



Air Products and Chemicals, Inc.  
7201 Hamilton Boulevard  
Allentown, PA 18195

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AIR QUALITY DIV.

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**REPORT ON MEASUREMENT SERVICES**

Performed for:  
**AIR PRODUCTS AND CHEMICALS, INC.**  
**DETROIT HYDROGEN PLANT**

**HYDROGEN PLANT HEATER STACK**

Client Reference No: 4502962362  
CleanAir Project No: 12427-1  
Revision 0: April 25, 2014

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To the best of our knowledge, the data presented in this report are accurate, complete, error free, legible and representative of the actual emissions during the test program. Clean Air Engineering operates in conformance with the requirements of ASTM D7036-04 Standard Practice for Competence of Air Emission Testing Bodies.

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**REVISION HISTORY**

**REPORT ON MEASUREMENT SERVICES**

***DRAFT REPORT REVISION HISTORY***

<b>Revision:</b>	<b>Date</b>	<b>Pages</b>	<b>Comments</b>
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***FINAL REPORT REVISION HISTORY***

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0	04/25/14	All	Final version of original document.

## PROJECT OVERVIEW

1-1

### INTRODUCTION

Air Products and Chemicals, Inc. (Air Products) contracted Clean Air Engineering (CleanAir) to perform emission measurements at the Detroit Hydrogen Plant in Detroit, Michigan.

All testing was conducted in accordance with the regulations set-forth by the United States Environmental Protection Agency (USEPA) and the Michigan Department of Environmental Quality (MDEQ). The permit limits are referenced in Michigan Department of Environmental Quality, Air Quality Division Permit to Install No. 63-08C, issued January 11, 2012.

### Key Project Participants

Individuals responsible for coordinating and conducting the test program were:

Jennifer Creitz – Air Products  
Sondra Klipp – Air Products  
Jorge Acevedo – MDEQ  
Thomas Gasloli – MDEQ  
Andy Obuchowski – CleanAir

### Test Program Parameters

The testing was performed at the Hydrogen (H<sub>2</sub>) Plant Heater Stack on March 18 through 21, 2014, and included the following emissions measurements:

- particulate matter (PM), assumed equivalent to filterable particulate matter (FPM) only
- total particulate matter less than 10 microns (µm) in diameter (Total PM<sub>10</sub>), assumed equivalent to the sum of the following constituents:
  - filterable particulate matter (FPM)
  - condensable particulate matter (CPM)
- sulfuric acid (H<sub>2</sub>SO<sub>4</sub>)
- volatile organic compounds (VOCs), assumed equivalent to total hydrocarbons (THC) minus the following constituents:
  - methane (CH<sub>4</sub>)
  - ethane (C<sub>2</sub>H<sub>6</sub>)
- nitrogen oxides (NO<sub>x</sub>)
- carbon monoxide (CO)
- flue gas composition (e.g., O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O)
- flue gas flow rate

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**PROJECT OVERVIEW**

1-2

**TEST PROGRAM SYNOPSIS****Test Schedule**

The on-site schedule followed during the test program is outlined in Table 1-1.

**Table 1-1:  
Schedule of Activities**

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	H2 Plant Heater Stack	USEPA Method 5/202	FPM/CPM	03/18/14	14:40	16:57
2	H2 Plant Heater Stack	USEPA Method 5/202	FPM/CPM	03/19/14	06:47	09:14
3	H2 Plant Heater Stack	USEPA Method 5/202	FPM/CPM	03/19/14	10:11	12:30
1	H2 Plant Heater Stack	USEPA Method 18/25A	VOC	03/19/14	08:43	09:43
2	H2 Plant Heater Stack	USEPA Method 18/25A	VOC	03/19/14	10:11	11:11
3	H2 Plant Heater Stack	USEPA Method 18/25A	VOC	03/19/14	11:31	12:31
0	H2 Plant Heater Stack	Draft ASTM CCM	Sulfuric Acid	03/19/14	15:01	16:02
1	H2 Plant Heater Stack	Draft ASTM CCM	Sulfuric Acid	03/20/14	08:30	09:30
2	H2 Plant Heater Stack	Draft ASTM CCM	Sulfuric Acid	03/20/14	11:16	12:16
3	H2 Plant Heater Stack	Draft ASTM CCM	Sulfuric Acid	03/20/14	13:20	14:20
1	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/20/14	13:41	14:02
2	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/20/14	15:03	15:26
3	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/20/14	16:26	16:48
4	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/20/14	17:06	17:27
5	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/20/14	17:47	18:08
6	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/21/14	06:53	07:17
7	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/21/14	07:33	07:54
8	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/21/14	08:10	08:31
9	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/21/14	08:54	09:16
10	H2 Plant Heater Stack	USEPA Method 3A/7E/10	O <sub>2</sub> /NO <sub>x</sub> /CO	03/21/14	09:34	09:55
1	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/20/14	08:42	09:01
2	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/20/14	11:29	11:57
3	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/20/14	13:41	13:55
4	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/20/14	15:10	15:25
5	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/20/14	16:30	16:46
6	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/20/14	17:06	17:27
7	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/20/14	17:48	18:02
8	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/21/14	06:51	07:06
9	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/21/14	07:35	07:50
10	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/21/14	08:10	08:26
11	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/21/14	08:54	09:12
12	H2 Plant Heater Stack	USEPA Method 2	Velocity & Flow Rate	03/21/14	09:32	09:50
1	H2 Plant Heater Stack	USEPA Method 4	H <sub>2</sub> O	03/20/14	15:03	16:03
2	H2 Plant Heater Stack	USEPA Method 4	H <sub>2</sub> O	03/20/14	16:26	18:02
3	H2 Plant Heater Stack	USEPA Method 4	H <sub>2</sub> O	03/21/14	06:51	08:26
4	H2 Plant Heater Stack	USEPA Method 4	H <sub>2</sub> O	03/21/14	08:54	09:54

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**PROJECT OVERVIEW**

1-3

**Results Summary**

Table 1-2 and Table 1-3 summarize the results of the test program. A more detailed presentation of the test conditions and results of analysis are shown on pages 2-1 through 2-15.

**Table 1-2:  
Summary of Emission Compliance Test Results**

<u>Source</u>	<u>Constituent (Units)</u>	<u>Sampling Method</u>	<u>Average Emission</u>	<u>Permit Limit<sup>1</sup></u>
<u>H<sub>2</sub> Plant Heater Stack</u>				
PM	(lb/MMBtu)	USEPA M-5	0.0008	0.0034
PM	(Ton/yr)	USEPA M-5	1.76	6.86
PM <sub>10</sub>	(lb/MMBtu)	USEPA M-5 / 202	0.0017	0.010
H <sub>2</sub> SO <sub>4</sub>	(ppmdv)	Draft ASTM CCM	0.23	N/A
H <sub>2</sub> SO <sub>4</sub>	(lb/MMBtu)	Draft ASTM CCM	0.0007	N/A
VOC	(lb/MMBtu)	USEPA M-25A / 18	0.0009	0.0055
NO <sub>x</sub>	(lb/MMBtu)	USEPA M-7E	0.0080	0.013
NO <sub>x</sub>	(ppmdv @ 0% O <sub>2</sub> )	USEPA M-7E	6.8	60
CO	(Ton/yr)	USEPA M-10	< 0.66	13

<sup>1</sup> Permit limits obtained from MDEQ Permit To Install No. 63-08C.

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**PROJECT OVERVIEW**

1-4

**Table 1-3:  
Summary of RATA Results**

Source	Reference Method (USEPA)	Relative Accuracy <sup>1</sup>	Units	Applicable Specification	Specification Limit <sup>2</sup>
Constituent (Units)					
<u>H<sub>2</sub> Plant Heater Stack</u>					
Flow rate (scfm)	M-2	8.8	% of RM	PS6	20% of RM
Flow rate (dscfm)	M-2	10.1	% of RM	PS6	20% of RM
O <sub>2</sub> (% dv)	M-3A	0.0	%dv	PS3	±1.0% dv
H <sub>2</sub> O (% vv)	M-4	9.7	% of RM	N/A	N/A
NOx (ppmdv)	M-7E	3.9	% of RM	PS2	20% of RM
NOx (lb/MMBtu)	M-7E	4.8	% of Std.	PS2	10% of Std. <sup>3</sup>
CO (ppmdv)	M-10	0.7	ppmdv	PS4A <sup>4</sup>	±5 ppmdv
CO (lb/hr)	M-10	0.4	% of Std.	PS4A <sup>4</sup>	5% of Standard <sup>5</sup>

<sup>1</sup> Relative Accuracy is expressed in terms of comparison to the reference method (% RM) or applicable emission standard (% Std.), equivalent to the permit limit in Table 1-2. The specific expression used depends on the specification limit.

<sup>2</sup> Specification limits obtained from 40 CFR 60, Appendix B, Performance Specifications, unless otherwise noted.

<sup>3</sup> NOX Standard = 0.013 lb/MMBtu

<sup>4</sup> For any sources emitting less than 200 ppmv of CO, PS4A applies. The PS4A RA limit is either < 10% of RM, < 5% of Standard, or ± 5 ppmv (abs. average difference plus 2.5 x confidence coefficient).

<sup>5</sup> CO Standard = 13 Ton/yr = 56.9lb/hr (assuming 8,760 operating hours/year)

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**Discussion of Test Program****FPM and CPM Testing - USEPA Method 5/202**

For this test program, PM emission rate is assumed equivalent to FPM emission rate and PM<sub>10</sub> emission rate is assumed equivalent to the sum of FPM and CPM emission rates (units of lb/hr, Ton/yr, or lb/MMBtu for all constituents).

The analytical procedures in EPA Method 202 include an ammonium titration of the inorganic sample fractions with pH less than 7.0 to neutralize acids with hygroscopic properties such as H<sub>2</sub>SO<sub>4</sub> that may be present in the sample. This step speeds up the sample desiccation process and allows the samples to come to a constant weight prior to weighing. The weight of ammonium added to the sample as a result of the titration is subtracted from the analytical result.

**PROJECT OVERVIEW**

1-5

The laboratory performing the gravimetric analysis (Clean Air Analytical Services) has determined that only samples with an initial pH less than 4.5 require a significant amount of ammonium neutralization, resulting in a correction in excess of 0.5 mg. Based on this observation, the laboratory has altered their procedures to read that a sample must have a pH lower than 4.5 in order to be titrated.

Since none of the inorganic sample fractions collected during this test program had a pH less than 4.5, they were not titrated per Clean Air Analytical Services' modified procedure. The sample fraction was observed to come to a constant weight without having to titrate the sample.

Three (3) 120-minute Method 5/202 test runs were performed. Run 1 was performed on March 18; Runs 2 and 3 were performed on March 19.

Upon analysis, the laboratory discovered that the back half inorganic rinse from Run 1 contained a foreign object believed to be a piece of glass. It is believed that the source of this object is a portion of glass impinger which broke during recovery of the sample train. The glass fragment is not representative of the actual stack gas emissions as the front half filter would not allow for objects of this size to pass through to the sample train.

The laboratory first attained a weight with the foreign object inside the sample. The object was then rinsed and removed then reanalyzed. While both analytical results are presented in the laboratory report, the reanalyzed Run 1 result with the glass piece removed was used to calculate the total PM<sub>10</sub> results.

The final results for each parameter were expressed as the average of three (3) valid runs and were below the permit limits for both PM and PM<sub>10</sub>.

*H<sub>2</sub>SO<sub>4</sub> Testing - Draft ASTM Controlled Condensation Method*

Prior to the first official test run, a 60-minute sample conditioning run was performed on March 19 in order to minimize the absorption capacity of the front-half components of the sample train (upstream of the H<sub>2</sub>SO<sub>4</sub>-collection portion of the sample train). The conditioning run was recovered in the same manner as the official test runs, but was not analyzed.

Three (3) 60-minute test runs were performed. Run 1 was performed on March 19; Runs 2 and 3 were performed on March 20. The final result was expressed as the average of three (3) valid runs.

**PROJECT OVERVIEW**

1-6

**VOC Testing - USEPA Method 25A and Method 18**

Three (3) 60-minute Method 25 test runs for THC were performed concurrently with three (3) 60-minute Method 18 bag collections for CH<sub>4</sub> and C<sub>2</sub>H<sub>6</sub> on March 19. The final results for each parameter were expressed as the average of three (3) valid runs.

VOC emission rate is normally equivalent to THC emission rate, minus CH<sub>4</sub> and C<sub>2</sub>H<sub>6</sub> emission rate (units of lb/hr, Ton/yr, or lb/MMBtu for all constituents). For CH<sub>4</sub> and C<sub>2</sub>H<sub>6</sub>, a non-detectable result was obtained for all runs, so no correction was made to the THC results.

Therefore, VOC emissions are equivalent to THC emissions. The final result for each parameter was expressed as the average of three (3) valid runs and was below the permit limit.

**Flow Rate, O<sub>2</sub>, NO<sub>x</sub>, and CO RATA Testing - USEPA Methods 2, 3A, 7E, and 10; Performance Specifications 2, 3, 4/4A, and 6**

Minute-average data points for O<sub>2</sub>, CO<sub>2</sub>, NO<sub>x</sub> and CO (dry basis) were collected over a period of 21 minutes for each Relative Accuracy Test Audit (RATA) Reference Method (RM) run. All RATA runs were 21 minutes in duration with Runs 2, 3, 6 and 9 having brief pauses in data acquisition. The average result for each RM run was calculated and compared to the average result from the facility continuous emissions monitoring system (CEMs) over identical time intervals in order to calculate relative accuracy (RA).

- For O<sub>2</sub>, RA is expressed as the average absolute difference between the RM and facility CEMs runs. The final result was below the limit of  $\pm 1.0\%$ dv set by PS3.
- For NO<sub>x</sub> concentration, RA is expressed as the percent difference between RM and facility CEMs runs. The final result was below the limit of 20% of the RM set by PS2.
- For NO<sub>x</sub> diluent, RA is expressed as the percent difference between RM and the applicable emission standard (permit limit) listed in Table 1-3. The final result was below the limit of 10% of the standard set by PS2.
- For CO concentration, the RA limit is expressed as the average absolute difference between the RM and facility CEMs runs, plus 2.5 times the confidence coefficient. The final result was below the limit of  $\pm 5$  ppm<sub>dv</sub> set by PS4A, which is applicable to sources that emit less than 200 ppm<sub>v</sub> of CO.
- For CO diluent, RA is expressed as the percent difference between RM and the applicable emission standard (permit limit) listed in Table 1-3. The final result was below the limit of 5% of the standard set by PS4A.
- CO<sub>2</sub> data was collected only as supplemental information.

**PROJECT OVERVIEW**

1-7

Facility flow rate CEMs were evaluated using Method 2 as the reference method. A complete flow and temperature traverse was performed during each 21-minute RATA run, converted to units of standard cubic feet per hour (scfh) and dry standard cubic feet per hour (dscfh), and then compared to facility CEMs results over the corresponding 21-minute intervals.

For flow rate, RA is expressed as the percent difference between RM and facility CEMs data. The final results were below the limit of 20% of the RM set by PS6.

RATA testing for O<sub>2</sub> (wet basis) did not take place as outlined in the test plan. CleanAir experienced issues with the communication between the wet O<sub>2</sub> analyzer and data acquisition system. The equipment problems resulted in no data being recorded on an O<sub>2</sub> (wet basis).

CleanAir notified Air Products of the inability to collect O<sub>2</sub> (wet basis) data prior to RATA testing. It was determined by Jennifer Creitz from Air Products, Thomas Gasloli from MDEQ and CleanAir that reference method O<sub>2</sub> (wet basis) testing was not necessary. Air Products used the facility O<sub>2</sub> (wet basis) values along with the O<sub>2</sub> (dry basis) values to determine moisture levels while CleanAir performed independent test runs in order to determine moisture levels.

Moisture data was used to convert flow rate from dry basis to wet basis. The original test plan was to perform moisture testing utilizing a Modified Method 4 sample train which used midjet impingers. While on-site, CleanAir noted that utilizing this approach could yield inaccurate moisture results. Using midjet impingers and a supporting metering system would not allow for significant sample volumes to be collected. As a result, the water volume collected would be low resulting in a larger margin of error when making volumetric and gravimetric measurements.

CleanAir proposed the following Modified Method 4 sampling technique which was accepted on-site by Jennifer Creitz from Air Products and approved on-site by Thomas Gasloli from MDEQ.

- Sample gas was extracted using an unheated stainless steel tube set at a single point at least one (1) meter from the stack wall. Moisture stratification is not expected at test locations without free water droplets present in the flue gas.
- After passing through the tube, the sample gas was drawn through gum rubber tubing and into four (4) iced knock-out jars. The knock-out jars were arranged in a series and contained identical contents as the impinger train prescribed by Method 4, but with gum rubber connections and stainless-steel internal components.
- Sample gas was extracted at a constant rate. At least 21 scf of flue gas was sampled.

**PROJECT OVERVIEW**

1-8

Moisture results for each RATA run were obtained from concurrently operated Draft ASTM CCM or modified Method 4 sample trains:

- For RATA Run 1, H<sub>2</sub>O data was obtained from Draft ASTM CCM Run 3.
- For RATA Run 2, H<sub>2</sub>O data was obtained from modified Method 4 Run 1.
- For RATA Runs 3, 4, and 5, H<sub>2</sub>O data was obtained from modified Method 4 Run 2.
- For RATA Runs 6, 7, and 8, H<sub>2</sub>O data was obtained from modified Method 4 Run 3.
- For RATA Runs 9 and 10, H<sub>2</sub>O data was obtained from modified Method 4 Run 4.

NO<sub>x</sub> and CO results from the RATA were converted from units of dry volume-based concentration (ppmdv) to mass-based emission rate units (lb/hr, Ton/yr, and lb/MMBtu) to demonstrate compliance with permit limits. The final results for each parameter were expressed as the average of all ten (10) RATA runs. The final results were below the permit limits.

*Calculation of Final Results*

Emission results in units of dry volume-based concentration (lb/dscf, ppmdv) were converted to units of pounds per million Btu (lb/MMBtu) by first calculating mass-based emissions in units of pounds per hour (lb/hr), and then applying the total heat input to the unit over each test interval (MMBtu/hr). Heat input data was provided by Air Products. Flow rates used in calculating lb/hr emissions were obtained in the following manner:

- For Method 5/202, flow rate measurements are incorporated into the sampling procedures.
- For Method 18/25A, flow rate measurements from the most nearly concurrent Method 5/202 test run were used.
- For Method 7E/10 and Draft ASTM CCM, a flow rate measurement, per Method 2 specifications, was performed concurrently with each test run.

## PROJECT OVERVIEW

1-9

### *General Considerations*

All run times listed throughout this report correspond to the plant time utilized by Air Products. Plant time is the time of the Air Products CEMs and data acquisition systems. The plant time is 114 minutes earlier than actual Eastern Time.

Testing on March 20, 2014, occurred with the unit operating at a slightly variable load condition, as opposed to the other test days. This was because of an inability for Air Products to supply a steady rate of hydrogen to the Marathon Petroleum Company (MPC) Detroit Refinery due to process issues within the refinery. It is believed that this is why the RATA flow data improves from Runs 1 through 5 performed on March 20 versus Runs 6 through 10 performed on March 21.

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*End of Section 1 – Project Overview*

**RESULTS**

2-1

**Table 2-1:  
FPM, CPM and Total PM<sub>10</sub> Emissions (USEPA M-5/202)**

Run No.		1	2	3	Average
Date (2014)		Mar 18	Mar 19	Mar 19	
Start Time (approx.)		14:40	06:47	10:11	
Stop Time (approx.)		16:57	09:14	12:30	
<b>Process Conditions</b>					
P <sub>1</sub>	Hydrogen production (Mscf/day)	52.5	52.5	52.5	52.5
P <sub>2</sub>	Aqueous NH <sub>3</sub> feed to SCR (lb/hr)	26.5	26.2	26.1	26.3
P <sub>3</sub>	SCR Inlet temperature (°F)	609.5	611.1	612.4	611.0
H <sub>i</sub>	Actual heat input (MMBtu/hr)	532.3	526.3	527.6	528.7
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	8,760
<b>Gas Conditions</b>					
O <sub>2</sub>	Oxygen (dry volume %)	3.9	3.5	3.5	3.6
CO <sub>2</sub>	Carbon dioxide (dry volume %)	17.7	18.0	18.0	17.9
T <sub>s</sub>	Sample temperature (°F)	314	311	313	313
B <sub>w</sub>	Actual water vapor in gas (% by volume)	15.5	14.8	15.9	15.4
<b>Gas Flow Rate</b>					
Q <sub>a</sub>	Volumetric flow rate, actual (acfm)	189,000	183,000	185,000	186,000
Q <sub>s</sub>	Volumetric flow rate, standard (scfm)	126,000	121,000	123,000	124,000
Q <sub>std</sub>	Volumetric flow rate, dry standard (dscfm)	107,000	103,000	103,000	104,000
<b>Sampling Data</b>					
V <sub>mstd</sub>	Volume metered, standard (dscf)	64.22	61.75	61.55	62.51
%I	Isokinetic sampling (%)	99.2	98.3	98.1	98.5
<b>Laboratory Data</b>					
m <sub>n</sub>	Total FPM (g)	0.00179	0.00208	0.00158	
m <sub>CPM</sub>	Total CPM (g)	0.00240	0.00254	0.00190	
m <sub>part</sub>	Total particulate (expressed as PM-10) (g)	0.00419	0.00462	0.00348	
n <sub>MDL</sub>	Number of non-detectable fractions	1 out of 2	N/A	N/A	
DLC	Detection level classification	DLL	ADL	ADL	
<b>FPM Results</b>					
C <sub>sd</sub>	Particulate Concentration (lb/dscf)	6.15E-08	7.43E-08	5.66E-08	6.41E-08
E <sub>lb/hr</sub>	Particulate Rate (lb/hr)	0.393	0.461	0.351	0.402
E <sub>T/yr</sub>	Particulate Rate (Ton/yr)	1.72	2.02	1.54	1.76
E <sub>Hi</sub>	Particulate Rate - Heat Input-based (lb/MMBtu)	0.0007	0.0009	0.0007	0.0008
<b>CPM Results</b>					
C <sub>sd</sub>	Particulate Concentration (lb/dscf)	8.23E-08	9.07E-08	6.80E-08	8.03E-08
E <sub>lb/hr</sub>	Particulate Rate (lb/hr)	0.527	0.563	0.422	0.504
E <sub>T/yr</sub>	Particulate Rate (Ton/yr)	2.31	2.47	1.85	2.21
E <sub>Hi</sub>	Particulate Rate - Heat Input-based (lb/MMBtu)	0.0010	0.0011	0.0008	0.0010
<b>Total Particulate (as PM10) Results</b>					
C <sub>sd</sub>	Particulate Concentration (lb/dscf)	1.44E-07	1.65E-07	1.25E-07	1.44E-07
E <sub>lb/hr</sub>	Particulate Rate (lb/hr)	0.920	1.024	0.773	0.906
E <sub>T/yr</sub>	Particulate Rate (Ton/yr)	4.03	4.48	3.39	3.97
E <sub>Hi</sub>	Particulate Rate - Heat Input-based (lb/MMBtu)	0.0017	0.0019	0.0015	0.0017

Average includes 3 runs.

Detection level classifications are defined as follows:

ADL = Above Detection Level - all fractions are above detection limit

DLL = Detection Level Limited - some fractions are below detection limit

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**RESULTS**

2-2

**Table 2-2:  
Uncertainty Analysis – FPM, CPM and Total PM<sub>10</sub> (USEPA M-5/202)**

	FPM Results (lb/MMBtu)		CPM Results (lb/MMBtu)		Total PM (as PM <sub>10</sub> ) Results (lb/MMBtu)	
Method	5/202		5/202		5/202	
Run No.	1	0.0007	1	0.0010	1	0.0017
	2	0.0009	2	0.0011	2	0.0019
	3	0.0007	3	0.0008	3	0.0015
SD	0.0001		0.0001		0.0002	
AVG	0.0008		0.0010		0.0017	
RSD	14.1%		14.6%		14.0%	
N	3		3		3	
SE	0.0001		0.0001		0.0001	
RSE	8.1%		8.4%		8.1%	
P	95.0%		95.0%		95.0%	
TINV	4.303		4.303		4.303	
CI +	0.0010		0.0013		0.0023	
AVG	0.0008		0.0010		0.0017	
CI -	0.0005		0.0006		0.0011	
TB +	0.0016		0.0020		0.0036	

AVG (average) is the mean value of the runs; N is the number of individual runs.

SD (standard deviation) and RSD (relative standard deviation) are measures of the variability of individual runs.

SE (standard error) and RSE (relative standard error) are measures of the variability of the average of the runs.

P (probability) is the confidence level associated with the two-tailed Student's t-distribution.

TINV (t-value) is the value of the Student's t-distribution as a function of P (probability) and N-1 (degrees of freedom).

CI (confidence interval) indicates that if the test is conducted again under the same conditions, the average would be expected to fall within the interval (CI- to CI+) about 95% of the time.

TB+ (upper tolerance bound) is the value below which 95% of future runs are expected to fall (assuming testing at the same conditions).

**RESULTS**

2-3

**Table 2-3:  
H<sub>2</sub>SO<sub>4</sub> Emissions (Draft ASTM CCM)**

Run No.		1	2	3	Average
Date (2014)		Mar 20	Mar 20	Mar 20	
Start Time (approx.)		08:30	11:16	13:20	
Stop Time (approx.)		09:30	12:16	14:20	
<b>Process Conditions</b>					
P <sub>1</sub>	Hydrogen production (Mscf/day)	39.3	39.2	40.6	39.7
P <sub>2</sub>	Aqueous NH <sub>3</sub> feed to SCR (lb/hr)	15.3	15.0	16.2	15.5
P <sub>3</sub>	SCR Inlet temperature (°F)	560.8	558.8	564.7	561.4
H <sub>i</sub>	Actual heat input (MMBtu/hr)	407.3	391.1	420.3	406.2
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	8,760
<b>Gas Conditions</b>					
O <sub>2</sub>	Oxygen (dry volume %)	3.7	3.6	3.7	3.7
CO <sub>2</sub>	Carbon dioxide (dry volume %)	17.9	17.9	17.8	17.8
T <sub>s</sub>	Sample temperature (°F)	314	317	322	319
B <sub>w</sub>	Actual water vapor in gas (% by volume)	15.5	16.5	15.0	15.6
<b>Gas Flow Rate</b>					
Q <sub>std</sub>	Volumetric flow rate, dry standard (dscfm) <sup>1</sup>	95,151	76,189	80,911	84,084
<b>Sampling Data</b>					
V <sub>mstd</sub>	Volume metered, standard (dscf)	25.10	25.42	25.03	25.18
<b>Laboratory Data (Ion Chromatography)</b>					
m <sub>n</sub>	Total H <sub>2</sub> SO <sub>4</sub> collected (mg)	0.0573	1.5649	0.3953	
<b>Sulfuric Acid Vapor (H<sub>2</sub>SO<sub>4</sub>) Results</b>					
C <sub>sd</sub>	H <sub>2</sub> SO <sub>4</sub> Concentration (lb/dscf)	5.04E-09	1.36E-07	3.48E-08	5.85E-08
C <sub>sd</sub>	H <sub>2</sub> SO <sub>4</sub> Concentration (ppmdv)	0.0198	0.534	0.137	0.230
E <sub>lb/hr</sub>	H <sub>2</sub> SO <sub>4</sub> Rate (lb/hr)	0.0288	0.621	0.169	0.273
E <sub>T/yr</sub>	H <sub>2</sub> SO <sub>4</sub> Rate (Ton/yr)	0.126	2.72	0.740	1.19
E <sub>Hi</sub>	H <sub>2</sub> SO <sub>4</sub> Rate - Heat Input-based (lb/MMBtu)	0.0001	0.0016	0.0004	0.0007

Average includes 3 runs.

<sup>1</sup> Flow rate from concurrently operated Method 2 test run.

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**RESULTS**

2-4

**Table 2-4:  
Uncertainty Analysis – H<sub>2</sub>SO<sub>4</sub> (Draft ASTM CCM)**

Method Run No.	H2SO4 Results (ppmdv)		H2SO4 Results (lb/MMBtu)	
		CCM		CCM
	1	0.0198	1	7.06E-05
	2	0.5336	2	1.59E-03
	3	0.1369	3	4.02E-04
<b>SD</b>		0.2693		7.97E-04
<b>AVG</b>		<b>0.2301</b>		<b>6.87E-04</b>
<b>RSD</b>		117.0%		116.1%
<b>N</b>		3		3
<b>SE</b>		0.1555		4.60E-04
<b>RSE</b>		67.6%		67.0%
<b>P</b>		95.0%		95.0%
<b>TINV</b>		4.303		4.303
<b>CI +</b>		0.8990		2.67E-03
<b>AVG</b>		<b>0.2301</b>		<b>6.87E-04</b>
<b>CI -</b>		-0.4389		-1.29E-03
<b>TB +</b>		2.292		6.79E-03

AVG (average) is the mean value of the runs; N is the number of individual runs.

SD (standard deviation) and RSD (relative standard deviation) are measures of the variability of individual runs.

SE (standard error) and RSE (relative standard error) are measures of the variability of the average of the runs.

P (probability) is the confidence level associated with the two-tailed Student's t-distribution.

TINV (t-value) is the value of the Student's t-distribution as a function of P (probability) and N-1 (degrees of freedom).

CI (confidence interval) indicates that if the test is conducted again under the same conditions, the average would be expected to fall within the interval (CI- to CI+) about 95% of the time.

TB+ (upper tolerance bound) is the value below which 95% of future runs are expected to fall (assuming testing at the same conditions).

**RESULTS****Table 2-5:  
THC, CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, and VOC Emissions (USEPA M-25A/18)**

Run No.		1	2	3	Average
Date (2014)		Mar 19	Mar 19	Mar 19	
Start Time (approx.)		08:43	10:11	11:31	
Stop Time (approx.)		09:43	11:11	12:31	
<b>Process Conditions</b>					
P <sub>1</sub>	Hydrogen production (MMscf/day)	52.5	52.5	52.5	52.5
P <sub>2</sub>	Aqueous NH <sub>3</sub> feed to SCR (lb/hr)	26.2	26.1	26.0	26.1
P <sub>3</sub>	SCR Inlet temperature	612.0	611.2	613.3	612.2
H <sub>i</sub>	Actual heat input (MMBtu/hr)	527.4	526.5	528.1	527.3
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	8,760
<b>Gas Conditions</b>					
O <sub>2</sub>	Oxygen (dry volume %)	3.16	3.18	3.21	3.18
CO <sub>2</sub>	Carbon dioxide (dry volume %)	18.2	18.2	18.2	18.2
B <sub>w</sub>	Actual water vapor in gas (% by volume) <sup>1</sup>	14.8	15.8	15.8	15.5
<b>Gas Flow Rate<sup>2</sup></b>					
Q <sub>std</sub>	Volumetric flow rate, dry standard (dscfm)	103,000	104,000	104,000	104,000
<b>THC Results</b>					
C <sub>sd</sub>	Concentration (ppmdv as C <sub>3</sub> H <sub>8</sub> )	0.79	0.57	0.53	0.63
C <sub>sd</sub>	Concentration (lb/dscf)	9.0E-08	6.5E-08	6.1E-08	7.2E-08
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	0.56	0.41	0.38	0.45
E <sub>T/yr</sub>	Emission Rate (Ton/yr)	2.5	1.8	1.7	2.0
E <sub>Hi</sub>	Emission Rate - Heat input-based (lb/MMBtu)	0.0011	0.0008	0.0007	0.0009
<b>Methane Results</b>					
C <sub>sd</sub>	Concentration (ppmdv)	<0.13	<0.13	<0.13	<0.13
C <sub>sd</sub>	Concentration (lb/dscf)	<5.2E-09	<5.2E-09	<5.2E-09	<5.2E-09
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	< 0.03	< 0.03	< 0.03	< 0.03
E <sub>T/yr</sub>	Emission Rate (Ton/yr)	< 0.14	< 0.14	< 0.14	< 0.14
E <sub>Hi</sub>	Emission Rate - Heat input-based (lb/MMBtu)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
<b>Ethane Results</b>					
C <sub>sd</sub>	Concentration (ppmdv)	<0.10	<0.10	<0.10	<0.10
C <sub>sd</sub>	Concentration (lb/dscf)	<8.0E-09	<8.0E-09	<8.0E-09	<8.0E-09
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	< 0.05	< 0.05	< 0.05	< 0.05
E <sub>T/yr</sub>	Emission Rate (Ton/yr)	< 0.22	< 0.22	< 0.22	< 0.22
E <sub>Hi</sub>	Emission Rate - Heat input-based (lb/MMBtu)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
<b>VOC Results</b>					
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	0.56	0.41	0.38	0.45
E <sub>T/yr</sub>	Emission Rate (Ton/yr)	2.5	1.8	1.7	2.0
E <sub>Hi</sub>	Emission Rate - Heat input-based (lb/MMBtu)	0.0011	0.0008	0.0007	0.0009

Average includes 3 runs.

080410 164528

<sup>1</sup> Moisture data used for ppmwv to ppmv correction obtained from nearly-concurrent M-5/202 runs.<sup>2</sup> Flow data used in lb/hr calculations was obtained from nearly-concurrent M-5/202 runs.

For methane and ethane, '&lt;' indicates a measured response below the analytical detection limit determined by the laboratory.

**RESULTS**

2-6

**Table 2-6:  
NO<sub>x</sub> and CO Emissions (USEPA M-7E/10)**

Run No.		1	2	3	4	5	6
Date (2014)		Mar 20	Mar 21				
Start Time (approx.)		13:41	15:03	16:26	17:06	17:47	06:53
Stop Time (approx.)		14:02	15:26	16:48	17:27	18:08	07:17
<b>Process Conditions</b>							
H <sub>i</sub>	Actual heat input (MMBtu/hr)	421.1	379.7	330.3	316.6	310.1	389.6
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	8,760	8,760	8,760
<b>Gas Conditions</b>							
O <sub>2</sub>	Oxygen (dry volume %)	3.2	3.4	3.4	3.4	3.5	3.3
CO <sub>2</sub>	Carbon dioxide (dry volume %)	18.6	18.6	18.7	18.7	18.6	18.6
B <sub>w</sub>	Actual water vapor in gas (% by volume) <sup>1</sup>	15.0	15.6	15.4	15.4	15.4	14.9
<b>Gas Flow Rate<sup>2</sup></b>							
Q <sub>std</sub>	Volumetric flow rate, dry standard (dscfm)	80,900	76,600	69,300	65,900	64,700	72,600
<b>Nitrogen Oxides Results</b>							
C <sub>sd</sub>	Concentration (ppmdv)	5.6	5.7	5.6	5.7	5.8	5.7
C <sub>sd-x</sub>	Concentration @ 0% O <sub>2</sub> (ppmdv)	6.7	6.8	6.6	6.8	7.0	6.8
C <sub>sd</sub>	Concentration (lb/dscf)	6.7E-07	6.8E-07	6.6E-07	6.8E-07	6.9E-07	6.9E-07
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	3.3	3.1	2.8	2.7	2.7	3.0
E <sub>T/yr</sub>	Emission Rate (Ton/yr)	14.3	13.6	12.1	11.8	11.8	13.1
E <sub>Hi</sub>	Emission Rate - Heat input-based (lb/MMBtu)	0.0078	0.0082	0.0084	0.0085	0.0087	0.0077
<b>Carbon Monoxide Results</b>							
C <sub>sd</sub>	Concentration (ppmdv)	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47
C <sub>sd-x</sub>	Concentration @ 0% O <sub>2</sub> (ppmdv)	<0.56	<0.56	<0.56	<0.56	<0.57	<0.56
C <sub>sd</sub>	Concentration (lb/dscf)	<3.4E-08	<3.4E-08	<3.4E-08	<3.4E-08	<3.4E-08	<3.4E-08
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	<0.17	<0.16	<0.14	<0.14	<0.13	<0.15
E <sub>T/yr</sub>	Emission Rate (Ton/yr)	<0.73	<0.69	<0.63	<0.60	<0.58	<0.66
E <sub>Hi</sub>	Emission Rate - Heat input-based (lb/MMBtu)	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004

<sup>1</sup> Moisture data obtained from concurrently operated Draft ASTM CCM or Method 4 sample train.

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<sup>2</sup> Flow data used in lb/hr calculations was obtained from concurrent M-2 runs.

For CO, '&lt;' indicates a measured response below the detection limit (assumed to be 1% of the instrument calibration span).

**RESULTS**

2-7

**Table 2-6 (Continued):  
NO<sub>x</sub> and CO Emissions (USEPA M-7E/10)**

Run No.		7	8	9	10	Average
Date (2014)		Mar 21	Mar 21	Mar 21	Mar 21	
Start Time (approx.)		07:33	08:10	08:54	09:34	
Stop Time (approx.)		07:54	08:31	09:16	09:55	
<b>Process Conditions</b>						
H <sub>i</sub>	Actual heat input (MMBtu/hr)	394.7	400.0	412.0	433.6	378.8
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	8,760	8,760
<b>Gas Conditions</b>						
O <sub>2</sub>	Oxygen (dry volume %)	3.2	3.3	3.3	3.3	3.3
CO <sub>2</sub>	Carbon dioxide (dry volume %)	18.7	18.6	18.5	18.7	18.6
B <sub>w</sub>	Actual water vapor in gas (% by volume) <sup>1</sup>	14.9	14.9	16.0	16.0	15.4
<b>Gas Flow Rate<sup>2</sup></b>						
Q <sub>std</sub>	Volumetric flow rate, dry standard (dscfm)	74,700	73,500	75,000	76,700	73,000
<b>Nitrogen Oxides Results</b>						
C <sub>std</sub>	Concentration (ppmdv)	5.8	5.7	5.9	5.6	5.7
C <sub>std-x</sub>	Concentration @ 0% O <sub>2</sub> (ppmdv)	6.9	6.8	7.0	6.7	6.8
C <sub>std</sub>	Concentration (lb/dscf)	6.9E-07	6.8E-07	7.1E-07	6.7E-07	6.8E-07
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	3.1	3.0	3.2	3.1	3.0
E <sub>7/yr</sub>	Emission Rate (Ton/yr)	13.6	13.2	14.0	13.6	13.1
E <sub>th</sub>	Emission Rate - Heat input-based (lb/MMBtu)	0.0079	0.0075	0.0077	0.0072	0.0080
<b>Carbon Monoxide Results</b>						
C <sub>std</sub>	Concentration (ppmdv)	<0.47	<0.47	<0.47	<0.47	<0.47
C <sub>std-x</sub>	Concentration @ 0% O <sub>2</sub> (ppmdv)	< 0.56	< 0.56	< 0.56	< 0.56	<0.56
C <sub>std</sub>	Concentration (lb/dscf)	<3.4E-08	<3.4E-08	<3.4E-08	<3.4E-08	<3.4E-08
E <sub>lb/hr</sub>	Emission Rate (lb/hr)	< 0.15	< 0.15	< 0.15	< 0.16	< 0.15
E <sub>7/yr</sub>	Emission Rate (Ton/yr)	< 0.68	< 0.66	< 0.68	< 0.69	< 0.66
E <sub>th</sub>	Emission Rate - Heat input-based (lb/MMBtu)	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004

Average includes 10 runs.

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<sup>1</sup> Moisture data obtained from concurrently operated Draft ASTM CCM or Method 4 sample train.<sup>2</sup> Flow data used in lb/hr calculations was obtained from concurrent M-2 runs.

For CO, '&lt;' indicates a measured response below the detection limit (assumed to be 1% of the instrument calibration span).

**RESULTS**

**Table 2-7:  
Standard Flow Rate Relative Accuracy (USEPA M-2 / PS6)**

Run No.	Start Time	Date (2014)	RM Data (scfh)	CEMS Data (scfh)	Difference (ppmdv)	Difference Percent
1	13:41	Mar 20	5,708,027	5,405,265	302,762	5.3%
2	15:03	Mar 20	5,442,934	4,900,589	542,345	10.0%
3 *	16:26	Mar 20	4,915,935	4,261,111	654,823	13.3%
4	17:06	Mar 20	4,675,543	4,091,709	583,834	12.5%
5	17:47	Mar 20	4,588,465	4,016,490	571,976	12.5%
6	06:53	Mar 21	5,122,471	4,987,685	134,786	2.6%
7	07:33	Mar 21	5,269,652	5,073,356	196,296	3.7%
8	08:10	Mar 21	5,184,559	5,132,922	51,637	1.0%
9	08:54	Mar 21	5,354,399	5,298,313	56,086	1.0%
10	09:34	Mar 21	5,477,201	5,564,525	-87,324	-1.6%
<b>Average</b>			<b>5,202,584</b>	<b>4,941,206</b>	<b>261,377</b>	<b>5.0%</b>

**Relative Accuracy Test Audit Results**

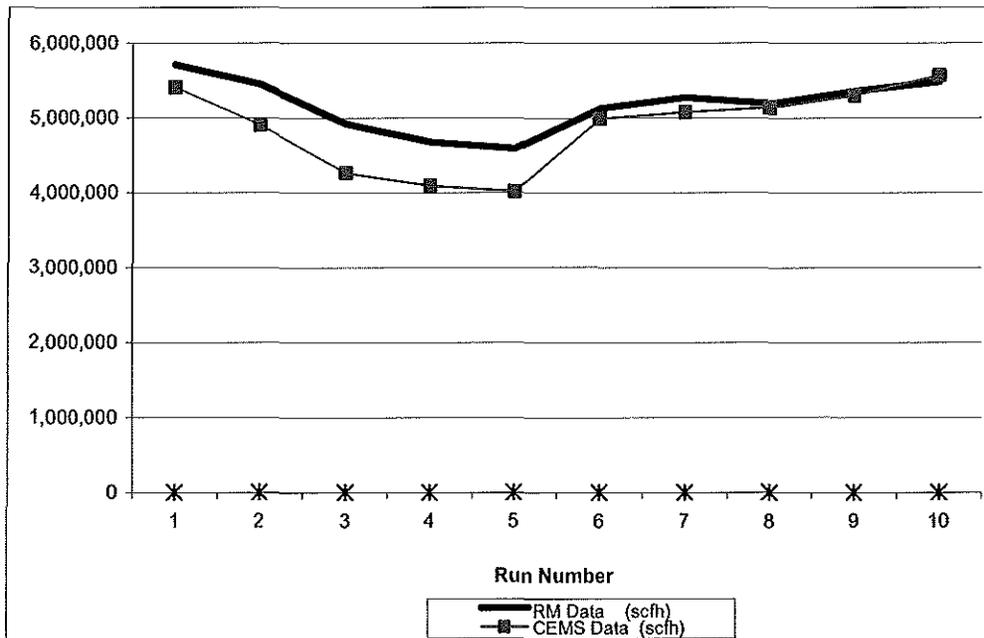
Standard Deviation of Differences	252,263	
Confidence Coefficient (CC)	193,906	
t-Value for 9 Data Sets	2.306	
Relative Accuracy (as % of RM)	<b>8.8%</b>	<b>Limit 20.0%</b>

RM = Reference Method (CleanAir Data)

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CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



**RESULTS**

**Table 2-8:  
Dry Standard Flow Rate Relative Accuracy (USEPA M-2 / PS6)**

Run No.	Start Time	Date (2014)	RM Data (dscfm)	CEMS Data (dscfm)	Difference (ppmdv)	Difference Percent
1	13:41	Mar 20	4,854,667	4,499,199	355,468	7.3%
2	15:03	Mar 20	4,594,517	4,086,749	507,768	11.1%
3 *	16:26	Mar 20	4,158,132	3,556,785	601,347	14.5%
4	17:06	Mar 20	3,954,797	3,412,987	541,810	13.7%
5	17:47	Mar 20	3,881,143	3,355,447	525,695	13.5%
6	06:53	Mar 21	4,357,721	4,175,267	182,455	4.2%
7	07:33	Mar 21	4,482,929	4,216,488	266,441	5.9%
8	08:10	Mar 21	4,410,540	4,278,100	132,440	3.0%
9	08:54	Mar 21	4,498,983	4,412,212	86,771	1.9%
10	09:34	Mar 21	4,602,167	4,637,591	-35,424	-0.8%
<b>Average</b>			<b>4,404,163</b>	<b>4,119,338</b>	<b>284,825</b>	<b>6.5%</b>

**Relative Accuracy Test Audit Results**

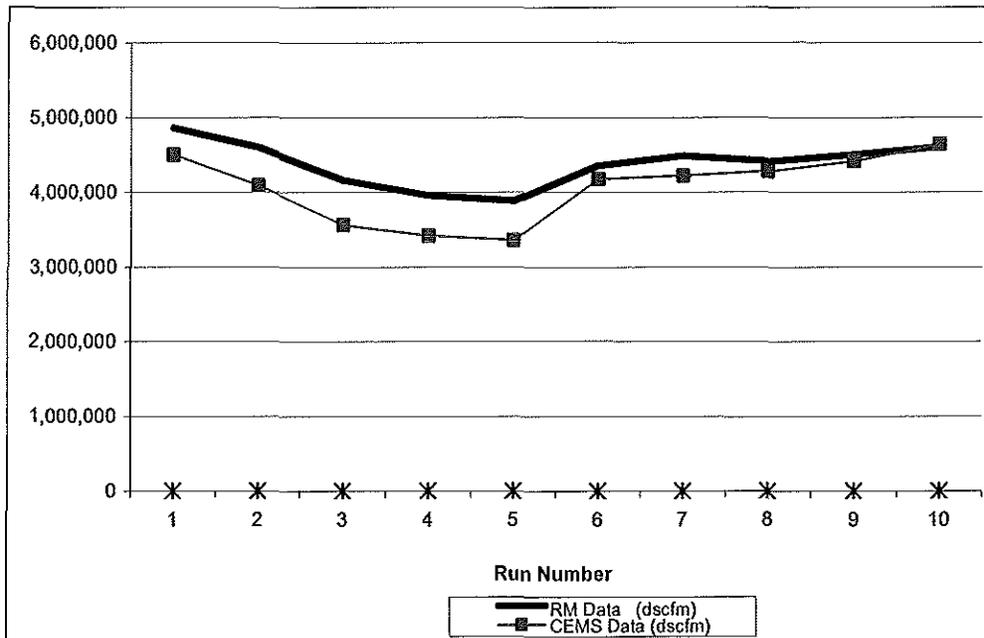
Standard Deviation of Differences	210,528	
Confidence Coefficient (CC)	161,826	
t-Value for 9 Data Sets	2.306	
Relative Accuracy (as % of RM)	10.1%	Limit 20.0%

RM = Reference Method (CleanAir Data)

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CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



**RESULTS**

**Table 2-9:  
H<sub>2</sub>O Concentration Relative Accuracy**

Run No.	Start Time	Date (2014)	RM Data (%wv)	CEMS Data (%wv)	Difference (ppmdv)	Difference Percent
1	13:41	Mar 20	15.0	16.8	-1.8	-12.1%
2	15:03	Mar 20	15.6	16.6	-1.0	-6.6%
3	16:26	Mar 20	15.4	16.6	-1.1	-7.4%
4	17:06	Mar 20	15.4	16.6	-1.2	-7.7%
5	17:47	Mar 20	15.4	16.5	-1.0	-6.8%
6	06:53	Mar 21	14.9	16.3	-1.4	-9.1%
7 *	07:33	Mar 21	14.9	16.9	-2.0	-13.2%
8	08:10	Mar 21	14.9	16.7	-1.7	-11.6%
9	08:54	Mar 21	16.0	16.7	-0.8	-4.7%
10	09:34	Mar 21	16.0	16.7	-0.7	-4.3%
<b>Average</b>			<b>15.4</b>	<b>16.6</b>	<b>-1.2</b>	<b>-7.7%</b>

**Relative Accuracy Test Audit Results**

Standard Deviation of Differences      0.387  
Confidence Coefficient (CC)                0.297  
t-Value for 9 Data Sets                      2.306

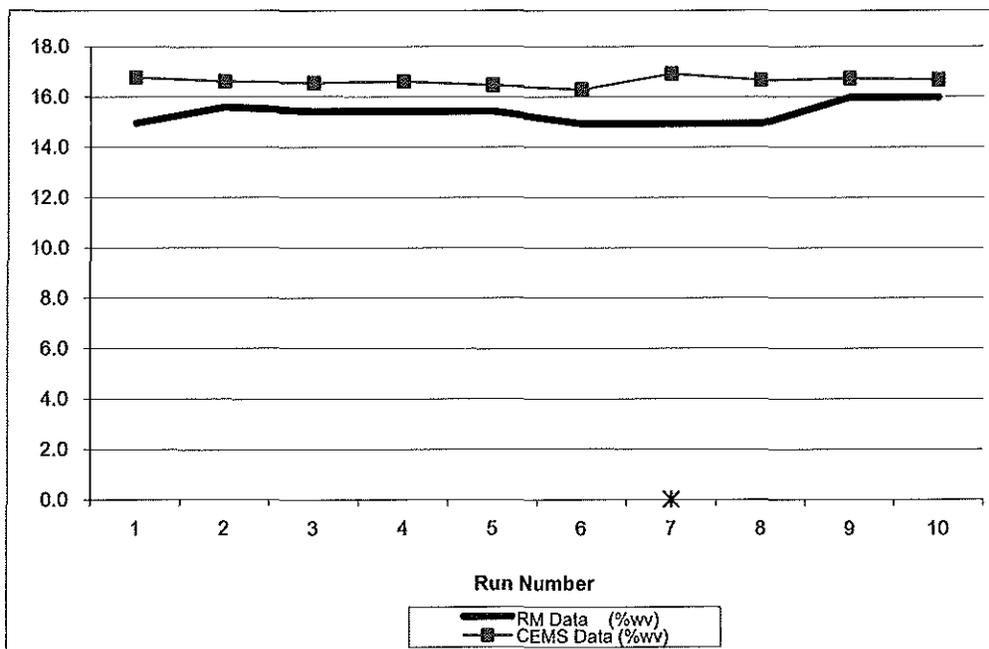
Relative Accuracy (as % of RM)            **9.7%**

RM = Reference Method (CleanAir Data)

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CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



**RESULTS**

2-11

**Table 2-10:  
O<sub>2</sub> Relative Accuracy (USEPA M-3A / PS3)**

Run No.	Start Time	Date (2014)	RM Data (%dv)	CEMS Data (%dv)	Difference (%dv)
1	13:41	Mar 20	3.2	3.2	0.0
2	15:03	Mar 20	3.4	3.4	0.0
3 *	16:26	Mar 20	3.4	3.4	0.0
4	17:06	Mar 20	3.4	3.4	0.0
5	17:47	Mar 20	3.5	3.5	0.0
6	06:53	Mar 21	3.3	3.3	0.0
7	07:33	Mar 21	3.2	3.3	0.0
8	08:10	Mar 21	3.3	3.3	0.0
9	08:54	Mar 21	3.3	3.3	0.0
10	09:34	Mar 21	3.3	3.3	0.0
<b>Average</b>			<b>3.3</b>	<b>3.3</b>	<b>0.0</b>

**Relative Accuracy Test Audit Results**

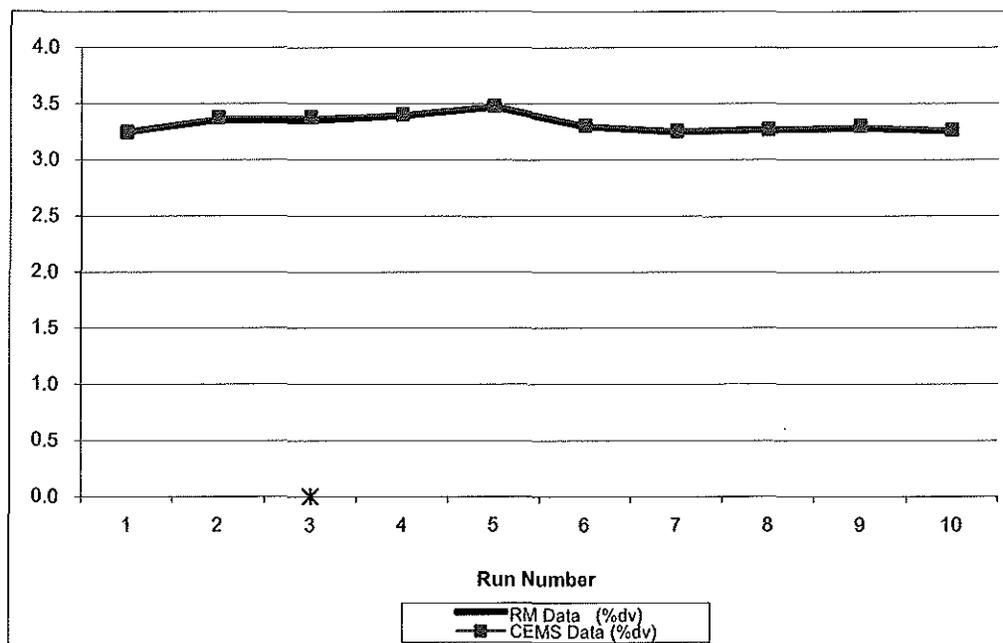
Standard Deviation of Differences	0.008	
Confidence Coefficient (CC)	0.006	
t-Value for 9 Data Sets	2.306	
<b>Avg. Abs. Diff. (%dv)</b>	<b>0.0</b>	<b>Limit 1.0</b>

RM = Reference Method (CleanAir Data)

040814 163513

CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



**RESULTS**

**Table 2-11:  
NO<sub>x</sub> Concentration Relative Accuracy (EPA 7E / PS2)**

Run No.	Start Time	Date (2014)	RM Data (ppmdv)	CEMS Data (ppmdv)	Difference (ppmdv)	Difference Percent
1	13:41	Mar 20	5.6	5.9	-0.2	-4.4%
2	15:03	Mar 20	5.7	5.8	-0.1	-2.3%
3	16:26	Mar 20	5.6	5.7	-0.2	-3.0%
4	17:06	Mar 20	5.7	5.9	-0.2	-2.8%
5	17:47	Mar 20	5.8	6.0	-0.2	-2.6%
6	06:53	Mar 21	5.7	5.9	-0.2	-3.0%
7	07:33	Mar 21	5.8	6.1	-0.2	-4.1%
8	08:10	Mar 21	5.7	6.0	-0.2	-4.3%
9 *	08:54	Mar 21	5.9	6.2	-0.3	-4.7%
10	09:34	Mar 21	5.6	5.8	-0.2	-3.4%
<b>Average</b>			<b>5.7</b>	<b>5.9</b>	<b>-0.2</b>	<b>-3.3%</b>

**Relative Accuracy Test Audit Results**

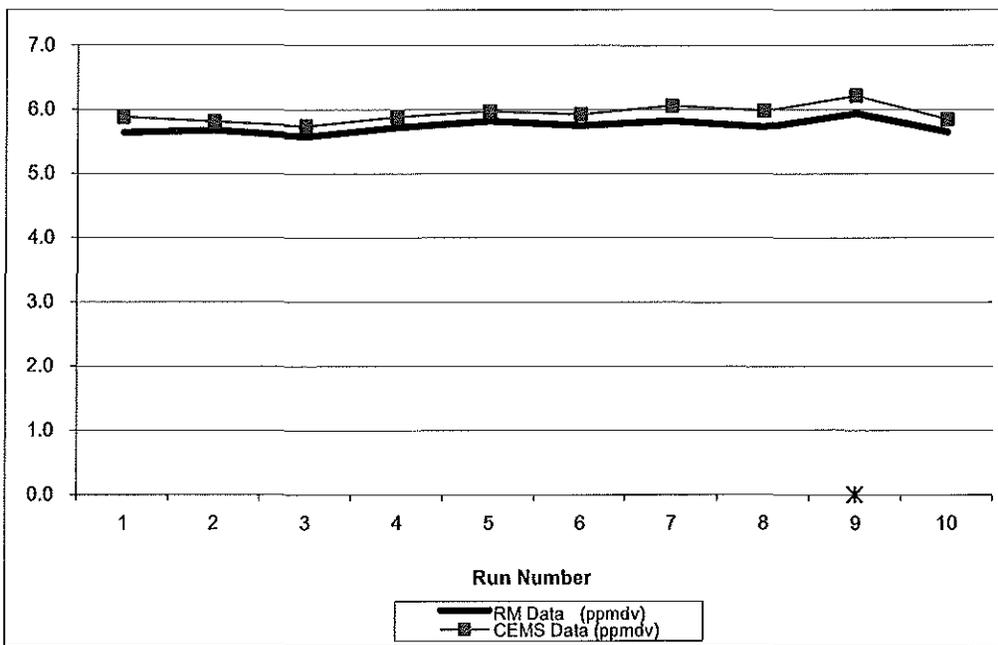
Standard Deviation of Differences	0.044	
Confidence Coefficient (CC)	0.034	
t-Value for 9 Data Sets	2.306	
Relative Accuracy (as % of RM)	<b>3.9%</b>	<b>Limit 20.0%</b>

RM = Reference Method (CleanAir Data)

040814 163513

CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



**RESULTS**

**Table 2-12:  
NO<sub>x</sub> Emission Rate Relative Accuracy (USEPA M-7E / PS2)**

Run No.	Start Time	Date (2014)	RM Data (lb/MMBtu)	CEMS Data (lb/MMBtu)	Difference (lb/MMBtu)	Difference Percent
1	13:41	Mar 20	0.008	0.008	0.000	2.4%
2	15:03	Mar 20	0.008	0.007	0.001	9.8%
3 *	16:26	Mar 20	0.008	0.007	0.001	12.4%
4	17:06	Mar 20	0.009	0.008	0.001	11.3%
5	17:47	Mar 20	0.009	0.008	0.001	10.1%
6	06:53	Mar 21	0.008	0.008	0.000	1.6%
7	07:33	Mar 21	0.008	0.008	0.000	-0.3%
8	08:10	Mar 21	0.008	0.008	0.000	-4.1%
9	08:54	Mar 21	0.008	0.008	0.000	-3.5%
10	09:34	Mar 21	0.007	0.008	0.000	-4.6%
<b>Average</b>			<b>0.008</b>	<b>0.008</b>	<b>0.000</b>	<b>2.8%</b>

**Relative Accuracy Test Audit Results**

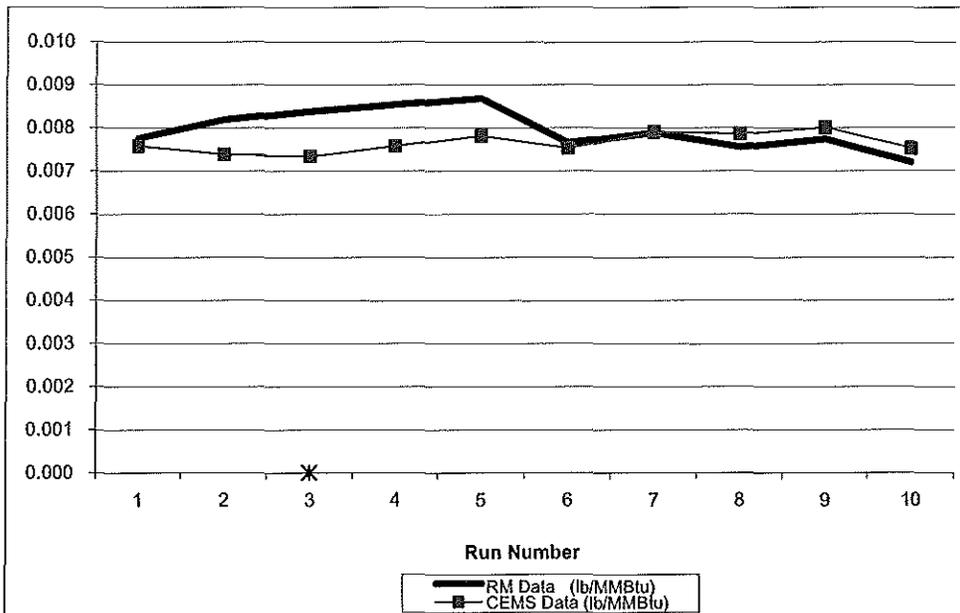
Standard Deviation of Differences	0.0005	
Confidence Coefficient (CC)	0.0004	
t-Value for 9 Data Sets	2.306	
		Limit
Relative Accuracy (as % of RM)	8.0%	20.0%
Relative Accuracy (as % of Appl. Std.)	4.8%	10.0%
Appl. Std. = 0.013 lb/MMBtu		

RM = Reference Method (CleanAir Data)

040814 163513

CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



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**RESULTS**

**Table 2-13:  
CO Concentration Relative Accuracy (USEPA M-10 / PS4A)**

Run No.	Start Time	Date (2014)	RM Data (ppmdv)	CEMS Data (ppmdv)	Difference (ppmdv)
1 *	13:41	Mar 20	0.0	0.7	-0.7
2	15:03	Mar 20	0.0	0.7	-0.7
3	16:26	Mar 20	0.0	0.7	-0.7
4	17:06	Mar 20	0.0	0.7	-0.7
5	17:47	Mar 20	0.0	0.7	-0.6
6	06:53	Mar 21	0.0	0.7	-0.7
7	07:33	Mar 21	0.0	0.7	-0.7
8	08:10	Mar 21	0.0	0.7	-0.7
9	08:54	Mar 21	0.0	0.7	-0.7
10	09:34	Mar 21	0.0	0.7	-0.7
<b>Average</b>			<b>0.0</b>	<b>0.7</b>	<b>-0.7</b>

**Relative Accuracy Test Audit Results**

Standard Deviation of Differences	0.030	
Confidence Coefficient (CC)	0.023	
t-Value for 9 Data Sets	2.306	
<b>Avg. Abs. Diff. + CC (ppmdv)</b>	<b>0.7</b>	<b>Limit</b>
		<b>5.0</b>

RM = Reference Method (CleanAir Data)

042314 112027

CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.

RM Data displayed is rounded to one decimal place. Results calculated from actual value measured.

AIR PRODUCTS AND CHEMICALS, INC.  
DETROIT HYDROGEN PLANT

Client Reference No: 4502962362  
CleanAir Project No: 12427-1

## RESULTS

2-15

**Table 2-14:**  
**CO Emission Rate Relative Accuracy (USEPA M-10 / PS4A)**

Run No.	Start Time	Date (2014)	RM Data (lb/hr)	CEMS Data (lb/hr)	Difference (lb/hr)
1 *	13:41	Mar 20	0.0	0.2	-0.2
2	15:03	Mar 20	0.0	0.2	-0.2
3	16:26	Mar 20	0.0	0.2	-0.2
4	17:06	Mar 20	0.0	0.2	-0.2
5	17:47	Mar 20	0.0	0.2	-0.2
6	06:53	Mar 21	0.0	0.2	-0.2
7	07:33	Mar 21	0.0	0.2	-0.2
8	08:10	Mar 21	0.0	0.2	-0.2
9	08:54	Mar 21	0.0	0.2	-0.2
10	09:34	Mar 21	0.0	0.2	-0.2
<b>Average</b>			<b>0.0</b>	<b>0.2</b>	<b>-0.2</b>

### Relative Accuracy Test Audit Results

Standard Deviation of Differences	0.019	
Confidence Coefficient (CC)	0.015	
t-Value for 9 Data Sets	2.306	
Relative Accuracy (as % of Appl. Std.)	0.4%	Limit
Appl. Std. = 56.94 lb/hr		5.0%

RM = Reference Method (CleanAir Data)

042314 112027

CEMS = Continuous Emissions Monitoring System (Air Products and Chemicals, Inc. Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.

RM Data displayed is rounded to one decimal place. Results calculated from actual value measured.

*End of Section 2 – Results*

**DESCRIPTION OF INSTALLATION**

3-1

**PROCESS DESCRIPTION**

Air Products owns and operates the Detroit Hydrogen Plant located within the Marathon Petroleum Company Detroit Refinery. The Hydrogen Plant supplies hydrogen (H<sub>2</sub>) to the Detroit Refinery, which is utilized in the petroleum refining process. Natural gas, refinery fuel gas and/or a high-pentane (C<sub>5</sub>H<sub>12</sub>) refinery stream are converted into 99.9% pure hydrogen (H<sub>2</sub>) and high-pressure steam through the use of steam/methane reforming technology. The unit consists of process vessels, a heater, compressors, pumps, piping, drains and other various components (pump and compressor seals, process valves, pressure relief valves, flanges, connectors, etc.).

The Hydrogen Plant Heater (EG71-H2HTR) is fired by a combination of refinery gas, pressure swing absorption gas, syngas and/or natural gas. The heater is equipped with a selective catalytic reduction (SCR) system to control emissions, which are vented to the atmosphere via the Hydrogen Plant Heater Stack (SV71-H1).

The testing described in this document was performed at the Hydrogen Plant Heater Stack.

**DESCRIPTION OF SAMPLING LOCATIONS**

Sampling point locations were determined according to USEPA Methods 1 and Performance Specification 2.

Table 3-1 outlines the sampling point configurations. The figures shown on the following pages illustrate the sampling points and orientation of sampling ports.

**Table 3-1:  
Sampling Points**

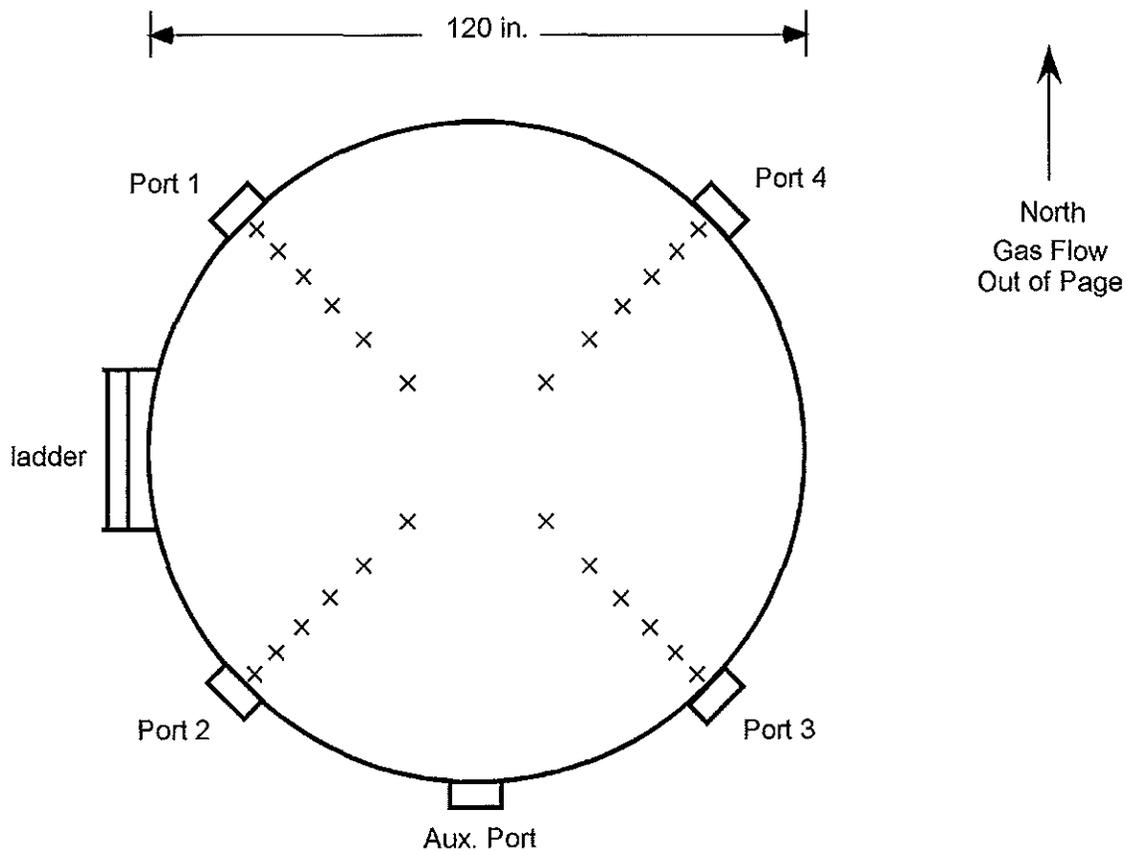
Source Constituent	Method (USEPA)	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
<u>H<sub>2</sub> Plant Heater Stack</u>							
FPM / CPM	M-5/202	1-3	4	6	5	120	3-1
Velocity & Flow Rate	M-2	1-12	4	6	varied	varied	3-1
H <sub>2</sub> SO <sub>4</sub>	Draft ASTM CCM	1-3	1	1	60	60	N/A <sup>1</sup>
H <sub>2</sub> O	M-4	1-4	1	1	60 or 95	60 or 95	N/A <sup>1</sup>
O <sub>2</sub> / CO <sub>2</sub> / CH <sub>4</sub> / C <sub>2</sub> H <sub>6</sub> / THC	M-3A / 18 / 25A	1-3	1	1	60	60	3-2 <sup>2</sup>
O <sub>2</sub> / NO <sub>x</sub> / CO (RATAs)	M-3A+PS3 / 7E+PS2 / 10+PS4A	1-10	1	3	7	21	3-2

<sup>1</sup> Sampling occurred at a single point at least 3.3 feet from the duct wall in a port on a lower test plane.

<sup>2</sup> Sampling occurred at a single point at least 3.3 feet from the duct wall.

**DESCRIPTION OF INSTALLATION**

3-2



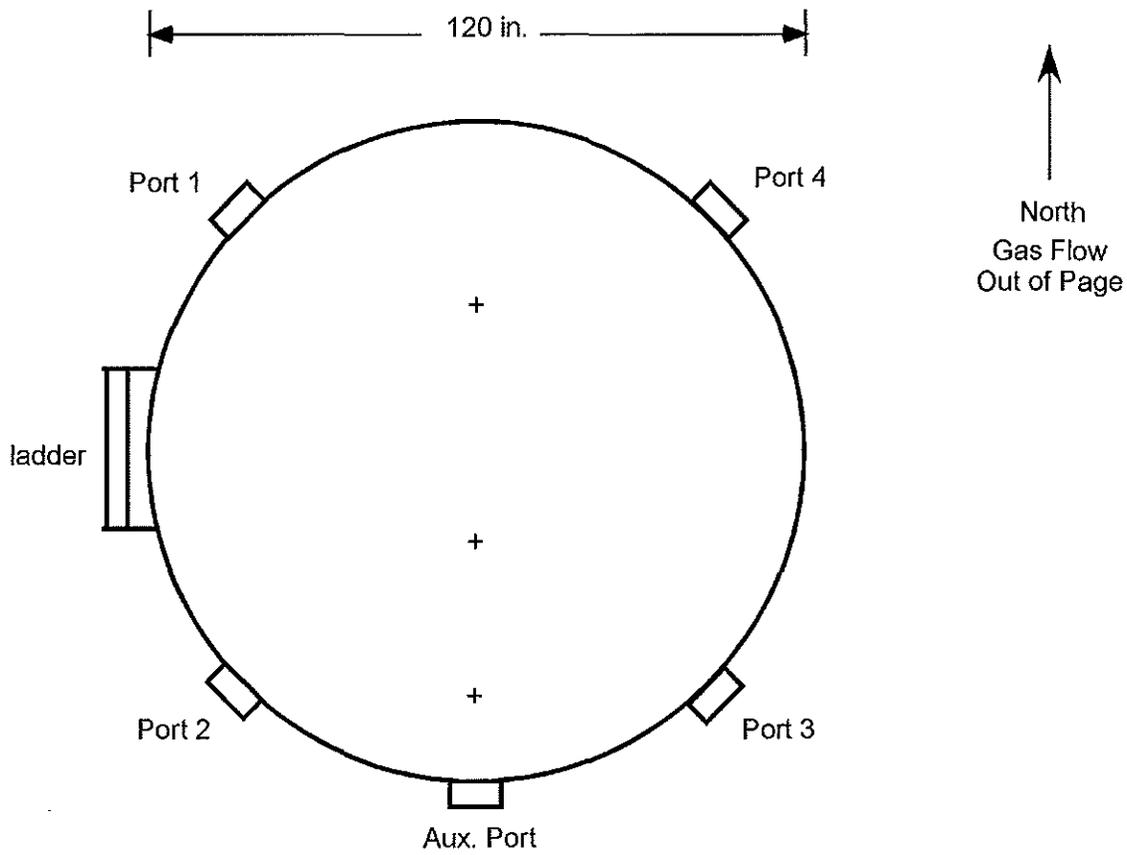
<u>Sampling Point</u>	<u>Port to Point Distance (in.)</u>
1	42.7
2	30.0
3	21.2
4	14.2
5	8.0
6	2.5

Duct diameters upstream from flow disturbance (A): 1.90 Limit: 0.5  
 Duct diameters downstream from flow disturbance (B): 5.93 Limit: 2.0

Figure 3-1: H<sub>2</sub> Plant Heater Stack EPA M-5/202 Sampling Points (USEPA M-1)

**DESCRIPTION OF INSTALLATION**

3-3



<u>Sampling Point</u>	<u>Port to Point Distance (in.)</u>
1	15.7
2	47.2
3	78.7

Duct diameters upstream from flow disturbance (A):	1.90	Limit: 0.5
Duct diameters downstream from flow disturbance (B):	5.93	Limit: 2.0

**Figure 3-2: H<sub>2</sub> Plant Heater Stack RATA Sampling Points (PS2)**

*End of Section 3 – Description of Installation*

**METHODOLOGY**

4-1

Clean Air Engineering followed procedures as detailed in USEPA Methods 1, 2, 3, 3A, 3B, 4, 5, 7E, 10, 18, 19, 25A, 202, Performance Specifications 2, 3, 4, 4A, 6 and the Draft ASTM Controlled Condensation Method (CCM). The following table summarizes the methods and their respective sources.

**Table 4-1:  
Summary of Sampling Procedures**

Title 40 CFR Part 60 Appendix A

Method 1	"Sample and Velocity Traverses for Stationary Sources"
Method 2	"Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)"
Method 3	"Gas Analysis for the Determination of Dry Molecular Weight"
Method 3A	"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
Method 3B	"Gas Analysis for the Determination of Emission Rate Correction Factor or Excess Air"
Method 4	"Determination of Moisture Content in Stack Gases"
Method 5	"Determination of Particulate Matter Emissions from Stationary Sources"
Method 7E	"Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
Method 10	"Determination of Carbon Monoxide Emissions from Stationary Sources"
Method 18	"Measurement of Gaseous Organic Compound Emissions by Gas Chromatography"
Method 19	"Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates"
Method 25A	"Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer"

Title 40 CFR Part 60 Appendix B (Performance Specifications (PS))

PS2	"Specifications and Test Procedures for SO <sub>2</sub> and NO <sub>x</sub> Continuous Emission Monitoring Systems in Stationary Sources"
PS3	"Specifications and Test Procedures for O <sub>2</sub> and CO <sub>2</sub> Continuous Emission Monitoring Systems in Stationary Sources"
PS4	"Specifications and Test Procedures for Carbon Monoxide Continuous Emission Monitoring Systems in Stationary Sources"
PS4A	"Specifications and Test Procedures for Carbon Monoxide Continuous Emission Monitoring Systems in Stationary Sources"
PS6	"Specifications and Test Procedures for Continuous Emission Rate Monitoring Systems in Stationary Sources"

Title 40 CFR Part 51 Appendix M

Method 202	"Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources"
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Draft Methods

Draft ASTM CCM	"Standard Test Method for Determination of Sulfur Trioxide and Sulfuric Acid Vapor and Mist, from Stationary Sources Using a Controlled Condensation Sampling System"
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These methods appear in detail in Title 40 of the Code of Federal Regulations (CFR) and are located on the internet at <http://ecfr.gpoaccess.gov>.

**METHODOLOGY**

4-2

Diagrams of the sampling apparatus and major specifications of the sampling, recovery and analytical procedures are summarized for each method in Appendix A.

CleanAir followed specific quality assurance and quality control (QA/QC) procedures as outlined in the individual methods and as prescribed in CleanAir's internal Quality Manual. Results of all QA/QC activities performed by CleanAir are summarized in Appendix D.

*PM and PM<sub>10</sub> Testing - USEPA Method 5/202*

PM and PM<sub>10</sub> emissions were determined using USEPA Method 5/202.

- For this test program, PM assumed is equivalent to filterable particulate matter (FPM).
- PM<sub>10</sub> is equivalent to the sum of filterable particulate matter less than 10 micrometers ( $\mu\text{m}$ ) in diameter (FPM<sub>10</sub>) and condensable particulate matter (CPM). The M-5/202 sample train yields a front-half, FPM result and a back-half, CPM result. Where appropriate, the total PM result (FPM plus CPM) from M-5/202 can be used as a worst-case estimation of as Total PM<sub>10</sub> since M-5 will collect all filterable particulate matter present in the flue gas (regardless of particle size). Since the Hydrogen Plant Heater is fired by a combination of refinery gas, pressure swing absorption gas, syngas and/or natural gas, the worst-case assumption can safely be made that any FPM in the flue gas exists as FPM<sub>10</sub> and can be collected using standard front-half filtration methods without additional 10  $\mu\text{m}$  speciation.

The front-half (M-5 portion) of the sampling train consisted of a glass nozzle, glass liner and filter holder heated to 250°F, and a quartz fiber filter. Flue gas samples were extracted isokinetically per M-5 requirements.

The back-half (M-202 portion) of the sampling train is designed to mimic ambient conditions and collect only the particles that would truly form CPM in the atmosphere by minimizing the sulfur dioxide (SO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>) interferences observed with earlier versions of the method, in which flue gas was bubbled through cold water and SO<sub>2</sub> and NO<sub>x</sub> were absorbed and partially oxidized before they could be purged out with nitrogen (N<sub>2</sub>).

Flue gas exiting the front-half heated filter passed through a coiled condenser and dry impinger system jacketed by water continually circulated at ambient temperature. Moisture was removed from the flue gas without bubbling through the condensed water. Flue gas then passed through a tetrafluoroethane (TFE) membrane filter at ambient temperature. The temperature of the flue gas at the exit of the filter was directly measured with an in-line thermocouple and maintained in the temperature range of 65 to 85°F.

**METHODOLOGY**

4-3

After exiting the ambient filter, the flue gas passed through two (2) additional impingers surrounded by ice in a "cold" section of the impinger bucket. The moisture collected in these impingers was not analyzed for CPM and was only collected to determine the flue gas moisture and thoroughly dry the gas. The sample gas then flowed into a calibrated dry gas meter where the collected sample gas volume was determined.

The front-half portion of the sample train (nozzle, probe and heated filter) was recovered per M-5 requirements, using acetone as the recovery solvent. The back-half of the sample train (heated filter outlet, condenser, dry impingers and TFE membrane filter) was recovered per M-202 requirements. The impinger train was purged with nitrogen (N<sub>2</sub>) at a rate of 14 liters per minute (lpm) for one (1) hour following each test run and prior to recovery.

A field train blank was assembled, purged and recovered as if it were an actual test sample; analysis of the field train blank was used to blank-correct the test run results. Reagent blanks were also collected to quantify background contamination. All samples and blanks were returned to CleanAir Analytical Services for gravimetric analysis. M-202 samples were maintained at a temperature < 85°F during transport to the laboratory.

*H<sub>2</sub>SO<sub>4</sub> Testing - Draft ASTM Controlled Condensation Method*

H<sub>2</sub>SO<sub>4</sub> emissions were determined referencing the Draft ASTM Controlled Condensation Method.

A gas sample was extracted from the source at a constant flow rate using a quartz-lined probe maintained at 650°F and a quartz fiber filter maintained at 650°F to remove particulate matter.

The sample then passed through a glass coil condenser for collection of sulfuric acid vapor and/or mist. A second quartz fiber filter (referred to as the sulfuric acid mist (SAM) filter) located at the condenser outlet collected any residual sulfuric acid mist that passed through the condenser. The condenser temperature was regulated by a circulating water jacket; the SAM filter temperature was regulated by a closed oven. Both the water jacket and SAM filter oven were maintained at 140°F ±9°F plus 2°F for each 1% moisture above 16% flue gas moisture (above the water dew point, which eliminates the oxidation of dissolved SO<sub>2</sub> into the H<sub>2</sub>SO<sub>4</sub>-collecting fraction of the sample train).

**METHODOLOGY**

4-4

After exiting the SAM filter, the sample gas then continued through a series of four (4) glass knock-out jars; two (2) containing water, one (1) empty, and one (1) containing silica gel for residual moisture removal. The exit temperature from the knock-out jar set was maintained below 68°F. The sample gas then flowed into a calibrated dry gas meter where the collected sample gas volume was determined.

The H<sub>2</sub>SO<sub>4</sub>-collecting portion of the sample train (condenser and SAM filter) was recovered into a single fraction using DI H<sub>2</sub>O as the recovery/extraction solvent; any H<sub>2</sub>SO<sub>4</sub> disassociated into sulfate ion (SO<sub>4</sub><sup>2-</sup>) and was stabilized in the H<sub>2</sub>O matrix until analysis.

Prior to the first official test run, a 60-minute sample conditioning run was performed in order to minimize the absorption capacity of the front-half components of the sample train (upstream of the H<sub>2</sub>SO<sub>4</sub>-collecting portion of the sample train). The conditioning run was recovered in the same manner as the official test runs, but the condenser rinse and SAM filter were not analyzed.

A field train blank was assembled, transported to the location, heated, leak-checked and recovered as if it were an actual test sample. Reagent blanks were collected to quantify background contamination.

Samples and blanks were returned to CleanAir Analytical Services for ion chromatography (IC) analysis.

*O<sub>2</sub>, CO<sub>2</sub>, and VOC Testing - USEPA Methods, 3A, 18, and 25A*

O<sub>2</sub> and CO<sub>2</sub> emissions were determined using a paramagnetic/NDIR CEMs analyzer per EPA Method 3A. VOC emissions were determined using USEPA Method 25A to quantify total hydrocarbon emissions (THC) and USEPA Method 18 to quantify methane (CH<sub>4</sub>) and ethane (C<sub>2</sub>H<sub>6</sub>) emissions. VOC emissions are equivalent to THC emissions, minus CH<sub>4</sub> and C<sub>2</sub>H<sub>6</sub> emissions.

**METHODOLOGY**

4-5

The M-3A/18/25A sampling system consisted of a heated probe, heated filter and heated sample line. Flue gas was extracted at a constant rate and delivered at 250°F to a tee at the end of the heated sample line.

- One leg of the tee was connected to a flame ionization analyzer (FIA) which continuously measured minute-average THC concentration expressed in terms of propane ( $C_3H_8$ ) on an actual (wet) basis.
- The other leg of the tee was connected to a gas conditioner which removed moisture before delivering the gas to a flow panel and the  $O_2/CO_2$  analyzers, which measured concentration on a dry basis (units of %<sub>dv</sub> or ppm<sub>dv</sub>).
- The M-18 gas sample was collected by pulling a slipstream from the flow panel and delivered it into a Tedlar bag at a constant rate. The moisture condensate was not collected for analysis as  $CH_4$  and  $C_2H_6$  are insoluble in water. Each bag was filled over a period of one (1) hour for each test run.

THC analyzer calibration was performed by introducing zero air, high, mid- and low-range  $C_3H_8$  calibration gases to the inlet of the sampling system's heated filter. Bias checks were performed before and after each sampling run in a similar manner.

$O_2/CO_2$  calibration error checks were performed by introducing zero nitrogen ( $N_2$ ), high-range and mid-range calibration gases to the inlet of each analyzer during calibration error checks. Bias checks were performed before and after each sampling run by introducing calibration gas to the inlet of the sampling system's heated filter. Per M-3A, the average results for each run were drift-corrected.

Analysis for  $CH_4$  and  $C_2H_6$  was performed off-site by CleanAir Analytical Services using gas chromatography (GC). Since moisture was removed from the sample prior to collection and GC analysis, the concentration results were on a dry basis. At least five (5) sample injections were analyzed for each run.

GC calibration was performed by generating a calibration curve from triplicate injections of three (3) distinct  $CH_4$  and  $C_2H_6$  concentrations introduced directly into the GC. Upon completion of calibration, a recovery study was performed by spiking two (2) of the bag samples with a known concentration of  $CH_4$  and  $C_2H_6$ , storing the bags for the same period of time prior to analysis as the field samples, and analyzing the bags to determine percent recovery.

**METHODOLOGY**

4-6

*Flow Rate, O<sub>2</sub>, CO<sub>2</sub>, NO<sub>x</sub>, and CO RATA Testing - USEPA Methods 3A, 7E, and 10; Performance Specifications 2, 3, and 4/4A*

Reference method flow rate measurements were determined from Type-S Pitot tube traverses per EPA Method 2 and PS 6. Reference method O<sub>2</sub> and CO<sub>2</sub> emissions were determined using a paramagnetic/NDIR CEMs analyzer per EPA Method 3A and Performance Specification 3. Reference method NO<sub>x</sub> emissions were determined using a chemiluminescent CEMs analyzer per EPA Method 7E and Performance Specification 2. Reference method CO emissions were determined using an infrared CEMs analyzer per EPA Method 10 and Performance Specification 4 or 4A.

The Method 3A/7E/10 sampling system consisted of a heated probe, heated filter and heated sample line. Flue gas was extracted at a constant rate at the points specified by the performance specification and delivered at 250°F to a gas conditioner which removed moisture. The flue gas was then delivered via a flow panel to an analyzer bank. Each analyzer measured concentration on a dry basis (units of %dv or ppm<sub>dv</sub>).

Calibration error checks were performed by introducing zero nitrogen (N<sub>2</sub>), high-range and mid-range calibration gases to the inlet of each analyzer during calibration error checks. Bias checks were performed before and after each sampling run by introducing calibration gas to the inlet of the sampling system's heated filter. Per M-3A, 7E and 10, the average results for each run were drift-corrected. Documentation of interference checks and NO<sub>2</sub> converter efficiency checks are included in Appendix D.

*General Considerations*

A verification of the absence of cyclonic flow was performed at the Hydrogen Plant Heater Stack on March 18 following Method 1 specifications. Documentation is included in Appendix E.

O<sub>2</sub> and CO<sub>2</sub> data for the non-instrumental (wet) sampling methods (used in molecular weight calculations and calculation of F<sub>d</sub>-based emissions) was obtained using a modified version of EPA Method 3B:

- Multi-point, integrated gas samples (IGS) were continuously collected at a constant rate from a slipstream of the exhaust of the sample trains into a flexible vinyl bag (IGS bag) per Method 3B specifications.
- A calibrated paramagnetic/IR analyzer was used in place of a traditional Orsat analyzer to measure O<sub>2</sub> and CO<sub>2</sub> concentrations of the IGS bags per Method 3A specifications.
- Documentation of preliminary instrument calibrations and post-analysis calibration checks are included in Appendix G.

**METHODOLOGY**

4-7

H<sub>2</sub>O data used for moisture correction of concentration data was obtained (when required) in the following manner during the test program:

- For Method 5/202, M-4 measurements are incorporated into the sampling and recovery procedures.
- For Draft ASTM CCM, a modified Method 4 measurement is incorporated into the sampling and recovery procedures.
  - Sample gas was extracted through a heated probe at a single point at least one (1) meter from the stack wall. Moisture stratification is not expected at test locations without free water droplets present in the flue gas.
  - Sample gas was extracted at a constant rate no greater than 0.75 cfm and at least 21 scf of flue gas was sampled.
  - After passing through the SAM condenser and filter, the sample gas was drawn through gum rubber tubing and into four (4) iced knock-out jars for moisture collection and measurement. The knock-out jars were arranged in a series and contain identical contents as the impinger train prescribed by Method 4, but with gum rubber connections and stainless-steel internal components.
- For Method 18 and M-25A, H<sub>2</sub>O data was obtained from concurrently-operated Method 5/202 trains.
- For RATA testing, H<sub>2</sub>O data was obtained from concurrently-operated Draft ASTM CCM trains or modified Method 4 trains.

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*End of Section 4 – Methodology*