FINAL REPORT

PACKAGING CORPORATION OF AMERICA

FILER CITY, MICHIGAN

2022 RELATIVE ACCURACY TEST AUDIT (RATA) TESTING: EUBOILER2, EUBOILER4A, AND EUBOILER5

RWDI #2201966

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EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) was retained by Packaging Corporation of America (PCA) to conduct a Relative Accuracy Testing Audit (RATA) at the PCA Filer City Mill location at 2246 Udell Street located in Filer City, Michigan. The RATA was completed from June 7th-9th, 2022, on EUBOILER2 and EUBOILER4A for Nitrogen Oxides (NO_x) and Oxygen (O_2), along with testing on EUBOILER5 for NO_x, O_2, and Carbon Monoxide (CO).

Summary of 2022 RATA

Parameter	EUBOILER2	EUBOILER4A	EUBOILER5
Oxides of Nitrogen (NO_x) Relative Accuracy	9.9%	3.5%	6.1%
Oxygen (O_2) Relative Accuracy	4.1%	3.0%	4.6%
Carbon Monoxide Relative Accuracy (ppmvd corrected to 3% O_2)	N/A	N/A	1.4%

The RATA is conducted annually and is a requirement under the facility permit to install (PTI) 209-18A. NO_x, CO, and O_2 measurements were collected using U.S. EPA Methods 7E, 10, and 3A under 40 CFR, Part 60 and Performance Specifications (PS) 2 and 4 stipulated in 40 CFR, Part 60.

The CEMS audited during this testing program include oxides of nitrogen (NO_X), carbon monoxide (CO), and oxygen (O_2). Data was collected for a minimum of nine 21-minute periods on each of the boilers.

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1 INTRODUCTION

RWDI USA LLC (RWDI) was retained by Packaging Corporation of America (PCA) to conduct a Relative Accuracy Testing Audit (RATA) at the PCA Filer City Mill location at 2246 Udell Street located in Filer City, Michigan. The RATA was completed from June 7th-9th, 2022, on EUBOILER2 and EUBOILER4A for Nitrogen Oxides (NO_x) and Oxygen (O_2), along with testing on EUBOILER5 for NO_x, O_2, and Carbon Monoxide (CO).

Table 1: Summary of Results

Parameter	EUBOILER2	EUBOILER4A	EUBOILER5
Oxides of Nitrogen Relative Accuracy (lb/MMBtu)	9.9%	3.5%	6.1%
Oxygen (O_2) Relative Accuracy	4.1%	3.0%	4.6%
Carbon Monoxide Relative Accuracy (ppmvd corrected to 3% O_2)	N/A	N/A	1.4%

The RATA is conducted annually and is a requirement under the facility permit to install (PTI) 209-18A. NO_x, CO, and O_2 measurements were collected using U.S. EPA Methods 7E, 10, and 3A under 40 CFR, Part 60 and Performance Specifications (PS) 2 and 4 stipulated in 40 CFR, Part 60.

The CEMS audited during this testing program include oxides of nitrogen (NO_x), carbon monoxide (CO), and oxygen (O_2). Data was collected for a minimum of nine 21-minute periods on each of the boilers.

Table 2: Test Personnel

Company	Position	Individual
RWDI	Project Supervisor	Brad Bergeron
RWDI	Senior Scientist	Mason Sakshaug
RWDI	Scientist	Hunter Griggs
PCA	Engineering Manager	Josh Kosmowski
PCA	Environmental Engineer	Zeb Jones
EGLE	Environmental Quality Analyst	Rob Dickman

2 PLANT AND SOURCE DESCRIPTION

2.1 Plant Overview

Boiler 2 – A maximum heat input rating of 186 MMBTU/hr and is equipped with low NO_x burners. The boiler was firing natural gas and/or biogas. Non-condensable gases (NCGs) from the low volume high, concentration (LVHC) system were primarily routed to Boiler 1 for destruction, with Boiler 2 and Boiler 4A as backup.

Boiler 4A – A natural gas and biogas fired Babcock and Wilcox Model Number FM120-97 boiler. The boilers maximum heat input rating is 227 MMBTU/hr and is equipped with low NO_x burners. NCGs from the LVHC system were primarily routed to Boiler 1 for destruction, with Boiler 2 and 4A as backup.

Boiler 5 – A bubbling fluidized bed (BFB) boiler with a heat input capacity of 302 MMBTU/hr. The boiler can burn wood, wood waste, primary clarifier residuals, paper recycling residuals, tire derived fuel (TDF), and natural gas.

2.2 Continuous Emission Monitors Specifications

The CEMS records data continuously and generates reports in compliance with 40 CFR Part 60 regulations. These reports were printed at the conclusion of each test. This data can be found in **Appendix A-C** for each boiler.

3 EUBOILER2, EUBOILER4A, AND EUBOILER5 OVERVIEW

	EUBOILER2	EUBOILER4A
Emission Unit Description [Including Process Equipment & Control Device(s)]	EUBOILER2 – 186 MMBTU/hr and EUBOILER4A – 227 MMBTU/hr.	
Parameter Tested	Oxygen and Nitrogen Oxides NO_x lb/MMBTU must be less than 20% RA	
Testing Monitoring Methods	EPA Method 3A and 7E	
	EUBOILER5	
Emission Unit Description [Including Process Equipment & Control Device(s)]	EUBOILER5 – 302 MMBTU/hr	
Parameter Tested	Oxygen, Nitrogen Oxides, and Carbon Monoxide NO_x lb/MMBTU must be less than 20% RA CO ppm @ 3% O_2 must be less than 5% when the applicable emission standard is used to calculate RA	
Testing Monitoring Methods	EPA Method 3A, 7E, and 10	

4 REFERENCE METHOD SAMPLING

The following section provides an overview of the sampling methodologies employed by the sampling program. The table below summarizes the reference methods used in this study.

Table 3: Summary of Sampling Methodologies

Parameter	Reference Method
RATA Methodology and Calculations	U.S EPA Performance Specifications 2 and 4
Oxides of Nitrogen	U.S. EPA Method 7E
Oxygen	U.S. EPA Method 3A
Carbon Monoxide	U.S. EPA Method 10
Nitrogen Oxide Emission Rates	U.S. EPA Method 19

4.1 Relative Accuracy Testing Audit

To satisfy the NO_x data accuracy requirement, the relative accuracy result for a minimum of nine performance test runs must meet the criteria outlined in section 8.4.4 of the US EPA PS 2 for NO_x. Performance Specification 4 will be followed for CO. A 21-minute period was used for each run. As per Performance Specification 2, traverse points were located at 16.7, 50.0, and 83.3 percent of the stack diameter. Each point was sample for 7 minutes in duration for each RATA run.

Prior to the RATA, a NO_2-to-NO conversion efficiency check was performed. The criteria of ≥ 90% was met for each daily check.

RWDI used a heated line over 250°F to avoid any condensation. All NO_x, CO, and O_2 data recorded was provided to EGLE.

4.1.1 Method Listing

The following test methods were used during the test program. These methods can be found in 40 CFR, Part 60, Appendix A and B.

- **Method 3A:** Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources.
- **Method 7E:** Determination of Nitrogen Oxides Emissions from Stationary Sources.
- **Method 10:** Determination of Carbon Monoxide Emissions from Stationary Sources.
- **Method 19:** Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates.
- **Performance Specification 2:** Specifications and Test Procedures for SO2 and NOx Continuous Emission Monitoring Systems in Stationary Sources.
- **Performance Specification 4:** Specifications and Test Procedures for CO Continuous Emission Monitoring Systems in Stationary Sources.

4.2 O_2 (EPA Method 3A), NOx (EPA Method 7E), and CO (EPA Method 10)

Zero and upscale calibration checks were conducted both before and after each test run to quantify measurement system calibration drift and sampling system bias. Upscale was either the mid- or high-range gas, whichever most closely approximates the flue gas level. During these checks, the calibration gases were introduced into the sampling system at the probe outlet so that the calibration gases are analyzed in the same manner as the flue gas samples.

A gas sample was continuously extracted from the stack and delivered to a series of gas analyzers, which measure the pollutant or diluent concentrations in the gas. The analyzers were calibrated on-site using EPA Protocol No. 1 certified calibration mixtures. The probe tip was equipped with a sintered stainless-steel filter for particulate removal. The end of the probe was connected to a heated Teflon sample line, which delivered the sample gases from the stack to the CEM system. The heated sample line was designed to maintain the gas temperature above 250°F to prevent condensation of stack gas moisture within the line.

Before entering the analyzers, the gas sample passed directly into a refrigerated condenser, which cools the gas to approximately 35°F to remove the stack gas moisture. After passing through the condenser, the dry gas enters a Teflon-head diaphragm pump and a flow control panel, which delivers the gas in series to the O_2, CO, and NO_x analyzers. Each of these analyzers measured the respective gas concentrations on a dry volumetric basis.

4.3 Gas Dilution (US EPA Method 205)

Calibration gas was mixed using an Environics 4040 Gas Dilution System. The mass flow controllers are factory calibrated using a primary flow standard traceable to the United States National Institute of Standards and Technology (NIST). Each flow controller utilizes an 11-point calibration table with linear interpolation, to increase accuracy and reduce flow controller nonlinearity. The calibration is done yearly, and the records are included in the Source Testing Report. A multi-point EPA Method 205 check was executed in the field prior to testing to ensure accurate gas-mixtures. The gas dilution system consisting of calibrated orifices or mass flow controllers and dilutes a high-level calibration gas to within ±2% of predicted values. The gas divider is capable of diluting gases at set increments and will be evaluated for accuracy in the field in accordance with US EPA Method 205 *"Verification of Gas Dilution Systems for Field Instrument Calibrations"*. The gas divider dilutions were measured to evaluate that the responses are within ±2% of predicted values. In addition, a certified mid-level calibration gas within ±10% of one of the tested dilution gases was introduced into an analyzer to ensure the response of the gas calibration is within ±2% of gas divider dilution concentration.

4.4 Nitrogen Oxides Emission Rate Calculation (EPA Methods 19)

4.4.1 Nitrogen Oxide Emission Rate Calculation

USEPA Method 19, "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates," was used to calculate a NO_x emission rate based on Oxygen concentrations and appropriate F-factors. Equation 19-1 from the method was used. Table 19-1 was used to determine the conversion factor for NO_x concentration ($1.194x10^{-7}$). Table 19-2 was used for the F-Factor (natural gas 8,710 dscf/10^6 BTU) on EUBOILER2. Due to the mixed fuels used in EUBOILER4A and EUBOILER5, the F-factor calculated by PCA based on a minute-by-minute fuel ratio was used in lieu of the Table 19-2 F-factor. These F-factors can be found in **Appendices B & C.**

$E = (1.194x10^{-7}) \times C_d \times F_d \times ((20.9/(20.9-\%O_{2d}))$

Where:

E = Pollutant Emission Rate (lb./10^6 BTU)
C_d = Pollutant Concentration, Dry Basis (ppm)
F_d = Fuel Factor, Dry Basis (dscf/10^6 BTU)
$\%O_{2d}$ = Oxygen Concentration, Dry Basis (%)

4.4.2 Carbon Monoxide Emission Rate Calculation

CO ppm levels were low on EUBOILER5. To meet the RATA for CO @ 3% O_2, RWDI used the applicable emission standard of 310 ppm @ 3% O_2 to calculate the RATA. Following PS 4, 13.2.

4.5 Quality Assurance and Quality Control Procedures

Quality assurance measures were implemented during the sampling program to ensure the integrity of the results. These measures included detailed documentation of field data, and equipment calibrations for all measured parameters.

Quality control procedures specific to the CEM monitoring included linearity checks, to determine the instrument performance, and reproducibility checks prior to its use in the field. Regular performance checks on the analyzers were also carried out during the testing program by performing zero and span calibration checks using EPA Protocol 1 gas standards. Sample system bias checks were also conducted. These checks were used to verify the ongoing precision of the monitor and sampling system over time. Pollutant-free (zero) air was introduced to perform the zero checks, followed by a known calibration (span) gas into the monitor. The response of the monitor to pollutant-free air and the corresponding sensitivity to the span gas were recorded regularly during the tests. Calibration certifications can be found in **Appendix D.** All field notes related to the testing can be found in **Appendix E.**

Per discussions on-site with EGLE representative Mr. Rob Dickman, during the testing of EUBOILER5 the CO span was set to a range much higher than the average concentration. From previously recorded data, high spikes were witnessed and expected during the testing. A higher range was used to ensure all data points were appropriately recorded.

5 RESULTS

The results for each boiler were within the limits.

6 BOILER OPERATING CONDITIONS

Operating conditions during the sampling were monitored by PCA personnel. Testing was performed while each of the boilers operated at greater than 50% load. Contact was kept between RWDI and boiler operators to ensure the boiler was running at all times during the testing.

TABLES

Table 4

Boiler 2 - RATA 2022 Results

Date: Tuesday, June 7, 2022

Test	RWDI Time		NOx				O_2				Emission Rate			Natural Gas
	Start Time	End Time	RM (dppm)	RM cor	CEMS (ppm)	di (ppm)	RM (d%)	RM (cor%)	CEMS (%)	di (%)	RM (lb/MMBTU	CEMS (lb/MMBTU)	di (lb/min)	(KSCFH)
1	8:49	9:09	52.12	53.69	53.1	0.59	8.61	8.68	8.5	0.2	0.0955	0.0930	0.0025	82.76
2	9:39	9:59	50.52	52.44	52.7	-0.26	8.87	8.87	8.5	0.3	0.0947	0.0930	0.0017	83.08
3	10:22	10:42	52.57	54.93	53.3	1.63	8.52	8.44	8.5	0.0	0.0958	0.0930	0.0028	82.80
4	11:17	11:37	56.70	59.70	53.2	6.50	8.16	8.07	8.4	-0.3	0.1011	0.0930	0.0081	83.33
5	11:53	12:13	56.08	59.62	53.0	6.62	8.23	8.14	8.4	-0.3	0.1016	0.0920	0.0096	83.30
6	12:27	12:47	57.51	60.52	53.1	7.42	8.17	8.08	8.4	-0.3	0.1026	0.0920	0.0106	83.21
7	12:58	13:18	57.92	60.53	53.2	7.33	8.20	8.12	8.4	-0.3	0.1029	0.0920	0.0109	83.18
8	13:30	13:50	57.54	59.74	52.9	6.84	8.15	8.12	8.4	-0.3	0.1016	0.0920	0.0096	82.99
9	14:01	14:21	56.96	58.18	53.1	5.08	8.19	8.18	8.4	-0.3	0.0994	0.0920	0.0074	82.89
10	**14:31**	**14:51**	**56.99**	**57.63**	**53.3**	**4.33**	**8.21**	**8.23**	**8.5**	**-0.2**	**0.0989**	**0.0930**	**0.0059**	**82.74**
	AVERAGE		--	57.70	53.07	4.64	--	8.3	8.4	-0.1	0.0995	0.0924	0.0070	83.06
	STDS		--	3.15	0.18	3.10	--	0.29	0.04	0.25	0.00326	0.00053	0.00368	--
	n		9				9				9			
	Full Scale		89.8				21				-			
	$t_{0.975}$		2.306				2.306				2.306			
	I d I		4.64				0.14				0.0070			
	I cc I		2.38				0.20				0.0028			
	Bias present? (Idl > Iccl)		**bias present**				**no bias**				**bias present**			
	Bias Factor		**1.09**				**0.98**				**1.08**			
	Relative Accuracy (20% limit)		**12.2%**				**4.1%**				**9.9%**			

Notes:

RM = Reference Method (RWDI measurements)
CEMS = Continuous Emission Monitor System (PCA data)
di = Difference between CEMS and RM for each point
n = number of tests
I d I = Absolute mean difference between the CEMS and RM results
Bolded test runs were not used in the RA calculation

Table 5

Boiler 4 - RATA 2022 Results

Date: Wednesday, June 08, 2022

Test	RWDI Time		NOx				O_2				Emission Rate			Natural Gas
	Start Time	End Time	RM (dppm)	RM cor	CEMS (ppm)	di (ppm)	RM (d%)	RM (cor%)	CEMS (%)	di (%)	RM (lb/MMBTU	CEMS (lb/MMBTU)	di (lb/min)	(KSCFH)
1	8:02	8:22	63.84	65.52	63.3	2.22	6.35	6.30	6.4	-0.1	0.0988	0.0960	0.0028	97
2	**8:40**	**9:00**	**61.98**	**64.15**	**61.8**	**2.35**	**6.22**	**6.17**	**6.3**	**-0.1**	**0.0959**	**0.0930**	**0.0029**	**91**
3	9:12	9:32	63.22	65.30	62.7	2.60	6.26	6.22	6.4	-0.2	0.0979	0.0950	0.0029	95
4	9:50	10:10	65.00	67.26	63.8	3.46	6.09	6.06	6.3	-0.2	0.0996	0.0960	0.0036	101
5	10:25	10:45	65.96	68.18	65.2	2.98	6.21	6.17	6.4	-0.2	0.1016	0.0980	0.0036	118
6	10:58	11:18	65.33	67.61	65.1	2.51	6.03	5.99	6.1	-0.1	0.0995	0.0970	0.0025	126
7	11:31	11:51	65.00	67.23	64.5	2.73	5.91	5.86	6.1	-0.2	0.0981	0.0960	0.0021	122
8	12:08	12:28	65.84	68.09	65.7	2.39	5.98	5.93	6.0	-0.1	0.0999	0.0970	0.0029	128
9	12:40	13:00	66.81	69.27	65.7	3.57	5.92	5.86	6.0	-0.2	0.1011	0.0970	0.0041	128
10	13:10	13:30	66.30	68.89	66.1	2.79	6.01	5.94	6.0	-0.1	0.1011	0.0980	0.0031	125
11	13:43	14:03	**67.14**	**69.88**	**66.2**	**3.68**	**5.99**	**5.92**	**6.1**	**-0.2**	**0.1024**	**0.0980**	**0.0044**	**130**
12	0:00	0:00												
		AVERAGE	--	67.48	64.68	2.81	--	6.0	6.2	-0.1	0.0997	0.0967	0.0030	116
		STDS	--	1.36	1.18	0.46	--	0.16	0.17	0.05	0.00134	0.00100	0.00062	--
		n	9				9				9			
		Full Scale	200				21				-			
		$t_{0.975}$	2.306				2.306				2.306			
		I d I	2.81				0.15				0.0030			
		I cc I	0.35				0.03				0.0005			
		Bias present? (Idl > Iccl)	**bias present**				**bias present**				**bias present**			
		Bias Factor	**1.04**				**0.98**				**1.03**			
		Relative Accuracy (20% limit)	**4.7%**				**3.0%**				**3.5%**			

Notes:

RM = Reference Method (RWDI measurements)
PEMS = Predictive Emission Monitors (DRP data)
di = Difference between PEMS and RM for each point
n = number of tests
I d I = Absolute mean difference between the PEMS and RM results
For measurements less than 20 ppm the difference must be < 2 ppm for NO_x and < 1 % for O_2

Table 6

*Boiler 5 - RATA 2022 R*esults

Date: Thursday, June 9, 2022

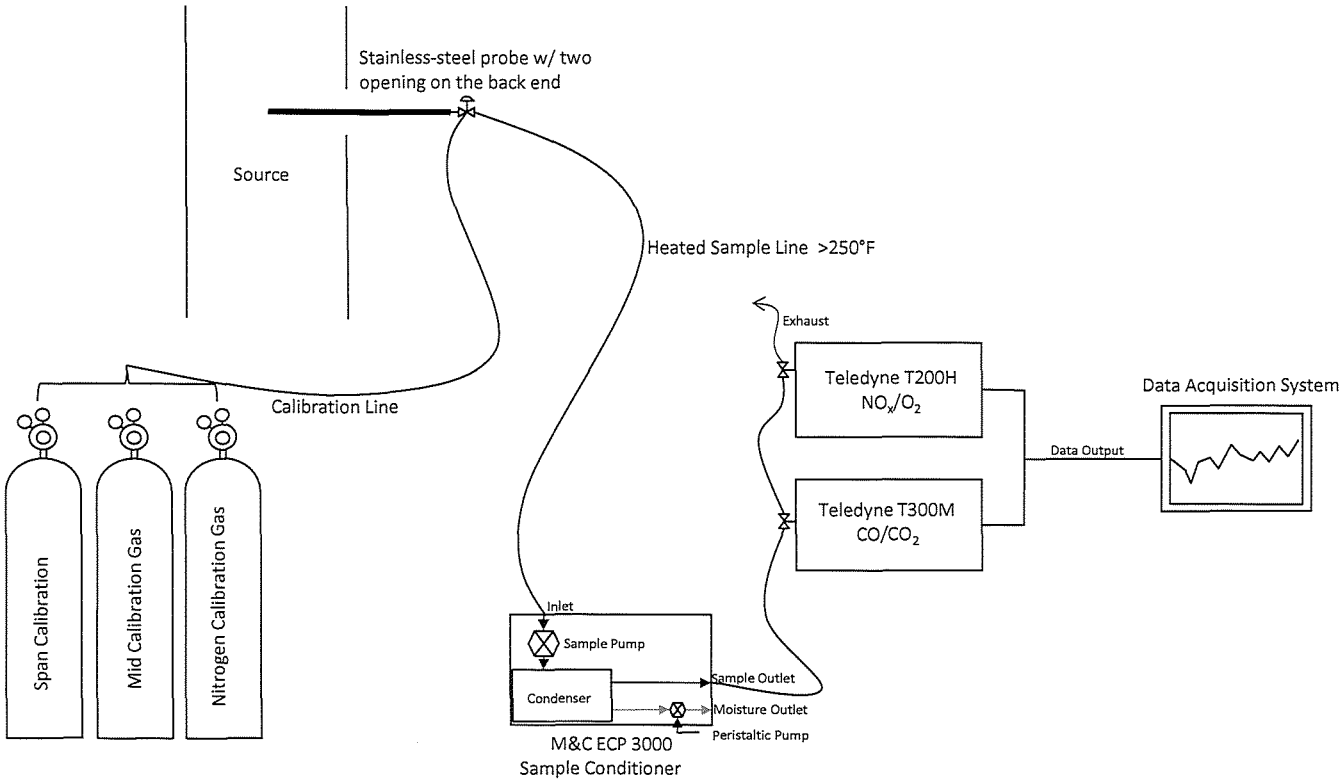
Test	RWDI Time		NOx				O_2				CO					Nox Emission Rate			Heat Input
	Start Time	End Time	RM (dppm)	RM cor	CEMS (ppm)	di (ppm)	RM (d%)	RM (cor%)	CEMS (%)	di (%)	RM (dppm)	RM cor	RM 3% O2	CEM 3% O2	di (dppm)	RM (lb/MMBTU	CEMS (lb/MMBTU)	di (lb/min)	(MMBtu/hr)
1	8:36	8:56	106.22	107.80	105.7	2.10	**8.22**	**8.15**	**7.7**	**0.5**	3.20	4.2	5.9	8.9	3.01	0.1999	0.1890	0.0109	170
2	9:16	9:36	104.66	106.46	102.1	4.36	8.13	8.08	7.8	0.2	**1.67**	**2.6**	**3.7**	**8.3**	**4.61**	0.1964	0.1850	0.0114	169
3	9:50	10:10	**108.58**	**110.30**	**106.6**	**3.70**	**8.12**	**8.16**	**7.7**	**0.4**	**4.15**	**5.6**	**7.8**	**10.7**	**2.88**	**0.2048**	**0.1920**	**0.0128**	**169**
4	10:23	10:43	109.95	111.53	107.6	3.93	8.08	8.13	7.8	0.3	2.44	3.8	5.3	9.4	4.07	0.2066	0.1940	0.0126	169
5	10:56	11:16	**107.93**	**110.10**	**105.5**	**4.60**	**7.73**	**7.75**	**7.5**	**0.3**	**3.46**	**4.7**	**6.4**	**10.6**	**4.22**	**0.1982**	**0.1860**	**0.0122**	**172**
6	11:37	11:57	108.39	110.95	106.8	4.15	7.68	7.71	7.4	0.3	3.26	4.4	5.9	9.8	3.86	0.1990	0.1870	0.0120	172
7	12:12	12:32	109.82	112.17	108.2	3.97	7.57	7.63	7.3	0.4	3.50	4.2	5.7	10.2	4.54	0.2001	0.1880	0.0121	172
8	12:43	13:03	107.04	108.59	104.8	3.79	7.80	7.86	7.5	0.4	2.98	3.9	5.4	9.9	4.53	0.1970	0.1850	0.0120	172
9	13:15	13:35	109.77	111.57	108.3	3.27	7.68	7.72	7.4	0.3	2.91	3.9	5.2	9.4	4.15	0.2003	0.1900	0.0103	172
10	14:13	14:33	107.15	108.43	104.6	3.83	7.68	7.72	7.4	0.3	3.45	4.4	6.0	10.2	4.16	0.1946	0.1830	0.0116	172
11	14:44	15:04	106.04	107.38	103.5	3.88	7.70	7.74	7.4	0.3	3.23	4.1	5.6	9.9	4.31	0.1931	0.1820	0.0111	172
12	15:17	15:37	**109.71**	**112.29**	**107.5**	**4.79**	7.45	7.49	7.1	0.3	3.73	4.5	6.1	10.5	4.45	**0.1982**	**0.1850**	**0.0132**	**172**
		AVERAGE	–	109.43	105.7	3.70	–	7.8	7.5	0.3		4.16	5.68	9.80	4.12	0.1986	0.1870	0.0116	171
		STDS	–	2.13	2.17	0.67	–	0.21	0.22	0.04		0.26	0.31	0.49	0.47	0.00395	0.00374	0.00070	–
		n	9				9				9					9			
		Full Scale	200				21				500					-			
		$t_{0.975}$	2.306				2.306				2.306					2.306			
		l d l	3.70				0.33				4.12					0.0116			
		l cc l	0.51				0.03				0.36					0.0005			
		Bias present? (ldl > lccl)	**bias present**				**bias present**				**bias present**					**bias present**			
		Bias Factor	**1.03**				**1.04**									**1.06**			
		Relative Accuracy (20% limit)	**3.8%**				**4.6%**				**1.4%**					**6.1%**			

Notes:

RM = Reference Method (RWDI measurements)
PEMS = Predictive Emission Monitors (DRP data)
di = Difference between PEMS and RM for each point
n = number of tests
l d l = Absolute mean difference between the PEMS and RM results
For measurements less than 20 ppm the difference must be < 2 ppm for NO_x and < 1 % for O_2

FIGURE

Figure No. 1: USEPA Method 3A,7E,10 Schematic



USEPA Method 3A,7E,10

Packaging Corporation of America

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Project# 2201966

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