

Report of...

CO Emission Testing & RAT

Performed for the...

Michigan Sugar Company
Caro, Michigan

On...

Gas Fired Boiler #4

December 11, 2014

022.38

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Network Environmental, Inc.
Grand Rapids, MI

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I. INTRODUCTION

Network Environmental, Inc. was retained by the Michigan Sugar Company to perform compliance emission sampling on their Gas Fired Boiler #4 located in Caro, Michigan.

The purpose of the testing was to conduct a Relative Accuracy Test (RAT) on the new Continuous Emissions Monitoring System (CEMS) that services Boiler #4. The CEMS on the boiler is for oxides of nitrogen (NO_x) and oxygen (O₂). The RAT was conducted in accordance with 40 CFR Part 60 Appendix B Performance Specifications 2 for NO_x and 3 for O₂.

In conjunction with the RAT, carbon monoxide (CO) emission sampling was conducted in order to document compliance with Michigan Department of Environmental Quality (MDEQ), Air Quality Division Permit To Install (PTI) No. 44-14. PTI No. 44-14 has established the following CO emission limit: 0.23 Lbs/MMBTU and 147.6 Tons/Year.

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

- Oxides of Nitrogen (NO_x) – U.S. EPA Method 7E
- Carbon Monoxide (CO) – U.S. EPA Method 10
- Oxygen (O₂) & Carbon Dioxide (CO₂) – U.S. EPA Method 3A
- Exhaust Gas Parameters (Air Flow Rate, Temperature, Moisture & Density) – U.S. EPA Methods 1 through 4

The sampling was performed on December 11, 2014 by Richard D. Eerdmans and David D. Engelhardt of Network Environmental, Inc.. Assisting with the testing were Mr. Steven Smock and Mr. Mark Wedding of the Michigan Sugar Company and Mr. Wesley Kirk of Monitoring Solutions. Ms. Sydney Bruestle, Mr. Jeremy Howe and Ms. Sharon LeBlanc of the Michigan Department of Environmental Quality (MDEQ) – Air Quality Division were present to observe the sampling and source operation.

II. PRESENTATION OF RESULTS

**II,1 TABLE 1
NO_x (LBS/MMBTU) RELATIVE ACCURACY TEST RESULTS
BOILER #4
MICHIGAN SUGAR COMPANY
CARO, MICHIGAN
DECEMBER 11, 2014**

Run #	Time	REFERENCE METHOD			CEM	DIFF
		NO _x (1)	O ₂ (2)	Lbs/MMBTU	Lbs/MMBTU	
1	09:10-09:35	111.9	3.2	0.137	0.130	0.007
2	09:48-10:13	108.6	3.5	0.135	0.129	0.006
3	10:25-10:50	109.1	3.3	0.135	0.130	0.005
4	11:04-11:29	111.6	3.1	0.137	0.130	0.007
5	11:42-12:07	110.8	3.3	0.137	0.131	0.006
6	12:24-12:49	109.3	3.6	0.137	0.131	0.006
7	13:02-13:27	113.1	3.3	0.140	0.132	0.008
8	13:41-14:06	112.7	3.2	0.138	0.132	0.006
9	14:20-14:45	115.8	3.2	0.142	0.135	0.007

Mean Reference Value 0.13756

Absolute Value of the Mean of the Difference 0.00644

Standard Deviation 0.00088

Confidence Co-efficient 0.00068

Relative Accuracy = 5.18% of the mean of the reference method

(1) = Concentration in term of PPM by volume on a dry basis

(2) = Concentration in terms of %

II.2 TABLE 2
NO_x (PPM - DRY) RELATIVE ACCURACY TEST RESULTS
BOILER #4
MICHIGAN SUGAR COMPANY
CARO, MICHIGAN
DECEMBER 11, 2014

Run #	Time	REFERENCE METHOD	CEM	DIFF
		PPM ⁽¹⁾	PPM ⁽¹⁾	
1	09:10-09:35	111.9	108.0	3.9
2	09:48-10:13	108.6	105.3	3.3
3	10:25-10:50	109.1	106.3	2.8
4	11:04-11:29	111.6	108.4	3.2
5	11:42-12:07	110.8	107.6	3.2
6	12:24-12:49	109.3	106.4	2.9
7	13:02-13:27	113.1	109.5	3.6
8	13:41-14:06	112.7	109.8	2.9
9	14:20-14:45	115.8	112.1	3.7

Mean Reference Value = 111.4333

Absolute Value of the Mean of the Differences = 3.2778

Standard Deviation = 0.3866

Confidence Co-efficient = 0.2972

Relative Accuracy = 3.21% of the mean of the reference method

(1) Concentration in terms of PPM by volume on a dry basis

II.3 TABLE 3
O₂ (% - DRY) RELATIVE ACCURACY TEST RESULTS
BOILER #4
MICHIGAN SUGAR COMPANY
CARO, MICHIGAN
DECEMBER 11, 2014

Run #	Time	REFERENCE METHOD	CEM	DIFF
		O ₂ ⁽¹⁾	O ₂ ⁽¹⁾	
1	09:10-09:35	3.2	2.8	0.4
2	09:48-10:13	3.5	3.2	0.3
3	10:25-10:50	3.3	3.1	0.2
4	11:04-11:29	3.1	2.8	0.3
5	11:42-12:07	3.3	3.0	0.3
6	12:24-12:49	3.6	3.2	0.4
7	13:02-13:27	3.3	2.9	0.4
8	13:41-14:06	3.2	2.8	0.4
9	14:20-14:45	3.2	2.8	0.4

Mean Reference Value = 3.3000

Absolute Value of the Mean of the Differences = 0.3444

Standard Deviation = 0.0726

Confidence Co-efficient = 0.0558

Relative Accuracy = 12.13% of the mean of the reference method

(1) Concentration in terms of % by volume on a dry basis

**II.4 TABLE 4
 CARBON MONOXIDE (CO) EMISSION RESULTS
 BOILER #4
 MICHIGAN SUGAR COMPANY
 CARO, MICHIGAN
 DECEMBER 11, 2014**

Sample	Time	Air Flow Rate DSCFM ⁽¹⁾	CO Concentration PPM ⁽²⁾	CO Mass Emission Rates	
				Lbs/Hr ⁽³⁾	Lbs/MMBTU ⁽⁴⁾
1	09:10-10:50	14,552	1.1	0.070	0.00083
2	11:04-12:49	14,856	1.0	0.065	0.00085
3	13:02-14:45	14,864	1.1	0.071	0.00082
Average		14,757	1.1	0.069	0.00080

- (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) Lbs/Hr = Pounds of CO Per Hour
 (4) Lbs/MMBTU = Pounds Of CO Per Million BTU Of Heat Input (Calculated Using Equation 2.1 From U. S. EPA Method 19 With An F-Factor of 8710 DSCF/MMBTU).

III. DISCUSSION OF RESULTS

III.1 NO_x (LBS/MMBTU) RAT – The results of the NO_x Lbs/MMBTU RAT can be found in Table 1 (Section II.1). The relative accuracy calculations were performed in terms of Lbs/MMBTU in accordance with U.S. EPA Reference Method 19. The Lbs/MMBTU results were calculated using the formula found in Section 2.1 of Method 19 for O₂ on a dry basis. The F factor used was 8,710. Nine (9) twenty-five (25) minute samples were collected from the boiler exhaust. Raw DAS output results were corrected per Equation 7E-5.

The relative accuracy for the NO_x CEMS using Lbs/MMBTU was 5.18% of the mean of the reference method samples.

According to Performance Specification 2 in 40 CFR Part 60 Appendix B, "The relative accuracy (RA) of the CEMS shall be no greater than 20 percent of the mean value of the reference method test data in terms of the units of the emission standard or 10 percent of the applicable standard, whichever is greater."

III.2 NO_x (PPM-DRY) RAT – The results of the NO_x PPM RAT can be found in Table 2 (Section II.2). The relative accuracy calculations were performed in terms of PPM (v/v) on a dry basis. Nine (9) twenty-five (25) minute samples were collected from the boiler exhaust. Raw DAS output results were corrected per Equation 7E-5.

The relative accuracy for the NO_x CEMS using PPM was 3.21% of the mean of the reference method samples.

According to Performance Specification 2 in 40 CFR Part 60 Appendix B, "The relative accuracy (RA) of the CEMS shall be no greater than 20 percent of the mean value of the reference method test data in terms of the units of the emission standard or 10 percent of the applicable standard, whichever is greater."

III.3 O₂ (%-DRY) RAT – The results of the O₂ RAT can be found in Table 3 (Section II.3). The relative accuracy calculations were performed in terms of % on a dry basis. Nine (9) twenty-five (25) minute samples were collected from the boiler exhaust. Raw DAS output results were corrected per Equation 7E-5.

The relative accuracy for the O₂ CEMS was 12.13% of the mean of the reference method samples.

According to Performance Specification 3 in 40 CFR Part 60 Appendix B, "The relative accuracy (RA) of the CEMS shall be no greater than 20 percent of the mean value of the reference method test data or the average difference no greater than 1% percent O₂.

III.4 CO Emissions – The CO emissions are summarized in Table 4 (Section II.4) as follows:

- Sample
- Time
- Air Flow Rate (DSCFM) – Dry Standard Cubic Feet Per Minute (Standard Temperature and Pressure = 68 °F and 29.92 Inches Hg)
- CO Concentration (PPM) – Parts Per Million (v/v) On A Dry Basis
- CO Emission Rates –
 - Lbs/Hr – Pounds of CO Per Hour
 - Lbs/MMBTU – Pounds of CO Per Million BTU of Heat Input (Calculated Using Equation 2.1 From U.S. EPA Method 19 With An F-Factor of 8710 DSCF/MMBTU)

The CO sampling was performed in conjunction with the RAT. Each sample consisted of three (3) – twenty five (25) minute sampling runs.

III.5 Calibration Drift Test – The highest percent drift for the NO_x monitor on Boiler #4 was 0.40% for the high level and 0.00% for the low level during the seven day drift test. The highest percent drift for the O₂ monitor on Boiler #4 was 0.40% for the high level and 0.40% for the low level during the seven day drift test. The drift test was conducted by Michigan Sugar staff and can be found in Appendix C.

II.6 Emission Limits – MDEQ Air Quality Division Permit To Install No.44-14 has established the following emission limits for this source:

<u>Compound</u>	<u>Emission Limit(s)</u>
NO _x	0.15 Lbs/MMBTU & 96.3 Tons/Year
CO	0.23 Lbs/MMBTU & 147.6 Tons/Year

99.46 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 boiler. A diagram of the NO_x sampling train is shown in Figure 1.

VI.2 Oxygen — The O₂ sampling was conducted in accordance with U.S. EPA Reference Method 3A. A Servomex Model 1400M portable stack gas analyzer was used to monitor the boiler exhaust. A heated probe was used to extract the sample gas from the stack. A heated Teflon sample line was used to transport the exhaust gases 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 O₂ concentrations (%).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 21.03% was used to establish the initial instrument calibration. Calibration gases of 12.06% and 5.989% 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 5.989% gas to determine the system bias. After each sample, a system zero and system injection of 5.989% 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 boiler. A diagram of the O₂ sampling train is shown in Figure 1.

VI.3 Carbon Dioxide — The CO₂ sampling was conducted in accordance with U.S. EPA Reference Method 3A. A Servomex Model 1400M portable stack gas analyzer was used to monitor the boiler exhaust. A heated probe was used to extract the sample gases from the stack. A heated Teflon sample line was used to transport the exhaust gases 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 CO₂ concentrations (%).

The analyzer was calibrated by direct injection prior to the testing. A span gas of 20.42% was used to establish the initial instrument calibration. Calibration gases of 11.98% and 5.989% 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 11.98% gas to determine the system bias. After each sample, a system zero and system injection of 11.98% 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 boiler. A diagram of the CO₂ sampling train is shown in Figure 1.

VI.4 Carbon Monoxide – The CO sampling was conducted in accordance with U.S. EPA Reference Method 10. A Thermo Environmental Model 48C gas analyzer was used to monitor the boiler exhaust. A heated probe was used to extract the sample gases from the exhaust stack. A heated Teflon sample line was used to transport the exhaust gases 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 92.97 PPM was used to establish the initial instrument calibration. A calibration gas of 49.66 PPM was 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 49.66 PPM gas to determine the system bias. After each sample, a system zero and system injection of 49.66 PPM were performed to establish system drift and system bias during the test period. All calibration gases were EPA Protocol 1 Certified.

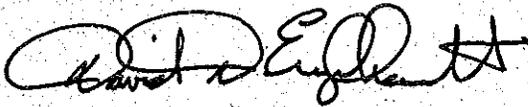
The analyzer was calibrated to the output of the data acquisition system (DAS) used to collect the data from the boiler. A diagram of the CO sampling train is shown in Figure 1.

VI.5 Moisture – The Boiler #4 moisture samples were collected in accordance with U.S. EPA Method 4. Three (3) samples were withdrawn from the stack and passed through a condensing coil with drop out before being passed through pre-weighed silica gel. The water collected was measured to the nearest 1 ml and the silica gel was re-weighed to the nearest 1 g. The moisture collected along with the sample volume was used to determine the percent moisture in the exhaust. Each sample was thirty (30) minutes in duration and had a minimum sample volume of twenty-one (21) standard cubic feet. A diagram of the moisture sampling train is shown in Figure 2.

VI.6 Air Flows – The air flow rates were determined in conjunction with the other sampling by employing U.S. EPA Reference Methods 1 and 2. The sampling for the source was conducted on the 59 Inch I.D. exhaust stack. A total of 12 traverse points (6 per sampling port) were used for the air flow determinations. The sample point dimensions are shown in Appendix F. Velocity pressures were determined using an S-Type pitot tube. Temperatures were measured using a Type K thermocouple. Oxygen and carbon dioxide content was determined in conjunction with the RATA. A diagram of the air flow sampling train is shown in Figure 3.

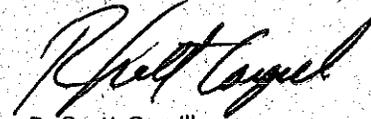
VI.7 Sampling Locations – Prior to the emission testing, preliminary velocity/cyclonic (turbulent) flow measurements/checks were conducted. All the sampling locations and flows passed the requirements of Methods 1 and 2. Also prior to the RATA sampling, a three point stratification test (as described in U.S. EPA Method 7E) was performed for the exhaust stack. The stratification test showed no stratification (< 5%), so a single sampling point was used for the gas sampling. The results of the stratification tests can be found in Appendix B.

This report was prepared by:



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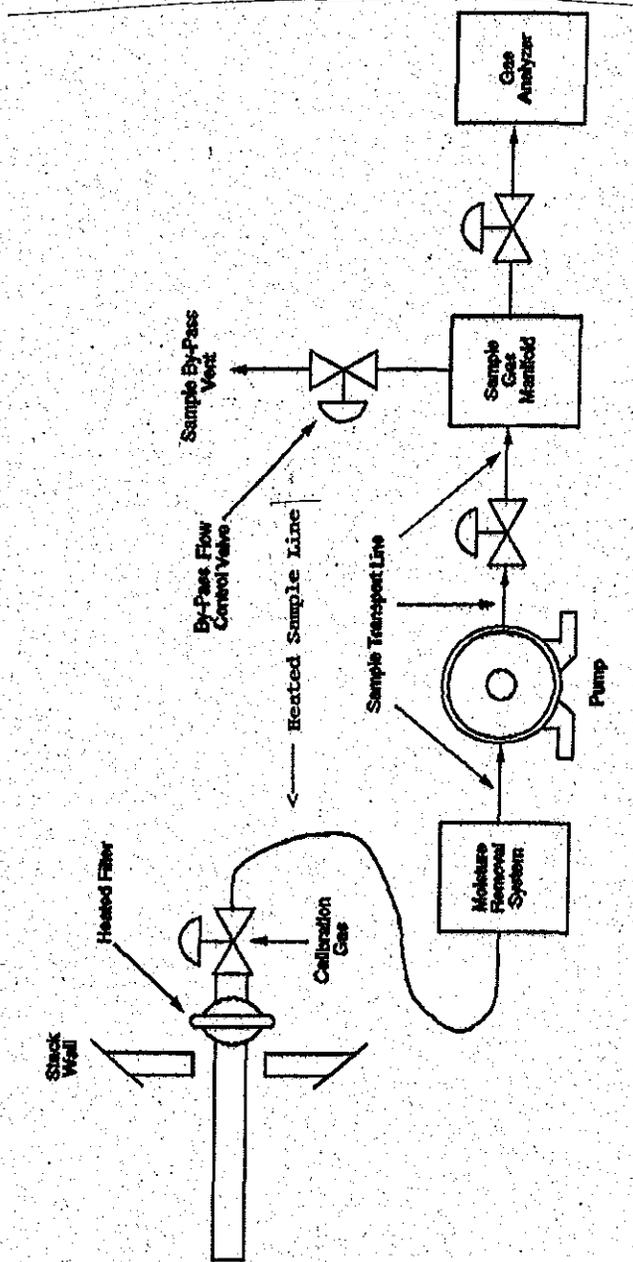


Figure 1
NO_x, CO, O₂ & CO₂
Sampling Train

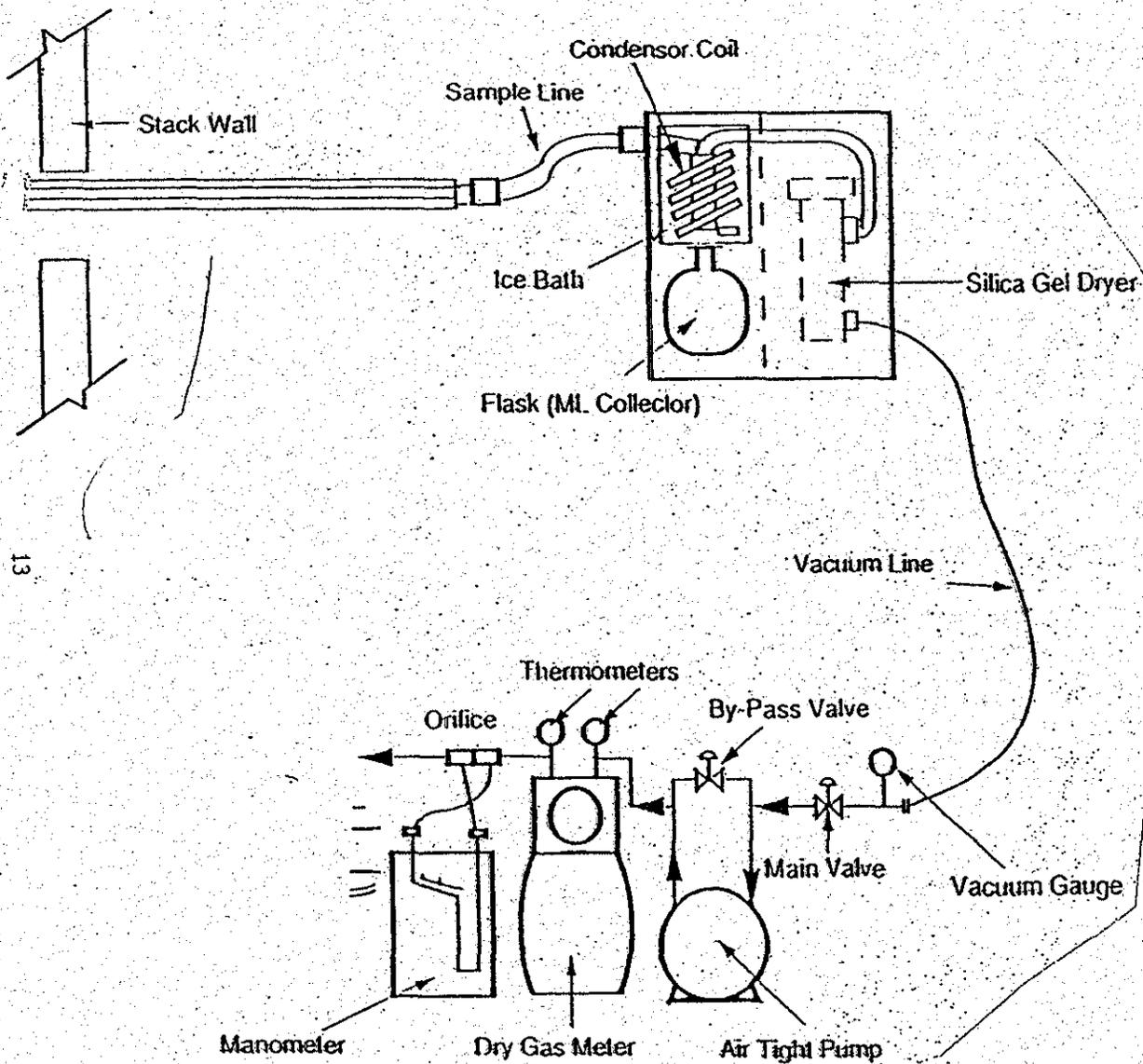


Figure 2

Moisture
Sampling Train

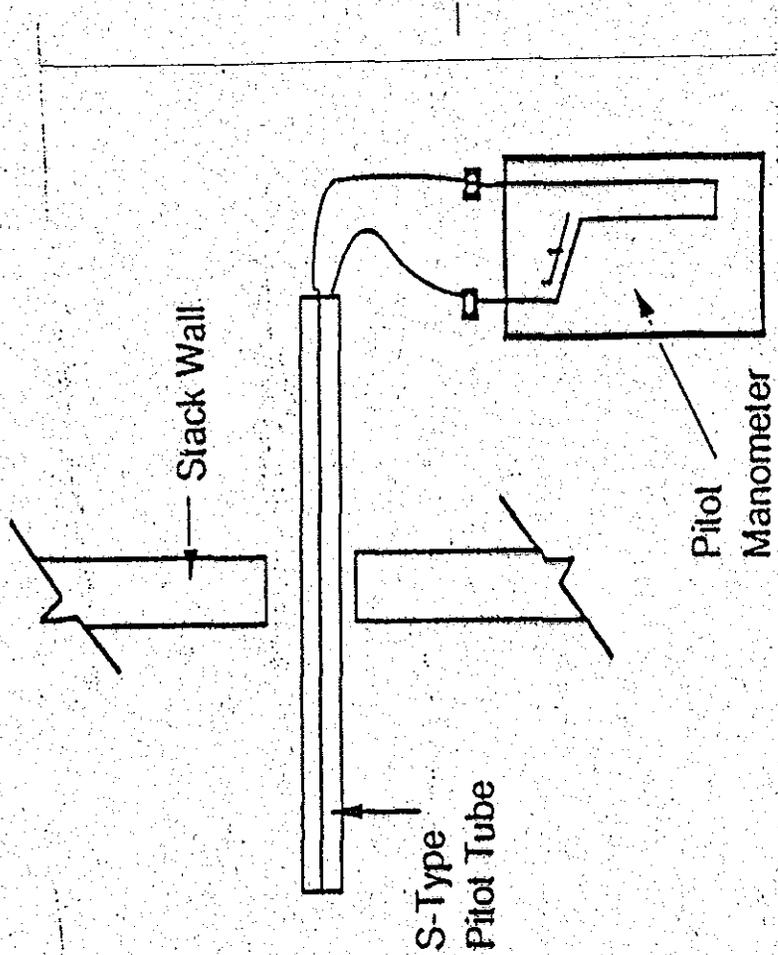


Figure 3

Air Flow
Sampling Train