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**COMPLIANCE TEST REPORT
DETERMINATION OF NO_x, CO AND VOC EMISSION RATES
FORD MOTOR COMPANY
LIVONIA AUTOMATIC TRANSMISSION NEW PRODUCT CENTER
LIVONIA, MICHIGAN**

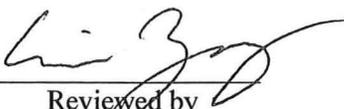


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Project # K1001
January 30, 2023

EXECUTIVE SUMMARY

KBD Technic was retained by Ford Motor Company to evaluate volatile organic compounds (VOCs), nitrogen oxides (NO_x), and carbon monoxide (CO) from a single thermal oxidizer under two separate fuel operating conditions. The source is located at the Livonia Automatic Transmission New Product Center located in Livonia, Michigan. The emissions test program was conducted on December 6th, 2022 and January 12th, 2023.

Table 1.1 Summary of test results

Test Condition	Emission Rates			Emission Factors		
	VOC (lb/hr)	CO (lb/hr)	NO _x (lb/hr)	VOC (lb/gal)	CO (lb/gal)	NO _x (lb/gal)
Gas	0.0075	0.62	2.15	0.0004	0.03	0.11
Diesel	0.0080	0.044	2.44	0.0008	0.004	0.24

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1.0 INTRODUCTION

KBD Technic was retained by Ford Motor Company to evaluate volatile organic compounds (VOCs), nitrogen oxides (NO_x), and carbon monoxide (CO) from a single thermal oxidizer under two separate fuel operating conditions. The source is located at the Livonia Automatic Transmission New Product Center located in Livonia, Michigan. The emissions test program was conducted on December 6th, 2022 and January 12th, 2023.

Testing consisted of three 60-minute test runs at each condition. The results of the emission test program are summarized in Table 1.2.

Table 1.2 Summary of test results

Test Condition	Emission Rates			Emission Factors		
	VOC (lb/hr)	CO (lb/hr)	NO _x (lb/hr)	VOC (lb/gal)	CO (lb/gal)	NO _x (lb/gal)
Gas	0.0075	0.62	2.15	0.0004	0.03	0.11
Diesel	0.0080	0.044	2.44	0.0008	0.004	0.24

The Air Quality Division (AQD) of Michigan's Department of Environmental Quality has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013, see Appendix A). The following is a summary of the emissions test program and results in the format outlined by the AQD document.

1.A Identification, location and dates of test

Sampling and analysis for the emissions test program on RTO 1 was conducted on December 6th, 2022 and January 12, 2023 at the Livonia Automatic Transmission New Product Center located at 35500 Plymouth Road, Livonia, Michigan 48150.

1.B Purpose of testing

The purpose of the emissions test program was to verify VOC, NO_x, and CO emission rates to demonstrate overall control efficiency to comply with the requirements of Michigan Department of Environmental Quality Air Quality Division Permit No. PTI 68-12B and PTI 68-12C for the Livonia Transmission New Product Center.

1.C Source description

The control device is a thermal oxidizer. The oxidizer temperature set point was 1550°F and averaged 1,523°F for the three test runs conducted under the gasoline fuel test condition. The

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oxidizer averaged 1,526°F for the three test runs conducted under the diesel fuel test condition.

1.D Testing personnel

Names and affiliations for personnel involved in the emissions test program are summarized in Table 1.3.

Table 1.3 Test personnel

Susan Hicks Environmental Engineer	Ford Motor Company 290 Town Center Drive Fairlane Plaza North, Suite 800 Dearborn, Michigan 48126	(313) 594-3185 shicks@ford.com
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2.0 SUMMARY OF RESULTS

Sections 2.a through 2.d summarize the results of the emissions test program.

2.A Operating data

Process operating data for this emissions test program is provided in Appendix B Process Data.

2.B Applicable permit

The applicable permit for this emissions test program is Permit No. PTI 68-12B and PTI 68-12C.

2.C Results

The results of the emissions test program are summarized by Table 2.1.

Table 2.1 Summary of test results

Test Condition	Emission Rates			Emission Factors		
	VOC (lb/hr)	CO (lb/hr)	NO _x (lb/hr)	VOC (lb/gal)	CO (lb/gal)	NO _x (lb/gal)
Gas	0.0075	0.62	2.15	0.0004	0.03	0.11
Diesel	0.0080	0.044	2.44	0.0008	0.004	0.24

2.D Emission regulation comparison

NA

3.0 SOURCE DESCRIPTION

Sections 3.A through 3.D provide a detailed description of the process.

3.A Process description

The facility operates 22 dynamometer test cells that are controlled by three thermal oxidizers. RTO 1 was tested for this emission survey.

3.B Process flow diagram



3.C Raw and finished materials

Pipeline quality natural gas is used in the oxidizer as combustion fuel.

3.D Process capacity

NA.

3.E Process instrumentation

The temperature of the thermal oxidizer was recorded every 15 minutes during the testing.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Sections 4.A through 4.D provide a summary of the sampling and analytical procedures used to verify emission rates.

4.A Sampling train and field procedures

The emissions test program utilized the following test methods;

Method 1 - Sample and Velocity Traverses for Stationary Sources

Method 2 - Determination of Stack Gas Velocity and Volumetric Flowrate

Method 3 - Determination of Molecular Weight of Dry Stack Gas (Fyrite)

Method 4 - Determination of Moisture Content in Stack Gases

Method 7E - Determination of Oxides of Nitrogen

Method 10 - Determination of Carbon Monoxide

Method 25A - Determination of Total Gaseous Organic Concentration using a Flame Ionization Analyzer

Method 205 - Verification of Gas Dilution Systems for Field Instrument Calibrations

◦ *Measurement Sites*

Location of measurement sites and the number of traverse points to be sampled were determined as specified in USEPA Reference Method 1, "*Sample and Velocity Traverses for Stationary Sources*".

◦ *Velocity, Flow Rate and Temperature*

The stack gas velocity and temperature were determined using USEPA Reference Method 2, "*Determination of Stack Gas Velocity and Volumetric Flow Rate (Type "S" Pitot Tube)*". The velocity pressure was measured with a Type "S" or a standard pitot tube and an oil or electronic manometer. The stack gas temperature was measured with a calibrated Type "K" thermocouple. One velocity traverse was made at each location during each hour of testing. A cyclonic flow check was conducted at the outlet of the RTO and found to be $\leq 20^\circ$.

◦ *Analysis for Carbon Dioxide and Oxygen*

The dry molecular weight was determined using USEPA Reference Method 3, "*Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight*". Several grab samples of the RTO outlet stack gas were analyzed with Fyrite combustion gas analyzers for oxygen and carbon dioxide.

◦ *Stack Gas Moisture*

Stack gas moisture content was determined using the principles of USEPA Reference Method 4, "*Determination of Moisture Content in Stack Gases*". The moisture content was determined using an impinger train that was weighed before and after each test to the nearest 0.5 g with a calibrated electronic balance. An unheated stainless steel probe and

flexible connector was used to extract the sample gas from a single point in the centroid of the stack. A drawing of the sample train is included in Figure 4.1.

◦ ***Nitrogen Oxides***

Nitrogen oxide emissions were determined using USEPA Reference Method 7E, "*Determination of Nitrogen Oxide Emissions From Stationary Sources-Instrumental Analyzer Procedure*". A continuous sample of the stack gas was extracted, the moisture was removed and the gas was then analyzed with a chemiluminescent analyzer. The instrument output was recorded on a chart recorder and instantaneously logged on a personal computer equipped with a data acquisition device. A drawing of the measurement system is included in Figure 4.2.

A NO₂ to NO conversion efficiency test was performed in the field. The required analyzer interference response was checked prior to its initial use in the field. The check consists of introducing CO, SO₂, CO₂, and O₂ to the analyzer and recording their response. The sum of the interference responses of the test gases was less than 2% of the span value.

Prior to the first test, the three-point analyzer calibration error test was performed by introducing the calibration gases directly into the analyzer. Next, the system bias check was performed by injecting either the high-level or mid-level calibration gas and the low-level calibration gas through the measurement system. The upscale and downscale system response time was determined at this time. A stratification check was also performed to determine the correct number of sampling points at each sample site. After each test run, a two-point system bias check and drift assessment was performed. If the drift checks were satisfactory, the post-run calibration data was used as the pre-run calibration data for the next run in the test sequence.

The calibration gases were mixtures of nitric oxide in nitrogen. The calibration gases were certified in accordance with "*EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards*".

◦ ***Carbon Monoxide***

Carbon monoxide emissions were determined using USEPA Reference Method 10, "*Determination of Carbon Monoxide Emissions From Stationary Sources*". A continuous sample was extracted, the moisture was removed, and the gas was then analyzed with a gas filter correlation NDIR CO analyzer. The instrument output was recorded on a chart recorder and instantaneously logged on a personal computer. A drawing of the measurement system is included in Figure 4.3.

Prior to the first test, the three-point analyzer calibration error test was performed by introducing the calibration gases directly into the analyzer. Next, the system bias check was performed by injecting either the high-level or mid-level calibration gas and the low-level calibration gas through the measurement system. The up-scale and downscale system response time was determined at this time. A stratification check was also performed to determine the correct number of sampling points at each sample site. After each test run, a two-point system bias check and drift assessment was performed. If the drift checks were satisfactory, the post-run calibration data was used as the pre-run calibration data for the next run in the test sequence.

The calibration gases were mixtures of carbon monoxide in nitrogen. The calibration gases were certified in accordance with "*EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards*".

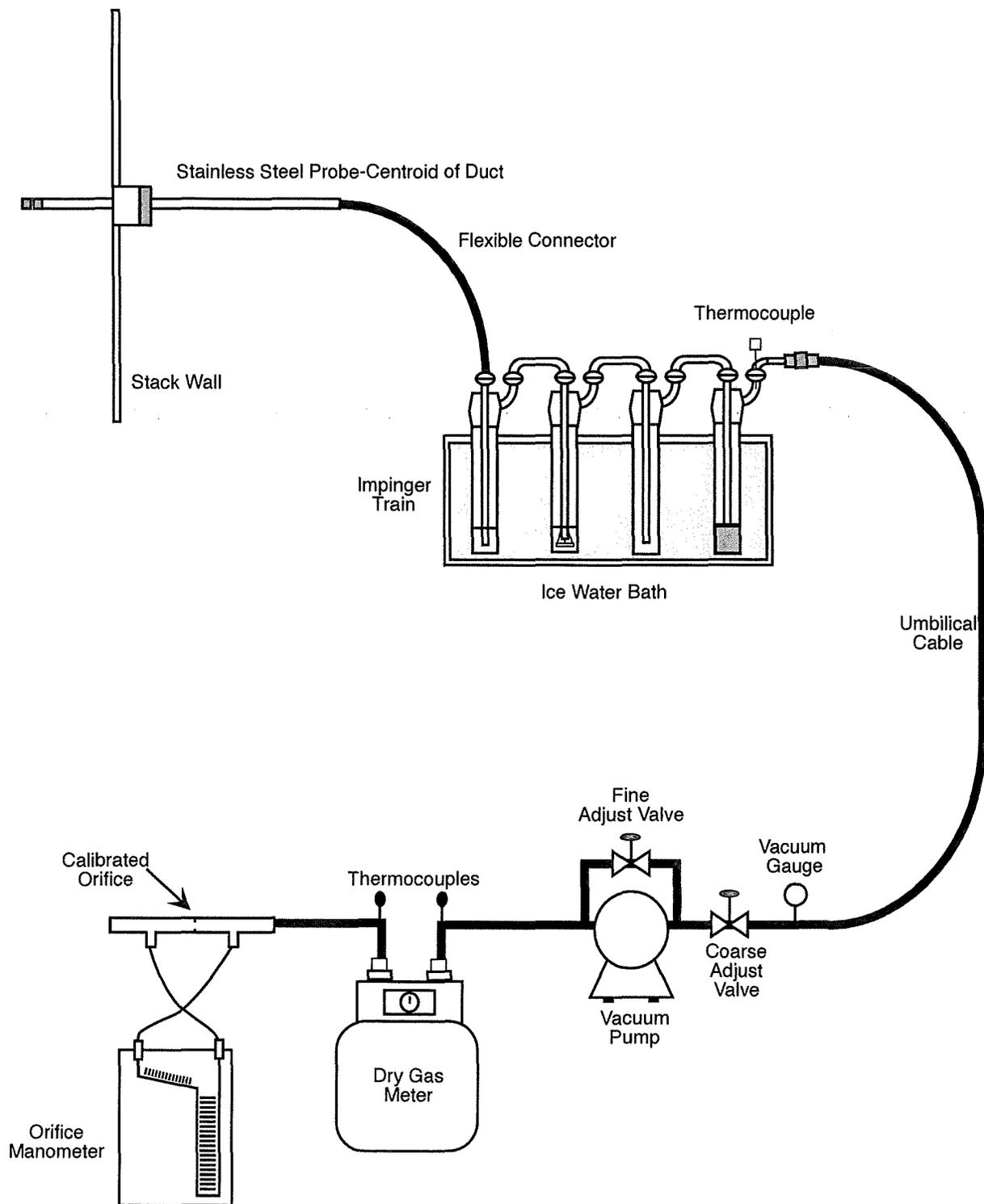


Figure 4.1 USEPA Reference Method 4 sampling train

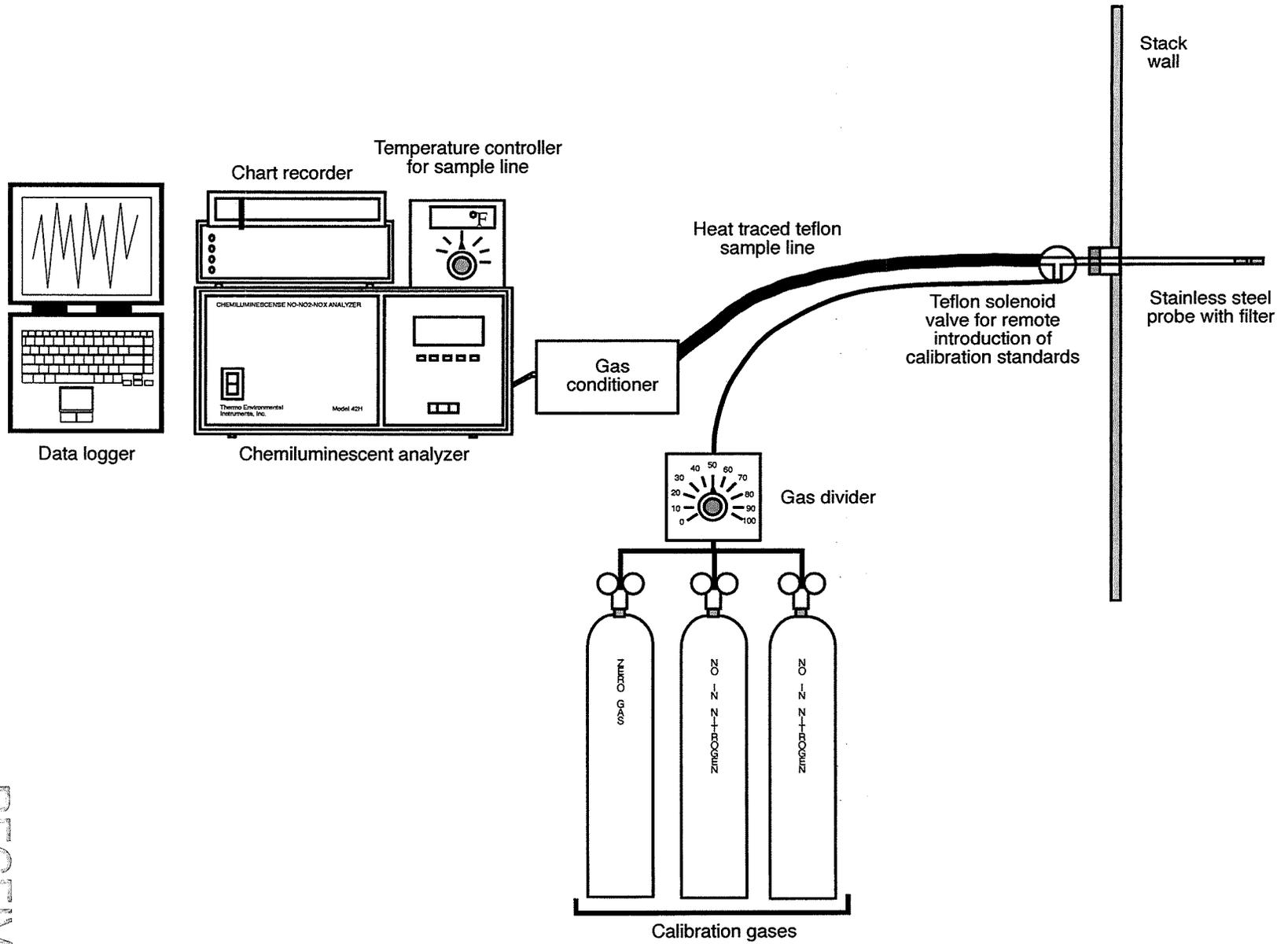


Figure 4.2 USEPA Reference Method 7E measurement system

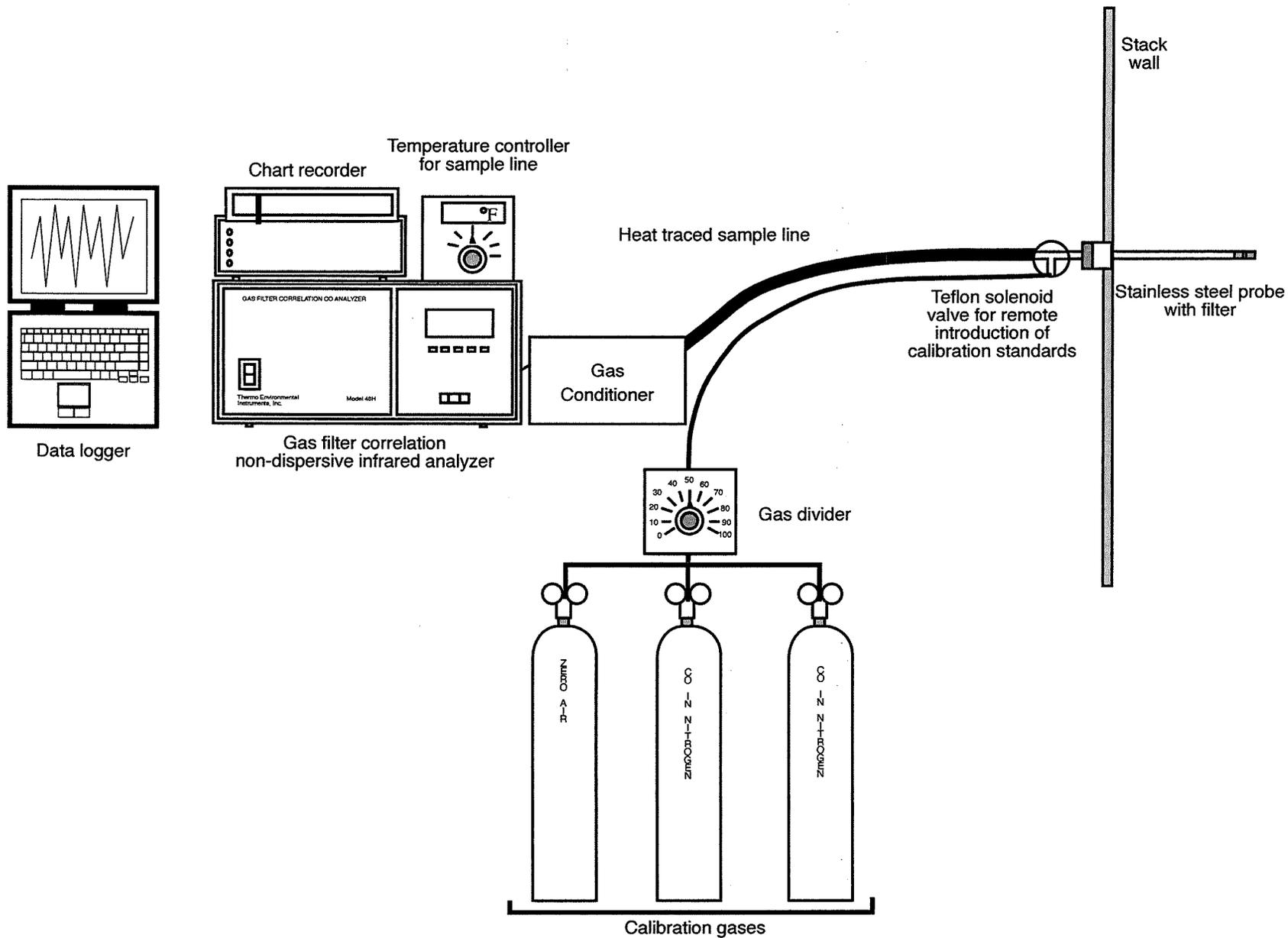


Figure 4.3 USEPA Reference Method 10 measurement system

◦ ***Volatile Organic Compounds***

The concentration of volatile organic compounds was determined using USEPA Reference Method 25A, *"Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer"*. Continuous samples of the inlet and outlet stack gas were extracted and analyzed with flame ionization analyzers (FIA). The analyzers were fueled with zero grade hydrogen. The sample gas was delivered to the analyzers through heat traced, Teflon sample lines and stainless steel probes. The temperature of the sample lines was controlled to $\geq 110^{\circ}\text{C}$ (230°F). The FIA output signals were recorded continuously on a chart recorder and instantaneously logged on a personal computer. A drawing of the measurement system is included in Figure 4.4.

The FIA's were calibrated as specified in the Reference Method with ultra zero air, low-level, mid-level, and high-level mixtures of propane in air. The calibration standards were certified by USEPA Protocol 1 *"Traceability Protocol for Establishing True Concentrations of Gases Used for Calibration and Audits of Continuous Source Emission Monitors"*. Prior to the first test and each subsequent test, the linearity of the sampling system was established by introducing the high level span gas and zero gas through the sampling system to the analyzer and making the necessary adjustments. The mid-level and the low-level calibration gas were then introduced to each measurement system to check for calibration error. After each test, the measurement system and analyzer response to zero air and the mid-level span gas were checked to determine drift.

◦ ***Gas dilution system***

All of or a portion of the calibration standards were prepared using a gas dilution system. Gas standards from cylinders certified by USEPA Protocol 1 *"Traceability Protocol for Establishing True Concentrations of Gases Used for Calibration and Audits of Continuous Source Emission Monitors"* are diluted with zero air. The gas dilution systems were verified in the field using USEPA Method 205, *"Verification of Gas Dilution Systems for Field Instrument Use"*.

◦ ***Quality Assurance***

The Quality Assurance procedures used in this survey include equipment calibration by USEPA and manufacturer's guidelines, use of standard published procedures for sample collection and analysis, and attention to the QA procedures included in the Reference Methods. The calibration procedures and results for the equipment used in this survey are included in Appendix A.

4.B Recovery and analytical procedures

Molecular weight and moisture content and samples were recovered and analyzed consistent with the specification of Methods 3 and 4.

4.C Sampling ports

The outlet sampling locations satisfy the minimum criteria for Method 1. See Figure 4.5 for the location of sampling ports.

4.D Traverse points

See Figure 4.5 for the location of traverse points.

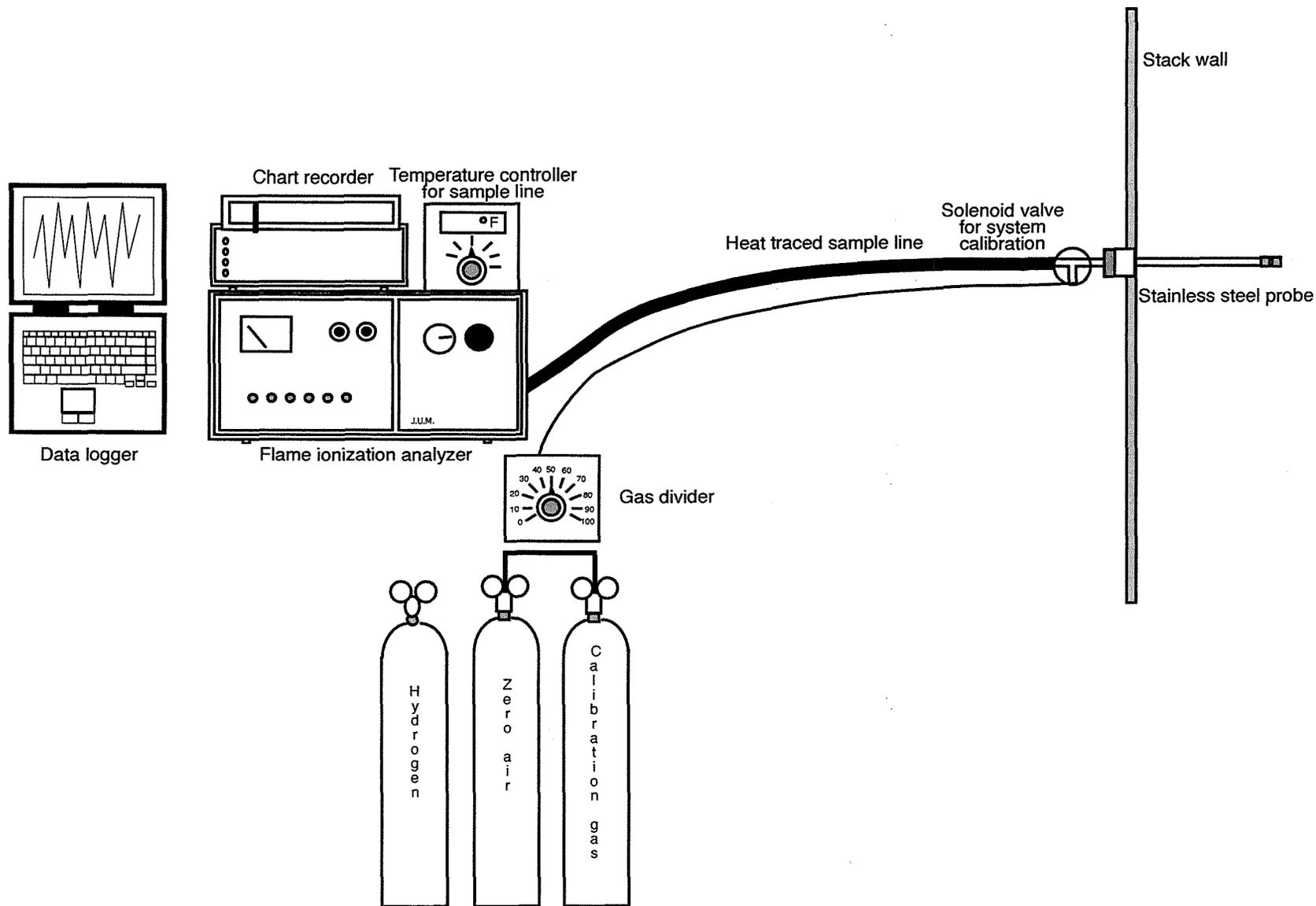
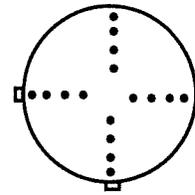
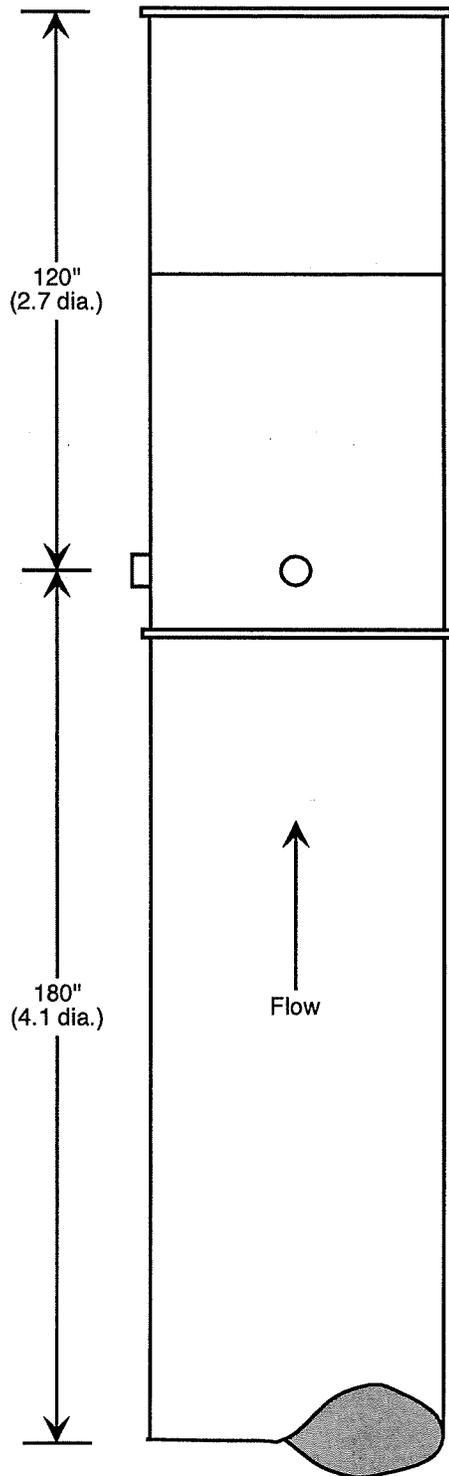


Figure 4.4 USEPA Reference Method 25A measurement system



Stack ID = 44.0"

Traverse Point	Distance From Stack Wall
1	1.4"
2	4.6"
3	8.5"
4	14.2"
5	29.8"
6	35.5"
7	39.4"
8	42.6"

Traverse Point Location

Figure 4.5 RTO 1 outlet site detail

5.0 TEST RESULTS AND DISCUSSION

5.A Results tabulation

The results of the emission test program while the dynamometer test cells were utilizing gasoline fuel are summarized in Tables 5.1 through Table 5.4. Graphic reproductions of the VOC, CO and NO_x concentration data while the dynamometer test cells were utilizing gasoline fuel are presented in Figures 5.1 through 5.3.

The results of the emission test program while the dynamometer test cells were utilizing diesel fuel are summarized in Tables 5.5 through Table 5.8. Graphic reproductions of the VOC, CO and NO_x concentration data while the dynamometer test cells were utilizing diesel fuel are presented in Figures 5.4 through 5.6.

5.B Discussion of test results

The NO_x, CO and VOC emission rates were below the allowable limit for this source.

5.C Sampling procedure variations

The emissions test program did not have any sampling procedure variations.

5.D Process or control device upsets

No upset conditions occurred during testing.

5.E Control device management

There has been no major maintenance performed during the past three months.

5.F Retest

This test program was not a re-test.

5.G Audit sample analyses

No audit samples were collected as part of the test program.

5.H Calibration sheets

Calibration data sheets are provided in Appendix A-Quality Assurance Procedures and Results. Field data calibration sheets are provided in Appendix C-Field Data Sheets.

5.I Sample calculations

Table 5.1 Summary of stack gas conditions - Gasoline fuel test condition

RUN #	DATE 2022	VELOCITY (fps)	VOLUMETRIC FLOW RATE			TEMP. (°F)	MOISTURE (%)	O ₂ (%)	CO ₂ (%)
			(acfm) ^a	(dscfm) ^b	(scfm) ^c				
1	12/6	22.5	14,281	10,629	10,801	222	1.6	21.0	0.0
2	12/6	23.1	14,611	10,924	11,115	218	1.7	21.0	0.0
3	12/6	22.5	14,260	10,874	11,077	204	1.8	21.0	0.0
Average		22.7	14,384	10,809	10,998	215	1.7	21.0	0.0

^a Feet per second at stack conditions.

^b Actual cubic feet per minute at stack conditions.

^c Dry standard cubic feet per minute at 68°F and 29.92" Hg.

^d Standard cubic feet per minute at 68°F and 29.92" Hg.

Table 5.2 Summary of VOC emission rates - Gasoline fuel test condition

RUN #	CONCENTRATION	MASS EMISSION RATE	
	(ppm) ^a	(lb/hr)	(lb/gal)
1	0.1	0.0074	0.0004
2	0.1	0.0076	0.0003
3	0.1	0.0076	0.0004
Average	0.1	0.0075	0.0004

^a Corrected for drift using Method 7E procedures

Table 5.3 Summary of carbon monoxide emission rates - Gasoline fuel test condition

RUN #	CONCENTRATION	MASS EMISSION RATE	
	(ppm) ^a	(lb/hr)	(lb/gal)
1	8.9	0.41	0.02
2	21.5	1.02	0.04
3	9.0	0.43	0.02
Average	13.1	0.62	0.03

^a Corrected for drift

Table 5.4 Summary of nitrogen oxide emission rates - Gasoline fuel test condition

RUN #	CONCENTRATION	MASS EMISSION RATE	
	(ppm) ^a	(lb/hr)	(lb/gal)
1	26.1	1.99	0.12
2	33.3	2.61	0.11
3	23.7	1.84	0.10
Average	27.7	2.15	0.11

^a Corrected for drift