

Report of...

Emission Sampling

Performed for...

Spectrum Health

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At ...

AIR QUALITY DIVISION

Spectrum Health Combined Laboratory

Grand Rapids, Michigan

On the

Tower 35 Engine Generator Exhaust

October 9, 2018

M2038 - TEST - 2018/10/09. ARS

Project #: 240.04

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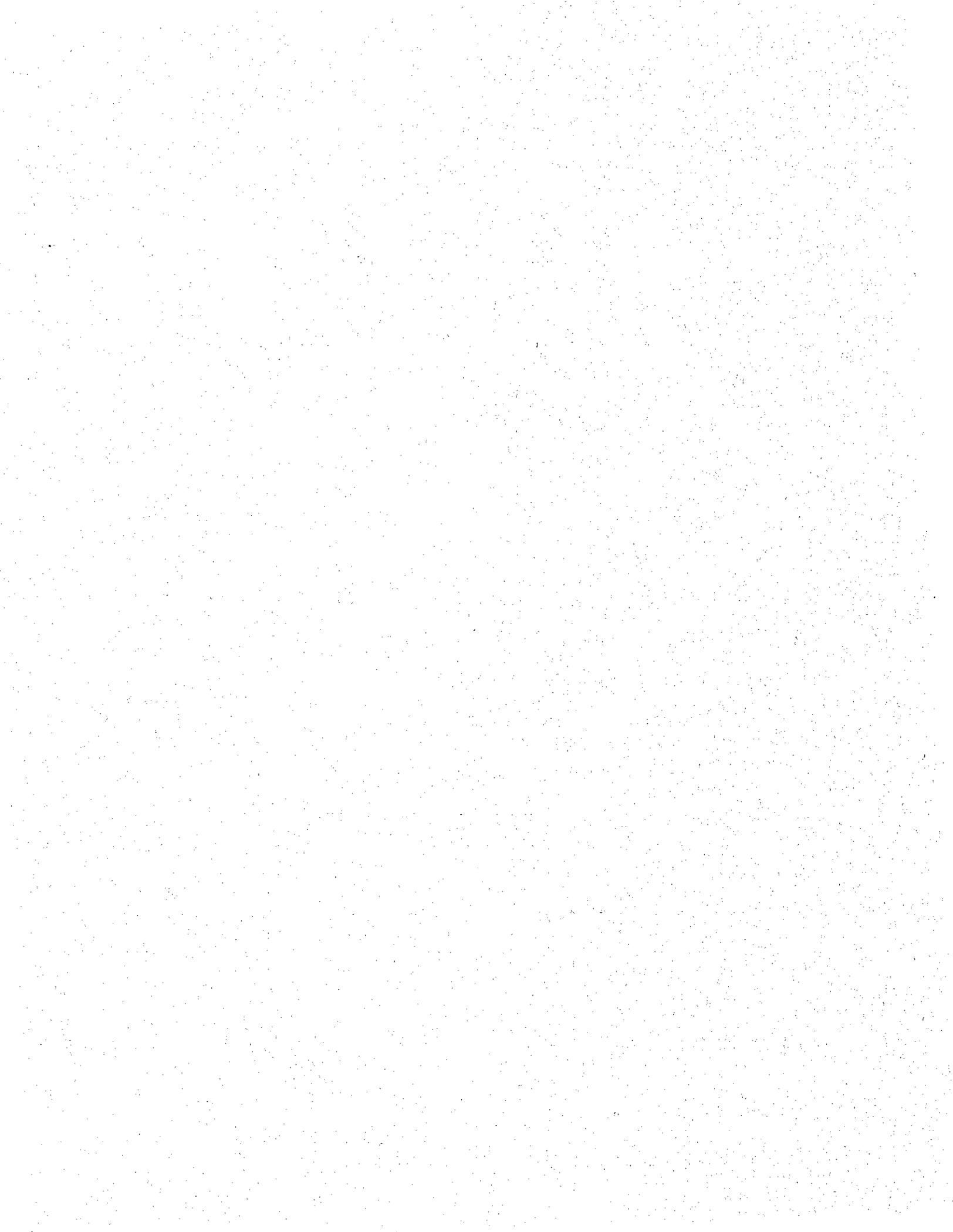
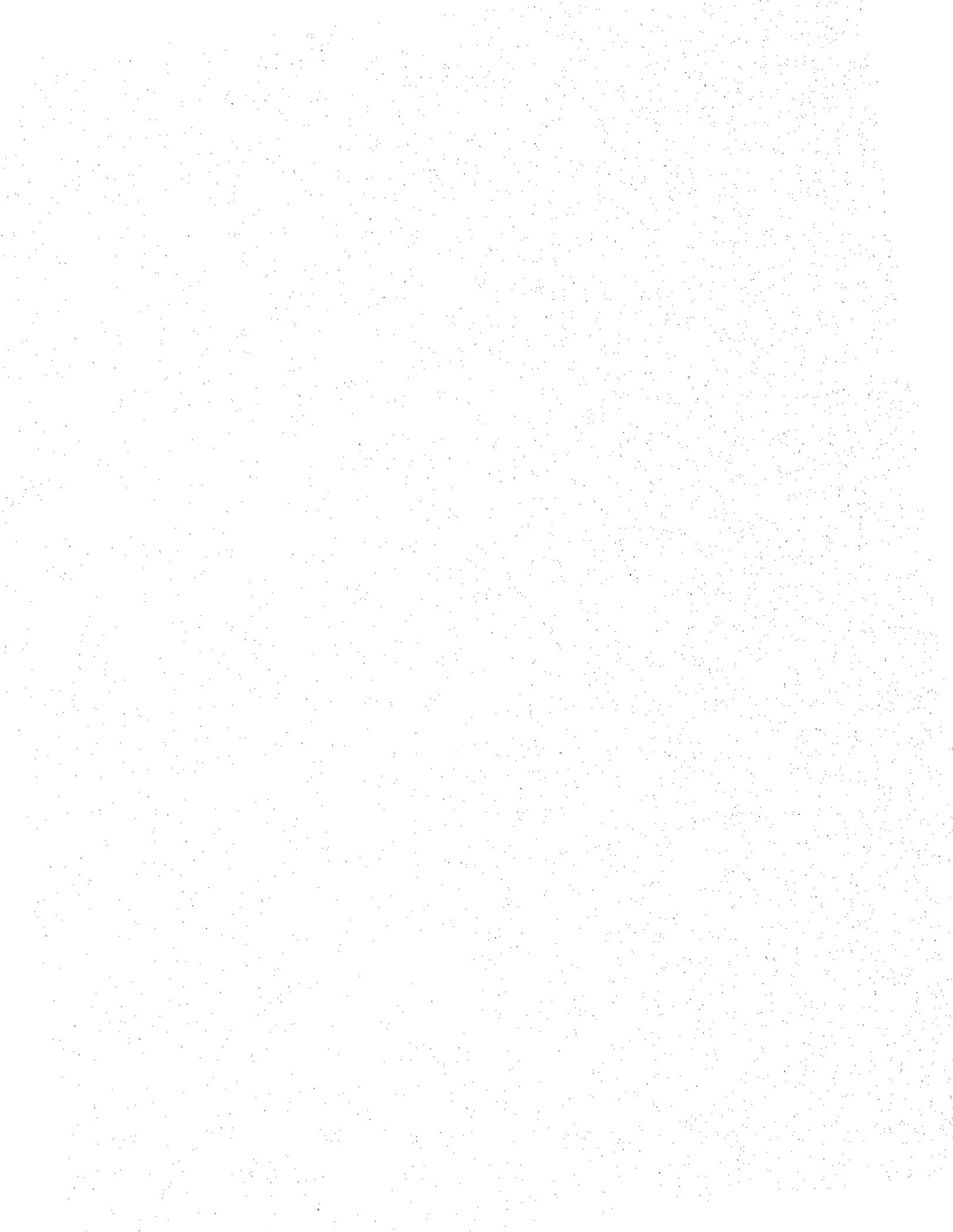


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I. INTRODUCTION

Network Environmental, Inc. was retained by Spectrum Health of Grand Rapids, Michigan to perform emission sampling on their engine-generator located at Spectrum Health Combined Laboratory in Grand Rapids, Michigan. The purpose of the testing was to comply with the requirements of their Permit to Install 72-11 and the requirements for stationary spark ignition internal combustion engines (40 CFR Part 60, Subpart JJJJ).

The scope of this project was to determine the oxides of nitrogen (NO_x), carbon monoxide (CO), and total hydrocarbon (VOC) emissions from the Tower 35 Generator.

The following reference test methods were employed to conduct the sampling:

- Carbon Monoxide (CO) – U.S. EPA Method 10
- Oxides of Nitrogen (NO_x) – U.S. EPA Method 7E
- Total Hydrocarbons (VOC) – U.S. EPA Methods 25A & 18
- Exhaust Gas Parameters (flow rate, temperature, moisture & density) – U.S. EPA Methods 1 through 4

The sampling was performed on October 9, 2018 by Stephan K. Byrd, R. Scott Cargill, and David D. Engelhardt of Network Environmental, Inc. Assisting with the source operation and data collection was Mr. Howard Hehrer of Spectrum Health. Mr. David Patterson and Mr. David Morgan of the MDEQ Air Quality Division were present to observe the testing and source operation.

II. PRESENTATION OF RESULTS

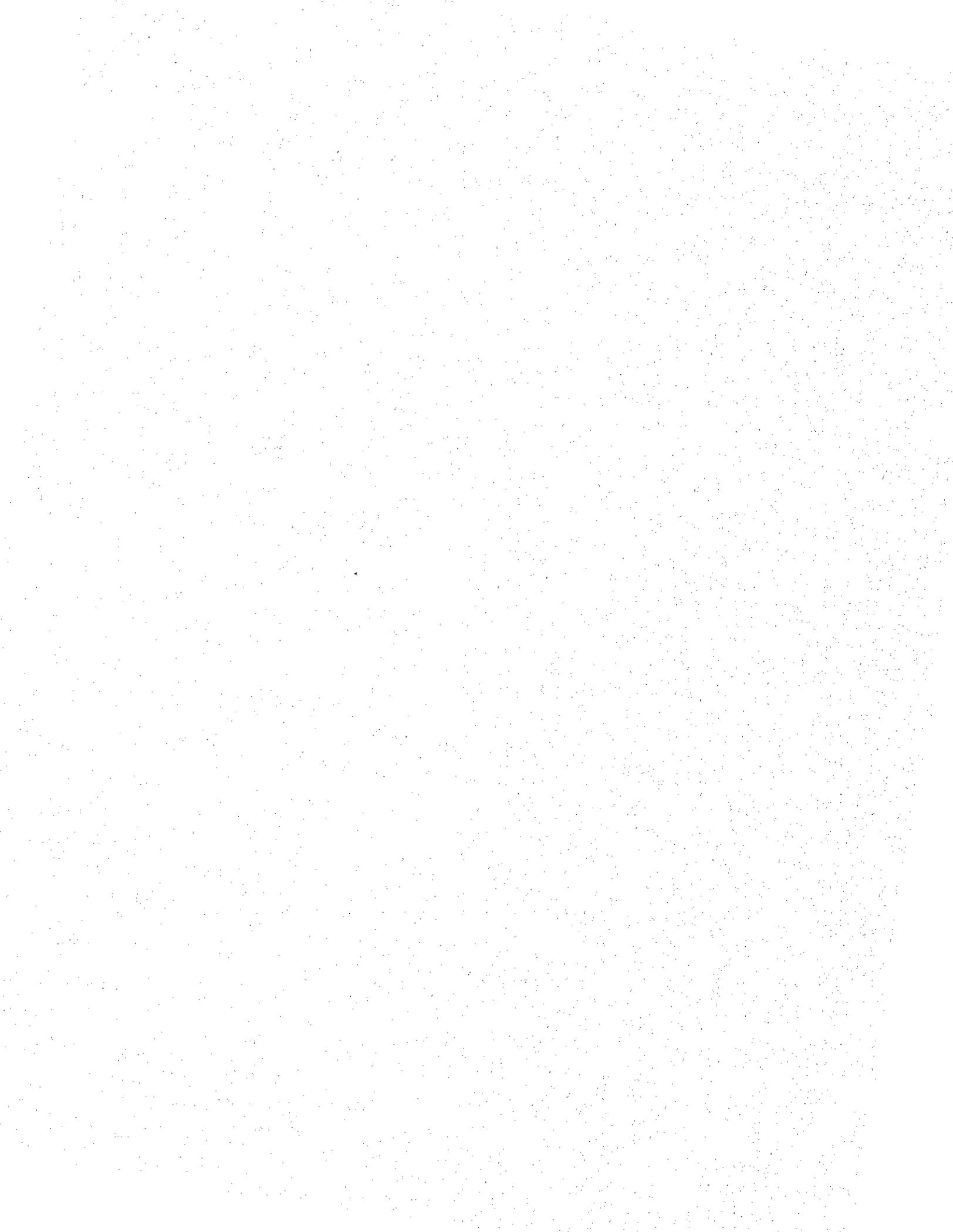
**II.1 TABLE 1
CARBON MONOXIDE (CO) EMISSION RESULTS
TOWER 35 ENGINE GENERATOR (EUENGINE1) EXHAUST
SPECTRUM HOSPITAL
GRAND RAPIDS, MICHIGAN
OCTOBER 9, 2018**

Sample	Time	Air Flow Rate DSCFM ⁽¹⁾	CO Concentration PPM ⁽²⁾	CO Lbs/Hr	CO g/hp-hr ⁽³⁾
1	10:23-11:23	2,702	418.1	4.89	1.52
2	13:37-14:37	2,723	394.1	4.65	1.44
3	14:58-15:58	2,706	386.3	4.51	1.48
Average		2,710	399.2	4.69	1.48

(1) DSCFM = Dry Standard Cubic Feet per Minute (Standard Temperature & Pressure = 68° F & 29.92 in. Hg)

(2) PPM = Parts Per Million (v/v) On A Dry Basis

(3) g/hp-hr = grams per horsepower hour (based on engine hp-hr rating of 1462).



**II.2 TABLE 2
OXIDES OF NITROGEN (NO_x) EMISSION RESULTS
TOWER 35 ENGINE GENERATOR (EUENGINE1) EXHAUST
SPECTRUM HOSPITAL
GRAND RAPIDS, MICHIGAN
OCTOBER 9, 2018**

Sample	Time	Air Flow Rate DSCFM ⁽¹⁾	NO _x Concentration PPM ⁽²⁾	NO _x Lbs/Hr	NO _x g/hp-hr ⁽³⁾
1	10:23-11:23	2,702	207.4	3.99	1.24
2	13:37-14:37	2,723	158.1	3.06	0.95
3	14:58-15:58	2,706	154.7	2.98	0.92
Average		2,860	173.4	3.34	1.04

(1) DSCFM = Dry Standard Cubic Feet per Minute (Standard Temperature & Pressure = 68 °F & 29.92 in. Hg)

(2) PPM = Parts Per Million (v/v) On A Dry Basis

(3) g/hp-hr = grams per horsepower hour (based on engine hp-hr rating of 1462).

**II.3 TABLE 3
TOTAL HYDROCARBON (VOC) EMISSION RESULTS
TOWER 35 ENGINE GENERATOR EXHAUST
SPECTRUM HOSPITAL
GRAND RAPIDS, MICHIGAN
OCTOBER 9, 2018**

Source	Sample	Time	Air Flow Rate SCFM ⁽¹⁾	THC Concentration PPM ⁽²⁾	Methane Concentration PPM ⁽³⁾	VOC Concentration PPM ⁽⁴⁾	VOC Mass Rate Lbs/Hr ⁽⁵⁾	VOC Mass Rate g/hp-hr ⁽⁶⁾
Engine #1	1	10:23-11:23	3,133	171.4	272	80.7	1.72	0.53
	2	13:37-14:37	3,157	189.4	294	91.4	1.96	0.61
	3	14:58-15:58	3,137	193.5	266	104.8	2.24	0.69
	Average		3,142	184.8	277.3	92.3	1.97	0.61

- (1) SCFM = Standard Cubic Feet per Minute (Standard Temperature & Pressure = 68 °F & 29.92 in. Hg)
 (2) THC PPM = Parts Per Million (v/v) Of Total Hydrocarbons On A Wet Basis As Propane
 (3) Methane PPM = Parts Per Million (v/v) Of Methane On a Dry Basis
 (4) VOC PPM = Part Per Million (v/v) of VOC (THC Minus Methane)
 (5) VOC Lbs/Hr = Pounds Of VOC (THC Minus Methane) Per Hour Calculated As Propane
 (6) VOC g/hp-hr = grams per horsepower hour (based on engine hp-hr rating of 1462).

III. DISCUSSION OF RESULTS

The results of the emission sampling are summarized in Tables 1 through 3 (Sections II.1 through II.3).

The results are presented as follows:

III.1 CO

Table 1 – Carbon Monoxide (CO) Emission Results Summary

- Sample
- Time
- Air Flow Rate (DSCFM) – Dry Standard Cubic Feet per Minute (STP = 68 °F & 29.92 in. Hg)
- CO Concentration (PPM) – Parts Per Million (v/v) on a Dry Basis
- CO Mass Emission Rate (Lbs/Hr) – Pounds of CO Per Hour
- CO Mass Emission Rate (g/hp-hr) – grams per horsepower hour

All raw CO sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

III.2 NO_x

Table 2 – Oxides of Nitrogen (NO_x) Emission Results Summary

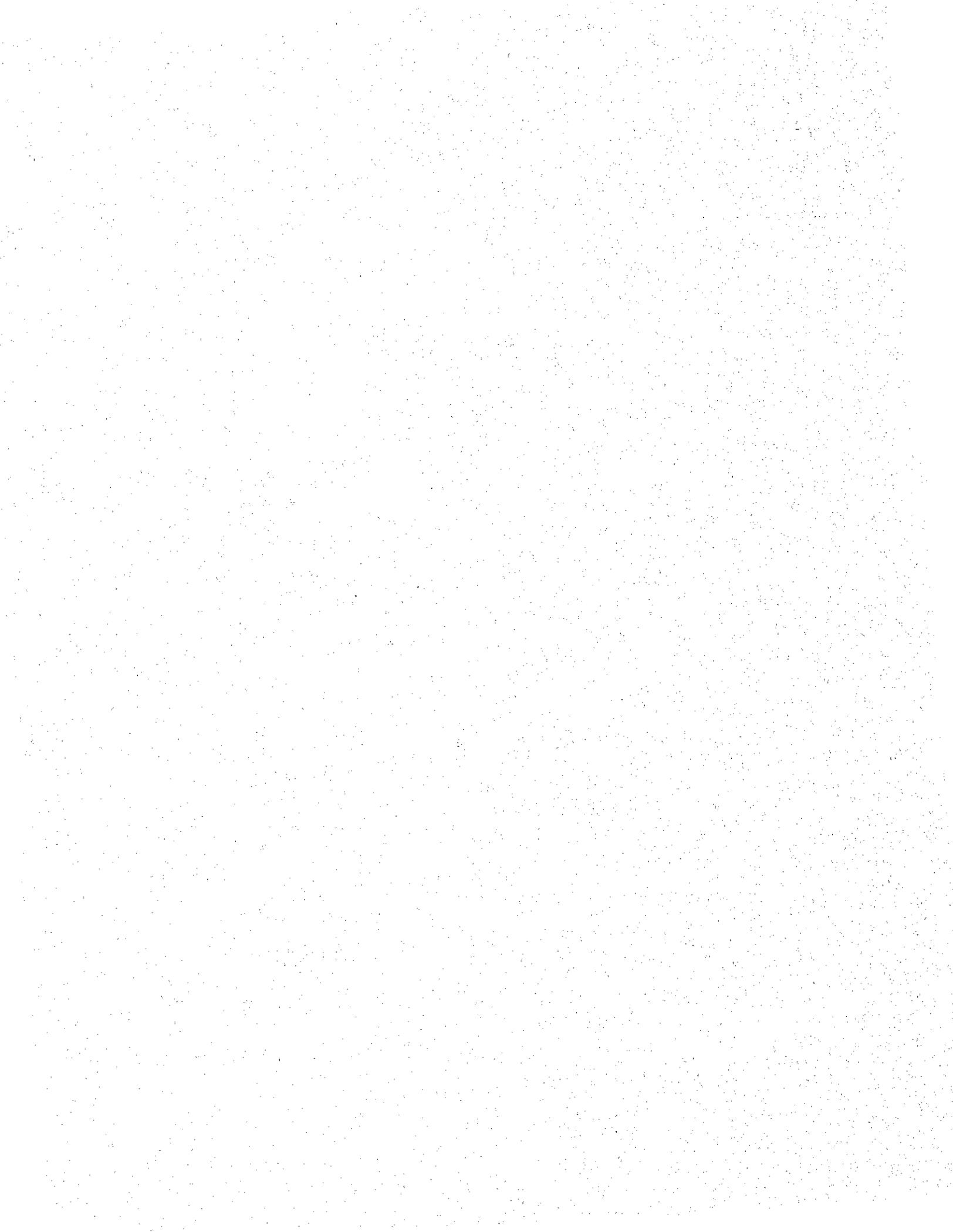
- Sample
- Time
- Air Flow Rate (DSCFM) – Dry Standard Cubic Feet per Minute (STP = 68 °F & 29.92 in. Hg)
- NO_x Concentration (PPM) – Parts Per Million (v/v) on a Dry Basis
- NO_x Mass Emission Rate (Lbs/Hr) – Pounds of NO_x Per Hour
- NO_x Mass Emission Rate (g/hp-hr) – grams per horsepower hour

All raw NO_x sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

III.3 VOC

Table 3 – Total Hydrocarbon (VOC) Emission Results Summary

- Sample
- Time
- Air Flow Rate (DSCFM) – Standard Cubic Feet per Minute (STP = 68 °F & 29.92 in. Hg)



- THC Concentration (PPM) – Parts Per Million of THC (v/v) on a Wet Basis as Propane
- Methane Concentration (PPM) – Parts Per Million of Methane (v/v) on a Wet Basis
- VOC Concentration (PPM) – Parts Per Million of VOC (THC Minus Methane) as propane
- VOC Mass Emission Rate (Lbs/Hr) – Pounds of VOC (THC Minus Methane) Per Hour
- VOC Mass Emission Rate (g/hp-hr) – grams per horsepower hour.

All raw VOC sample data was calibration corrected using Equation 7E-5 from U.S. EPA Method 7E.

The methane concentrations were converted to a propane basis using a response factor of 3.00 (PPM Methane as Propane = PPM Methane/3.0 the VOC results were calculated taking the THC results minus the methane results (on a propane basis).

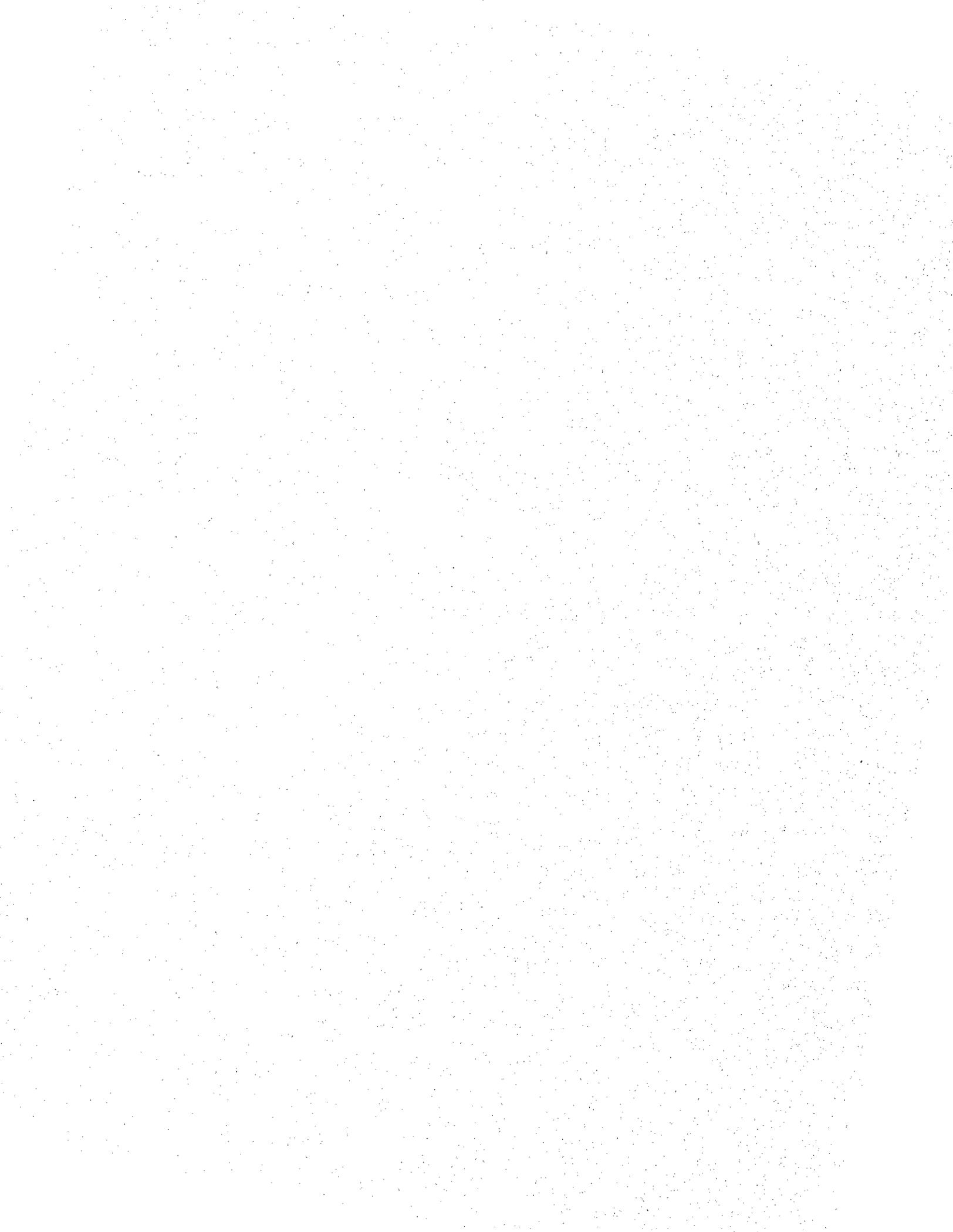
III.4 Emission Limits

The emission limits as specified in Permit No. 72-11 are as follows:

Test Parameter	Limit
CO	4.0 g/hp-hr
NO _x	2.0 g/hp-hr
VOC	1.0 g/hp-hr

IV. SOURCE DESCRIPTION

The source sampled was Tower 35 Engine Generator, which is a natural gas fired emergency engine-generator (CAT G3516). The rated capacity of this engine is 1462 bhp. Source operating data during the testing can be found in Appendix B.



V. SAMPLING AND ANALYTICAL PROTOCOL

The sampling location was on the 14 inch I.D. exhaust stack with 2 sample ports in a location approximately 6 duct diameters downstream and approximately 4 duct diameters upstream from the nearest disturbances.

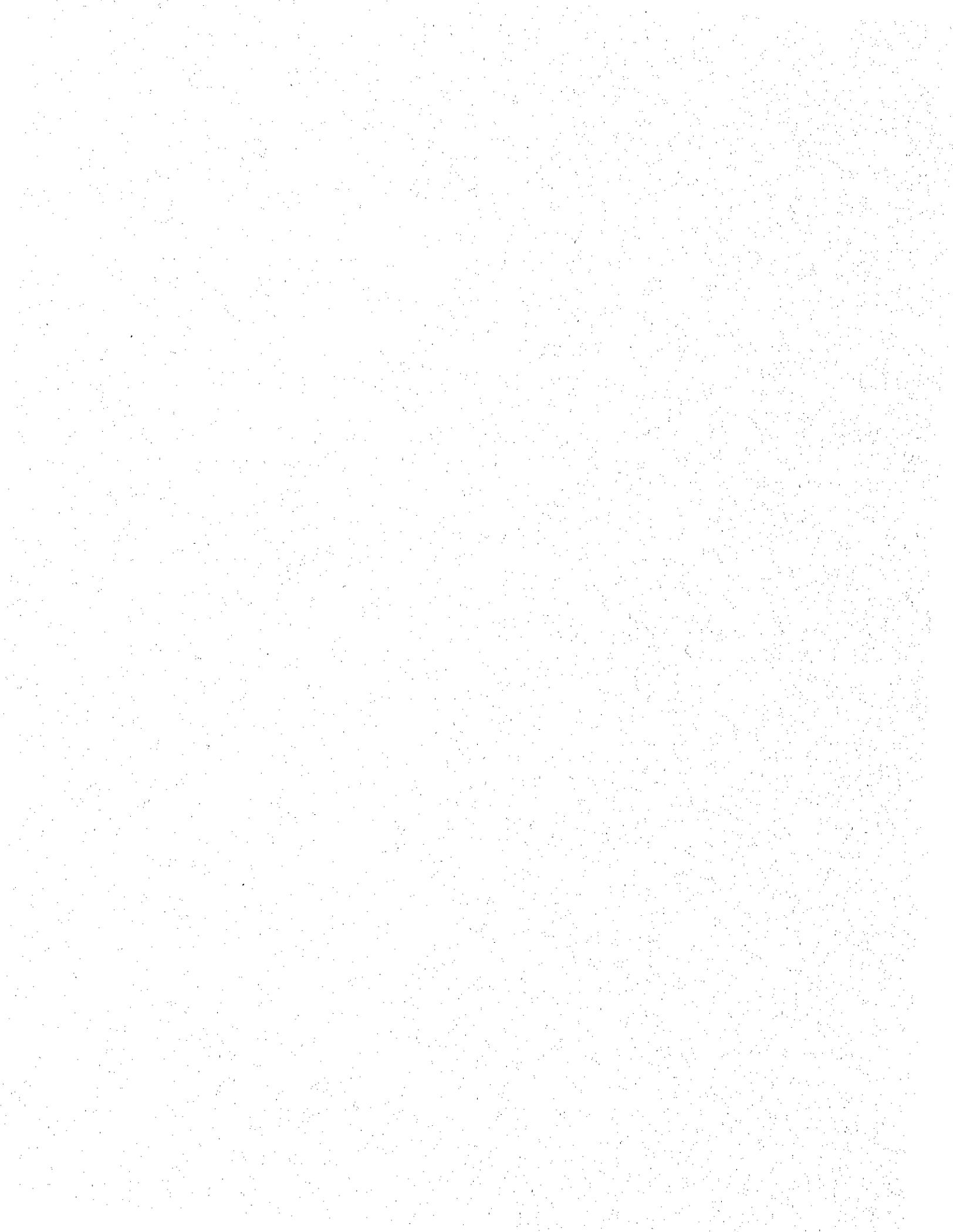
V.1 Carbon Monoxide – The CO sampling was conducted in accordance with U.S. EPA Reference Method 10. A Thermal Environmental Model 48C gas analyzer was used to monitor the exhaust. A heated Teflon sample line was used to transport the exhaust gases to a heated manifold and then to a gas conditioner to remove moisture and reduce the temperature. From the gas conditioner stack gases were passed to the analyzer. The analyzer produces instantaneous readouts of the CO concentrations (PPM).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 985.3 PPM was used to establish the initial instrument calibration. Calibration gases of 254.0 PPM and 498.0 PPM were used to determine the calibration error of the analyzer. The sampling system (from the back of the stack probe to the analyzer) was injected using the 498.0 PPM gas to determine the system bias. After each sample, a system zero and system injection of 498.0 PPM were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified.

The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhaust. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. A diagram of the sampling train is shown in Figure 1.

V.2 Oxides of Nitrogen – The NO_x sampling was conducted in accordance with U.S. EPA Reference Method 7E. A Thermal Environmental Model 42H gas analyzer was used to monitor the exhaust. A heated Teflon sample line was used to transport the exhaust gases to a heated manifold and then to a gas conditioner to remove moisture and reduce the temperature. From the gas conditioner stack gases were passed to the analyzer. The analyzer produces instantaneous readouts of the NO_x concentrations (PPM).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 486.9 PPM was used to establish the initial instrument calibration. Calibration gases of 124.0 PPM and 250.1 PPM were used to determine the calibration error of the analyzer. A direct injection of 49.6 PPM nitrogen dioxide (NO₂) was performed to show the conversion efficiency of the monitor. The conversion efficiency was 94.35% (46.8 PPM). The sampling system (from the back of the stack probe to the analyzer) was injected using the



250.1 PPM gas to determine the system bias. After each sample, a system zero and system injection of 250.1 PPM were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified.

The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhaust. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. A diagram of the sampling train is shown in Figure 1.

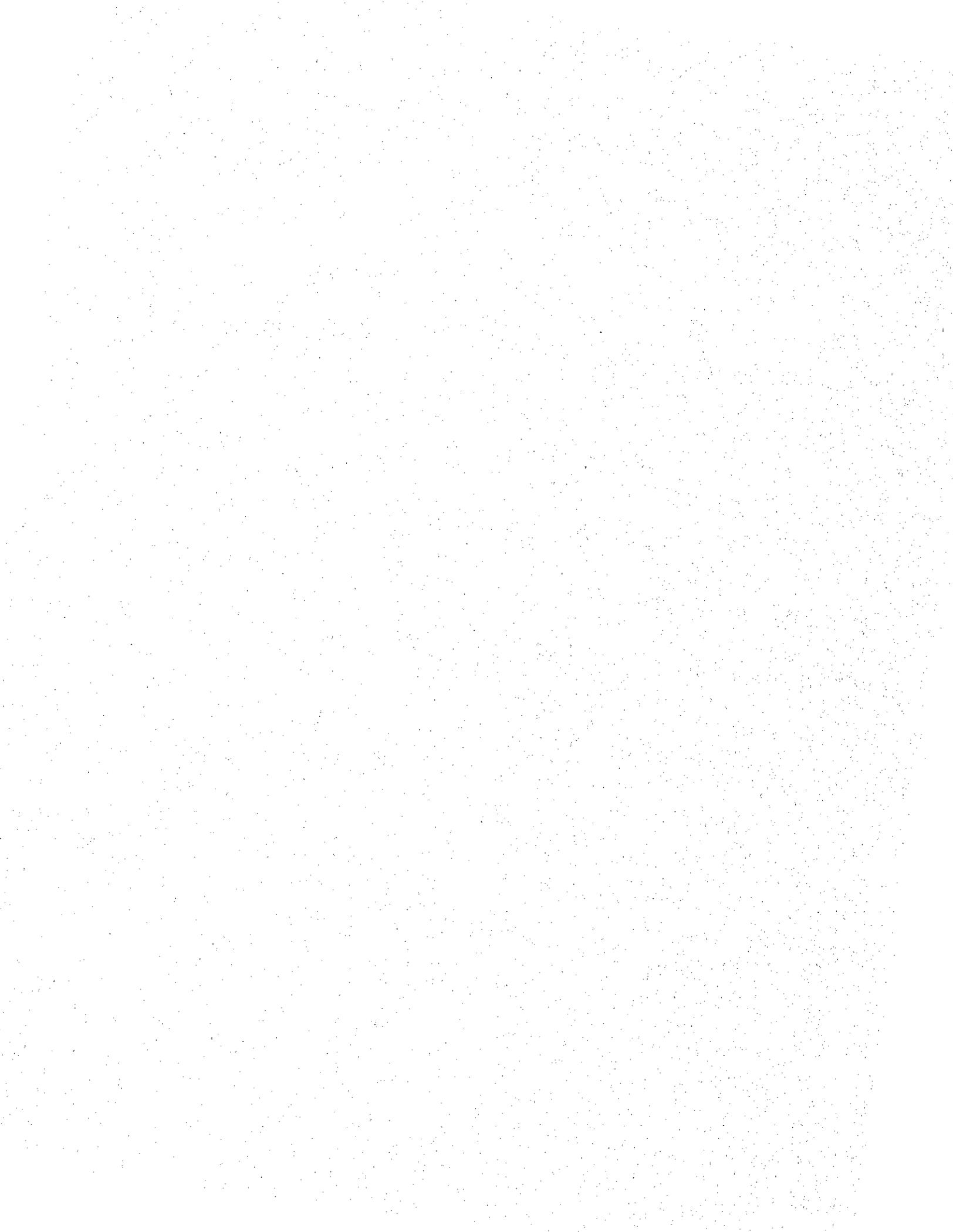
V.3 Total Hydrocarbons (THC) – The THC sampling was conducted in accordance with U.S. EPA Reference Method 25A. A J.U.M. Model 3-500 flame ionization detector (FID) analyzer was used to monitor the exhausts. Sample gas was extracted through a heated probe. A heated Teflon sample line was used to transport the exhaust gases to a heated manifold and then to the analyzer. The analyzer produces instantaneous readouts of the total hydrocarbon (THC) concentrations (PPM).

The analyzer was calibrated by system injection (from the back of the stack probe to the analyzer) prior to the testing. A span gas of 491.0 PPM was used to establish the initial instrument calibration. Calibration gases of 151.1 PPM and 247.1 PPM were used to determine the calibration error of the analyzer. After each sample, a system zero and system injection of 151.1 PPM were performed to establish system drift and system bias during the test period. All calibration gases used were EPA Protocol Propane Calibration Gases. Three (3) samples were collected from the exhaust. Each sample was sixty (60) minutes in duration.

The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the exhaust. The analyzer averages were corrected for calibration error and drift using formula EQ.7E-5 from 40 CFR Part 60, Appendix A, Method 7E. Figure 1 is a diagram of the VOC sampling train.

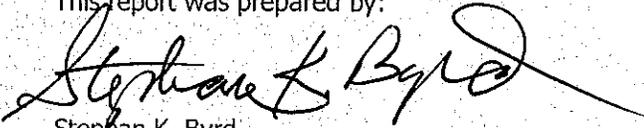
V.4 Methane – The methane sampling was conducted in accordance U.S. EPA Method 18. Integrated bag samples were collected in Tedlar bags during each of the three sixty minute runs.

The samples were overnighted to the laboratory for analysis. The samples were analyzed by gas chromatograph for methane in accordance with the method. All the quality assurance and quality control procedures listed in the methods were incorporated in the sampling and analysis.



V.5 Exhaust Gas Parameters – The exhaust gas parameters (air flow rate, temperature, moisture and density) were determined in conjunction with the other sampling by employing U.S. EPA Methods 1 through 4. A Orsat bag was collected from the exhaust of the moisture train. The bag was analyzed by Orsat for O₂ and CO₂. Three (3) velocity traverses and one (1) moisture sample were collected. All the quality assurance and quality control procedures listed in the methods were incorporated in the sampling and analysis.

This report was prepared by:

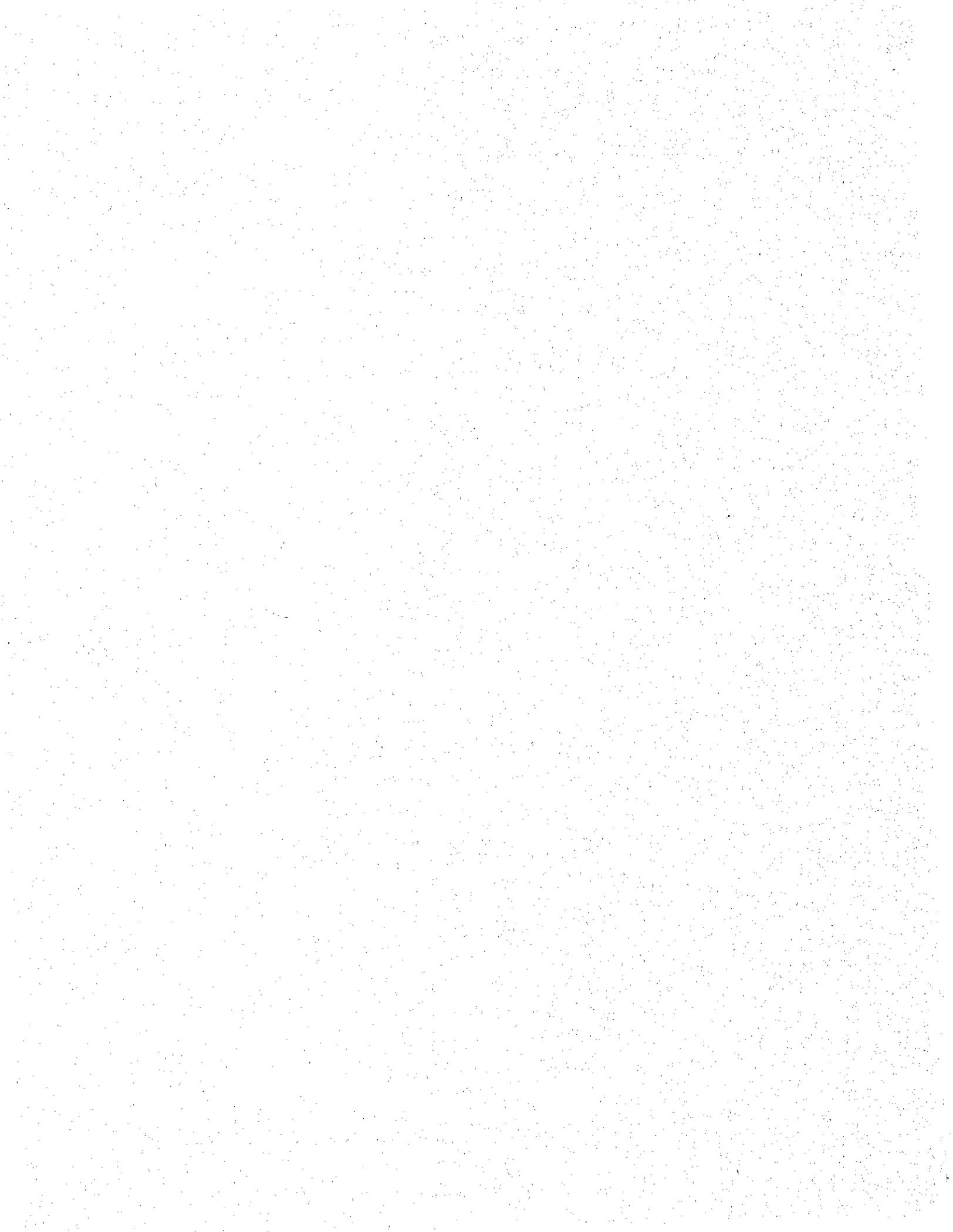


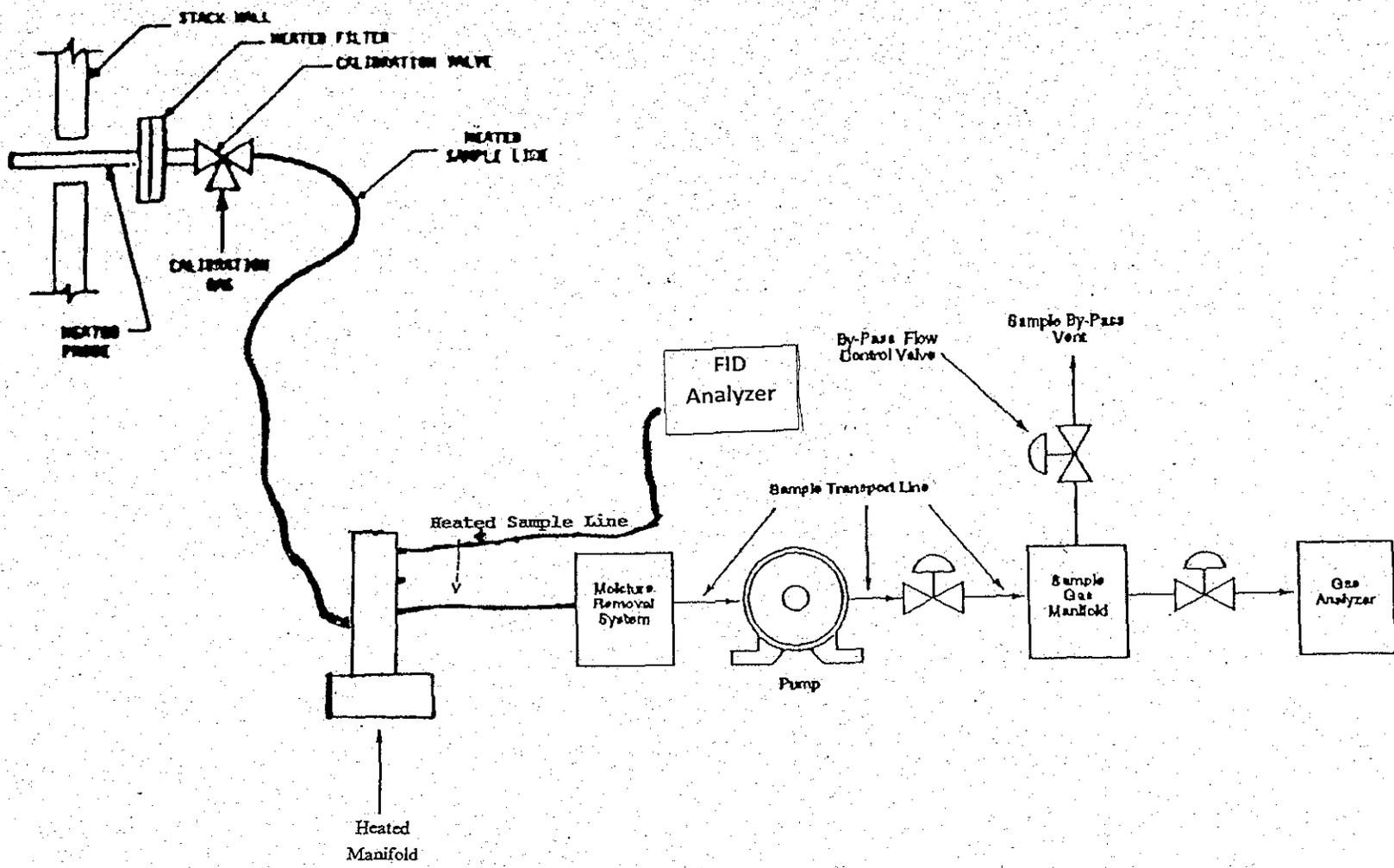
Stephan K. Byrd
President

This report was reviewed by:



David D. Engelhardt
Vice President





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Figure 1
 **NO_x , CO & THC
 Sampling Train**