0.33	2.16
Total Particulate	0.74	4.80	0.41	2.62	0.52	3.38	0.78	5.00	0.61	3.95
Approach										
Flow Rate, dscfm	29,039		31,585		31,876		35,067		31,892	
Fuel Flow, lbs/hr	453		453		453		453		453	
Filterable	1.13	2.49	1.74	3.38	1.47	3.25	1.09	2.42	1.36	3.00
Condensible[A]	0.28	0.69	ND	ND	ND	ND	0.35	0.77	0.16	0.35
Total Particulate	1.41	3.12	1.74	3.83	1.47	3.25	1.44	3.18	1.52	3.35
Max. Continuous										
Flow Rate, dscfm	36,909		38,474		37,800		40,130		38,329	
Fuel Flow, lbs/hr	612		612		612		612		612	
Filterable	4.84	7.91	2.33	3.81	2.50	4.09	1.80	2.94	2.87	3.61
Condensible[A]	ND	ND	ND	ND	ND	ND	0.30	0.50	0.76	0.12
Total Particulate	4.84	7.91[B]	2.33	3.81	2.50	4.09	2.10	3.43	2.95	3.78

(A) – Aqueous fraction only. The organic condensible fraction accounted for approximately 40% of the condensible fraction at Ground Idle, 12% at Approach, and <2% at Max. Continuous.

(B) – Not included in average.

ND - Not Detected.

TABLE 5-21
ENGINE B (SERIAL No. RA0156)
PT6A-68
EMISSIONS FACTOR SUMMARY
PARTICULATE

	Run Number									
	1		2		3		Composite		Average	
	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
Flight Idle										
Flow Rate, dscfm	16,981		16,664		16,296		17,583		16,881	
Fuel Flow, lbs/hr	180		180		180		180		180	
Filterable	0.37	2.03	0.57	3.16	0.39	2.16	0.28	1.55	0.40	2.23
Condensible^A	0.36	1.98	0.36	1.99	0.32	1.78	0.37	2.08	0.35	1.96
Total Particulate	0.72	4.01	0.93	5.15	0.71	3.94	0.65	3.63	0.75	4.18
Descend										
Flow Rate, dscfm	26,452		27,948		26,500		27,896		27,199	
Fuel Flow, lbs/hr	328		328		328		328		328	
Filterable	0.73	2.23	1.90	5.80	0.68	2.08	0.52	1.60	0.64	1.97
Condensible^A	0.41	1.25	0.25	0.76	0.48	1.47	0.47	1.42	0.45	1.38
Total Particulate	1.14	3.48	2.15	6.56$^{(B)}$	1.16	3.54	0.99	3.02	1.10	3.35
Max. Continuous										
Flow Rate, dscfm	36,211		37,594		36,143		37,942		36,972	
Fuel Flow, lbs/hr	611		611		611		611		611	
Filterable	1.83	3.00	3.43	5.62	1.89	3.09	1.25	2.04	2.10	3.44
Condensible^A	0.28	0.47	ND	ND	ND	ND	0.60	0.99	0.22	0.36
Total Particulate	2.12	3.46	3.43	5.62	1.89	3.09	1.85	3.03	2.32	3.80

(A) – Aqueous fraction only. The organic condensible fraction accounted for approximately 38% at Flight Idle, <2% at Descend, and <2% at Max. Continuous.
(B) - Not included in average.
ND - Not Detected.

lbs/100 lbs fuel at descend, and 3.80 lbs/1000 lbs fuel at max. continuous. It was noted in the field that the condensable fraction had a heavy yellow discoloration at the lower engine settings as shown in Figure 5-3. It appeared that unburned fuel passed through the engine and into the exhaust stream. The organic fraction of the condensible particulate matter was approximately 40% of the total condensible fraction at ground idle and approximately 38% at flight idle. The condensible particulate matter presented contains only the aqueous fraction.

5.5.1 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 Tables 5-22 and 5-23 for each engine. 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.

With the exception of the approach samples, there is an insufficient amount of non-carbon particles upon which to perform any size distribution analyses. The vast majority (nearly 100%) of the material in all samples (except the blank) is composed of very small (less than 0.5 μm) carbon particles that are aggregated together. Some of the aggregates are consistent with aciniform carbon soot (visually like bunches of grapes). Others appear to be degraded or incompletely formed soot particles in aggregates. The individual soot particles are generally in the 20 to 30 nanometer range. The aggregates are generally greater than 0.5 micrometer. Due to the fragile nature of the aggregates, it was not possible to obtain reliable diameter ranges for the carbon particles. Different preparation methods used to redistribute the particles from the overloaded filters produced different particle size distributions.

The majority of the particulate mass collected was in the size range greater than 7.5 microns. The particles larger than 7.5 microns contributed to approximately 65% of the total mass collected.

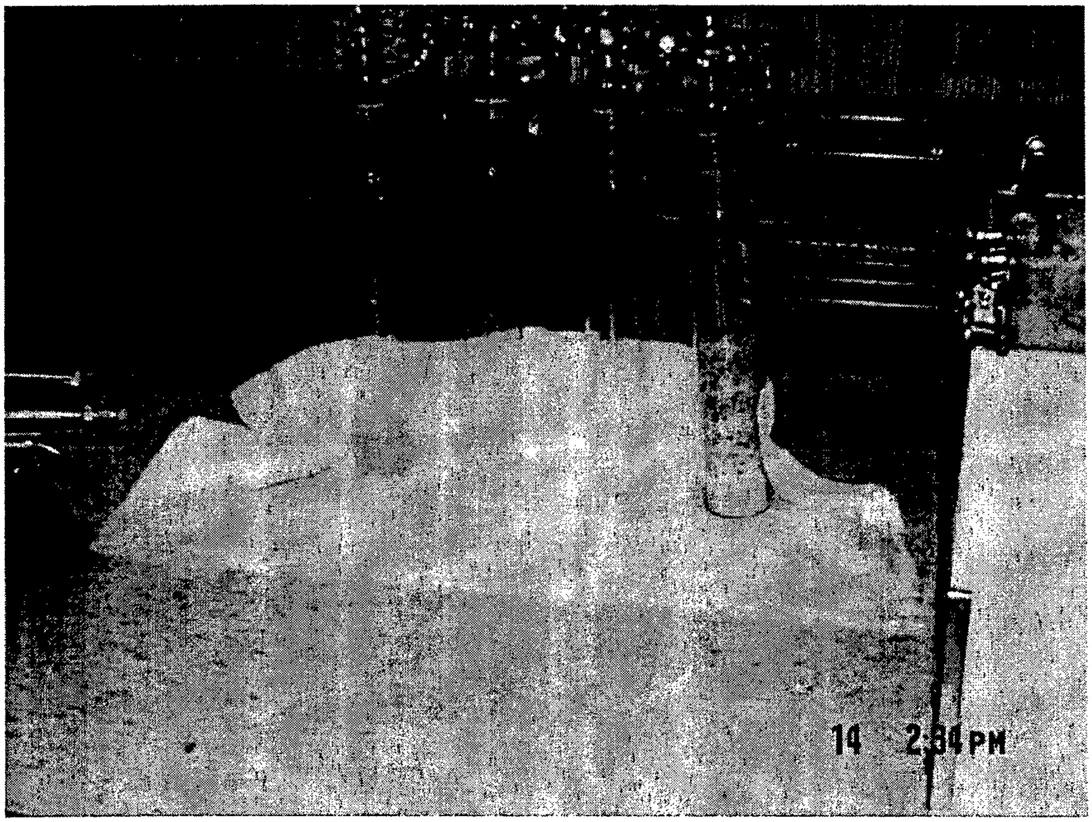

Figure 5-3. Particulate Train Impinger Solution Ground Idle Setting

Note: Discoloration in the left impinger is due to organics present in the exhaust stream.

TABLE 5-22

Percentages of Non-Carbon Particles in Various Diameter Ranges by Number of Particles

Engine A – Serial No. RA0154

	Ground Idle	Approach	Max.	Blank
Diameter Range (um)				
.5-2.5	NA*	88.8%	NA*	NA*
2.5-5.0	—	7.6%	—	—
5.0-7.5	—	1.8%	—	—
7.5-10	—	1.4%	—	—
>10	—	0.4%	—	—

*NA - Insufficient particles for a valid statistical analysis
Particles could not be counted due to conglomeration.

Percentages of Non-Carbon Particles in Various Diameter Range by Estimated Mass of Particles

Engine A – Serial No. RA0154

	Ground Idle	Approach	Max.	Blank
Diameter Range (um)				
.5-2.5	NA*	7.3%	NA*	NA*
2.5-5.0	—	12.6%	—	—
5.0-7.5	—	14.9%	—	—
7.5-10	—	48.1%	—	—
>10	—	17.1%	—	—

*NA - Insufficient particles for a valid statistical analysis

TABLE 5-23

Percentages of Non-Carbon Particles in Various Diameter Ranges by Number of Particles

Engine B – Serial No. RA0156

	Flight Idle	Descend	Max.	Blank
Diameter Range (um)				
.5-2.5	NA*	93.9%	NA*	NA*
2.5-5.0	—	5.7%	—	—
5.0-7.5	—	0.3%	—	—
7.5-10	—	0.0%	—	—
>10	—	0.1%	—	—

*NA - Insufficient particles for a valid statistical analysis
Particles could not be counted due to conglomeration.

Percentages of Non-Carbon Particles in Various Diameter Ranges by Estimated Mass of Particles

Engine B – Serial No. RA0156

	Flight Idle	Descend	Max.	Blank
Diameter Range (um)				
.5-2.5	NA*	20.4%	NA*	NA*
2.5-5.0	—	28.6%	—	—
5.0-7.5	—	8.7%	—	—
7.5-10	—	0.0%	—	—
>10	—	42.3%	—	—

*NA - Insufficient particles for a valid statistical analysis

5.6 EXHAUST FLOW DETERMINATION

The engine exhaust flow at the engine tailpipe was calculated using several methods in order to provide an opportunity to review data sets and disregard inconsistent data. Carbon balance, F-factor, and oxygen balance methods were used to determine the engine exhaust flow rate. The test cell exhaust was measured directly using traditional EPA methods (U.S. EPA 40 CFR 60, Appendix A). The oxygen balance methodology provided the most representative exhaust flow data at all settings except for the max continuous setting F-factor was used. The methodologies correlated well at each flight engine setting.

5.7 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 5-24 and 5-25.

5.8 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 5-26.

5.9 T-6A TEXAN II AGSE EMISSION FACTORS

Emission factors for the ground equipment which supports the T-6A Texan II aircraft are provided in Table 5-27. These data were provided to AFIERA/RSEQ by the equipment manufacturer.

TABLE 5-24. JP-8+100 FUEL ANALYSIS

Parameter	Analytical Method	Result
Btu/lb	ASTM D-240	18,800 Btu/lb
Sulfur %	ASTM D-5453	0.03%
Carbon %	ASTM D-5291	85.75%
Nitrogen %	ASTM 4629	0.0005%
Hydrogen %	ASTM D-5291	13.91%
Ash %	ASTM D482	<0.001%
Naphthenes %	PONA Analysis	50.85%
Aromatics %	PONA Analysis	23.35%
Parafins %	PONA Analysis	25.55%
Olefins %	PONA Analysis	0.25%

TABLE 5-25. SUMMARY OF SOURCE TARGET METALS FROM JP-8+100 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	**0.053**
Chromium	6010	<0.013
Cobalt	6010	<0.013
Copper	6010	<0.025
Lead	6010	<0.063
Manganese	6010	<0.013
Mercury	7470	<0.0005
Nickel	6010	<0.038
Phosphorus	365.2	**0.25**
Selenium	6010	<0.13
Silver	6010	<0.013
Thallium	6010	<0.075
Zinc	6010	**0.093**

TABLE 5-26.
PT6A-68 OPERATING DATA

Condition	Fuel Flow (lbs/hr)	Torque (ft*lb)	Horsepower (Average)
Engine A – Serial No. RA0154			
Ground Idle	155	148	26
Flight Idle	179	202	42
Approach	449	1521	580
Max. Continuous	612	2888	1101
Engine B – Serial No. RA0156			
Ground Idle	156	158	28
Flight Idle	180	208	43
Descend	328	687	241
Approach	449	1520	579
Max. Continuous	611	2889	1101

TABLE 5-27
T6-A TEXAN II AGSE EMISSION FACTORS

AGSE Type and Family	HC + NO_x (g/kW*hr)	CO (g/kW*hr)	Particulate (g/kW*hr)
Cabin Pressure Tester (YHZXL3.43U37)	8.49	2.99	0.63
Cabin Pressure Tester (YHZXL3.43C19)	9.01	3.83	0.51
Ground Power Unit (AK70411)	7.61	1.3	0.52
Hydraulic Test Stand (1334)	13.0	374.1	(A)

(A) – Particulate data is unavailable for engine.

5.10 RECOMMENDATIONS

The potential fuel misting at the ground idle and flight idle settings should be investigated and eliminated if possible.

Misting of the fuel in the exhaust is most likely due to the inadequate atomization and poor combustion of the fuel in the combustor.

One of the problems that may be caused by fuel misting is leaving trace amounts of JP-8 on homes and properties surrounding the air fields. We recommend that the T-6 SPO look at this issue to determine if it can be eliminated.

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APPENDIX A

EXAMPLE CALCULATIONS

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

ΔH = 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

ΔP = 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, °R

Ts = Average temperature of stack gas, °R

Tstd = Temperature at standard conditions, (528 °R)

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

∅ = Total sampling time, minutes

NOTE: Standard condition = 68 °F and 29.92 in.Hg

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.

$$Vwstd = 0.04707 \times Vlc$$

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.

$$Ms = Md(1-Bws) + 18Bws$$

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.

$$Qs = 60 \times Vs \times As$$

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).

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

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

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

14. Heat input, MM Btu/hr fuel.

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

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

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

EXAMPLE CALCULATIONS FOR GASEOUS POLLUTANTS MEASURED BY CONTINUOUS EMISSION MONITORS (CEMs)

1) Concentrations, parts per million, dry basis:

$$\text{ppm, dry} = \text{ppm, wet basis} \div \left(1 - \frac{\text{BWS,\%}}{100}\right)$$

2) Pollutant Mass Emission Rate, pounds per hour.

$$\text{PMR, lb/hr} = \frac{\text{ppm, dry x Compound Molecular Weight}}{(385.3 \times 10^6)} \times \text{dscfm} \times 60$$

Molecular Weights of Target Compounds

TGO = Total Gaseous Organics 16.01 (Methane)
SO_2 = Sulfur Dioxide 64.05
NO_2 = Nitrogen Oxides 46.00
CO = Carbon Monoxide 28.01
BWS = Proportion by Volume of Water Vapor in the Gas Stream
PMR = Pollutant Mass Emission Rate, pounds per hour
DSCFM = Dry standard cubic feet per minute

Summary of Stack Gas Parameters and Test Results
030414.008C.5.050
USAF/Pratt & Whitney Canada
US EPA Test Method 5 - Particulate Matter
T6 Engine Exhaust Stack
Page 1 of 2

	RUN NUMBER ***RUN DATE*** ***RUN TIME***	***A-APP-M5-1*** ***05/15/2002*** ***0750-0955***	***A-APP-M5-2*** ***05/15/2002*** ***1015-1146***	***A-APP-M5-3*** ***05/15/2002*** ***1226-1327***	***A-APP-M5-Comp*** ***05/15/2002*** ***0750-1306***	***Average***
	MEASURED DATA					
P_{static}	Stack Static Pressure, inches H_2O	5.00	5.00	5.00	5.00	5.00
y	Meter Box Correction Factor	0.999	0.999	0.999	0.999	0.999
P_{bar}	Barometric Pressure, inches Hg	30.40	30.40	30.40	30.40	30.40
V_m	Sample Volume, ft^3	85.030	47.736	48.746	208.012	97.381
$Dp^{1/2}$	Average Square Root Dp, (in. H_2O)$^{1/2}$	1.6440	1.8043	1.8302	1.9606	1.8098
DH	Avg Meter Orifice Pressure, in. H_2O	1.69	2.00	2.06	2.85	2.15
T_m	Average Meter Temperature, °F	61	74	73	66	69
T_s	Average Stack Temperature, °F	304	314	319	285	306
V_{lc}	Condensate Collected, ml	14.1	10.9	13.6	34.8	18.4
CO_2	Carbon Dioxide content, % by volume	2.0	2.0	2.0	2.0	2.0
O_2	Oxygen content, % by volume	19.0	19.0	19.0	19.0	19.0
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:	1	1	1	1	
As	Diameter or Dimensions, inches:	24.00	24.00	24.00	24.00	24.00
Q	Sample Run Duration, minutes	120	60	60	240	120
D_n	Nozzle Diameter, inches	0.175	0.175	0.175	0.175	0.175
	CALCULATED DATA					
A_n	Nozzle Area, ft^2	0.000167	0.000167	0.000167	0.000167	0.000167
$V_{m(std)}$	Standard Meter Volume, ft^3	87.790	48.121	49.239	213.316	99.617
$V_{m(std)}$	Standard Meter Volume, m^3	2.486	1.363	1.394	6.040	2.821
Q_m	Average Sampling Rate, dscfm	0.732	0.802	0.821	0.889	0.811
P_s	Stack Pressure, inches Hg	30.77	30.77	30.77	30.77	30.77
B_{ws}	Moisture, % by volume	0.8	1.1	1.3	0.8	1.0
$B_{ws(sat)}$	Moisture (at saturation), % by volume	476.7	552.6	594.1	355.7	494.8
V_{wstd}	Standard Water Vapor Volume, ft^3	0.664	0.513	0.640	1.638	0.864
$1-B_{ws}$	Dry Mole Fraction	0.992	0.989	0.987	0.992	0.990
M_d	Molecular Weight (d.b.), lb/lb•mole	29.08	29.08	29.08	29.08	29.08
M_s	Molecular Weight (w.b.), lb/lb•mole	29.00	28.96	28.94	29.00	28.97
V_s	Stack Gas Velocity, ft/s	109.2	120.8	122.9	128.7	120.4
A	Stack Area, ft^2	3.1	3.1	3.1	3.1	3.14
Q_a	Stack Gas Volumetric flow, acfm	41,186	45,523	46,346	48,504	45,390
Q_s	Stack Gas Volumetric flow, dscfm	29,039	31,585	31,876	35,067	31,892
Q_s	Stack Gas Volumetric flow, dscmm	822	894	903	993	903
I	Isokinetic Sampling Ratio, %	94.8	95.5	96.9	95.4	95.6

Summary of Stack Gas Parameters and Test Results
030414.008C.5.050
USAF/Pratt & Whitney Canada
US EPA Test Method 5 - Particulate Matter
T6 Engine Exhaust Stack
Page 2 of 2

	RUN NUMBER	***A-APP-M5-1***	***A-APP-M5-2***	***A-APP-M5-3***	***A-APP-M5-Comp***	***Average***
	RUN DATE	***05/15/2002***	***05/15/2002***	***05/15/2002***	***05/15/2002***	
	RUN TIME	***0750-0955***	***1015-1146***	***1226-1327***	***0750-1306***	
	EMISSIONS DATA					
	<u>Particulate Matter</u>					
PM	Filter Weight Gain, mg	21.15	15.35	12.05	44.65	
PM	Beaker Weight Gain, mg	4.65	4.65	5.15	5.7	
PM	Total Catch, g	0.0258	0.0200	0.0172	0.0504	0.0283
C_{PM}	**Concentration, gr/dscf**	**4.54E-03**	**6.41E-03**	**5.39E-03**	**3.64E-03**	**5.00E-03**
C_{PM}	**Concentration, lb/dscf**	**6.48E-07**	**9.16E-07**	**7.70E-07**	**5.20E-07**	**7.14E-07**
E_{PM}	**Emission Rate, lb/hr**	**1.13E+00**	**1.74E+00**	**1.47E+00**	**1.09E+00**	**1.36E+00**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**2.49E+00**	**3.83E+00**	**3.25E+00**	**2.42E+00**	**3.00E+00**
	<u>Condensible Matter</u>					
PM	Organic Gain, mg	0	0	0	0	
PM	Aqueous Gain, mg	6.5	0	0	16	
PM	Total Catch, g	0.0065	0.0000	0.0000	0.0160	0.0056
C_{PM}	**Concentration, gr/dscf**	**1.14E-03**	**0.00E+00**	**0.00E+00**	**1.16E-03**	**5.75E-04**
C_{PM}	**Concentration, lb/dscf**	**1.63E-07**	**0.00E+00**	**0.00E+00**	**1.65E-07**	**8.21E-08**
E_{PM}	**Emission Rate, lb/hr**	**2.84E-01**	**0.00E+00**	**0.00E+00**	**3.48E-01**	**1.58E-01**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**6.28E-01**	**0.00E+00**	**0.00E+00**	**7.68E-01**	**3.49E-01**
	<u>Total Particulate Matter</u>					
PM	Total Catch, g	3.23E-02	2.00E-02	1.72E-02	6.64E-02	3.40E-02
C_{PM}	**Concentration, gr/dscf**	**5.68E-03**	**6.41E-03**	**5.39E-03**	**4.80E-03**	**5.57E-03**
C_{PM}	**Concentration, lb/dscf**	**8.11E-07**	**9.16E-07**	**7.70E-07**	**6.86E-07**	**7.96E-07**
E_{PM}	**Emission Rate, lb/hr**	**1.41E+00**	**1.74E+00**	**1.47E+00**	**1.44E+00**	**1.52E+00**
E_{PM}	**Emission Rate, lb/1000 lb fuel**	**3.12E+00**	**3.83E+00**	**3.25E+00**	**3.18E+00**	**3.35E+00**
F	Fuel Flow, lb/hr	453	453	453	453	

Summary of Stack Gas Parameters and Test Results
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USAF/Pratt & Whitney, Canada
Test Method 0011 - Aldehyde/Ketones
T6 Engine Exhaust Stack
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	RUN NUMBER	***A-GI-0011***	***A-APP-0011***	***A-MAX-0011***	***Average***
	RUN DATE	***05/14/2002***	***05/15/2002***	***05/15/2002***	
	RUN TIME	***1305-1508***	***0750-0951***	***1400-1603***	
	MEASURED DATA				
P_{static}	Stack Static Pressure, inches H_2O	-0.25	5.00	6.00	3.58
y	Meter Box Correction Factor	1.018	1.018	1.018	1.018
P_{bar}	Barometric Pressure, inches Hg	30.15	30.40	30.40	30.32
V_m	Sample Volume, ft^3	95.260	123.262	83.658	100.727
$Dp^{1/2}$	Average Square Root Dp, (in. $H_2O)^{1/2}$	0.8517	1.9859	2.3100	1.7159
DH	Avg Meter Orifice Pressure, in. H_2O	2.02	3.50	0.66	2.06
T_m	Average Meter Temperature, °F	57	66	81	68
T_s	Average Stack Temperature, °F	258	284	327	290
V_{lc}	Condensate Collected, ml	27.8	31.0	26.5	28.4
CO_2	Carbon Dioxide content, % by volume	1.0	2.0	2.0	1.7
O_2	Oxygen content, % by volume	20.0	19.0	19.0	19.3
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:	1	1	1	
As	Diameter or Dimensions, inches:	24.00	24.00	24.00	24.00
F	Fuel Flow, lb/hr	155	453	612	
Q	Sample Run Duration, minutes	120	120	180	140
D_n	Nozzle Diameter, inches	0.252	0.190	0.117	0.186
	CALCULATED DATA				
A_n	Nozzle Area, ft^2	0.000346	0.000197	0.000075	0.000206
$V_{m(std)}$	Standard Meter Volume, ft^3	100.251	129.010	84.552	104.604
$V_{m(std)}$	Standard Meter Volume, m^3	2.839	3.653	2.394	2.962
Q_m	Average Sampling Rate, dscfm	0.835	1.075	0.470	0.793
P_s	Stack Pressure, inches Hg	30.13	30.77	30.84	30.58
B_{ws}	Moisture, % by volume	1.3	1.1	1.5	1.3
$B_{ws(sat)}$	Moisture (at saturation), % by volume	232.6	350.1	664.0	415.6
V_{wstd}	Standard Water Vapor Volume, ft^3	1.309	1.459	1.247	1.338
$1-B_{ws}$	Dry Mole Fraction	0.987	0.989	0.985	0.987
M_d	Molecular Weight (d.b.), lb/lb•mole	28.96	29.08	29.08	29.04
M_s	Molecular Weight (w.b.), lb/lb•mole	28.82	28.96	28.92	28.90
V_s	Stack Gas Velocity, ft/s	55.6	130.3	155.8	113.9
A	Stack Area, ft^2	6.3	6.3	6.3	6.28
Q_a	Stack Gas Volumetric flow, acfm	20,966	49,131	58,745	42,947
Q_s	Stack Gas Volumetric flow, dscfm	15,322	35,440	40,018	30,260
Q_s	Stack Gas Volumetric flow, dscmm	434	1,004	1,133	857
I	Isokinetic Sampling Ratio, %	98.9	96.8	98.8	98.2

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Test Method 0011 - Aldehyde/Keytones
T6 Engine Exhaust Stack
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	RUN NUMBER	***A-GI-0011***	***A-APP-0011***	***A-MAX-0011***	
	RUN DATE	***05/14/2002***	***05/15/2002***	***05/15/2002***	***Average***
	RUN TIME	***1305-1508***	***0750-0951***	***1400-1603***	
	EMISSIONS DATA				
HCHO	Formaldehyde				
	Target Catch, µg	1.30E+04	2.30E+03	9.80E+01	5.13E+03
	Concentration, µg/dscm	4.58E+03	6.30E+02	4.09E+01	1.75E+03
	Emission Rate, lb/hr	7.45E-01	3.05E-01	1.47E-02	3.55E-01
	Emission Rate, lb/1000 lb fuel	4.80E+00	6.73E-01	2.40E-02	1.83E+00
CH_3CHO	Acetaldehyde				
	Target Catch, µg	2.30E+03	1.30E+02	2.70E+01	8.19E+02
	Concentration, µg/dscm	8.10E+02	3.56E+01	1.13E+01	2.86E+02
	Emission Rate, lb/hr	4.64E-02	4.71E-03	1.69E-03	1.76E-02
	Emission Rate, lb/1000 lb fuel	2.99E-01	1.04E-02	2.76E-03	1.04E-01
CH_2CHCHO	Acrolein				
	Target Catch, µg	5.50E+03	*8.20E+01*	*5.70E+00*	1.86E+03
	Concentration, µg/dscm	1.94E+03	2.24E+01	2.38E+00	6.54E+02
	Emission Rate, lb/hr	1.11E-01	2.97E-03	3.56E-04	3.81E-02
	Emission Rate, lb/1000 lb fuel	7.16E-01	6.56E-03	5.82E-04	2.41E-01
$CH_3CH_2CH_2OH$	Propanol				
	Target Catch, µg	1.00E+03	*8.20E+01*	*5.70E+00*	3.63E+02
	Concentration, µg/dscm	3.52E+02	2.24E+01	2.38E+00	1.26E+02
	Emission Rate, lb/hr	2.02E-02	2.97E-03	3.56E-04	7.83E-03
	Emission Rate, lb/1000 lb fuel	1.30E-01	6.56E-03	5.82E-04	4.58E-02
$CH_3CHCHCHO$	Crotonaldehyde				
	Target Catch, µg	1.60E+03	*8.20E+01*	*5.70E+00*	5.63E+02
	Concentration, µg/dscm	5.64E+02	2.24E+01	2.38E+00	1.96E+02
	Emission Rate, lb/hr	3.23E-02	2.97E-03	3.56E-04	1.19E-02
	Emission Rate, lb/1000 lb fuel	2.08E-01	6.56E-03	5.82E-04	7.18E-02
$CH_3COC_5H_{11}$	Methyl Ethyl Ketone/Butyraldehydes				
	Target Catch, µg	5.60E+03	*8.20E+01*	*5.70E+00*	1.90E+03
	Concentration, µg/dscm	1.97E+03	2.24E+01	2.38E+00	6.66E+02
	Emission Rate, lb/hr	1.13E-01	2.97E-03	3.56E-04	3.88E-02
	Emission Rate, lb/1000 lb fuel	7.29E-01	6.56E-03	5.82E-04	2.45E-01
C_6H_5CHO	Benzaldehyde				
	Target Catch, µg	1.80E+03	1.00E+02	*5.70E+00*	6.35E+02
	Concentration, µg/dscm	6.34E+02	2.74E+01	2.38E+00	2.21E+02
	Emission Rate, lb/hr	3.63E-02	3.63E-03	3.56E-04	1.34E-02
	Emission Rate, lb/1000 lb fuel	2.34E-01	8.00E-03	5.82E-04	8.10E-02
$CH_3)_2CHCH_2CHC$	Isopentanal				
	Target Catch, µg	*4.20E+02*	*8.20E+01*	*5.70E+00*	1.69E+02
	Concentration, µg/dscm	1.48E+02	2.24E+01	2.38E+00	5.76E+01
	Emission Rate, lb/hr	8.47E-03	2.97E-03	3.56E-04	3.93E-03
	Emission Rate, lb/1000 lb fuel	5.47E-02	6.56E-03	5.82E-04	2.06E-02

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T6 Engine Exhaust Stack
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	RUN NUMBER	***A-GI-0011***	***A-APP-0011***	***A-MAX-0011***	
	RUN DATE	***05/14/2002***	***05/15/2002***	***05/15/2002***	***Average***
	RUN TIME	***1305-1508***	***0750-0951***	***1400-1603***	
	EMISSIONS DATA - Continued				
$CH_3(CH_2)_3CHO$	Pentanal				
	Target Catch, µg	7.40E+02	*8.20E+01*	*5.70E+00*	2.76E+02
	Concentration, µg/dscm	2.61E+02	2.24E+01	2.38E+00	9.52E+01
	Emission Rate, lb/hr	1.49E-02	2.97E-03	3.56E-04	6.09E-03
	Emission Rate, lb/1000 lb fuel	9.63E-02	6.56E-03	5.82E-04	3.45E-02
$C_6H_4CH_3CHO$	o-Tolualdehyde				
	Target Catch, µg	*4.20E+02*	*8.20E+01*	*5.70E+00*	1.69E+02
	Concentration, µg/dscm	4.20E+02	2.24E+01	2.38E+00	1.48E+02
	Emission Rate, lb/hr	2.41E-02	2.97E-03	3.56E-04	9.13E-03
	Emission Rate, lb/1000 lb fuel	1.55E-01	6.56E-03	5.82E-04	5.41E-02
$CH_3(CH_2)_4CHO$	Hexanal				
	Target Catch, µg	*1.20E+03*	*8.20E+01*	*5.70E+00*	4.29E+02
	Concentration, µg/dscm	4.23E+02	2.24E+01	2.38E+00	1.49E+02
	Emission Rate, lb/hr	2.42E-02	2.97E-03	3.56E-04	9.18E-03
	Emission Rate, lb/1000 lb fuel	1.56E-01	6.56E-03	5.82E-04	5.44E-02
	m, p-Tolualdehyde				
	Target Catch, µg	1.20E+03	9.00E+01	*5.70E+00*	4.32E+02
	Concentration, µg/dscm	1.20E+01	6.98E-01	6.74E-02	4.25E+00
	Emission Rate, lb/hr	2.42E-02	3.26E-03	3.56E-04	9.28E-03
	Emission Rate, lb/1000 lb fuel	1.56E-01	7.20E-03	5.82E-04	5.47E-02

Run #A-GI-0011 had a Rpt. Limit of 420

Run #A-APP-0011 had a Rpt. Limit of 82

Run #A-MAX-0011had a Rpt. Limit of 5.7

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PAH
T6 Engine Exhaust Stack
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	RUN NUMBER	***A-GI-PAH***	***A-APP-PAH***	***A-MAX_PAH***	
	RUN DATE	***05/14/2002***	***05/15/2002***	***05/15/2002***	***Average***
	RUN TIME	***1305-1800***	***0750-1326***	***1400-1738***	
	MEASURED DATA				
P_{static}	Stack Static Pressure, inches H_2O	-0.25	5.00	6.00	3.58
y	Meter Box Correction Factor	0.994	0.994	0.994	0.994
P_{bar}	Barometric Pressure, inches Hg	30.15	30.40	30.40	30.32
V_m	Sample Volume, L^3	53.130	45.150	48.920	49.067
$Dp^{1/2}$	Average Square Root Dp, (in. $H_2O)^{1/2}$	0.9228	1.9600	2.3150	1.7326
T_m	Average Meter Temperature, °F	55	64	77	65
T_s	Average Stack Temperature, °F	255	285	327	289
CO_2	Carbon Dioxide content, % by volume	1.0	2.0	1.0	1.3
O_2	Oxygen content, % by volume	20.0	19.0	20.0	19.7
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:	1	1	1	
As	Diameter or Dimensions, inches:	24.00	24.00	24.00	24.00
F	Fuel Flow, lb/hr	155.00	453.00	612.00	
Q	Sample Run Duration, minutes	240	240	168	216
	CALCULATED DATA				
$V_{m(std)}$	Standard Meter Volume,L^3	54.560	45.947	48.578	49.695
$V_{m(std)}$	Standard Meter Volume,ft^3	1.927	1.622	1.715	1.755
P_s	Stack Pressure, inches Hg	30.13	30.77	30.84	30.58
B_{ws}	Moisture, % by volume	1.4	1.9	1.1	1.5
$1\text{-}B_{ws}$	Dry Mole Fraction	0.986	0.981	0.989	0.985
M_d	Molecular Weight (d.b.), lb/lb•mole	28.96	29.08	28.96	29.00
M_s	Molecular Weight (w.b.), lb/lb•mole	28.81	28.87	28.84	28.84
V_s	Stack Gas Velocity, ft/s	60.1	128.9	156.4	115.1
A	Stack Area, ft^2	3.1	3.1	3.1	3.14
Q_a	Stack Gas Volumetric flow, acfm	22,820	48,738	58,990	43,516
Q_s	Stack Gas Volumetric flow, dscfm	16,160	34,288	39,760	30,069
Q_s	Stack Gas Volumetric flow, dscmm	458	971	1,126	851
	Napthalene				
	Analysis, ug/sample	*1.0*	*1.0*	5.3	**2.4**
	Molecular Weight, MW	128.2	128.2	128.2	**128.2**
	Concentration, lb/dscf	**1.14E-09**	**1.36E-09**	**6.80E-09**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**3.43E-03**	**4.08E-03**	**2.04E-02**	**9.31E-03**
	Parts Per Million, Dry Basis	**3.48E-03**	**4.15E-03**	**2.07E-02**	**9.43E-03**
	Emission Rate, lb/hr	**1.12E-03**	**2.84E-03**	**1.64E-02**	**6.79E-03**
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	2.68E-02	**1.34E-02**

	2-Methylnapthalene				
	Analysis, *u*g/sample	*1.0*	*1.0*	4.7	**2.2**
	Molecular Weight, MW	142.2	142.2	142.2	**142.2**
	Concentration, lb/dscf	**1.14E-09**	**1.36E-09**	**6.03E-09**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**3.09E-03**	**3.67E-03**	**1.63E-02**	**7.70E-03**
	Parts Per Million, Dry Basis	**3.14E-03**	**3.75E-03**	**1.65E-02**	**7.80E-03**
	Emission Rate, lb/hr	**1.12E-03**	**2.84E-03**	**1.45E-02**	**6.17E-03**
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	2.38E-02	**1.24E-02**
	2-Chloronapthalene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	**1.0**
	Molecular Weight, MW	162.6	162.6	162.6	**162.6**
	Concentration, lb/dscf	**1.14E-09**	**1.36E-09**	**1.28E-09**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**2.71E-03**	**3.21E-03**	**3.04E-03**	**2.99E-03**
	Parts Per Million, Dry Basis	**2.74E-03**	**3.28E-03**	**3.07E-03**	**3.03E-03**
	Emission Rate, lb/hr	**1.12E-03**	**2.84E-03**	**3.09E-03**	**2.35E-03**
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	**6.19E-03**
	Acenapthene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	**1.0**
	Molecular Weight, MW	154.2	154.2	154.2	**154.2**
	Concentration, lb/dscf	**1.14E-09**	**1.36E-09**	**1.28E-09**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**2.85E-03**	**3.39E-03**	**3.20E-03**	**3.15E-03**
	Parts Per Million, Dry Basis	**2.89E-03**	**3.45E-03**	**3.24E-03**	**3.20E-03**
	Emission Rate, lb/hr	**1.12E-03**	**2.84E-03**	**3.09E-03**	**2.35E-03**
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	**6.19E-03**
	Acenapthylene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	**1.0**
	Molecular Weight, MW	152.2	152.2	152.2	**152.2**
	Concentration, lb/dscf	**1.14E-09**	**1.36E-09**	**1.28E-09**	**0.0**
ppmdv	**Parts Per Million, Wet Basis**	**2.89E-03**	**3.43E-03**	**3.25E-03**	**3.19E-03**
	Parts Per Million, Dry Basis	**2.93E-03**	**3.50E-03**	**3.28E-03**	**3.24E-03**
	Emission Rate, lb/hr	**1.12E-03**	**2.84E-03**	**3.09E-03**	**2.35E-03**
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	**6.19E-03**
	Fluorene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	**1.0**
	Molecular Weight, MW	166.2	166.2	166.2	**166.2**
	Concentration, lb/dscf	**1.14E-09**	**1.36E-09**	**1.28E-09**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**2.65E-03**	**3.14E-03**	**2.97E-03**	**2.92E-03**
	Parts Per Million, Dry Basis	**2.68E-03**	**3.20E-03**	**3.01E-03**	**2.96E-03**
	Emission Rate, lb/hr	**1.12E-03**	**2.84E-03**	**3.09E-03**	**2.35E-03**
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	**6.19E-03**
	Phenanthrene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	**1.0**
	Molecular Weight, MW	178.0	178.0	178.0	**178.0**
	Concentration, lb/dscf	**1.14E-09**	**1.36E-09**	**1.28E-09**	**0.0**
ppmdv	**Parts Per Million, Dry Basis**	**2.47E-03**	**2.94E-03**	**2.78E-03**	**2.73E-03**
	Parts Per Million, Dry Basis	**2.51E-03**	**2.99E-03**	**2.81E-03**	**2.77E-03**
	Emission Rate, lb/hr	**1.12E-03**	**2.84E-03**	**3.09E-03**	**2.35E-03**
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	**6.19E-03**

	Anthracene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	178.2	178.2	178.2	178.2
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	**Parts Per Million, Dry Basis**	2.47E-03	2.93E-03	2.77E-03	2.72E-03
	Parts Per Million, Dry Basis	2.50E-03	2.99E-03	2.80E-03	2.77E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Fluoranthene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	202.3	202.3	202.3	202.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	**Parts Per Million, Dry Basis**	2.17E-03	2.58E-03	2.44E-03	2.40E-03
	Parts Per Million, Dry Basis	2.21E-03	2.63E-03	2.47E-03	2.44E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Pyrene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	202.3	202.3	202.3	202.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	**Parts Per Million, Dry Basis**	2.17E-03	2.58E-03	2.44E-03	2.40E-03
	Parts Per Million, Dry Basis	2.21E-03	2.63E-03	2.47E-03	2.44E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Chrysens				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	228.3	228.3	228.3	228.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	**Parts Per Million, Dry Basis**	1.93E-03	2.29E-03	2.16E-03	2.13E-03
	Parts Per Million, Dry Basis	1.95E-03	2.33E-03	2.19E-03	2.16E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Benzo(a)anthracene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	228.3	228.3	228.3	228.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	**Parts Per Million, Dry Basis**	1.93E-03	2.29E-03	2.16E-03	2.13E-03
	Parts Per Million, Dry Basis	1.95E-03	2.33E-03	2.19E-03	2.16E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Benzo(b)fluoranthene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	252.3	252.3	252.3	252.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	**Parts Per Million, Dry Basis**	1.74E-03	2.07E-03	1.96E-03	1.92E-03
	Parts Per Million, Dry Basis	1.77E-03	2.11E-03	1.98E-03	1.95E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03

	Benzo(k)fluoranthene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	252.3	252.3	252.3	252.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	Parts Per Million, Dry Basis	1.74E-03	2.07E-03	1.96E-03	1.92E-03
	Parts Per Million, Dry Basis	1.77E-03	2.11E-03	1.98E-03	1.95E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Benzo(a)pyrene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	252.3	252.3	252.3	252.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	Parts Per Million, Dry Basis	1.74E-03	2.07E-03	1.96E-03	1.92E-03
	Parts Per Million, Dry Basis	1.77E-03	2.11E-03	1.98E-03	1.95E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Indeno(1,2,3-c,d)pyrene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	276.3	276.3	276.3	276.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	Parts Per Million, Dry Basis	1.59E-03	1.89E-03	1.79E-03	1.76E-03
	Parts Per Million, Dry Basis	1.62E-03	1.93E-03	1.81E-03	1.78E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Dibenz(a,h)anthracene				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	278.4	278.4	278.4	278.4
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	Parts Per Million, Dry Basis	1.58E-03	1.88E-03	1.78E-03	1.74E-03
	Parts Per Million, Dry Basis	1.60E-03	1.91E-03	1.79E-03	1.77E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03
	Benzo(g,h,l,perylene)				
	Analysis, *u*g/sample	*1.0*	*1.0*	*1.0*	1.0
	Molecular Weight, MW	276.3	276.3	276.3	276.3
	Concentration, lb/dscf	1.14E-09	1.36E-09	1.28E-09	0.0
ppmdv	Parts Per Million, Dry Basis	1.59E-03	1.89E-03	1.79E-03	1.76E-03
	Parts Per Million, Dry Basis	1.62E-03	1.93E-03	1.81E-03	1.78E-03
	Emission Rate, lb/hr	1.12E-03	2.84E-03	3.09E-03	2.35E-03
	Emission Rate, lb/1000 lb fuel	7.24E-03	6.28E-03	5.06E-03	6.19E-03

Run #A-APP-PAH had a Rpt. Limit of 1

Run #A-MAX-PAH had a Rpt. Limit of 1

Run #A-GI-PAH had a Rpt. Limit of 1

Summary of Stack Gas Parameters and Test Results

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USAF/Pratt & Whitney Canada

SW-846 Method 0030 - VOST

T6 Engine Exhaust Stack

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	RUN NUMBER	***A-App-0030-1***	***A-App-0030-2***	***A-App-0030-3***	
	RUN DATE	***05/15/2002***	***05/15/2002***	***05/15/2002***	***Average***
	RUN TIME	***0750-0950***	***1015-1120***	***1220-1326***	
	MEASURED DATA				
γ	Meter Box Correction Factor	1.046	1.046	1.046	1.046
P_{bar}	Barometric Pressure, inches Hg	30.40	30.40	30.40	30.40
P_{static}	Stack Static Pressure, inches H_2O	5.00	5.00	5.00	5.00
V_m	Sample Volume, L	25.740	14.890	15.480	18.703
T_m	Average Meter Temperature, °F	61	71	69	67
C_p	Pitot Tube Coefficient	0.84	0.84	0.84	0.84
	Circular Stack? 1=Y,0=N:	1	1	1	
As	Diameter or Dimensions, inches:	24.00	24.00	24.00	24.00
F	Fuel Flow, lb/hr	453.00	453.00	453.00	453.00
Θ	Sample Run Duration, minutes	60	60	60	60
	CALCULATED DATA				
$V_{m(std)}$	Standard Meter Volume, dscl	27.712	15.729	16.414	19.952
$V_{m(std)}$	Standard Meter Volume, dscf	0.979	0.555	0.580	0.70
P_s	Stack Pressure, inches Hg	30.77	30.77	30.77	30.77
A	Stack Area, ft^2	3.14	3.14	3.14	3.14
Q_a	Stack Gas Volumetric flow, acfm	41,312	45,706	46,566	44,528
Q_s	Stack Gas Volumetric flow, dscfm	28,664	31,042	31,230	30,312
$Q_{s(cmm)}$	Stack Gas Volumetric flow, dscmm	812	879	884	858

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T6 Engine Exhaust Stack

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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
Acetone				
Molecular Weight, g/g-mole	58.08	58.08	58.08	
Target Catch, µg	0.09	0.09	0.10	0.09
Concentration, mg/dscm [a]	3.36E-03	5.78E-03	5.85E-03	5.00E-03
Concentration, ppbvd [b]	1.39E+00	2.40E+00	2.42E+00	2.07E+00
Emission Rate, lb/hr [c]	3.60E-04	6.73E-04	6.84E-04	5.72E-04
Emission Rate, lb/1000 lb fuel	7.95E-04	1.48E-03	1.51E-03	1.26E-03
Benzene				
Molecular Weight, g/g-mole	78.11	78.11	78.11	
Target Catch, µg	{1.76}	0.90	{0.84}	1.17
Concentration, mg/dscm [a]	{6.35E-02}	5.72E-02	{5.12E-02}	5.73E-02
Concentration, ppbvd [b]	{1.96E+01}	1.76E+01	{1.58E+01}	1.76E+01
Emission Rate, lb/hr [c]	{6.82E-03}	6.65E-03	{5.99E-03}	6.49E-03
Emission Rate, lb/1000 lb fuel	1.51E-02	1.47E-02	1.32E-02	1.43E-02
Bromodichloromethane				
Molecular Weight, g/g-mole	163.83	163.83	163.83	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	5.30E-02	9.33E-02	8.94E-02	7.86E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Bromoform				
Molecular Weight, g/g-mole	252.73	252.73	252.73	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	3.43E-02	6.05E-02	5.80E-02	5.09E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04

[a] Milligrams per dry standard cubic meter at 68° F (20° C) and 1 atm.

[b] Parts per billion by volume.

[c] Pounds per hour.

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T6 Engine Exhaust Stack

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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
Bromomethane				
Molecular Weight, g/g-mole	94.94	94.94	94.94	
Target Catch, μg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	9.14E-02	1.61E-01	1.54E-01	1.36E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
2-Butanone				
Molecular Weight, g/g-mole	72.11	72.11	72.11	
Target Catch, μg	*0.05*	*0.05*	*0.05*	0.05
Concentration, mg/dscm [a]	1.80E-03	3.18E-03	3.05E-03	2.68E-03
Concentration, ppbvd [b]	6.02E-01	1.06E+00	1.02E+00	8.93E-01
Emission Rate, lb/hr [c]	1.94E-04	3.70E-04	3.56E-04	3.07E-04
Emission Rate, lb/1000 lb fuel	4.28E-04	8.16E-04	7.87E-04	6.77E-04
1,3 Butadiene				
Molecular Weight, g/g-mole	54.09	54.09	54.09	
Target Catch, μg	*0.05*	*0.05*	*0.05*	0.05
Concentration, mg/dscm [a]	1.80E-03	3.18E-03	3.05E-03	2.68E-03
Concentration, ppbvd [b]	8.02E-01	1.41E+00	1.35E+00	1.19E+00
Emission Rate, lb/hr [c]	1.94E-04	3.70E-04	3.56E-04	3.07E-04
Emission Rate, lb/1000 lb fuel	4.28E-04	8.16E-04	7.87E-04	6.77E-04
Carbon disulfide				
Molecular Weight, g/g-mole	76.13	76.13	76.13	
Target Catch, μg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	1.14E-01	2.01E-01	1.92E-01	1.69E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04

[a] Milligrams per dry standard cubic meter at 68° F (20° C) and 1 atm.

[b] Parts per billion by volume.

[c] Pounds per hour.

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T6 Engine Exhaust Stack
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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
Carbon tetrachloride				
Molecular Weight, g/g-mole	153.84	153.84	153.84	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	5.64E-02	9.94E-02	9.53E-02	8.37E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Chlorobenzene				
Molecular Weight, g/g-mole	112.56	112.56	112.56	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	7.71E-02	1.36E-01	1.30E-01	1.14E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Chlorodibromomethane				
Molecular Weight, g/g-mole	208.28	208.28	208.28	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	4.17E-02	7.34E-02	7.04E-02	6.18E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Chloroethane				
Molecular Weight, g/g-mole	65.51	65.51	65.51	
Target Catch, µg	*{0.01}*	*{0.01}*	*{0.01}*	0.01
Concentration, mg/dscm [a]	{3.61E-04}	{6.36E-04}	{6.09E-04}	5.35E-04
Concentration, ppbvd [b]	{1.32E-01}	{2.33E-01}	{2.24E-01}	1.97E-01
Emission Rate, lb/hr [c]	{3.87E-05}	{7.39E-05}	{7.13E-05}	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Chloroform				
Molecular Weight, g/g-mole	119.39	119.39	119.39	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	7.27E-02	1.28E-01	1.23E-01	1.08E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04

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T6 Engine Exhaust Stack

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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
Chloromethane				
Molecular Weight, g/g-mole	50.49	50.49	50.49	
Target Catch, µg	0.03	0.01	*0.01*	0.02
Concentration, mg/dscm [a]	1.19E-03	6.36E-04	6.09E-04	8.12E-04
Concentration, ppbvd [b]	5.67E-01	3.03E-01	2.90E-01	3.87E-01
Emission Rate, lb/hr [c]	1.28E-04	4.40E-07	7.13E-05	6.65E-05
Emission Rate, lb/1000 lb fuel	2.82E-04	9.71E-07	1.57E-04	1.47E-04
1,1-Dichloroethane				
Molecular Weight, g/g-mole	98.96	98.96	98.96	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	8.77E-02	1.55E-01	1.48E-01	1.30E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
1,2-Dichloroethane				
Molecular Weight, g/g-mole	98.96	98.96	98.96	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	8.77E-02	1.55E-01	1.48E-01	1.30E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
1,1-Dichloroethene				
Molecular Weight, g/g-mole	96.94	96.94	96.94	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	8.95E-02	1.58E-01	1.51E-01	1.33E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04

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USAF/Pratt & Whitney Canada

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T6 Engine Exhaust Stack
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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
cis-1,2-Dichloroethene				
Molecular Weight, g/g-mole	96.94	96.94	96.94	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	8.95E-02	1.58E-01	1.51E-01	1.33E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
trans-1,2-Dichloroethene				
Molecular Weight, g/g-mole	96.94	96.94	96.94	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	8.95E-02	1.58E-01	1.51E-01	1.33E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
1,2-Dichloropropane				
Molecular Weight, g/g-mole	112.99	112.99	112.99	
Target Catch, µg	*{0.01}*	*{0.01}*	*{0.01}*	0.01
Concentration, mg/dscm [a]	{3.61E-04}	{6.36E-04}	{6.09E-04}	5.35E-04
Concentration, ppbvd [b]	{7.68E-02}	{1.35E-01}	{1.30E-01}	1.14E-01
Emission Rate, lb/hr [c]	{3.87E-05}	{7.39E-05}	{7.13E-05}	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04

[a] Milligrams per dry standard cubic meter at 68° F (20° C) and 1 atm.

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T6 Engine Exhaust Stack

030414.008c.5.050

	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
cis-1,3-Dichloropropene				
Molecular Weight, g/g-mole	110.97	110.97	110.97	
Target Catch, µg	*0.01*	*{0.01}*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	{6.36E-04}	6.09E-04	5.35E-04
Concentration, ppbvd [b]	7.82E-02	{1.38E-01}	1.32E-01	1.16E-01
Emission Rate, lb/hr [c]	3.87E-05	{7.39E-05}	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
trans-1,3-Dichloropropene				
Molecular Weight, g/g-mole	110.97	110.97	110.97	
Target Catch, µg	*{0.01}*	*{0.01}*	*{0.01}*	0.01
Concentration, mg/dscm [a]	{3.61E-04}	{6.36E-04}	{6.09E-04}	5.35E-04
Concentration, ppbvd [b]	{7.82E-02}	{1.38E-01}	{1.32E-01}	1.16E-01
Emission Rate, lb/hr [c]	{3.87E-05}	{7.39E-05}	{7.13E-05}	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Ethylbenzene				
Molecular Weight, g/g-mole	106.17	106.17	106.17	
Target Catch, µg	{0.03}	{0.02}	*{0.01}*	0.02
Concentration, mg/dscm [a]	{1.01E-03}	{1.21E-03}	{6.09E-04}	9.42E-04
Concentration, ppbvd [b]	{2.29E-01}	{2.74E-01}	{1.38E-01}	2.14E-01
Emission Rate, lb/hr [c]	{1.08E-04}	{1.40E-04}	{7.13E-05}	1.07E-04
Emission Rate, lb/1000 lb fuel	2.39E-04	3.10E-04	1.57E-04	2.36E-04
2-Hexanone				
Molecular Weight, g/g-mole	100.16	100.16	100.16	
Target Catch, µg	*0.05*	*0.05*	*0.05*	0.05
Concentration, mg/dscm [a]	1.80E-03	3.18E-03	3.05E-03	2.68E-03
Concentration, ppbvd [b]	4.33E-01	7.63E-01	7.32E-01	6.43E-01
Emission Rate, lb/hr [c]	1.94E-04	3.70E-04	3.56E-04	3.07E-04
Emission Rate, lb/1000 lb fuel	4.28E-04	8.16E-04	7.87E-04	6.77E-04

[a] Milligrams per dry standard cubic meter at 68° F (20° C) and 1 atm.

[b] Parts per billion by volume.

[c] Pounds per hour.

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T6 Engine Exhaust Stack

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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
Methylene chloride				
Molecular Weight, g/g-mole	84.93	84.93	84.93	
Target Catch, µg	{0.03}	{0.02}	{0.03}	0.03
Concentration, mg/dscm [a]	{1.05E-03}	{1.02E-03}	{2.01E-03}	1.36E-03
Concentration, ppbvd [b]	{2.96E-01}	{2.88E-01}	{5.69E-01}	3.84E-01
Emission Rate, lb/hr [c]	1.12E-04	1.18E-04	2.35E-04	1.55E-04
Emission Rate, lb/1000 lb fuel	2.48E-04	2.61E-04	5.19E-04	3.43E-04
4-Methyl-2-pentanone				
Molecular Weight, g/g-mole	100.16	100.16	100.16	
Target Catch, µg	*0.05*	*0.05*	*0.05*	0.05
Concentration, mg/dscm [a]	1.80E-03	3.18E-03	3.05E-03	2.68E-03
Concentration, ppbvd [b]	4.33E-01	7.63E-01	7.32E-01	6.43E-01
Emission Rate, lb/hr [c]	1.94E-04	3.70E-04	3.56E-04	3.07E-04
Emission Rate, lb/1000 lb fuel	4.28E-04	8.16E-04	7.87E-04	6.77E-04
Styrene				
Molecular Weight, g/g-mole	104.15	104.15	104.15	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	8.33E-02	1.47E-01	1.41E-01	1.24E-01
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04

[a] Milligrams per dry standard cubic meter at 68° F (20° C) and 1 atm.

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T6 Engine Exhaust Stack

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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
1,1,2,2-Tetrachloroethane				
Molecular Weight, g/g-mole	167.85	167.85	167.85	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	5.17E-02	9.11E-02	8.73E-02	7.67E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Tetrachloroethene				
Molecular Weight, g/g-mole	165.83	165.83	165.83	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	5.23E-02	9.22E-02	8.84E-02	7.76E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Toluene				
Molecular Weight, g/g-mole	94.14	94.14	94.14	
Target Catch, µg	0.34	{0.18}	0.08	0.20
Concentration, mg/dscm [a]	1.24E-02	{1.14E-02}	4.81E-03	9.56E-03
Concentration, ppbvd [b]	3.17E+00	{2.92E+00}	1.23E+00	2.44E+00
Emission Rate, lb/hr [c]	1.33E-03	{1.33E-03}	5.63E-04	1.08E-03
Emission Rate, lb/1000 lb fuel	2.94E-03	2.94E-03	1.24E-03	2.37E-03

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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
1,1,1-Trichloroethane				
Molecular Weight, g/g-mole	133.40	133.40	133.40	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	6.51E-02	1.15E-01	1.10E-01	9.65E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
1,1,2-Trichloroethane				
Molecular Weight, g/g-mole	133.40	133.40	133.40	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	6.51E-02	1.15E-01	1.10E-01	9.65E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Trichloroethene				
Molecular Weight, g/g-mole	131.39	131.39	131.39	
Target Catch, µg	*0.01*	*0.01*	*0.01*	0.01
Concentration, mg/dscm [a]	3.61E-04	6.36E-04	6.09E-04	5.35E-04
Concentration, ppbvd [b]	6.61E-02	1.16E-01	1.12E-01	9.80E-02
Emission Rate, lb/hr [c]	3.87E-05	7.39E-05	7.13E-05	6.13E-05
Emission Rate, lb/1000 lb fuel	8.55E-05	1.63E-04	1.57E-04	1.35E-04
Trichlorofluoromethane (Freon 11)				
Molecular Weight, g/g-mole	137.37	137.37	137.37	
Target Catch, µg	0.02	0.01	0.01	0.01
Concentration, mg/dscm [a]	6.49E-04	6.99E-04	6.70E-04	6.73E-04
Concentration, ppbvd [b]	1.14E-01	1.22E-01	1.17E-01	1.18E-01
Emission Rate, lb/hr [c]	6.97E-05	8.13E-05	7.84E-05	7.65E-05
Emission Rate, lb/1000 lb fuel	1.54E-04	1.80E-04	1.73E-04	1.69E-04

[a] Milligrams per dry standard cubic meter at 68° F (20° C) and 1 atm.

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T6 Engine Exhaust Stack
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	A-App-0030-1	A-App-0030-2	A-App-0030-3	Average
o-Xylene				
Molecular Weight, g/g-mole	106.17	106.17	106.17	
Target Catch, µg	0.04	0.02	*0.01*	0.02
Concentration, mg/dscm [a]	1.37E-03	1.46E-03	6.09E-04	1.15E-03
Concentration, ppbvd [b]	3.11E-01	3.31E-01	1.38E-01	2.60E-01
Emission Rate, lb/hr [c]	1.47E-04	1.70E-04	7.13E-05	1.30E-04
Emission Rate, lb/1000 lb fuel	3.25E-04	3.75E-04	1.57E-04	2.86E-04
m-Xylene & p-Xylene				
Molecular Weight, g/g-mole	106.17	106.17	106.17	
Target Catch, µg	0.09	0.06	*0.01*	0.05
Concentration, mg/dscm [a]	3.21E-03	3.75E-03	6.09E-04	2.52E-03
Concentration, ppbvd [b]	7.28E-01	8.50E-01	1.38E-01	5.72E-01
Emission Rate, lb/hr [c]	3.45E-04	4.36E-04	7.13E-05	2.84E-04
Emission Rate, lb/1000 lb fuel	7.61E-04	9.63E-04	1.57E-04	6.27E-04
Vinyl acetate				
Molecular Weight, g/g-mole	86.09	86.09	86.09	
Target Catch, µg	*0.05*	*0.05*	*0.05*	0.05
Concentration, mg/dscm [a]	1.80E-03	3.18E-03	3.05E-03	2.68E-03
Concentration, ppbvd [b]	5.04E-01	8.88E-01	8.51E-01	7.48E-01
Emission Rate, lb/hr [c]	1.94E-04	3.70E-04	3.56E-04	3.07E-04
Emission Rate, lb/1000 lb fuel	4.28E-04	8.16E-04	7.87E-04	6.77E-04

[a] Milligrams per dry standard cubic meter at 68° F (20° C) and 1 atm.

[b] Parts per billion by volume.

[c] Pounds per hour.

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F-FACTOR METHOD
EXAMPLE CALCULATIONS

Client: Pratt & Whitney
Test Run No.: 1
Engine: A
Test Condition: Max Continuous

Location: Engine
Test Date: 05/14/2002

Inputs

Outlet Conc. THC, wet ppm	TCE	2
Outlet Conc. O2, dry percent	O2D	15.75666198
Outlet Conc. CO2, dry percent	C2D	3.946396112
Outlet Conc. CO, dry ppm	COD	58.92250746
Outlet Moisture, percent	BWE	1.5
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	612
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 =	3.06
STOICHIOMETRIC AIR REQUIRED, scf/min	QS =	MF*FMD*KC_2
	QS =	1,860
EXHAUST DRY STANDARD FLOWRATE, dscf/min	QFE_1 =	QS*(1+EAF)
	QFE_1 =	7,555
EXHAUST WET STANDARD FLOWRATE, wscf/min	QWE_1 =	QFE_1/(1-BWE/100)
	QWE_1 =	7,670
NITROGEN IN EXHAUST, % dry basis	ND =	100-(O2D+C2D+(COD*KC_1)+(TCE*KC_1*(1-(BWE/100))))
	ND =	80.29
INLET DRY STANDARD VOLUMETRIC FLOW, dscf/min	QFI_1 =	QFE_1*((ND/100)/(1-(20.9/100)))
	QFI_1 =	7,669
INLET WET STANDARD VOLUMETRIC FLOW, wscf/min	QWI_1 =	QFI_1/(1-BWI/100)
	QWI_1 =	7,718

CARBON BALANCE FLOW METHOD
EXAMPLE CALCULATIONS

Client:	Pratt & Whitney	Location:	Engine
Test Run No.:	1	Test Date:	05/15/2002
Engine:	A		
Test Condition:	Approach		

Inputs

Inlet Conc. CO2, ppm	C2I	0
Inlet Conc. CO, ppm	CO1	1.66
Inlet Conc. THC, ppm	TC1	0.94
Outlet Conc. THC, wet ppm	TCE	5.321429
Outlet Conc. O2, dry percent	O2D	16.22688
Outlet Conc. CO2, dry percent	C2D	3.514731
Outlet Conc. CO, dry ppm	COD	163.1424
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	448
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*0.44)+(0.04*20.4))*(1-(2/100))+0.18*2
MWE = 29.04326

Wet Mole. Weight Inlet (Ambient), lb/lbmole
MWI = (28.84*(1-(BWI/100)))+(0.18*BWI)
MWI = (28.84*(1-(0.63/100)))+(0.18*0.63)
MWI = 28.6774

Wet Conc. CO2 in Exhaust, wet %
C2E = C2D*(1-(BWE/100))
C2E = 0.44*(1-(2/100))
C2E = 3.46201

Wet Conc. CO in Exhaust, wet %
COE = KC1*COD*(1-(BWE/100))
COE = 0.0001*95*(1-(2/100))
COE = 0.01607

Weight Fraction Carbon in Exhaust
CE = (C2E+COE+(KC1*TCE))*12.01/MWE/100
CE = (0.00931+0.4312+(0.0001*220))*12.01/28.67/100
CE = 0.014385

Weight Fraction Carbon in Inlet
CI = KC1*(C2I+COI+TCI)*12.01/MWI/100
CI = 0.0001*(0+458+2.5)*12.01/28.77/100
CI = 1.09E-06

Mass Rate Exhaust, lb/hr
ME = MF*(FC-CI)/(CE-CI)
ME = 15232*(0.8649-0.000192)/(0.001938-0.000192)
ME = 26636.33

Exhaust Wet Standard Flowrate, wscf/min
QCE_{1w} = KC2*ME*385.35/MWE
QCE_{1w} = 0.016667*7,546,512*385.35/28.67
QCE_{1w} = 5890.36

Exhaust Dry Standard Flowrate, dscf/min
QCE_{1d} = ((100-BWE)/100)*QCE_{1w}
QCE_{1d} = ((100-2)/100)*1,690,641
QCE_{1d} = 5802.004

Mass Rate Inlet, lb/hr
MI = MF*(FC-CE)/(CE-CI)
MI = 15,232*(0.8649-0.001938)/(0.001938-0.000192)
MI = 26188.33

Inlet Wet Std. Vol. Flow, wscf/min
QCI_{1w} = KC2*MI*385.35/MWI
QCI_{1w} = 0.016667*7,531,280*385.35/28.77
QCI_{1w} = 5865.173

Inlet Dry Std. Vol. Flow, dscf/min
QCI_{1d} = ((100-BWI)/100)*QCI_{1w}
QCI_{1d} = ((100-0.6335)/100)*1,681,209
QCI_{1d} = 5777.195

OXYGEN MASS BALANCE EXAMPLE

Approach - Run 1 - Engine A

MEASURED TEST CELL EXHAUST CONDITIONS

FLOW	41189.05 actual cubic feet per minute (ACFM)
	29272.18 wet standard cubic feet per minute (WSCFM)
	29038 dry standard cubic feet per minute (DSCFM)

TEMPERATURE	304 oF
MOISTURE	0.8 %
PRESSURE	5 IN H2O
	0.367647 IN Hg

BAROMETRIC	30.4 IN Hg
STACK PRESSURE	30.76765 IN Hg

	%	ppm	g/MOLE	SV SCF/LB
CO2	0.78		44.009	8.76
O2	20.16		31.998	12.05
N2	79.06		28.014	13.77
CO	3.91E-05	39	28.01	13.77
NO2	9.64E-06	9.64	46.005	8.38
THC	2.38E-06	2	16.00	24.11
TOTAL	100.00			
H2O	0.80		18.015	21.41

STACK MASS FLOW

Calculated based on the measurements using EPA sampling methods

SPECIES	LB/MIN	SCFM	% WET	% DRY
CO2	25.837	226.437	0.774	0.780
O2	485.545	5852.713	19.994	20.155
N2	1667.531	22958.835	78.432	79.065
CO	0.001	0.011	3.88E-05	3.91E-05
NO2	3.34E-04	2.80E-03	9.56E-06	9.64E-06
THC	0.000	0.001	2.36E-06	2.38E-06
TOTAL DRY	2178.914	29038.000		100.000
H2O	10.93776	234.177	0.800	
TOTAL WET	2189.852	29272.177	100.000	

CALCULATED INDUCED COOLING AIR VOLUME

The mass of oxygen is calculated using the "Goal Seek" function in Excel to set the oxygen content at the engine exhaust to the target oxygen that was measured at the engine exhaust tip.

SPECIES	LB/MIN	SCFM	% DRY	% WET
O2	423.905	5109.720	20.890	20.483
N2	1405.446	19350.403	79.110	77.567
TOTAL DRY	1829.352	24460.123	100.000	
H2O	22.723	486.497		1.950
TOTAL WET	1852.074	24946.620		100.000

PERCENT STACK FLOW	85.22 %
AMBIENT TEMPERATURE	55 oF
SATURATION MOISTURE	0.013 LB/LB dilution air (DA)
RELATIVE HUMIDITY	95 %
ACTUAL MOISTURE	0.012 LB/LB dilutioin air (DA)

CONDITIONS AT ENGINE EXHAUST TIP

SPECIES	LB/MIN	SCFM	% WET	% DRY	TARGET O2
CO2	25.837	226.437	5.235	4.946	
O2	61.639	742.993	17.177	16.230	16.23 Measured value
N2	262.085	3608.432	83.421	78.823	
CO	0.001	0.011	0.000	0.000	
NO2	3.34E-04	2.80E-03	6.47E-05	6.11E-05	
THC	0.000	0.001	1.60E-05	1.51E-05	
TOTAL DRY	349.562	4577.877		100.000	
H2O	-11.785	-252.320	-5.833		
TOTAL WET	337.777	4325.558	100.000		

PARTICULATE MATTER IN AMBIENT AIR

CONCETRATION	65 ug/M3
	1.43298E-07 LB/M3
INLEAKAGE	24946.62 WSCFM
	706.41 M3/MIN
MASS	0.006073628 LB/HR

Summary of Stack Gas Parameters and Test Results

030414.008c.5.050
USAF/Pratt & Whitney, Canada
US EPA Test Method TO-14
T6 Engine Exhaust Stack
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	RUN NUMBER	***A-GI-TO14***	***A-APP-TO14***	***A-MAX-TO14***	
	RUN DATE	***05/14/2002***	***05/15/2002***	***05/15/2002***	***Average***
	RUN TIME				
F	Fuel Flow, lb/hr	155	453	612	
Q_s	Stack Gas Volumetric flow, dscfm	3,185	7,149	7,583	5,972
	Benzene				
	Parts Per Billion, Dry Basis	2,200.0	62.0	1.2	**754.4**
	Molecular Weight, MW	78.1	78.1	78.1	**78.1**
ppmdv	**Parts Per Million, Dry Basis**	**2.20**	**0.06**	**0.00**	**0.75**
	Emission Rate, lb/hr	**8.52E-02**	**5.39E-03**	**1.11E-04**	**3.02E-02**
	Emission Rate, lb/1000 lb fuel	**5.50E-01**	**1.19E-02**	**1.81E-04**	**1.87E-01**

	RUN NUMBER	***B-FI-TO14***	***B-D-TO14***	***B-MAX-TO14***	
	RUN DATE	***05/16/2002***	***05/16/2002***	***05/17/2002***	***Average***
	RUN TIME				
F	Fuel Flow, lb/hr	180	328	611	
Q_s	Stack Gas Volumetric flow, dscfm	3,870	6,416	7,573	5,953
	Benzene				
	Parts Per Billion, Dry Basis	1,800.0	380.0	1.9	**727.3**
	Molecular Weight, MW	78.1	78.1	78.1	**78.1**
ppmdv	**Parts Per Million, Dry Basis**	**1.80**	**0.38**	**0.00**	**0.73**
	Emission Rate, lb/hr	**6.97E-02**	**3.30E-02**	**1.75E-04**	**3.43E-02**
	Emission Rate, lb/1000 lb fuel	**1.86E-03**	**8.84E-04**	**4.69E-06**	**9.18E-04**

Summary of Stack Gas Parameters and Test Results
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USAF/ Pratt & Whitney Canada
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Engine Outlet
Page 1 of 2

	RUN NUMBER	***A-GI-TO11***	***A-APP-TO11***	***A-MAX-TO11***	***Average***
	RUN DATE	***05/14/2002***	***05/15/2002***	***05/15/2002***	
	RUN TIME	***1325-1340***	***0800-0815***	***1440-1455***	
	MEASURED DATA				
y	Meter Box Correction Factor	1.000	1.000	1.000	1.000
P_{bar}	Barometric Pressure, inches Hg	30.15	30.40	30.40	30.32
V_m	Sample Volume, L^3	32.670	33.100	33.100	32.957
T_m	Average Meter Temperature, °F	77	73	75	75
T_s	Average Stack Temperature, °F	954	972	1024	983
Q	Sample Run Duration, minutes	15	15	15	15
	CALCULATED DATA				
$V_{m(std)}$	Standard Meter Volume,L^3	32.369	33.315	33.191	32.959
$V_{m(std)}$	Standard Meter Volume,ft^3	1.143	1.176	1.172	1.164
Q_s	Stack Gas Volumetric flow, dscfm	3,185	7,149	7,583	5,972
Q_s	Stack Gas Volumetric flow, dscmm	90	202	215	169
HCHO	Formaldehyde				
	Analysis, ug/sample	8.1	4.6	0.8	**33.9**
	Molecular Weight, MW	30.0	30.0	30.0	**30.0**
	Concentration, lb/dscf	**1.56E-08**	**8.60E-09**	**1.50E-09**	**8.57E-09**
	Emission Rate, lb/hr	**2.98E-03**	**3.69E-03**	**6.83E-04**	**2.45E-03**
	Emission Rate, lb/1000 lb fuel	**1.92E-02**	**8.15E-03**	**1.12E-03**	**9.49E-03**

Run #A-GI-TO11 had a Rpt. Limit of 0.050
Run #A-APP-TO11 had a Rpt. Limit of 0.050
Run #A-MAX had a Rpt. Limit of 0.050

Fuel Flow (lb/hr) =	**1.55E+02**	**4.53E+02**	**6.12E+02**

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Plant: ______________________________

Date: ______________________________

Sampling Location: ______________________________

Inside of Far Wall to Outside of Nipple: ______________

Inside of Near Wall to Outside of Nipple (Nipple Length): ________

Stack I.D.: ______________________________

Distance Downstream from Flow Disturbance (Distance B):

__________ inches / Stack I.D. = ________ dd

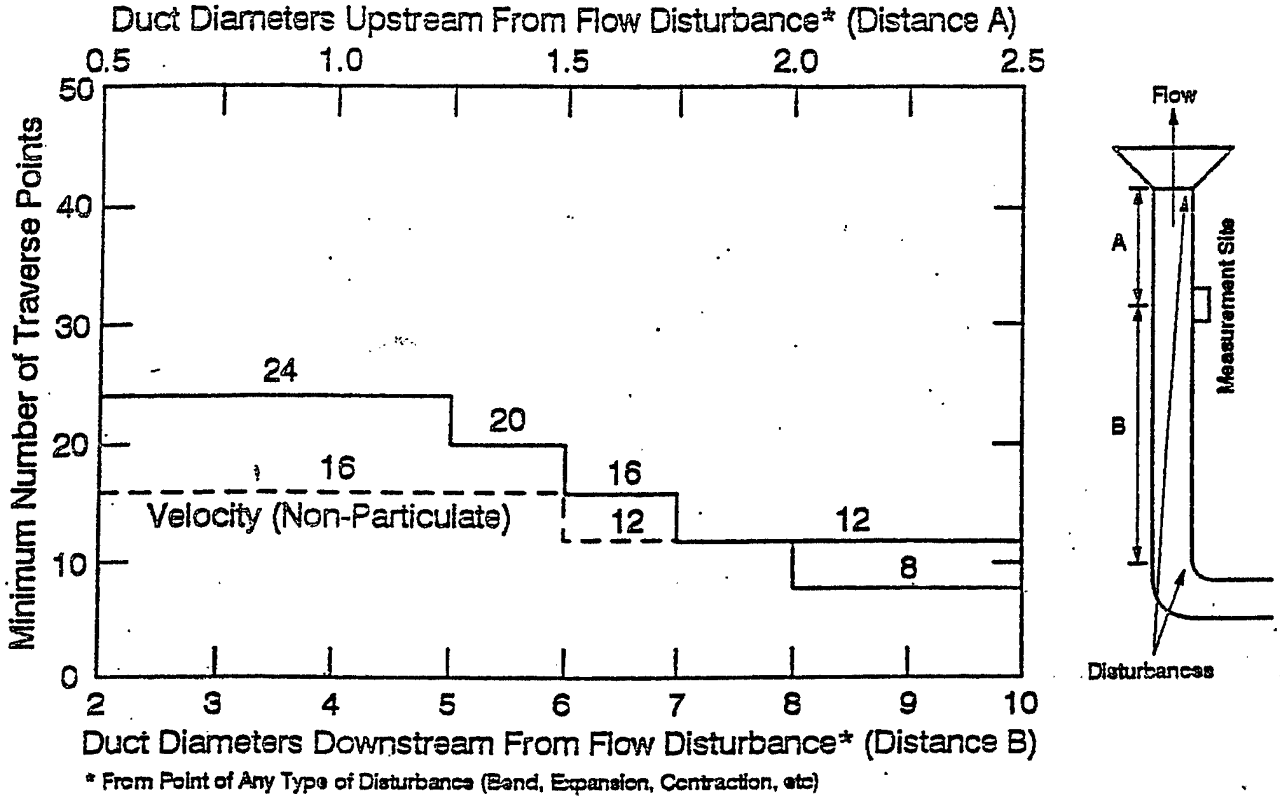
Distance Upstream from Flow Disturbance (Distance A):

__________ inches / Stack I.D. = ________ dd

Calculated By: ______________________________

Schematic of Sampling Location

Traverse Point Number	Fraction of Length	Length (inches)	Product of Columns 2 & 3 (To nearest 1/8")	Nipple Length (inches)	Traverse Point Location (Sum of Col. 4 & 5)



LOCATION OF TRAVERSE POINTS IN CIRCULAR DUCTS
(Fraction of Stack Diameter from Inside Wall to Traverse Point)

Traverse Point Number on a Diameter	Number of Traverse Points on a Diameter				
	4	6	8	10	12
1	0.067	0.044	0.032	0.026	0.021
2	0.250	0.146	0.105	0.082	0.067
3	0.750	0.296	0.194	0.146	0.118
4	0.933	0.704	0.323	0.226	0.177
5		0.854	0.677	0.342	0.250
6		0.956	0.806	0.658	0.356
7			0.895	0.774	0.644
8			0.968	0.854	0.750
9				0.918	0.823
10				0.974	0.882
11					0.933
12					0.979

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).

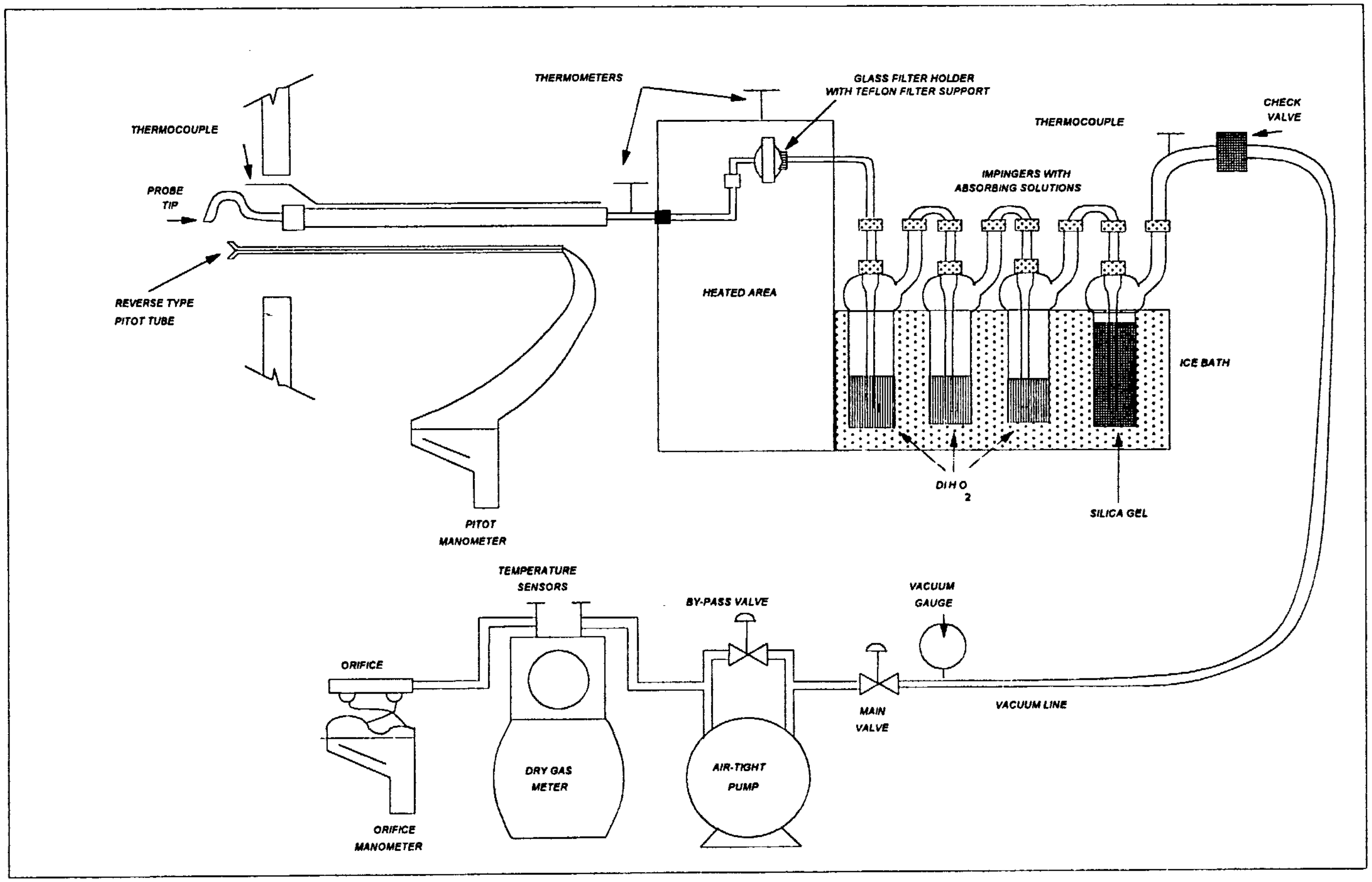


FIGURE 1
PARTICULATE (front and backhalf) SAMPLING TRAIN
EPA METHOD 5 AND METHOD 202

- 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 $\underline{+}$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.

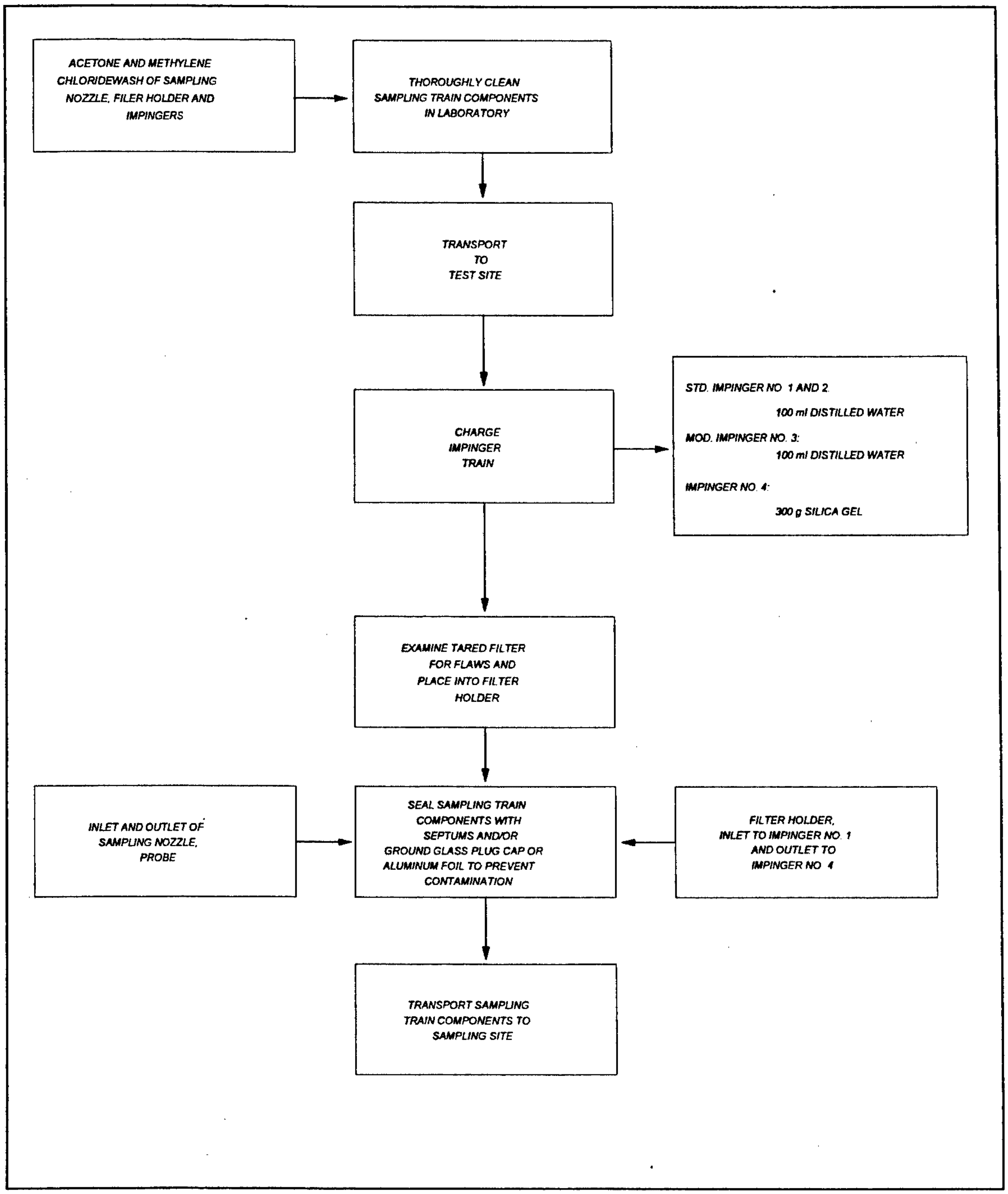


FIGURE 2
PREPARATION PROCEDURES FOR PARTICULATE (M5/M202) SAMPLING TRAIN

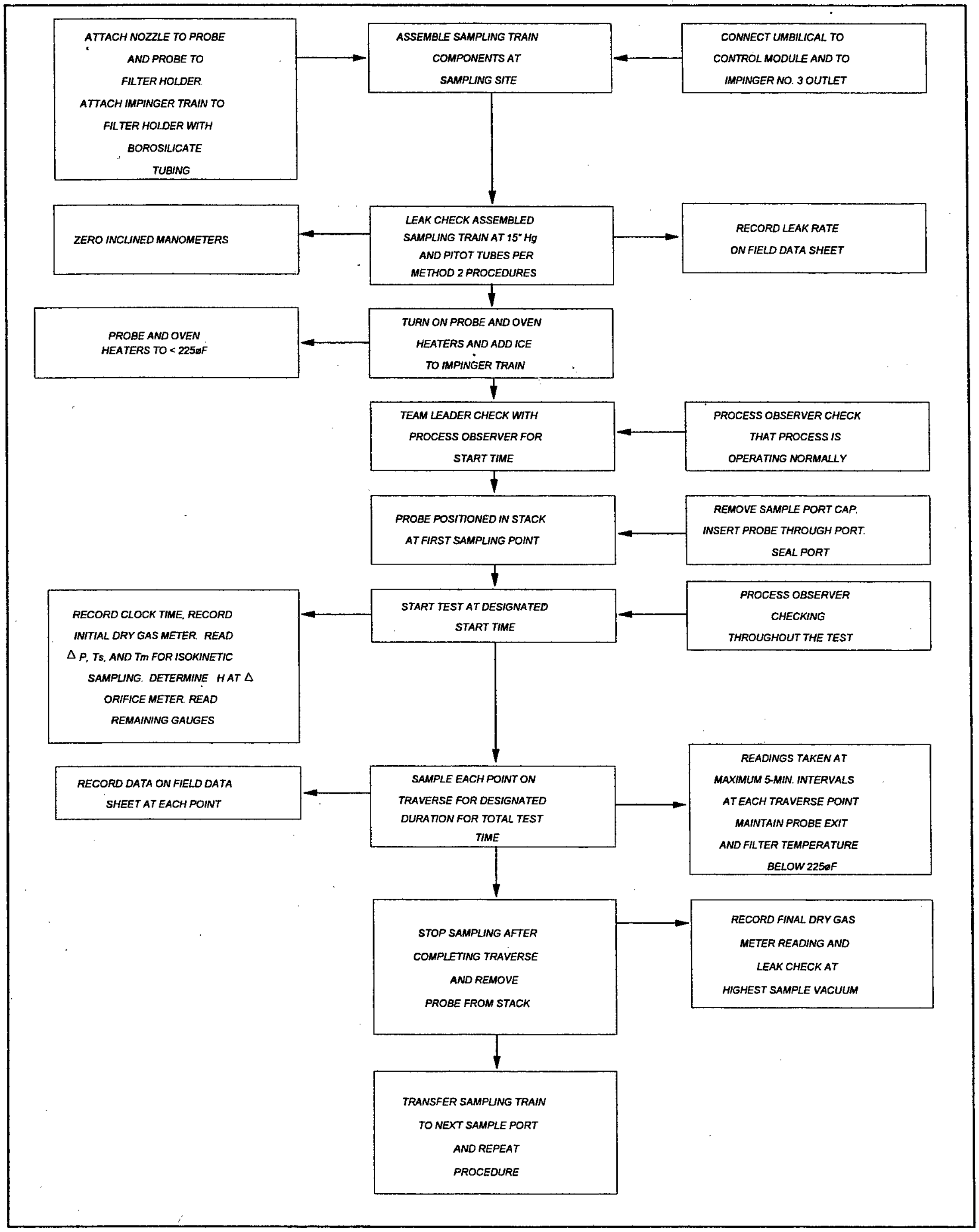


FIGURE 3
TEST PROCEDURES FOR PARTICULATES (M5/M202)

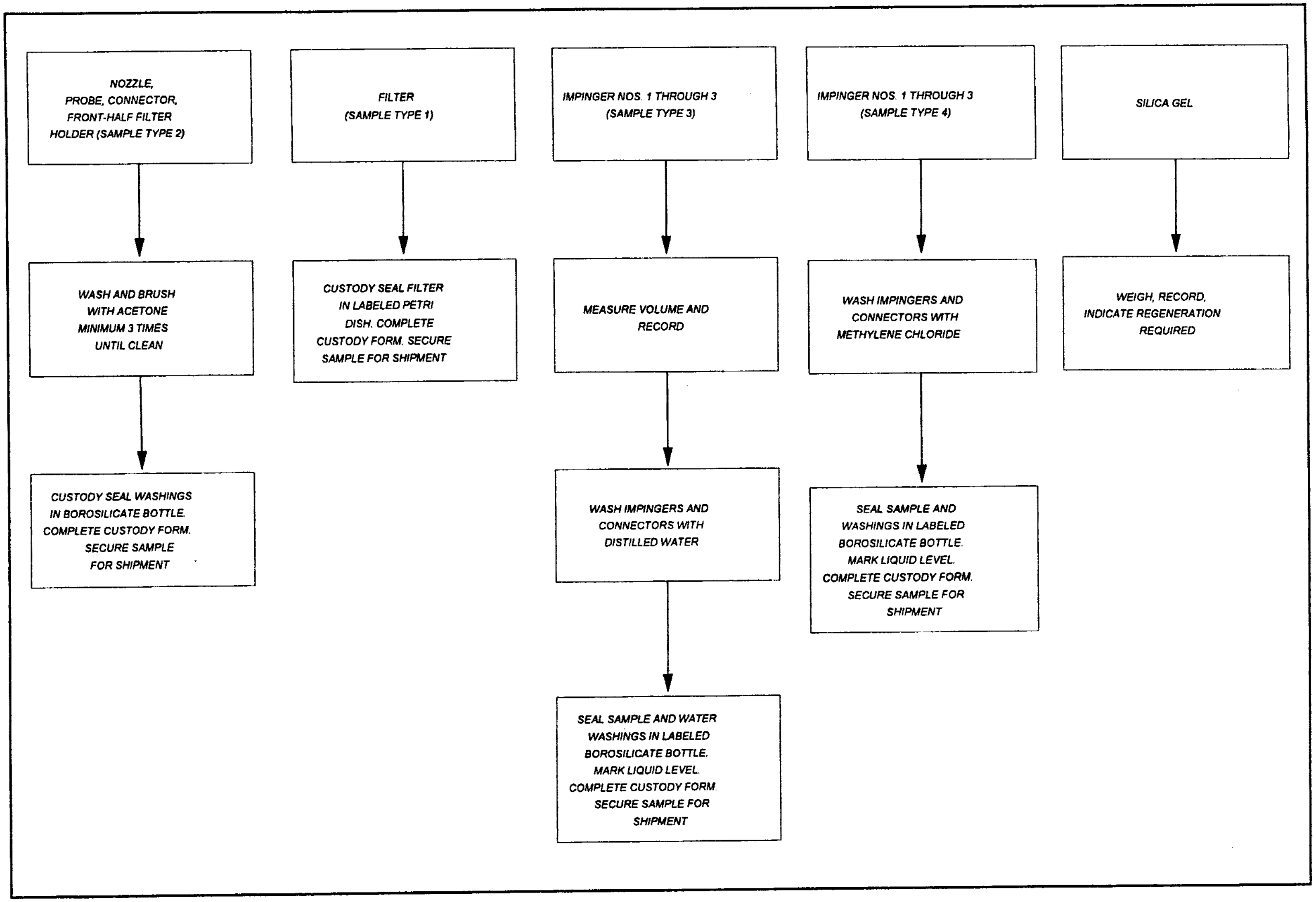


FIGURE 4
SAMPLE RECOVERY PROCEDURES FOR PARTICULATE (M5/M202) SAMPLING TRAIN

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).

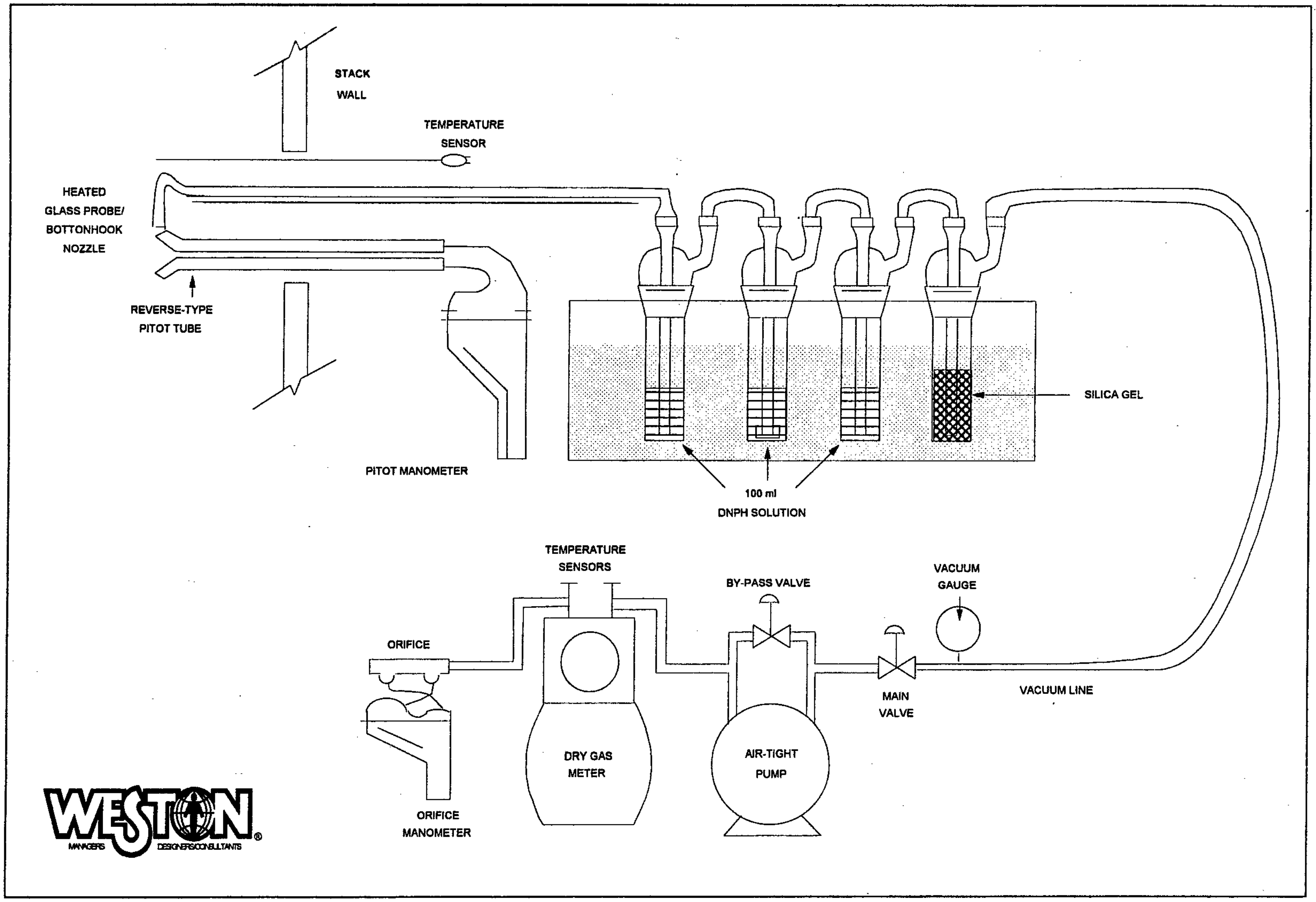


FIGURE 1
EPA METHOD 0011 - FORMALDEHYDE SAMPLING TRAIN

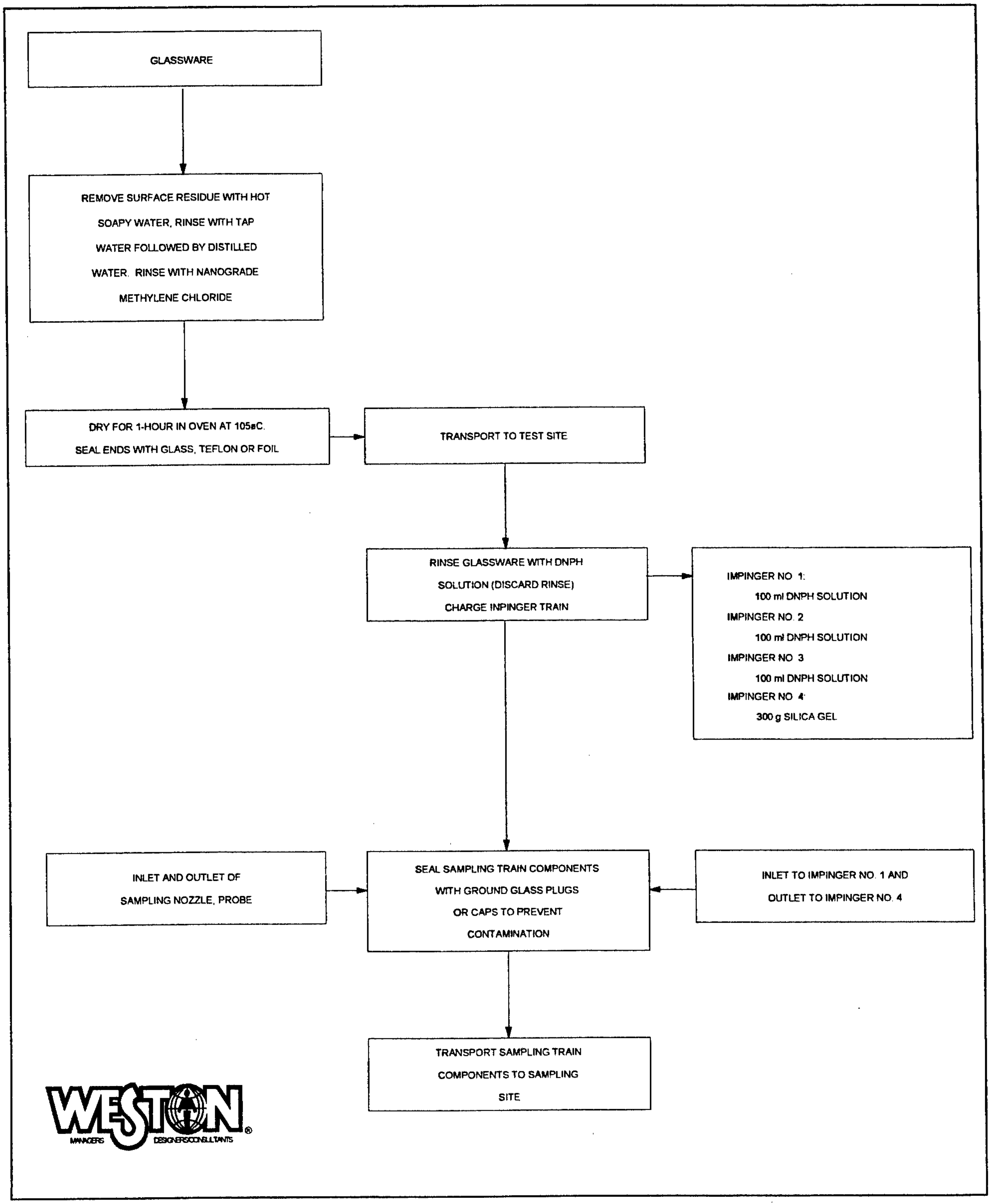


FIGURE 2
PREPARATION PROCEDURES FOR FORMALDEHYDE SAMPLING TRAIN

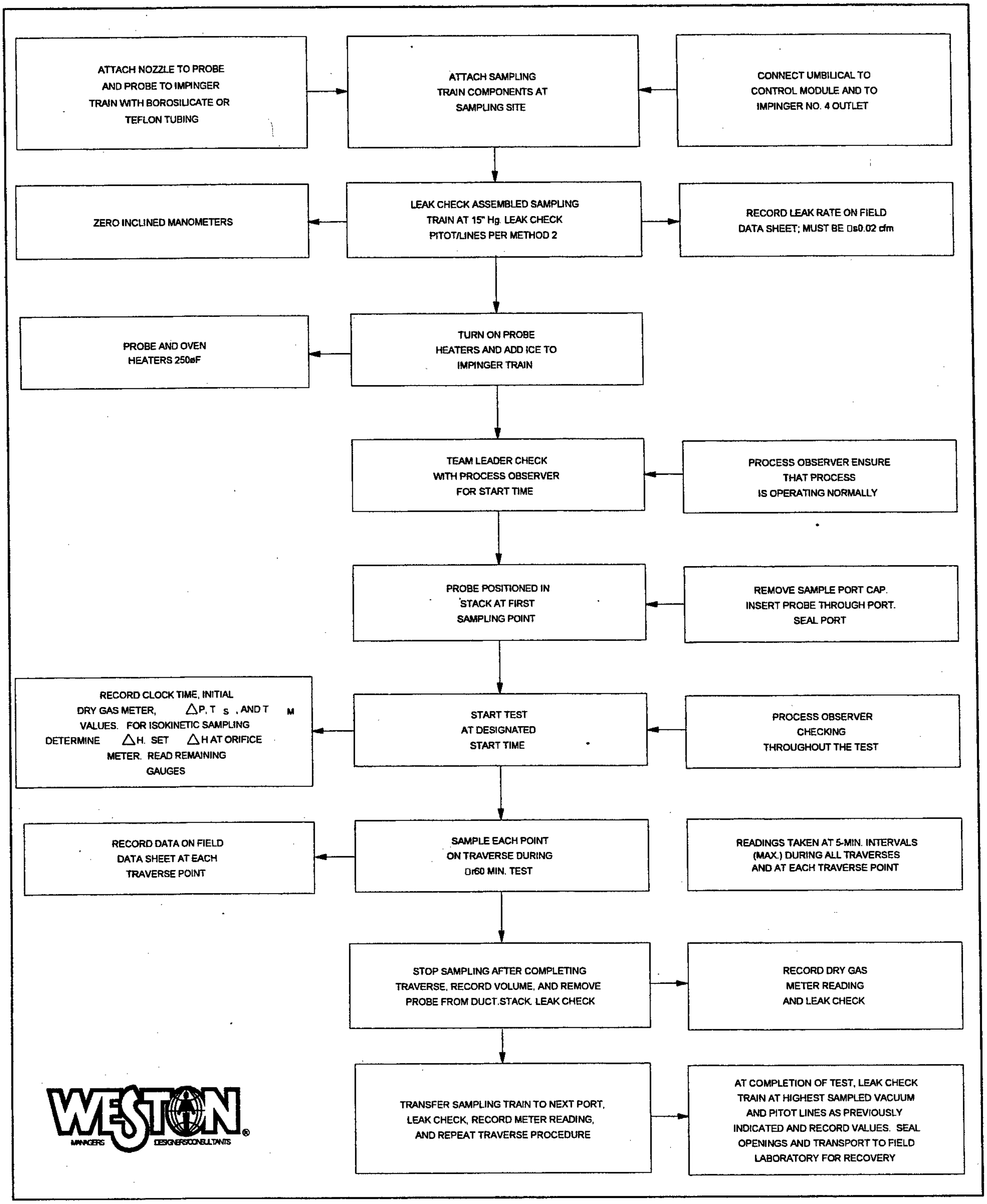


FIGURE 3
SAMPLING PROCEDURES FOR FORMALDEHYDE

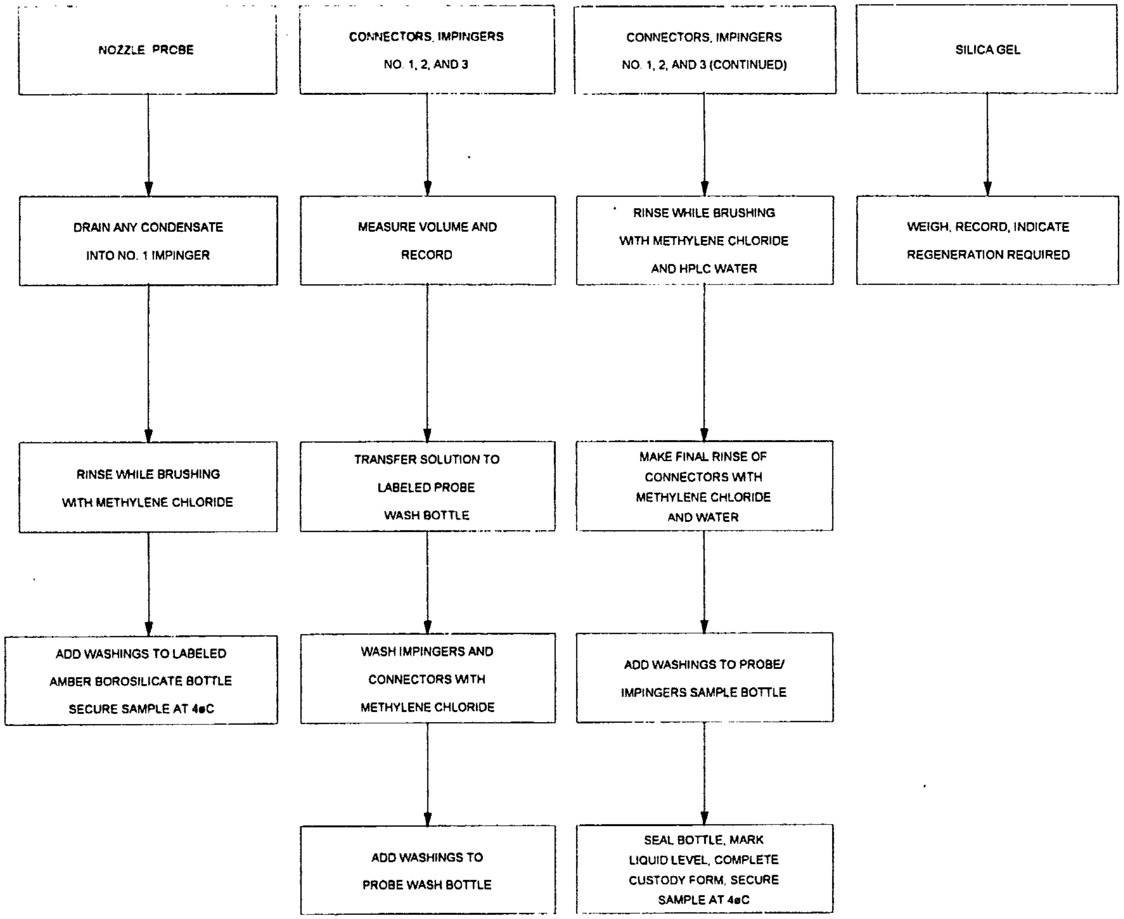


FIGURE 4
SAMPLE RECOVERY PROCEDURES FOR FORMALDEHYDE SAMPLING TRAIN

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.

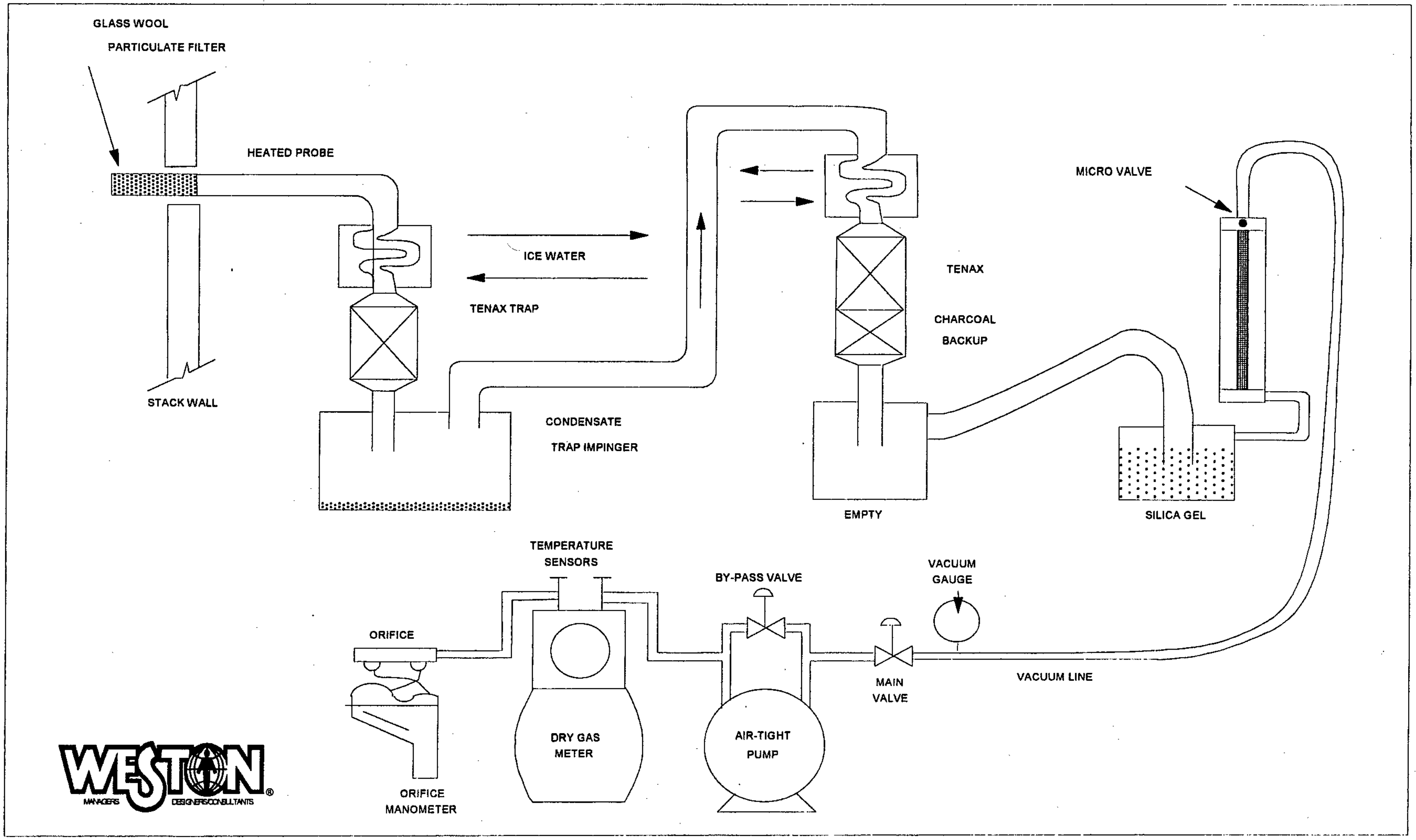


FIGURE 1
EPA METHOD 0030 - VOLATILE ORGANIC SAMPLING TRAIN (VOST)

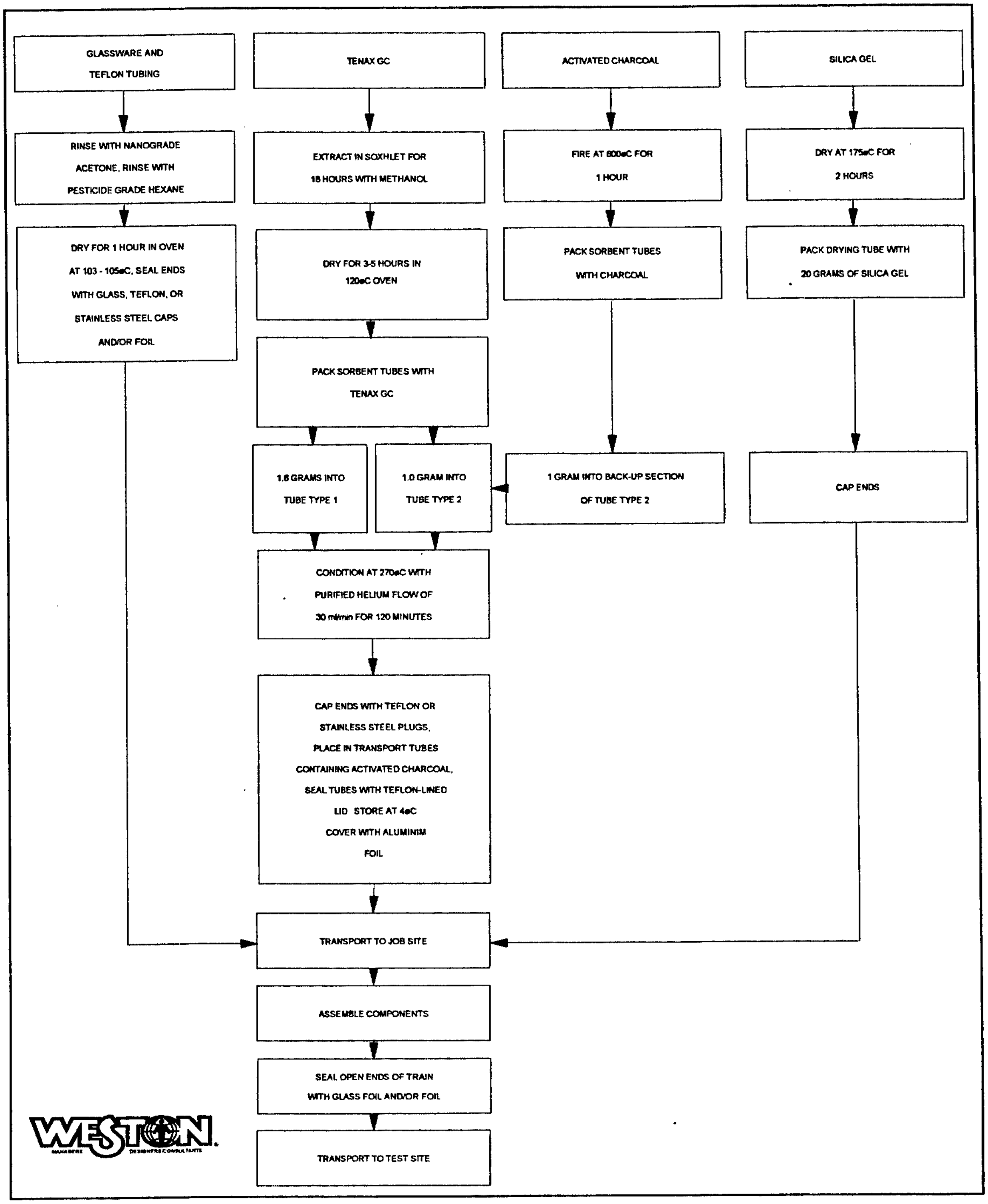


FIGURE 2
PREPARATION PROCEDURES FOR VOLATILE ORGANICS SAMPLING TRAIN

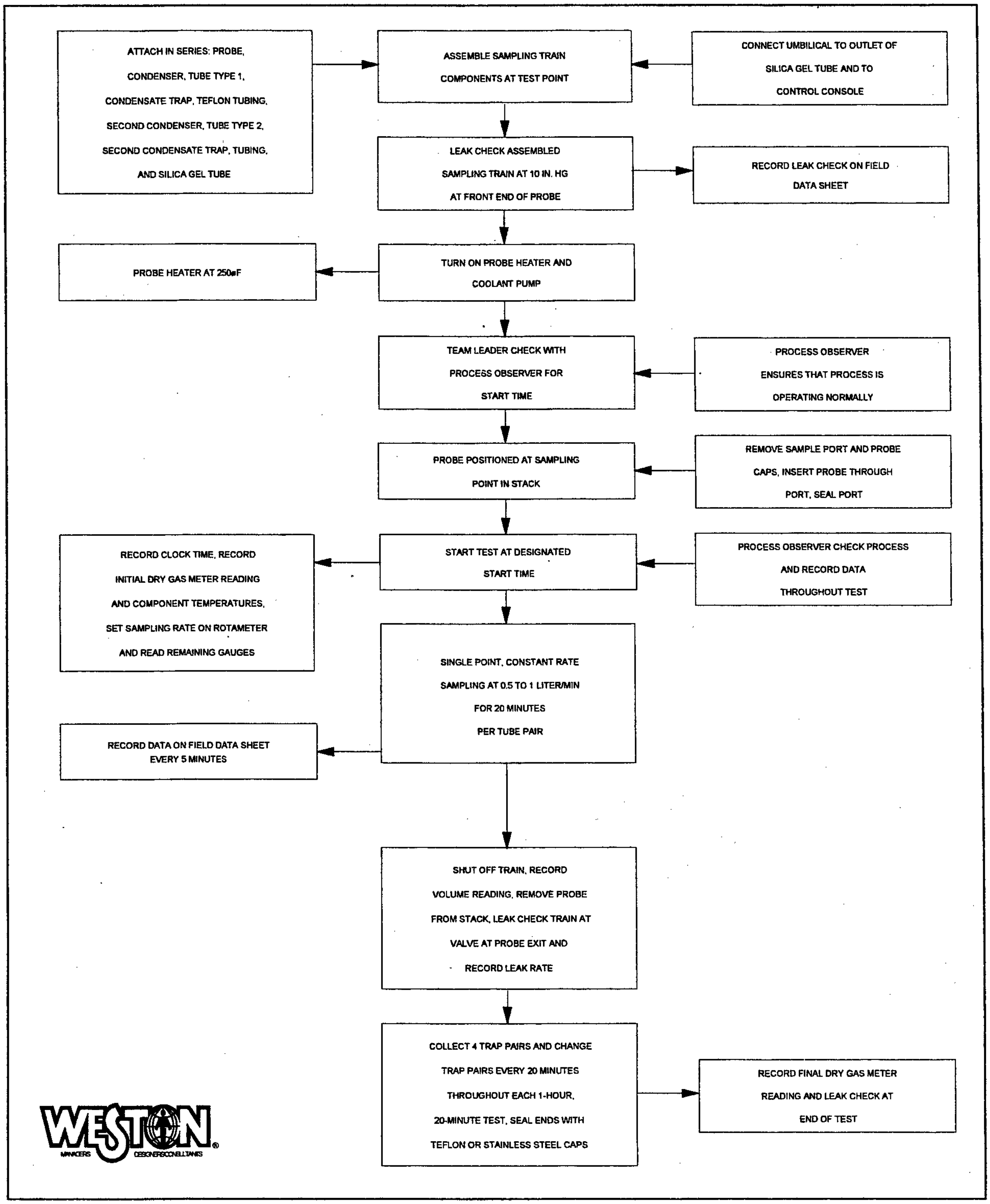


FIGURE 3
SAMPLING PROCEDURES FOR VOLATILE ORGANICS

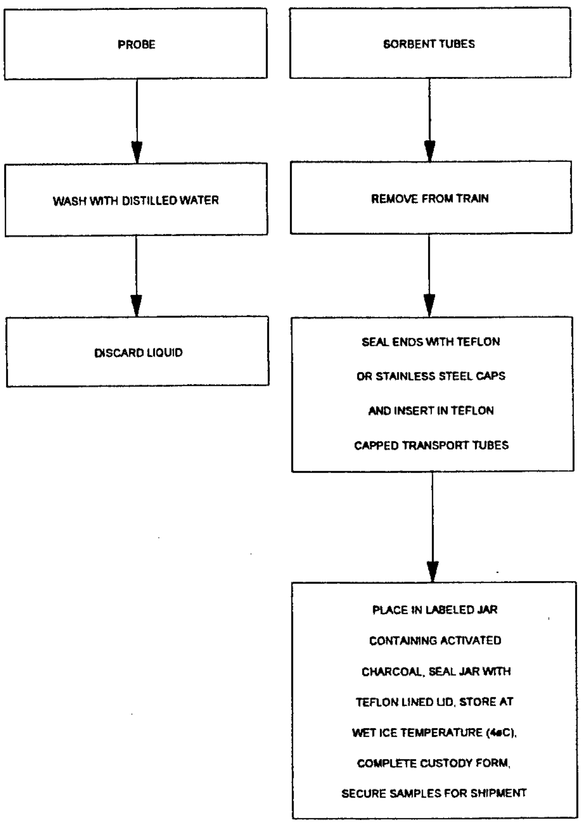


FIGURE 4
RECOVERY PROCEDURES FOR VOLATILE ORGANICS

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.

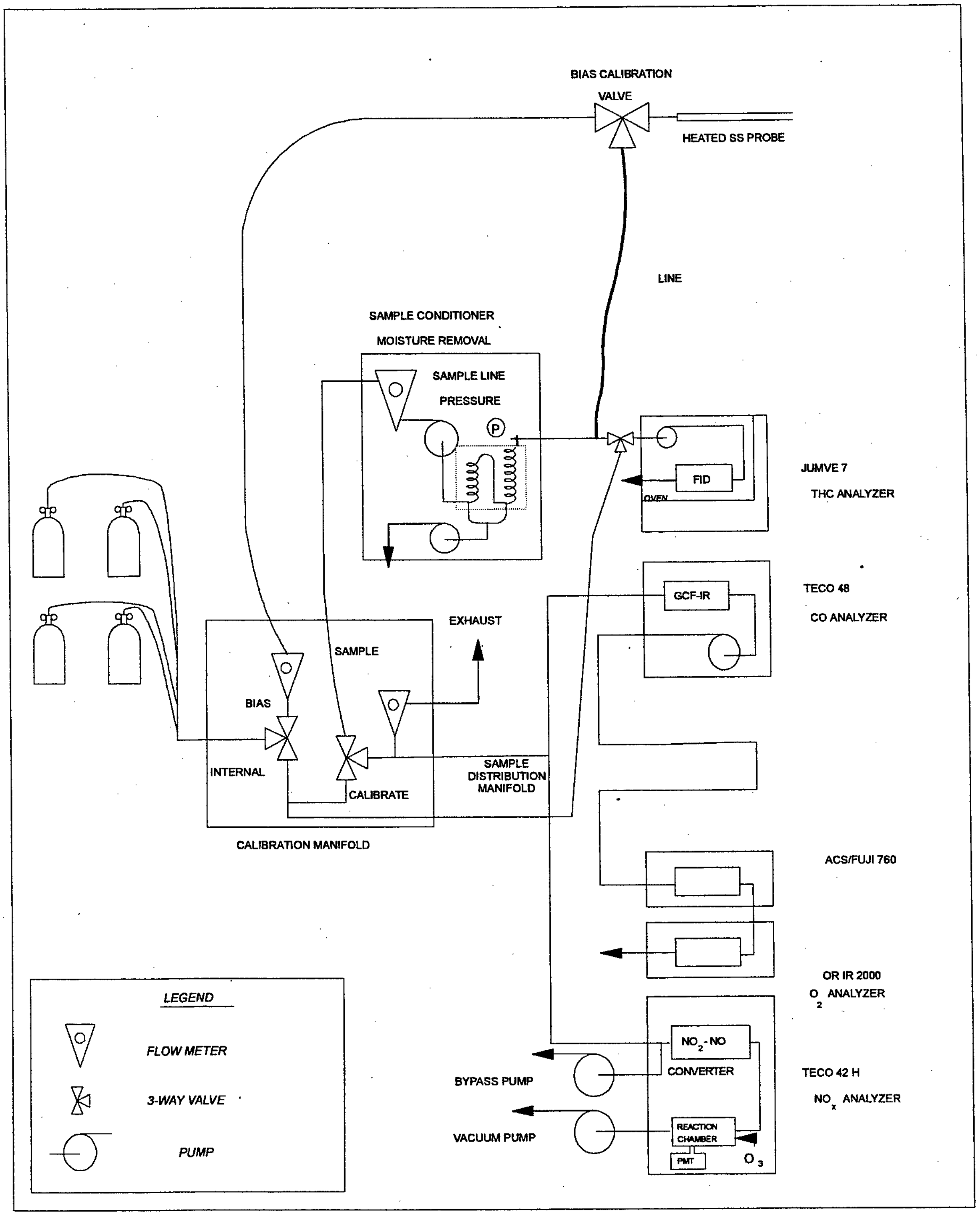


Figure 1

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.

APPENDIX C

CEM FIELD DATA

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	13:13-14:12	1395.7	447.8	-4.2	442.5	2,450	155	1403.4	15.00	96.7642
2	15:50-16:24	1347.0	447.8	-7.0	439.5	2,407	155	1358.0	14.26	91.9773
3	17:01-17:35	1329.4	902.8	-8.0	893.5	2,419	155	1339.4	14.13	91.1892
							Average	1366.9	14.46	93.3102
FI	18:07-18:26	1076.5	902.8	-8.0	893.5	2,908	179	1086.1	13.78	76.9616

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:	Pratt & Whitney
Sampling Location:	Exhaust - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	13:14-14:42	336.6	300.9	-0.3	292.5	11,161	155	346.2	16.86	108.7437
2	15:38-16:20	332.2	300.9	-0.7	289.0	15,872	155	345.8	23.94	154.4513
3	17:01-17:52	296.1	300.9	-0.9	287.5	17,304	155	309.8	23.38	150.8675
							Average	334.0	21.39	138.0208
FI	18:07-18:26	241.5	300.9	-0.9	287.5	16,965	179	252.8	18.71	104.5281

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/14/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No	Start-Stop Time	Raw Data (ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	14:16-14:41	-6.0	447.8	-4.2	442.5	0.00
2	15:31-15:44	-6.5	447.8	-7.0	439.5	0.48
3	17:38-18:01	-7.5	902.8	-8.0	893.5	0.50
					Average	0.33

Calibration Error Correction

Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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	13:13-14:12	3.2	10.5	0.3	10.5	3.0
2	15:50-16:24	3.2	10.5	0.3	10.5	2.9
3	17:01-17:35	3.2	10.5	0.4	10.7	2.8
				Average		2.9
FI	18:07-18:26	3.1	10.5	0.4	10.7	2.8

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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	13:14-14:42	0.692	1.01	-0.03	0.97	0.728
2	15:38-16:20	0.686	1.01	-0.03	0.97	0.723
3	17:01-17:52	0.624	1.01	-0.02	0.97	0.657
				Average		0.703
FI	18:07-18:26	0.647	1.0	0.0	1.0	0.681

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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	14:16-14:41	0.32	10.52	0.34	10.50	0.000
2	15:31-15:44	0.31	10.52	0.33	10.50	0.000
3	17:38-18:01	0.31	10.52	0.44	10.65	0.000
				Average		0.000

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location	Engine - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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	13:13-14:1	16.6	20.5	-0.2	20.2	17.0
2	15:50-16:2	16.6	20.5	-0.2	20.3	16.9
3	17:01-17:3	16.6	20.5	-0.2	20.3	16.9
					Average	16.9
FI	18:07-18:2	16.8	20.5	-0.2	20.3	17.0

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location	Exhaust - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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	13:14-14:4	19.8	20.5	-0.4	20.2	20.0
2	15:38-16:2	20.3	20.5	-0.4	20.5	20.3
3	17:01-17:5	20.8	20.5	-0.3	20.9	20.3
					Average	20.2
FI	18:07-18:2	20.684	20.5	-0.3	20.9	20.242

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location	Ambient
Date:	05/14/2002
Project Number:	030414.0008C.5.005
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	14:16-14:4	20.7	20.5	-0.2	20.2	21.1
2	15:31-15:4	20.7	20.5	-0.2	20.3	21.0
3	17:38-18:0	20.7	20.5	-0.2	20.3	21.0
					Average	21.0

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

Total Hydrocarbon Data Correction

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information				
Run No	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	13:13-14:12	613.1	2,450	0.05	613.4	3.74	24.1583
2	15:50-16:24	586.7	2,407	0.05	587.0	3.52	22.7095
3	17:01-17:35	594.1	2,419	0.05	594.4	3.58	23.1186
				Average	598.3	3.62	23.33
FI	18:07-18:26	477.4	2,908	0.05	477.7	3.46	19.3344

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:	Pratt & Whitney
Sampling Location:	Exhaust - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information				
Run No	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)	Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
1	13:14-14:42	227.4	11,161	0.05	227.5	6.33	40.8116
2	15:38-16:20	226.0	15,872	0.05	226.1	8.94	57.6943
3	17:01-17:52	208.3	17,304	0.05	208.4	8.99	57.9685
				Average	220.7	8.08	52.16
FI	18:07-18:26	128.1	16,965	0.05	128.2	5.42	30.2677

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/14/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No	Start-Stop Time	Raw Data (ppm)
1	14:16-14:41	4.57
2	15:31-15:44	-2.88
3	17:38-18:01	-2.57

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No	Start-Stop Time	Raw Data (% or 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	13:13-14:12	18.0	46.7	0.2	45.7	2,450	155	18.4	0.32	2.0797
2	15:50-16:24	19.9	46.7	0.6	48.0	2,407	155	19.1	0.33	2.1223
3	17:01-17:35	21.3	46.7	1.3	50.1	2,419	155	19.2	0.33	2.1443
							Average	18.9	0.33	2.1154
FI	18:07-18:26	20.9	46.7	1.3	50.1	2,908	179	18.7	0.39	2.1817

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:	Pratt & Whitney
Sampling Location:	Exhaust - Ground Idle
Date:	05/14/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No	Start-Stop Time	Raw Data (% or 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	13:14-14:42	1.59	10.1	0.2	10.7	11,161	155	1.3	0.11	0.6961
2	15:38-16:20	1.72	10.1	0.4	10.3	15,872	155	1.4	0.16	1.0211
3	17:01-17:52	1.58	10.1	0.4	10.7	17,304	155	1.2	0.14	0.9240
							Average	1.3	0.14	0.8804
FI	18:07-18:26	1.8	10.1	0.4	10.7	16,965	179	1.4	0.17	0.9462

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/14/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	14:16-14:41	0.17	46.7	0.2	45.7	0.02
2	15:31-15:44	-0.04	46.7	0.6	48.0	0.00
3	17:38-18:01	0.39	46.7	1.3	50.1	0.00
					Avera	0.01

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Source Information		Calibration Corrected Data	Mass Emission Rate	Mass Emission Rate
Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	07:52-09:01	159.2	300.9	-7.0	299.5	6,080	448	163.1	4.33	9.6574
2	10:17-10:51	148.3	300.9	-6.5	296.0	6,048	448	153.9	4.06	9.0647
3	12:29-13:03	148.4	300.9	-7.0	295.0	5,972	448	154.9	4.03	9.0045
							Average	157.3	4.14	9.2422

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:	Pratt & Whitney
Sampling Location:	Exhaust - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

						Source Information		Calibration Corrected Data	Mass Emission Rate	Mass Emission Rate
Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	07:52-09:15	37.7	300.9	-1.1	297.5	38,123	448	39.1	6.50	14.5051
2	10:17-11:10	34.9	300.9	-0.9	299.0	34,195	448	35.9	5.35	11.9427
3	12:29-13:21	36.0	300.9	-0.9	298.5	35,815	448	37.1	5.79	12.9261
							Average	37.3	5.88	13.1246

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	09:05-09:24	-5.3	300.9	-7.0	299.5	1.66
2	10:55-11:14	-4.5	300.9	-6.5	296.0	1.94
3	13:06-13:25	-4.7	300.9	-7.0	295.0	2.25
					Averag	1.95

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:52-09:01	3.4	10.5	-0.1	10.4	3.5
2	10:17-10:51	3.4	10.5	-0.2	10.4	3.6
3	12:29-13:03	3.5	10.5	-0.1	10.4	3.6
				Average		3.6

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:52-09:15	0.757	1.01	-0.02	0.99	0.780
2	10:17-11:10	0.740	1.01	-0.02	0.99	0.763
3	12:29-13:21	0.767	1.01	-0.02	0.99	0.792
				Average		0.778

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:05-09:24	-0.14	10.52	-0.14	10.40	0.000
2	10:55-11:14	-0.15	10.52	-0.16	10.35	0.011
3	13:06-13:25	-0.15	10.52	-0.13	10.40	0.000
				Average		0.004

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:52-09:01	15.9	20.5	-0.6	20.3	16.2
2	10:17-10:51	15.9	20.5	-0.6	20.3	16.2
3	12:29-13:03	15.8	20.5	-0.6	20.3	16.1
				Average		16.2

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:52-09:15	20.5	20.5	-0.3	20.9	20.2
2	10:17-11:10	20.2	20.5	-0.3	20.6	20.1
3	12:29-13:21	20.5	20.5	-0.3	20.9	20.1
				Average		20.1

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:05-09:24	20.7	20.5	-0.6	20.3	21.0
2	10:55-11:14	20.7	20.5	-0.6	20.3	21.0
3	13:06-13:25	20.8	20.5	-0.6	20.3	21.0
				Average		21.0

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

Total Hydrocarbon Data Correction

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)	Source Information		Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Stack Flow (dscfm)	Stack Moisture (%)			
1	07:52-09:01	5.3	6,080	0.05	5.3	0.08	0.1800
2	10:17-10:51	2.7	6,048	0.05	2.7	0.04	0.0913
3	12:29-13:03	2.9	5,972	0.05	2.9	0.04	0.0977
				Average	3.7	0.06	0.123

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:	Pratt & Whitney
Sampling Location:	Exhaust - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)	Source Information		Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Stack Flow (dscfm)	Stack Moisture (%)			
1	07:52-09:15	2.4	38,123	0.05	2.4	0.23	0.5052
2	10:17-11:10	1.6	34,195	0.05	1.6	0.13	0.3013
3	12:29-13:21	1.6	35,815	0.05	1.6	0.14	0.3185
				Average	1.9	0.17	0.37

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	09:05-09:24	0.94
2	10:55-11:14	-0.07
3	13:06-13:25	-0.13

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information		Calibration Corrected Data	Mass Emission Rate	Mass Emission Rate
			Calibration Data							
Run No.	Start-Stop Time	Raw Data (% or ppm)	Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	07:52-09:01	63.1	46.7	-0.5	44.1	6,080	448	66.6	2.90	6.4758
2	10:17-10:51	65.6	46.7	-0.5	45.1	6,048	448	67.8	2.94	6.5533
3	12:29-13:03	66.4	46.7	-0.3	46.0	5,972	448	67.3	2.88	6.4259
							Average	67.2	2.91	6.4850

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:	Pratt & Whitney
Sampling Location:	Exhaust - Approach
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Source Information		Calibration Corrected Data	Mass Emission Rate	Mass Emission Rate
			Calibration Data							
Run No.	Start-Stop Time	Raw Data (% or ppm)	Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	(lb/1000 lb fuel)
1	07:52-09:15	9.79	10.1	0.1	10.2	38,123	448	9.6	2.63	5.8774
2	10:17-11:10	10.09	10.1	0.3	10.4	34,195	448	9.8	2.40	5.3539
3	12:29-13:21	10.53	10.1	0.3	10.4	35,815	448	10.2	2.61	5.8314
							Average	9.9	2.55	5.6876

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

						Calibration Corrected Data
			Calibration Data			
Run No.	Start-Stop Time	Raw Data (% or ppm)	Cma	Co	Cm	(% or ppm)
1	09:05-09:24	-0.32	46.7	-0.5	44.1	0.14
2	10:55-11:14	-0.21	46.7	-0.5	45.1	0.24
3	13:06-13:25	0.14	46.7	-0.3	46.0	0.44
					Averag	0.27

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate b/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	14:05-14:54	52.0	300.9	-7.0	294.5	9,358	612	58.9	2.41	3.9298
2	15:25-15:59	49.7	300.9	-7.0	294.5	9,443	612	56.6	2.33	3.8107
3	16:51-17:24	48.0	300.9	-7.0	293.5	8,632	612	55.1	2.07	3.3888
							Average	56.9	2.27	3.7098

<u>Calibration Error Correction</u>
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
<u>Mass Emission Rate (lb/hr)</u>
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
<u>Mass Emission Rate (lb/1000 lb fuel)</u>
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:	Pratt & Whitney
Sampling Location	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate b/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	14:05-15:02	15.6	300.9	-1.0	297.5	36,910	612	16.7	2.69	4.3996
2	15:25-16:20	15.1	300.9	-1.0	296.5	38,474	612	16.3	2.73	4.4563
3	16:51-17:37	14.8	300.9	-0.9	296.5	37,800	612	15.9	2.62	4.2736
							Average	16.3	2.68	4.3765

<u>Calibration Error Correction</u>
Cgas=(Cobs-Co)*(Cma/(Cm-Co))
<u>Mass Emission Rate (lb/hr)</u>
E(lb/hr)=Cgas*MWgas*Qs(dscfm)*60/385300000
<u>Mass Emission Rate (lb/1000 lb fuel)</u>
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:	Pratt & Whitney
Sampling Location	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No	Start-Stop Time	Raw Data (ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	14:57-15:06	-5.4	300.9	-7.0	294.5	1.61
2	16:03-16:17	-6.1	300.9	-7.0	294.5	0.86
3	17:29-17:42	-6.0	300.9	-7.0	293.5	0.96
					Averag	1.14

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:05-14:54	3.8	10.5	-0.3	10.5	3.9
2	15:25-15:59	3.8	10.5	-0.4	10.4	4.0
3	16:51-17:24	3.8	10.5	-0.4	10.5	4.0
				Average		4.0

Calibration Error Correction

Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:05-15:02	1.017	1.01	-0.02	0.99	1.042
2	15:25-16:20	1.027	1.01	-0.02	0.99	1.052
3	16:51-17:37	1.009	1.01	-0.02	0.98	1.035
				Average		1.043

Calibration Error Correction

Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:57-15:06	-0.13	10.52	-0.25	10.45	0.121
2	16:03-16:17	-0.14	10.52	-0.35	10.40	0.203
3	17:29-17:42	-0.14	10.52	-0.35	10.50	0.205
				Average		0.176

Calibration Error Correction

Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:05-14:5	15.4	20.5	-0.6	20.3	15.8
2	15:25-15:5	15.4	20.5	-0.6	20.3	15.8
3	16:51-17:2	15.4	20.5	-0.6	20.3	15.8
					Average	15.8

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:05-15:0	20.2	20.5	-0.3	21.1	19.6
2	15:25-16:2	20.2	20.5	-0.3	21.0	19.6
3	16:51-17:3	20.1	20.5	-0.3	20.9	19.7
					Average	19.7

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:57-15:0	20.8	20.5	-0.6	20.3	21.0
2	16:03-16:1	20.8	20.5	-0.6	20.3	21.1
3	17:29-17:4	20.8	20.5	-0.6	20.3	21.1
					Average	21.0

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

Total Hydrocarbon Data Correction

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Informat		Correcte	Mass	Mass
Run No	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moistur (%)	Data Dry Basi (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	14:05-14:54	2.0	9,358	1.70	2.0	0.05	0.0775
2	15:25-15:59	2.0	9,443	1.70	2.0	0.05	0.0782
3	16:51-17:24	2.0	8,632	0.30	2.0	0.04	0.0705
				Avera	2.0	0.05	0.075

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:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Informat		Correcte	Mass	Mass
Run No	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moistur (%)	Data Dry Basi (ppm)	Emission Rate (lb/hr)	Emission Rate (lb/1000 lb fuel)
1	14:05-15:02	0.5	36,910	1.70	0.5	0.05	0.0764
2	15:25-16:20	0.5	38,474	1.70	0.5	0.05	0.0797
3	16:51-17:37	0.5	37,800	0.30	0.5	0.05	0.0772
				Avera	0.5	0.05	0.08

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No	Start-Stop Time	Raw Data (ppm)
1	14:57-15:06	-0.15
2	16:03-16:17	-0.59
3	17:29-17:42	-0.39

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

			Calibration Data			Source Information		Calibration Corrected Data	Mass Emissio Rate	Mass Emission Rate
Run No	Start-Stop Time	Raw Data (% or ppm)	Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	lb/1000 lb fuel
1	14:05-14:54	89.0	46.7	-0.4	45.1	9,358	612	91.8	6.15	10.0558
2	15:25-15:59	89.1	46.7	-0.5	44.2	9,443	612	93.7	6.34	10.3544
3	16:51-17:24	90.6	46.7	-0.6	44.5	8,632	612	94.6	5.85	9.5576
							Average	93.3	6.11	9.9892

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:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

			Calibration Data			Source Information		Calibration Corrected Data	Mass Emissio Rate	Mass Emission Rate
Run No	Start-Stop Time	Raw Data (% or ppm)	Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)	(% or ppm)	(lb/hr)	lb/1000 lb fuel
1	14:05-15:02	19.05	10.1	0.2	10.4	36,910	612	18.7	4.94	8.0651
2	15:25-16:20	19.45	10.1	0.3	10.4	38,474	612	19.1	5.27	8.6053
3	16:51-17:37	19.45	10.1	0.3	10.2	37,800	612	19.5	5.29	8.6466
							Average	19.1	5.16	8.4390

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

			Calibration Data			Calibration Corrected Data
Run No	Start-Stop Time	Raw Data (% or ppm)	Cma	Co	Cm	(% or ppm)
1	14:57-15:06	-0.26	46.7	-0.4	45.1	0.14
2	16:03-16:17	-0.45	46.7	-0.5	44.2	0.06
3	17:29-17:42	-0.40	46.7	-0.6	44.5	0.16
					Averag	0.12

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	09:34-10:09	1013.9	902.8	-8.5	894.5	2,865	179	1022.1	12.77	71.3537
2	10:48-11:22	1042.1	902.8	-12.5	880.0	2,821	179	1066.8	13.13	73.3328
3	13:08-13:42	1054.8	902.8	-13.5	879.0	2,806	179	1080.6	13.23	73.8925
							Average	1056.5	13.04	72.8597

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:	Pratt & Whitney
Sampling Location:	Exhaust - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	09:34-10:28	251.4	300.9	-1.0	301.0	11,963	179	251.5	13.12	73.3066
2	10:47-11:41	252.0	300.9	-1.0	299.0	12,334	179	253.8	13.65	76.2704
3	13:08-14:01	260.6	300.9	-1.0	298.5	11,919	179	262.8	13.66	76.3319
							Average	256.0	13.48	75.3030

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	10:12-10:26	-10.9	902.8	-8.5	894.5	0.00
2	11:25-11:39	-12.9	902.8	-12.5	880.0	0.00
3	13:46-14:00	-12.4	902.8	-13.5	879.0	1.07
					Averag	0.36

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:34-10:09	2.7	10.5	-0.3	10.5	2.9
2	10:48-11:22	2.7	10.5	-0.3	10.5	2.9
3	13:08-13:42	2.8	10.5	-0.3	10.5	3.0
					Average	2.9

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:34-10:28	0.703	1.01	-0.03	1.00	0.715
2	10:47-11:41	0.700	1.01	-0.03	1.00	0.713
3	13:08-14:01	0.727	1.01	-0.02	1.00	0.740
					Average	0.723

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	10:12-10:26	-0.15	10.52	-0.30	10.50	0.146
2	11:25-11:39	-0.15	10.52	-0.25	10.50	0.098
3	13:46-14:00	-0.15	10.52	-0.30	10.50	0.147
					Average	0.130

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:34-10:09	16.8	20.5	-0.5	20.4	17.0
2	10:48-11:22	16.7	20.5	-0.5	20.4	16.9
3	13:08-13:42	16.6	20.5	-0.5	20.3	16.9
					Average	16.9

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:34-10:28	20.5	20.5	-0.4	21.0	20.0
2	10:47-11:41	20.5	20.5	-0.4	21.0	20.0
3	13:08-14:01	20.4	20.5	-0.4	20.9	20.0
					Average	20.0

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	10:12-10:26	20.8	20.5	-0.5	20.4	20.9
2	11:25-11:39	20.8	20.5	-0.5	20.4	21.0
3	13:46-14:00	20.7	20.5	-0.5	20.3	21.0
					Average	20.9

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

Total Hydrocarbon Data Correction

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:34-10:09	481.7	2,865	0.05	482.0	3.44	19.2197
2	10:48-11:22	512.5	2,821	0.05	512.7	3.60	20.1337
3	13:08-13:42	511.8	2,806	0.05	512.0	3.58	20.0008
				Average	502.3	3.54	19.785

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:	Pratt & Whitney
Sampling Location:	Exhaust - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	09:34-10:28	134.9	11,963	0.05	135.0	4.02	22.4736
2	10:47-11:41	138.6	12,334	0.05	138.6	4.26	23.8006
3	13:08-14:01	140.4	11,919	0.05	140.5	4.17	23.3083
				Average	138.0	4.15	23.19

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	10:12-10:26	2.77
2	11:25-11:39	3.49
3	13:46-14:00	3.07

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No.	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)			
1	09:34-10:09	21.6	46.7	-0.4	45.3	2,865	179	22.5	0.46	2.5794
2	10:48-11:22	21.3	46.7	-0.5	46.6	2,821	179	21.6	0.44	2.4439
3	13:08-13:42	21.3	46.7	-0.5	47.2	2,806	179	21.4	0.43	2.4022
							Average	21.8	0.44	2.4752

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:	Pratt & Whitney
Sampling Location:	Exhaust - Flight Idle
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No.	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)			
1	09:34-10:28	2.20	10.1	0.3	11.2	11,963	179	1.8	0.15	0.8412
2	10:47-11:41	2.20	10.1	0.5	11.2	12,334	179	1.6	0.14	0.7891
3	13:08-14:01	2.25	10.1	0.5	11.3	11,919	179	1.6	0.14	0.7783
							Average	1.7	0.14	0.8029

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	10:12-10:26	0.16	46.7	-0.4	45.3	0.53
2	11:25-11:39	0.06	46.7	-0.5	46.6	0.51
3	13:46-14:00	0.01	46.7	-0.5	47.2	0.50
					Averag	0.51

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

			Calibration Data			Source Information				
Run No.	Start-Stop Time	Raw Data (ppm)	Cma	Co	Cm	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	14:57-15:31	359.5	300.9	-14.5	885.0	4,679	328	125.1	2.55	7.7851
2	16:12-16:47	353.9	300.9	-17.0	887.0	4,755	328	123.5	2.56	7.8079
3	17:32-18:06	351.7	300.9	-17.5	885.0	4,777	328	123.1	2.56	7.8200
							Average	123.9	2.56	7.8044

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:	Pratt & Whitney
Sampling Location:	Exhaust - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

			Calibration Data			Source Information				
Run No.	Start-Stop Time	Raw Data (ppm)	Cma	Co	Cm	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	14:57-15:50	97.5	300.9	-0.9	298.0	20,369	328	99.1	8.80	26.8421
2	16:12-17:04	96.4	300.9	-1.0	298.0	20,030	328	98.0	8.56	26.1054
3	17:32-18:23	96.5	300.9	-0.7	298.5	18,741	328	97.7	7.99	24.3557
							Average	98.3	8.45	25.7677

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

			Calibration Data			
Run No.	Start-Stop Time	Raw Data (ppm)	Cma	Co	Cm	Calibration Corrected Data (% or ppm)
1	15:35-15:49	-13.0	300.9	-14.5	885.0	0.51
2	16:51-17:00	-13.4	300.9	-17.0	887.0	1.20
3	18:09-18:19	-13.5	300.9	-17.5	885.0	1.34
					Averag	1.01

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:57-15:31	3.1	10.5	-0.3	10.6	3.3
2	16:12-16:47	3.1	10.5	-0.3	10.6	3.3
3	17:32-18:06	3.1	10.5	-0.3	10.5	3.3
				Average		3.3

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:57-15:50	0.820	1.01	-0.03	1.00	0.833
2	16:12-17:04	0.820	1.01	-0.03	1.00	0.833
3	17:32-18:23	0.829	1.01	-0.03	1.00	0.840
				Average		0.835

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	15:35-15:49	-0.14	10.52	-0.30	10.56	0.151
2	16:51-17:00	-0.14	10.52	-0.30	10.55	0.155
3	18:09-18:19	-0.14	10.52	-0.30	10.50	0.157
				Average		0.154

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:57-15:31	16.2	20.5	-0.6	20.4	16.5
2	16:12-16:47	16.2	20.5	-0.6	20.3	16.5
3	17:32-18:06	16.2	20.5	-0.6	20.3	16.5
				Average		16.5

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	14:57-15:50	20.2	20.5	-0.4	20.8	19.9
2	16:12-17:04	20.1	20.5	-0.3	20.8	19.9
3	17:32-18:23	20.1	20.5	-0.3	20.8	19.8
				Average		19.8

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	15:35-15:49	20.7	20.5	-0.6	20.4	20.8
2	16:51-17:00	20.7	20.5	-0.6	20.3	20.9
3	18:09-18:19	20.7	20.5	-0.6	20.3	21.0
				Average		20.9

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

Total Hydrocarbon Data Correction

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)			
1	14:57-15:31	59.1	4,679	0.05	59.2	0.69	2.1028
2	16:12-16:47	48.4	4,755	0.05	48.4	0.57	1.7476
3	17:32-18:06	43.0	4,777	0.05	43.0	0.51	1.5599
				Average	50.2	0.59	1.803

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:	Pratt & Whitney
Sampling Location:	Exhaust - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

			Source Information		Corrected Data Dry Basis (ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
Run No.	Start-Stop Time	Raw Data (ppm)	Stack Flow (dscfm)	Stack Moisture (%)			
1	14:57-15:50	17.4	20,369	0.05	17.5	0.89	2.7007
2	16:12-17:04	15.9	20,030	0.05	15.9	0.79	2.4225
3	17:32-18:23	15.5	18,741	0.05	15.5	0.72	2.2063
				Average	16.3	0.80	2.44

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	15:35-15:49	5.61
2	16:51-17:00	4.12
3	18:09-18:19	3.50

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No.	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)			
1	14:57-15:31	46.0	46.7	-0.4	47.1	4,679	328	45.6	1.53	4.6639
2	16:12-16:47	47.3	46.7	-0.4	46.2	4,755	328	47.8	1.63	4.9647
3	17:32-18:06	47.7	46.7	-0.5	46.9	4,777	328	47.4	1.62	4.9507
							Average	47.0	1.59	4.8598

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:	Pratt & Whitney
Sampling Location:	Exhaust - Descend
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No.	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)			
1	14:57-15:50	6.48	10.1	0.5	11.2	20,369	328	5.6	0.82	2.4988
2	16:12-17:04	6.76	10.1	0.6	11.1	20,030	328	5.9	0.85	2.6004
3	17:32-18:23	6.82	10.1	0.5	11.0	18,741	328	6.0	0.81	2.4764
							Average	5.9	0.83	2.5252

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	N0x
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	15:35-15:49	-0.07	46.7	-0.4	47.1	0.28
2	16:51-17:00	0.44	46.7	-0.4	46.2	0.79
3	18:09-18:19	0.45	46.7	-0.5	46.9	0.94
					Averag	0.67

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	07:20-08:10	50.9	300.9	-3.8	293.5	9,271	624	55.3	2.24	3.5852
2	08:38-09:12	51.7	300.9	-7.0	294.0	9,808	624	58.7	2.51	4.0229
3	09:47-10:21	50.4	300.9	-7.0	289.0	9,571	624	58.4	2.44	3.9057
							Average	57.5	2.39	3.8380
Approach	1055-1105	145.0	300.9	-7.0	289.0	7,140	448	154.5	4.81	10.7419
Ground Idle	1108-1118	1330.0	300.9	-7.0	289.0	3,165	155	1359.1	18.76	121.0435

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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 (% or ppm)	Mass Emission Rate (lb/hr)	Mass Emission Rate (lb/1000 lb fuel)
			Cma	Co	Cm	Stack Flow (dscfm)	Fuel Flow (lb/hr)			
1	07:20-08:14	17.6	88.9	-0.9	87.5	36,210	624	18.6	2.94	4.7177
2	08:37-09:29	17.6	88.9	-0.9	87.5	37,594	624	18.6	3.06	4.9006
3	09:47-10:39	17.5	88.9	-0.9	88.0	36,144	624	18.4	2.90	4.6401
							Average	18.6	2.97	4.7528
Approach	1055-1105	45.6	88.9	-0.9	88.0	30,833	448	46.5	6.25	13.9591
Ground Idle	1108-1118	300.0	88.9	-0.9	88.0	14,436	155	300.9	18.95	122.2370

Pollutant	MWgas
CO	28.01
Methane	16.00
NOx	46.01
SO2	64.06

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	CO
Molecular Weight:	28.01

Run No.	Start-Stop Time	Raw Data (ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:13-08:20	-6.4	300.9	-3.8	293.5	0.00
2	09:15-09:29	-6.2	300.9	-7.0	294.0	0.79
3	10:25-10:39	-6.5	300.9	-7.0	289.0	0.49
					Averag	0.42

Calibration Error Correction

Cgas=(Cobs-Co)*(Cma/(Cm-Co))

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:20-08:10	3.9	10.5	-0.2	10.5	4.0
2	08:38-09:12	3.9	10.5	-0.2	10.5	4.0
3	09:47-10:21	3.9	10.5	-0.2	10.5	4.1
				Average		4.0

Approach	1055-1105	3.5	10.5	-0.2	10.5	3.63
Ground Idle	1108-1118	2.8	10.5	-0.2	10.5	2.99

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:20-08:14	1.098	1.01	-0.02	1.01	1.101
2	08:37-09:29	1.089	1.01	-0.03	1.00	1.092
3	09:47-10:39	1.107	1.01	-0.03	1.00	1.110
				Average		1.101

Approach	1055-1105	0.9	1.0	0.0	1.0	0.88
Ground Idle	1108-1118	0.7	1.0	0.0	1.0	0.69

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	08:13-08:20	-0.05	10.52	-0.15	10.50	0.094
2	09:15-09:29	-0.06	10.52	-0.15	10.45	0.092
3	10:25-10:39	-0.06	10.52	-0.20	10.50	0.137
				Average		0.108

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

	Start-Stop	Raw Data	Calibration Data			Calibration Corrected Data
Run No.	Time	(% or ppm)	Cma	Co	Cm	(% or ppm)
1	07:20-08:10	15.4	20.5	-0.5	20.5	15.6
2	08:38-09:12	15.4	20.5	-0.5	20.4	15.6
3	09:47-10:21	15.4	20.5	-0.4	20.4	15.6
				Average		15.6

Approach	1055-1105	16.0	20.5	-0.4	20.4	16.2
Ground Idle	1108-1118	16.8	20.5	-0.4	20.4	16.9

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

	Start-Stop	Raw Data	Calibration Data			Calibration Corrected Data
Run No.	Time	(% or ppm)	Cma	Co	Cm	(% or ppm)
1	07:20-08:14	19.8	20.5	-0.4	20.8	19.5
2	08:37-09:29	19.8	20.5	-0.3	20.8	19.5
3	09:47-10:39	19.8	20.5	-0.3	20.8	19.5
				Average		19.5

Approach	1055-1105	20.1	20.5	-0.3	20.8	19.8
Ground Idle	1108-1118	20.4	20.5	-0.3	20.8	20.0

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

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	O2
Molecular Weight:	

	Start-Stop	Raw Data	Calibration Data			Calibration Corrected Data
Run No.	Time	(% or ppm)	Cma	Co	Cm	(% or ppm)
1	08:13-08:20	20.9	20.5	-0.5	20.5	21.0
2	09:15-09:29	20.9	20.5	-0.5	20.4	21.0
3	10:25-10:39	20.9	20.5	-0.4	20.4	21.0
				Average		21.0

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

Total Hydrocarbon Data Correction

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:20-08:10	2.0	9,271	2.10	2.0	0.05	0.0756
2	08:38-09:12	2.0	9,808	0.60	2.0	0.05	0.0788
3	09:47-10:21	2.0	9,571	1.90	2.0	0.05	0.0779
				Average	2.0	0.05	0.077

Approach	1055-1105	2.7	7,140	1.10	2.7	0.05	0.1084
Ground Idle	1108-1118	625.0	3,165	1.90	637.1	5.02	32.4114

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:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
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	07:20-08:14	0.5	36,210	2.10	0.5	0.05	0.0738
2	08:37-09:29	0.5	37,594	0.60	0.5	0.05	0.0755
3	09:47-10:39	0.5	36,144	1.90	0.5	0.05	0.0736
				Average	0.5	0.05	0.07

Approach	1055-1105	1.3	30,833	1.10	1.3	0.10	0.2254
Ground Idle	1108-1118	174.0	14,436	1.90	177.4	6.38	41.1593

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	THC
Molecular Weight:	16.00

Run No.	Start-Stop Time	Raw Data (ppm)
1	08:13-08:20	0.40
2	09:15-09:29	0.19
3	10:25-10:39	-0.35

CEM Data Correction Data Sheet

Plant Name:	Pratt & Whitney
Sampling Location:	Engine - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	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)			
1	07:20-08:10	89.5	46.7	-0.8	44.7	9,271	624	92.8	6.16	9.8764
2	08:38-09:12	88.0	46.7	-0.8	44.5	9,808	624	91.6	6.44	10.3191
3	09:47-10:21	88.9	46.7	-0.7	45.1	9,571	624	91.5	6.27	10.0518
							Average	92.0	6.29	10.0824

Approach	1055-1105	66.1	46.7	-0.7	45.1	7,140	448	68.2	3.49	7.7850
Ground Idle	1108-1118	19.8	46.7	-0.7	45.1	3,165	155	21.0	0.48	3.0651

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:	Pratt & Whitney
Sampling Location:	Exhaust - Max Continuous
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	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)			
1	07:20-08:14	19.05	10.1	-0.1	10.8	36,210	624	17.7	4.60	7.3749
2	08:37-09:29	19.45	10.1	0.3	11.0	37,594	624	18.0	4.86	7.7843
3	09:47-10:39	19.45	10.1	0.3	11.1	36,144	624	17.9	4.64	7.4299
							Average	17.9	4.70	7.5297

Approach	1055-1105	12.0	10.1	0.3	11.1	30,833	448	10.9	2.41	5.3891
Ground Idle	1108-1118	2.8	10.1	0.3	11.1	14,436	155	2.4	0.24	1.5783

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:	Pratt & Whitney
Sampling Location:	Ambient
Date:	05/15/2002
Project Number:	030414.0008C.5.005
CEM Operator:	Doug Allen
Pollutant:	NOx
Molecular Weight:	46.01

Run No.	Start-Stop Time	Raw Data (% or ppm)	Calibration Data			Calibration Corrected Data (% or ppm)
			Cma	Co	Cm	
1	08:13-08:20	-0.09	46.7	-0.8	44.7	0.73
2	09:15-09:29	-0.26	46.7	-0.8	44.5	0.51
3	10:25-10:39	-0.38	46.7	-0.7	45.1	0.32
					Averag	0.52

Calibration Error Correction

Cgas=(Cobs-Co)*(Cma/(Cm-Co))

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	48	--	1	--
	Volatile organics[2]	48	1 pair	1 pair	12 pair
	Aldehydes and Ketones	4	1	1	--
AMBIENT (BACKGROUND)					
	Particulate	4	1	--	--
	Volatile organics	5	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).

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[*] 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	Liquids, filters, and resins	AG/500 mL	NA	NA
	Condensable particulate		AG/1.0 L	NA	NA
	Volatile organics		G/40 mL	≤4 °C	14 days
			AG/1L	≤4 °C	14 days to exit/40 days to analysis
	Aldehydes and Ketones	Liquid	AG/1.0 L	≤4 °C	14 days
AMBIENT	Particulate	Filter	E	NA	NA
	Volatile organics	Whole air	S	NA	30 days
		Filter/PUF	G/A	4 ± 2°C	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 <u>same day</u> 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

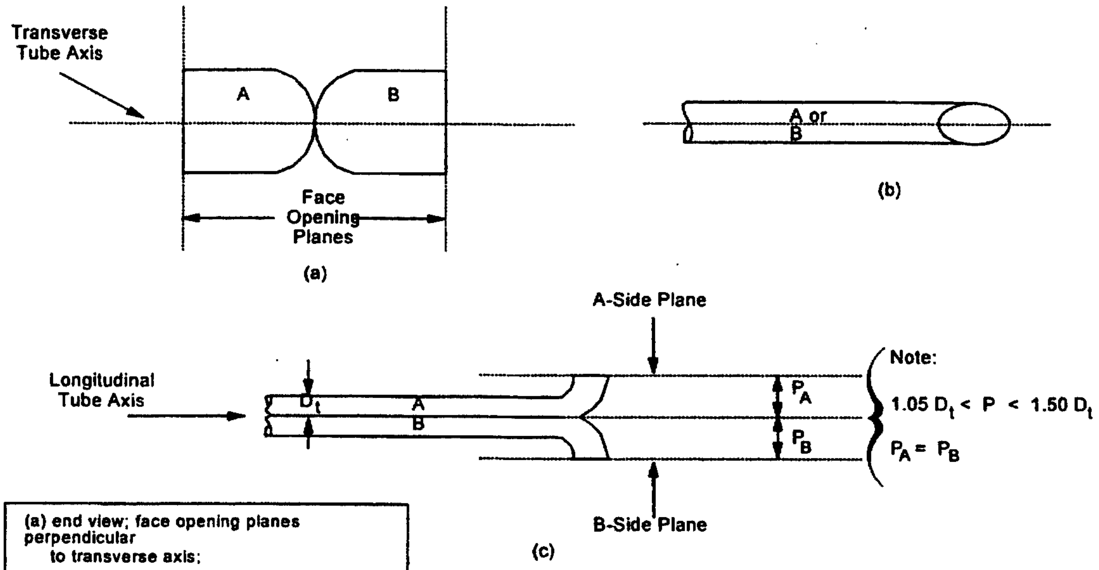
QA/QC – CALIBRATION DATA

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.

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

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[**] 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	12/18/2001	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	12/18/2001	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	12/21/2001	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	12/21/2001	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	12/21/2001	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	12/18/2001	1.7	1.2	0.2	1.7	0.8	1.2	0.941	0.013	0.020	0.538	0.539	0.375	1.255	**ACCEPT**
P3-4P	12/18/2001	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	12/21/2001	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	12/18/2001	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	12/21/2001	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	12/21/2001	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	12/21/2001	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	12/21/2001	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	12/21/2001	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	12/21/2001	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	12/21/2001	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	12/26/2001	0.3	0.9	0.7	1.4	1.1	1.4	0.941	0.018	0.023	0.475	0.475	0.375	1.255	**ACCEPT**
P6-3P	12/26/2001	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	12/26/2001	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	12/26/2001	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	12/26/2001	2.7	0.6	1.4	0.1	0.6	0.4	0.945	0.010	0.007	0.465	0.466	0.375	1.260	**ACCEPT**
P8-2	12/26/2001	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	12/27/2001	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	12/27/2001	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	12/26/2001	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	12/26/2001	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	12/26/2001	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	12/26/2001	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

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.

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-2	Bar. Press.(Pb):	29.60	in. Hg
Date:	December 28, 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	888.319	899.355	909.944	923.732	933.873	944.622
Vw_2	Final RTM	899.158	909.736	923.451	933.679	944.276	957.125
Vd_1	Initial DGM	914.925	926.118	936.890	950.946	961.281	972.234
Vd_2	Final DGM	925.929	936.678	950.662	961.090	971.886	984.918
Tw	Ave. Temp RTM °F	67	68	67	69	68	70
Td	Ave. Temp DGM °F	70	74	76	79	80	82
t	Time (min.)	25.0	20.0	23.0	14.0	13.0	11.0
$Vw_2 - Vw_1$	Net Volume RTM	10.839	10.381	13.507	9.947	10.403	12.503
$Vd_2 - Vd_1$	Net Volume DGM	11.004	10.560	13.772	10.144	10.605	12.684
	Y	0.989	0.992	0.995	0.995	0.998	0.998
	dH@	1.493	1.556	1.609	1.652	1.727	1.718

AVERAGE Y =	**0.999**	(Reference meter correction factor of 1.004)			
Average Y Range =		0.979	TO	1.019	**ACCEPT**
AVERAGE dH@ =	**1.626**				
Average dH@ Range =		1.426	TO	1.826	**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-2	Bar. Press.(Pb):	29.60	in. Hg
Date:	May 20, 2002	Pretest Gamma:	0.999	
Calibrated By	AH	Pretest dH@:	1.626	
Plant:	Pratt & Whitney			

		RUN 1	RUN 2	RUN 3
DH	Delta H	3.30	3.30	3.30
in Hg	Vacuum	14.00	14.00	14.00
Vw_1	Initial RTM	402.128	412.560	434.418
Vw_2	Final RTM	412.560	434.418	445.882
Vd_1	Initial DGM	443.224	453.643	475.588
Vd_2	Final DGM	453.643	475.588	487.141
Tw	Ave. Temp RTM °F	69.0	68.0	69.0
Td	Ave. Temp DGM °F	74.0	85.0	89.0
t	Time (min.)	10.0	21.0	11.0
$Vw_2 - Vw_1$	Net Volume RTM	10.432	21.858	11.464
$Vd_2 - Vd_1$	Net Volume DGM	10.419	21.945	11.553
	Y	1.002	1.020	1.021
	dH@	1.702	1.669	1.659

AVERAGE Y = **1.006**

% Difference from Yearly Y = **0.669** **ACCEPT**

AVERAGE dH@ = **1.676**

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: 28-Dec-01
INDICATOR NO.: MB-2
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	-2	0.4
2	1.520	100	98	0.4
3	3.819	200	200	0.0
4	6.092	300	298	0.3
5	8.314	400	397	0.3
6	10.560	500	498	0.2
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	1899	0.0

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{(\text{Equivalent Temp., }^{\circ}\text{R} - \text{Digital Indicator Temp., }^{\circ}\text{R}) * (\ 1}{(\text{ Equivalent Temp., }^{\circ}\text{R})}$

Where °R = °F + 460

ACCEPT

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-3	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	744.504	755.112	766.486	777.265	787.316	804.974
Vw_2	Final RTM	754.779	766.243	777.125	787.137	804.709	816.980
Vd_1	Initial DGM	487.815	498.517	510.017	520.938	531.144	549.075
Vd_2	Final DGM	498.183	509.769	520.799	530.952	548.814	560.246
Tw	Ave. Temp RTM °F	66	65	66	66	67	66
Td	Ave. Temp DGM °F	68	72	74	75	78	79
t	Time (min.)	25.0	22.0	18.0	14.0	22.0	10.0
$Vw_2 - Vw_1$	Net Volume RTM	10.275	11.131	10.639	9.872	17.393	12.006
$Vd_2 - Vd_1$	Net Volume DGM	10.368	11.252	10.782	10.014	17.670	11.171
	Y	0.994	1.001	0.999	0.999	1.000	1.090
	dH@	1.661	1.626	1.588	1.671	1.769	1.526

AVERAGE Y =	**1.018**	(Reference meter correction factor of 1.004)			
Average Y Range =		0.998	TO	1.038	**ACCEPT**
AVERAGE dH@ =	**1.640**				
Average dH@ Range =		1.440	TO	1.840	**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-3	Bar. Press.(Pb):	29.60	in. Hg
Date:	May 20, 2002	Pretest Gamma:	1.018	
Calibrated By	AH	Pretest dH@:	1.640	
Plant:	Pratt & Whitney			

		RUN 1	RUN 2	RUN 3
DH	Delta H	5.00	5.00	5.00
in Hg	Vacuum	3.00	3.00	3.00
Vw_1	Initial RTM	360.720	371.659	382.435
Vw_2	Final RTM	371.659	382.435	393.362
Vd_1	Initial DGM	236.524	247.310	258.280
Vd_2	Final DGM	247.310	258.280	269.152
Tw	Ave. Temp RTM °F	69.0	68.0	68.0
Td	Ave. Temp DGM °F	69.0	73.0	76.0
t	Time (min.)	9.0	9.0	9.0
$Vw_2 - Vw_1$	Net Volume RTM	10.939	10.776	10.927
$Vd_2 - Vd_1$	Net Volume DGM	10.786	10.970	10.872
	Y	1.002	0.979	1.008
	dH@	1.917	1.954	1.889

AVERAGE Y = **0.988**

% Difference from Yearly Y = **-2.985** **ACCEPT**

AVERAGE dH@ = **1.920**

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: 27-Dec-01 INDICATOR NO.: MB-3

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	-2	0.4
2	1.520	100	98	0.4
3	3.819	200	200	0.0
4	6.092	300	298	0.3
5	8.314	400	397	0.3
6	10.560	500	498	0.2
7	22.251	1000	999	0.1
8	29.315	1300	1298	0.1
9	36.166	1600	1599	0.0
10	42.732	1900	1898	0.1

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{(\text{Equivalent Temp},.^{\circ}R - \text{Digital Indicator Temp.}, ^{\circ}R) * (1C}{(\text{Equivalent Temp.}, ^{\circ}R)}$

Where $^{\circ}R = {}^{\circ}F + 460$

ACCEPT

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-4	Bar. Press.(Pb):	29.60	in. Hg
Date:	December 28, 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	818.544	829.341	839.754	850.757	862.383	873.248
Vw_2	Final RTM	829.167	839.528	850.495	862.096	872.806	887.856
Vd_1	Initial DGM	96.934	107.848	118.403	129.530	141.283	152.274
Vd_2	Final DGM	107.679	118.175	129.254	140.982	151.817	167.005
Tw	Ave. Temp RTM °F	66	65	66	66	67	66
Td	Ave. Temp DGM °F	69	73	70	75	76	80
t	Time (min.)	25.0	20.0	18.0	16.0	13.0	13.0
$Vw_2 - Vw_1$	Net Volume RTM	10.623	10.187	10.741	11.339	10.423	14.608
$Vd_2 - Vd_1$	Net Volume DGM	10.745	10.327	10.851	11.452	10.534	14.731
	Y	0.993	1.000	0.995	1.003	1.001	1.008
	dH@	1.551	1.601	1.570	1.654	1.726	1.738

AVERAGE Y =	**1.004**	(Reference meter correction factor of 1.004)			
Average Y Range =		0.984	TO	1.024	**ACCEPT**
AVERAGE dH@ =	**1.640**				
Average dH@ Range =		1.440	TO	1.840	**ACCEPT**

Calculations

$$Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw + 460))$$

$$dH@ = 0.0317 * dHd / (Pb (Td + 460)) * (((Tw + 460) * t) / Vw)^2$$

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-4	Bar. Press.(Pb):	29.60	in. Hg
Date:	May 20, 2002	Pretest Gamma:	1.004	
Calibrated By	AH	Pretest dH@:	1.640	
Plant:	Eramet			

		RUN 1	RUN 2	RUN 3
DH	Delta H	1.30	1.30	1.30
in Hg	Vacuum	2.00	2.00	2.00
Vw_1	Initial RTM	284.145	301.254	313.025
Vw_2	Final RTM	301.254	313.025	324.771
Vd_1	Initial DGM	551.420	568.744	580.704
Vd_2	Final DGM	568.744	580.704	592.691
Tw	Ave. Temp RTM °F	67.0	67.0	68.0
Td	Ave. Temp DGM °F	75.0	77.0	80.0
t	Time (min.)	26.0	18.0	18.0
$Vw_2 - Vw_1$	Net Volume RTM	17.109	11.771	11.746
$Vd_2 - Vd_1$	Net Volume DGM	17.324	11.960	11.987
	Y	0.999	1.000	0.999
	dH@	1.669	1.684	1.688

AVERAGE Y =	**0.991**	
% Difference from Yearly Y =	**-1.337**	**ACCEPT**
AVERAGE dH@ =	**1.680**	

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:	28-Dec-01	INDICATOR NO.:	MB-4
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	-2	0.4
2	1.520	100	98	0.4
3	3.819	200	199	0.2
4	6.092	300	298	0.3
5	8.314	400	396	0.5
6	10.560	500	497	0.3
7	22.251	1000	998	0.1
8	29.315	1300	1296	0.2
9	36.166	1600	1596	0.2
10	42.732	1900	1895	0.2

Percent difference must be less than or equal to 0.5 %

Percent difference: $$\frac{(\text{Equivalent Temp,.}^{\circ}\text{R - Digital Indicator Temp., }^{\circ}\text{R}) * (\ 1}{(\text{ Equivalent Temp., }^{\circ}\text{R})}$$

Where $^{\circ}R = {}^{\circ}F + 460$

ACCEPT

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-6	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	529.749	544.569	555.602	566.912	581.155	592.225
Vw_2	Final RTM	544.168	555.080	566.035	580.934	591.948	602.648
Vd_1	Initial DGM	971.633	986.638	997.808	9.238	23.641	34.854
Vd_2	Final DGM	986.220	997.286	1008.353	23.408	34.568	45.401
Tw	Ave. Temp RTM °F	71	74	71	69	67	67
Td	Ave. Temp DGM °F	72	74	72	74	79	82
t	Time (min.)	36.0	22.0	19.0	21.0	15.0	10.0
$Vw_2 - Vw_1$	Net Volume RTM	14.419	10.511	10.433	14.022	10.793	10.423
$Vd_2 - Vd_1$	Net Volume DGM	14.587	10.648	10.545	14.170	10.927	10.547
	Y	0.989	0.985	0.989	0.995	1.005	1.006
	dH@	1.769	1.879	1.882	1.888	2.132	2.021

AVERAGE Y =	**0.999**	(Reference meter correction factor of 1.004)			
Average Y Range =		0.979	TO	1.019	**ACCEPT**
AVERAGE dH@ =	**1.929**				
Average dH@ Range =		1.729	TO	2.129	**ACCEPT**

Calculations

$$Y = (Vw * Pb * (Td + 460)) / (Vd * (Pb + (dHd / 13.6)) * (Tw + 460))$$

$$dH@ = 0.0317 * dHd / (Pb (Td + 460)) * (((Tw + 460) * t) / Vw)^2$$

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).

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	

Calibrated By: AH

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[a] Type of calibration used.

[b] Allowable tolerance ±2°F

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE:	28-Dec-01	**THERMOCOUPLE NUMBER:**	MB-2
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	67	1
2	Cold Bath	38	38	0
3	Hot Bath	168	168	0
Outlet 1	Ambient Air	68	67	1
2	Cold Bath	38	38	0
3	Hot Bath	168	168	0

ACCEPT

[a] Type of calibration used.

[b] Allowable tolerance ±5°F

Comments:

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 27-Dec-01

THERMOCOUPLE NUMBER: MB-3

AMBIENT TEMPERATURE: 68 °F

BAROMETRIC PRES.(In.Hg): 29.50

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	68	0
2	Cold Bath	35	37	2
3	Hot Bath	180	179	1
Outlet				
1	Ambient Air	68	68	0
2	Cold Bath	33	33	0
3	Hot Bath	180	179	1

ACCEPT

[a] Type of calibration used.

[b] Allowable tolerance ±5°F

Comments:

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 28-Dec-01

THERMOCOUPLE NUMBER: MB-4

AMBIENT TEMPERATURE: 69 °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	69	69	0
2	Cold Bath	34	34	0
3	Hot Bath	150	147	3
Outlet 1	Ambient Air	69	67	2
2	Cold Bath	34	35	1
3	Hot Bath	150	148	2

ACCEPT

[a] Type of calibration used.

[b] Allowable tolerance ±5°F

Comments:

ENVIRONMENTAL QUALITY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 26-Dec-01

THERMOCOUPLE NUMBER: MB-6

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	68	0
2	Cold Bath	35	35	0
3	Hot Bath	178	175	3
Outlet 1	Ambient Air	68	69	1
2	Cold Bath	35	34	1
3	Hot Bath	178	176	2

ACCEPT

[a] Type of calibration used.

[b] Allowable tolerance ±5°F

Comments:

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:

ENVIRONMENTAL QUALTIY MANAGEMENT

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 02-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

ACCEPT

[a] Type of calibration used.

[b] Allowable tolerance ±5°F

Comments:

TEMPERATURE SENSOR CALIBRATION DATA FORM FOR METER BOX

DATE: 02-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

ACCEPT

[a] Type of calibration used.

[b] Allowable tolerance ±5°F

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	12/27/2001	67	0.19	38	0.40	162	0.48	442	0.22	ACCEPT
	Pitot		68		40		159		440		
T2-2	Reference	12/27/2001	67	0.00	38	0.20	172	0.95	460	0.22	ACCEPT
	Pitot		67		39		166		458		
T2-3	Reference	12/27/2001	67	0.19	38	0.20	180	0.78	460	0.65	ACCEPT
	Pitot		68		39		175		454		
T2-4	Reference	01/04/2001	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	12/26/2001	68	0.00	36	0.20	184	0.31	458	0.98	ACCEPT
	Pitot		68		37		182		449		
T2-7	Reference	03/27/2002	73	0.19	38	0.40	165	0.16	368	0.36	ACCEPT
	Pitot		72		36		164		365		
T3-1	Reference	12/27/2001	67	0.19	39	0.00	156	0.49	460	0.76	ACCEPT
	Pitot		68		39		153		453		
T3-2	Reference	12/27/2001	67	0.19	38	0.40	168	0.16	442	0.44	ACCEPT
	Pitot		68		40		167		438		
T3-3P	Reference	12/28/2001	68	0.19	40	0.40	172	0.63	460	0.43	ACCEPT
	Pitot		67		42		168		456		
T3-4P	Reference	12/28/2001	68	0.19	36	0.20	162	0.16	460	0.65	ACCEPT
	Pitot		67		37		161		454		
T3-5	Reference	12/26/2001	68	0.19	38	0.20	188	0.62	456	0.11	ACCEPT
	Pitot		67		37		184		455		
T3-6	Reference	12/26/2001	68	0.00	38	0.20	187	0.46	456	0.11	ACCEPT
	Pitot		68		39		184		455		
T4-1	Reference	12/28/2001	68	0.19	39	0.20	177	0.16	460	0.22	ACCEPT
	Pitot		67		40		176		458		
T4-2	Reference	12/28/2001	68	0.00	39	0.20	178	0.31	460	0.54	ACCEPT
	Pitot		68		40		176		455		
T4-3P	Reference	12/28/2001	68	0.00	36	0.00	184	0.31	436	0.00	ACCEPT
	Pitot		68		36		186		436		
T4-4P	Reference	12/28/2001	68	0.00	36	0.20	180	0.16	440	0.67	ACCEPT
	Pitot		68		37		179		434		
T4-5	Reference	12/28/2001	68	0.00	35	0.61	152	0.16	460	0.65	ACCEPT
	Pitot		68		38		151		454		
T4-6	Reference	12/26/2001	68	0.00	35	0.00	179	0.63	458	0.00	ACCEPT
	Pitot		68		35		175		458		
T4-7	Reference	12/26/2001	68	0.00	36	0.40	178	0.47	458	0.11	ACCEPT
	Pitot		68		38		175		457		
T4-8	Reference	03/27/2002	73	0.19	37	0.20	165	0.16	400	0.35	ACCEPT
	Pitot		72		36		164		397		
T5-1	Reference	12/28/2001	68	0.00	36	0.20	181	0.00	450	0.11	ACCEPT
	Pitot		68		37		181		449		
T5-2P	Reference	12/28/2002	68	0.00	37	0.00	186	0.31	458	0.22	ACCEPT
	Pitot		68		37		184		456		
T5-3	Reference	12/28/2001	68	0.00	36	0.20	178	0.16	450	0.22	ACCEPT
	Pitot		68		37		177		448		
T5-4	Reference	03/27/2002	73	0.19	36	0.20	170	0.32	390	0.24	ACCEPT
	Pitot		72		35		168		388		
T5-5	Reference	03/27/2002	73	0.19	36	0.20	170	0.32	402	0.35	ACCEPT
	Pitot		72		35		168		399		
T6-1	Reference	12/28/2001	68	0.00	38	0.20	198	0.30	451	0.33	ACCEPT
	Pitot		68		39		196		448		
T6-2	Reference	12/28/2001	68	0.00	38	0.20	198	0.15	451	0.11	ACCEPT
	Pitot		68		39		199		450		
T6-3P	Reference	12/28/2001	68	0.00	38	0.00	198	0.15	453	0.22	ACCEPT
	Pitot		68		38		197		451		
T6-4P	Reference	12/28/2001	68	0.00	37	0.00	200	0.15	454	0.11	ACCEPT
	Pitot		68		37		199		453		
T6-5	Reference	12/28/2001	68	0.19	38	0.00	198	0.30	451	0.11	ACCEPT
	Pitot		67		38		196		450		
T7-1	Reference	12/28/2001	68	0.19	37	0.40	180	0.31	450	0.55	ACCEPT
	Pitot		69		39		178		445		
T8-1	Reference	12/28/2001	68	0.00	37	0.40	190	0.62	456	0.44	ACCEPT
	Pitot		68		39		186		452		
T8-2	Reference	12/28/2001	68	0.19	37	0.20	200	0.30	440	0.11	ACCEPT
	Pitot		69		38		198		439		
T8-3P	Reference	12/28/2001	68	0.19	37	0.20	181	0.16	440	0.33	ACCEPT
	Pitot		69		38		180		437		
T8-4P	Reference	12/28/2001	68	0.00	37	0.00	181	0.16	440	0.44	ACCEPT
	Pitot		68		37		180		436		
T8-5	Reference	12/28/2001	68	0.00	37	0.40	202	0.45	460	0.65	ACCEPT
	Pitot		68		39		199		454		
T9-1	Reference	12/28/2001	68	0.00	38	0.20	183	0.16	440	0.00	ACCEPT
	Pitot		68		39		182		440		
10-1	Reference	12/28/2001	68	0.00	38	0.20	181	0.16	448	0.22	ACCEPT
	Pitot		68		39		182		446		
T11-1	Reference	12/28/2001	68	0.00	39	0.00	180	0.31	448	0.55	ACCEPT
	Pitot		68		39		178		443		

4

ENVIRONMENTAL QUALITY MANAGEMENT

Box No.:	MB-6	Bar. Press.(Pb):	29.60	in. Hg
Date:	May 21, 2002	Pretest Gamma:	0.999	
Calibrated By	AH	Pretest dH@:	1.929	
Plant:	Pratt & Whitney			

		RUN 1	RUN 2	RUN 3
DH	Delta H	1.00	1.00	1.00
in Hg	Vacuum	5.00	5.00	5.00
Vw_1	Initial RTM	447.384	457.772	473.670
Vw_2	Final RTM	457.772	473.670	483.498
Vd_1	Initial DGM	920.444	930.899	946.915
Vd_2	Final DGM	930.899	946.915	956.869
Tw	Ave. Temp RTM °F	66.0	66.0	67.0
Td	Ave. Temp DGM °F	70.0	74.0	75.0
t	Time (min.)	19.0	29.0	18.0

$Vw_2 - Vw_1$	Net Volume RTM	10.388	15.898	9.828
$Vd_2 - Vd_1$	Net Volume DGM	10.455	16.016	9.954
	Y	0.999	1.005	1.000
	dH@	1.870	1.846	1.865

AVERAGE Y = **0.992**

% Difference from Yearly Y = **-0.651** **ACCEPT**

AVERAGE dH@ = **1.860**

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-6

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	99	0.2
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	1599	0.0
10	42.732	1900	1899	0.0

Percent difference must be less than or equal to 0.5 %

Percent difference: $\frac{\text{(Equivalent Temp,.}^{o}\text{R - Digital Indicator Temp., }^{o}\text{R) * (1}}{\text{(Equivalent Temp., }^{o}\text{R)}}$

Where $^{o}R = {}^{o}F + 460$

ACCEPT

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

Box No.: MB7 Bar. Press.(Pb) 29.60 in. Hg

Date: May 20, 2002 Pretest Gamma 1.001

Calibrated AH Pretest dH@: 1.775

Plant: ERAMET

		RUN 1	RUN 2	RUN 3
DH	Delta H	1.30	1.30	1.30
in Hg	Vacuum	1.00	1.00	1.00
Vw_1	Initial RTM	328.869	339.437	349.948
Vw_2	Final RTM	339.437	349.948	359.760
Vd_1	Initial DGM	350.721	361.263	371.771
Vd_2	Final DGM	361.263	371.771	381.630
Tw	Ave. Temp RT	67.0	66.0	67.0
Td	Ave. Temp DC	71.0	74.0	76.0
t	Time (min.)	16.0	16.0	15.0
Vw_2 - Vw_1	Net Volume R	10.568	10.511	9.812
Vd_2 - Vd_1	Net Volume D	10.542	10.508	9.859
	Y	1.007	1.012	1.009
	dH@	1.669	1.671	1.686

AVERAGE Y = **1.001**

% Difference from Yearly **-0.049** **ACCEPT**

AVERAGE dH@ = **1.675**

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: 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: $$\frac{(\text{Equivalent Temp,.}^{\circ}\text{R - Digital Indicator Temp., }^{\circ}\text{R}) * (\ 1\text{C}}{(\text{ Equivalent Temp., }^{\circ}\text{R})}$$

Where $^{\circ}R = {}^{\circ}F + 460$

ACCEPT

ENVIRONMENTAL QUALITY MANAGEMENT

Date:	01/07/2002	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**

$QDGM = (((Vm_2 - Vm_1) * TBm^{o}R) / (Tm^{o}R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y= 0.9711

Environmental Quality Management

Date:	05/21/2002	Flow Rate:	**0.5**
Vost Box Number:	VB-1	Rotameter Setting:	0.5
		Bubble Meter Temp. :	70

Run 1			
Bubble Meter		Meter Box	
1	492.2	Initial Volume	6075.00
2	492.2	Final Volume	6085.00
3	492.3	Initial Temp.	72
4	492.1	Final Temp.	77
5	491.7	Average Temp.	74.5
6	491.9	Time:	20.03
7	491.7	QDGM=	495.048
Average:	**492.07**	Y=	**0.9940**

Run 2			
Bubble Meter		Meter Box	
1	500.4	Initial Volume	6086.00
2	500.4	Final Volume	6096.00
3	500.2	Initial Temp.	77
4	500.7	Final Temp.	80
5	500.2	Average Temp.	78.5
6	500.1	Time:	19.42
7	501.2	QDGM=	506.805
Average:	**500.46**	Y=	**0.9875**

Run 3			
Bubble Meter		Meter Box	
1	500.2	Initial Volume	6097.00
2	498	Final Volume	6107.00
3	498.2	Initial Temp.	80
4	500.5	Final Temp.	83
5	500.4	Average Temp.	81.5
6	498	Time:	19.63
7	500.3	QDGM=	498.606
Average:	**499.37**	Y=	**1.0015**

$QDGM = (((Vm_2 - Vm_1) * TBm^{o}R) / (Tm^{o}R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y= **0.9943**

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE: 02-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:

$$\frac{(\text{Equivalent Temp.}.{}^{\circ}\text{R} - \text{Digital Indicator Temp., }{}^{\circ}\text{R}) * (100\%)}{(\text{Equivalent Temp., }{}^{\circ}\text{R})}$$

Where $^{\circ}R = {}^{\circ}F + 460$

ACCEPT

ENVIRONMENTAL QUALITY MANAGEMENT

Date: 01/03/2002
Vost Box Number: VB-2

Flow Rate: **0.25 l/min**
Rotameter Setting: 0.3
Bubble Meter Temp. : 70

Run 1			
Bubble Meter		Meter Box	
1	230.5	Initial Volume	4473.00
2	233.1	Final Volume	4476.00
3	233.5	Initial Temp.	87
4	233.5	Final Temp.	87
5	234.4	Average Temp.	87
6	233.7	Time:	15.60
7	233.7	QDGM=	186.331
Average:	**233.20**	Y=	**1.2515**

Run 2			
Bubble Meter		Meter Box	
1	233.7	Initial Volume	4477.00
2	233.7	Final Volume	4480.00
3	233.8	Initial Temp.	87
4	233.4	Final Temp.	87
5	233.5	Average Temp.	87
6	233.3	Time:	16.23
7	233.3	QDGM=	179.098
Average:	**233.53**	Y=	**1.3039**

Run 3			
Bubble Meter		Meter Box	
1	233.1	Initial Volume	4481.00
2	233.1	Final Volume	4484.00
3	233.1	Initial Temp.	87
4	233.1	Final Temp.	87
5	233	Average Temp.	87
6	233	Time:	15.77
7	233.3	QDGM=	184.322
Average:	**233.10**	Y=	**1.2646**

$QDGM = (((Vm_2 - Vm_1) * TBm^{o}R) / (Tm^{o}R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y= **1.2734**

Environmental Quality Management

Date: 05/21/2002
Vost Box Number: VB-2
Flow Rate: **0.5**
Rotameter Setting: 0.5
Bubble Meter Temp. : 70

Run 1

Bubble Meter		Meter Box	
1	483.5	Initial Volume	5085.00
2	482.9	Final Volume	5095.00
3	484.5	Initial Temp.	77
4	483.2	Final Temp.	81
5	483.2	Average Temp.	79
6	482.7	Time:	20.9
7	483.1	QDGM=	470.480
Average:	**483.33**	Y=	**1.0273**

Run 2

Bubble Meter		Meter Box	
1	476.9	Initial Volume	5096.00
2	477.4	Final Volume	5106.00
3	477.2	Initial Temp.	77
4	477.6	Final Temp.	81
5	476.2	Average Temp.	79
6	477	Time:	21.32
7	477.3	QDGM=	461.211
Average:	**477.09**	Y=	**1.0344**

Run 3

Bubble Meter		Meter Box	
1	476.1	Initial Volume	5107.00
2	475.8	Final Volume	5117.00
3	475.4	Initial Temp.	81
4	474.3	Final Temp.	85
5	475.3	Average Temp.	83
6	474.3	Time:	22.12
7	474.8	QDGM=	441.256
Average:	**475.14**	Y=	**1.0768**

$QDGM = (((Vm_2 - Vm_1) * TBm^{o}R) / (Tm^{o}R * Time)) * 1000$

Y = Bm Average / QDGM

Average Y= 1.0462

ENVIRONMENTAL QUALITY MANAGEMENT

THERMOCOUPLE DIGITAL INDICATOR
CALIBRATION DATA SHEET

DATE:	02-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: $$\frac{(\text{Equivalent Temp}, {}^{\circ}R - \text{Digital Indicator Temp.}, {}^{\circ}R) * (100\%)}{(\text{Equivalent Temp.}, {}^{\circ}R)}$$

Where $^{\circ}R = {}^{\circ}F + 460$

ACCEPT

APPENDIX F

T-6A AGSE EMISSION FACTORS

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AERONAUTICAL SYSTEMS CENTER (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

21 JUL 2000

MEMORANDUM FOR HQ AETC~~/XPR~~SYNCN

FROM: ASC/YT
Bldg 11A, Room 201-I
1970 Monahan Way
Wright-Patterson AFB OH 45433-7211

SUBJECT: T-6A Unique Powered Support Equipment Engine Environmental Data Request
(Your Memo, 20 Apr 00)

1. As requested, the attachments provide the air emissions and noise level data that is currently available for the ground support equipment engines used to maintain T-6A aircraft. The equipment includes (1) cabin pressure tester, part number 96268-100, (2) ground power unit, part number Jet-X-D-4P, and (3) hydraulic test stand, part number 05-3005-1100.

2. The manufacturing suppliers were unable to provide sufficient data for occupational noise exposure to the ground crew from the support equipment engines. However, the Flight Training System Program Office (ASC/YT) has altered plans to perform noise tests to T-6A aircraft at Hondo AFB, Texas, during the next quarter to include noise level measurements of the support equipment engines. Results from this testing should complete the data required to update the air permits and National Environmental Policy Act (NEPA) documentation needed for beddown of the T-6A aircraft. This data should be available by November 2000.

3. If there are any comments or questions please feel free to contact Mr. Alexei Lozada-Ruiz, ASC/YT Chief of Environmental Management, at DSN 674-4222, or e-mail at Alexei.Lozada-Ruiz@wpafb.af.mil.

CHARLES R. DAVIS, Colonel, USAF
Director
Flight Training System Program Office

COPY

List of Attachments: **Manufacturer/vendor contact information**

1. Cabin Pressure Tester Data (Engine Model: 3M41 Hatz Diesel Engine)
    a. Hatz Diesel Engine Emission Certification
    b. 3M40 Series design documentation
    c. Vehicle output, torque, technical data, and installation data
    d. Test cycles (engine speed and smoke), exhaust emission test results (CO, HC, NOx, particulate matter, smoke value, and NO2)
    e. Engine noise levels with different Hatz silent packs.

2. Ground Power Unit (Serial Numbers: 498pso3453, 199pso3490, 199pso3491, 199pso3482)
    a. Hobart engine emission data

3. Hydraulic Test Stand (Engine Model: Briggs & Stratton 1334)
    a. Exhaust air emission results (CO, HC+NOx)
    b. Fax from Tronair indicating noise data not available

Attachment 1

Cabin Pressure Tester
Engine Model: 3M41 Hatz Diesel Engine

Manufacturer: **Motorenfabrik Hatz**
Engine category: **Nonroad CI**
Cert contact: **Jens Badorrek**

1. EPA Standard Engine Family: YHZXL3.43U37
2. Process Code: New Sub - continued
3. Test Data Set: 3
4. Engine Code: N/A
5. Engine Model: 2M41Z
6. Displacement(s) (cid Or Liters): 1.716 l
7. Engine I.d. Number: 10511980002336
8. Rated HP @ Rated RPM: 34.6 @ 2500
9. Torque (ft-lb) @ Engine RPM: 77.2 @ 2000
10. WAIVERs:

CO	PM	Smoke	Idle Co
NA	NA	NA	NA

11. Cold Start? NA
12. Certification Fuel. Diesel (Part 89, Sub D, Appdx A, Table 4)
13. Special Test Device No
14. Test Procedure: Nonroad, 8 Mode & Smoke

15. Official Test Results **16. Deterioration Factors**

Date:	10/29/98	10/29/98	10/29/98	
	Test 1	Test 2	Test 3	
HC/OMHCE				
NMHC/OMNMHCE				
HC + NOx	8.41	8.47	8.59	0.32
CARBON MONOXIDE	3.15	2.90	2.91	0.500
OXIDE OF NITROGEN				0.000
PARTICULATE	0.650	0.640	0.600	0.080
FORMALDEHYDE				
ACCELERATION (%opacity)	6.5	6.8	7.2	0.9
LUGGING (Gen) (%opacity)	7.4	7.3	7.5	3.2
PEAK (%opacity)	7.2	7.4	8.8	0.4
IDLE CO %				
CO2				

17. Certification Levels (Rounded Test Results)

Units – g/kW-hr --units

		STDs g/BHP-hr g/kW-hr	FELs
HC/OMHCE		e Missie Missing:	
NMHC/OMNMHCE		e Missie Missing:	
NMHC + NOx	8.5	e Missie Missing:	N/A
CARBON MONOXIDE	3.2	e Missie Missing:	
OXIDE OF NITROGEN		e Missie Missi	N/A
PARTICULATE	0.63	e Missie Missi	N/A
FORMALDEHYDE		e Missie Missing:	
ACCELERATION (%opacity)	8	e Missing:	
LUGGING (Gen) (%opacity)	11	e Missing:	
PEAK (%opacity)	8	e Missing:	
DLE CO%		e Missing:	

Manufacturer: **Motorenfabrik Hatz**
Engine category: **Nonroad CI**
Cert contact: **Jens Badorrek**

1. EPA Standard Engine Family: YHZXL3.43C19
2. Process Code: New Sub - continued
3. Test Data Set: 3
4. Engine Code: N/A
5. Engine Model: 2M41Z
6. Displacement(s) (cid Or Liters): 1.716 l
7. Engine I.d. Number: 10511980002336
8. Rated HP @ Rated RPM: 33.2 @ 2300
9. Torque (ft-lb) @ Engine RPM: 76.2 @ 2300
10. WAIVERs: CO NA; PM NA; Smoke NA; Idle Co NA
11. Cold Start? NA
12. Certification Fuel: Diesel (Part 89,Sub D,Appdx A,Table 4)
13. Special Test Device No
14 Test Procedure: Nonroad, D2 (Special Procedure)

15. Official Test Results

Date:	10/29/98	10/29/98	10/29/98	**16. Deterioration Factors**
	Test 1	Test 2	Test 3	
HC/OMHCE				0.000
NMHC/OMNMHCE				
HC + NOx	8.94	8.91	9.17	0.000
CARBON MONOXIDE	3.77	3.89	3.82	1.200
OXIDE OF NITROGEN				0.000
PARTICULATE	0.550	0.520	0.460	0.100
FORMALDEHYDE				
ACCELERATION (%opacity)				
LUGGING (Gen) (%opacity)				
PEAK (%opacity)				
IDLE CO %				
CO2				

17. Certification Levels (Rounded Test Results)

	Units-- g/kW-hr --Units	STDs g/BHP-hr g/kW-hr	FELs
HC/OMHCE		e Missie Missing:	
NMHC/OMNMHCE		e Missie Missing:	
NMHC + NOx	9.0	e Missie Missing:	N/A
CARBON MONOXIDE	3.8	e Missie Missing:	
OXIDE OF NITROGEN		e Missie Missi	N/A
PARTICULATE	0.51	e Missie Missi	N/A
FORMALDEHYDE		e Missie Missing:	
ACCELERATION (%opacity)		e Missing:	
LUGGING (Gen) (%opacity)		e Missing:	
PEAK (%opacity)		e Missing:	
IDLE CO%		e Missing:	

2/4

Attachment 2

Ground Power Unit
Serial Numbers: 498pso3453, 199pso3490, 199pso3491, 199pso3482

Perkins

Perkins International - North America
David Scheidt - Regional Technical Manager
5690 E 50 N
Columbus, IN 47203

Telephone: 812 375-2495
Facsimile: 812 375-2496

Fax Cover Sheet

To	Roger Sutor
Fax	248 474-3817
Telephone:	248 474-3817
From	David Scheidt
Fax:	812 375-2496
Telephone:	812 375-2495
Date	March 31, 2000

Number of pages, including cover sheet 1

Subject Hobart AR70423 emissions data

Roger,

Following is the EPA 8 mode emissions test data for Hobart 1004-42 engine AR70423:

Engine model	NOX g/kw-hr	HC g/kw-hr	CO g/kw-hr	PT g/kw-hr
AK70411	7 4	0 71	1 3	0 57

Please contact me at 812 375-2495 if you have any questions regarding this matter.

Best Regards,

David Scheidt

David Scheidt
Regional Technical Manager

Attachment 3

Hydraulic Test Stand
Engine Model: Briggs & Stratton 1334

Subject: ATTN: Paul Borton
Date: Wed, 20 Oct 1999 11:05:55 -0500
From: "Allan Schmitz" <Schmitz.Allan@basco.com>
To: <mail@tronair.COM>

To: Paul Borton
From: Allan Schmitz (Briggs & Stratton)

Paul,

The emission data you requested for the model 1334 are available publicly. Based on when you purchased the engine, my best estimate is that it is a Model Year 1999 engine. If that is the case, the emissions test data are as follows:

Carbon Monoxide (CO) = 374.1 grams per kilowatt hour [g/kW-hr]
Hydrocarbons plus Oxides of Nitrogen (HC+NOx) = 13.0 grams per kilowatt hour [g/kw-hr].

These are the official test data we supplied to USEPA for purposes of receiving emissions certification.

If you have any questions on this material, feel free to call me at 414-259-5589.

Regards,
Allan Schmitz
Briggs & Stratton Corporation

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