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Relative Accuracy Test
Audit Test Report

Carbon Green BioEnergy, LLC
Woodbury Facility
Thermal Oxidizer Stack (C10)
Lake Odessa, Michigan
Project No. M243706
September 12, 2024

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Relative Accuracy Test Audit
Test Report

Carbon Green BioEnergy, LLC
Woodbury Facility
Thermal Oxidizer Stack (C10)
Lake Odessa, Michigan
September 12, 2024

Report Submittal Date
September 30, 2024

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Project No. M243706

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1.0 EXECUTIVE SUMMARY

Mostardi Platt conducted a Continuous Emissions Monitoring System (CEMS) Relative Accuracy Test Audit (RATA) test program for Carbon Green BioEnergy, LLC at the Woodbury Facility in Lake Odessa, Michigan, on the Thermal Oxidizer Stack (C10) on September 12, 2024. This report summarizes the results of the test program and test methods.

The test location, test date, and test parameters are summarized below.

TEST INFORMATION		
Test Location	**Test Date**	**Test Parameters**
Thermal Oxidizer Stack (C10)	September 12, 2024	Oxygen (O_2) and Nitrogen Oxides (NO_X)

The purpose of the test program was to demonstrate the relative accuracies of the Thermal Oxidizer Stack (C10) O_2 and NO_X analyzers during the specified operating condition. The test results from this test program indicate that each CEMS meets the United States Environmental Protection Agency (USEPA) annual performance specification for relative accuracy as published in 40 Code of Federal Regulations Part 60 (40CFR60).

RATA RESULTS					
Test Location	**Date**	**Parameter**	**Units**	**Relative Accuracy Acceptance Criteria**	**Relative Accuracy (RA)**
Thermal Oxidizer Stack (C10)	9/12/24	NO_X	lb/mmBtu	≤ 20.0% of the mean reference value	1.81%
		NO_X	ppmvd	≤ 20.0% of the mean reference value	1.28%
		NO_X	lb/hr	≤ 20.0% of the mean reference value	1.63%
		O_2	% dry	≤ 20.0% of the mean reference value	2.84%

The gas cylinders used to perform the RATA are summarized below.

GAS CYLINDER INFORMATION				
Parameter	**Gas Vendor**	**Cylinder Serial Number**	**Cylinder Value**	**Expiration Date**
NO_X	Airgas	CC426016	0.0 ppm	6/11/2032
NO_X	Airgas	AAL072995	73.71 ppm	2/9/2032
NO_X	Airgas	SG9170599BAL	124.1 ppm	4/5/2030
O_2	Airgas	AAL072995	0.0 %	2/9/2032
O_2	Airgas	CC426016	11.95 %	6/11/2032
O_2	Airgas	CC357302	22.10 %	5/28/2032

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The identification of individuals associated with the test program is summarized below.

TEST PERSONNEL INFORMATION		
Location	**Address**	**Contact**
Test Facility	Carbon Green BioEnergy, LLC 7795 Saddlebag Lake Road Lake Odessa, Michigan 48849	Edward Thomas (616) 374-3635 (phone) (517) 712-9034 (fax) ethomas@cgbioenergy.com
Testing Company Supervisor	Mostardi Platt 888 Industrial Drive Elmhurst, Illinois 60126	Christopher C. Yarman Project Manager 630-993-2100 (phone) cyarman@mp-mail.com
Testing Company Personnel		August Woywod Test Technician

2.0 TEST METHODOLOGY

Emission testing was conducted following the United States Environmental Protection Agency (USEPA) methods specified in 40CFR60, Appendix A in addition the Mostardi Platt Quality Manual. Schematics of the test section diagram and sampling train used are included in Appendix A and B respectively. Calculation nomenclature are included in Appendix C. Copies of analyzer print-outs for each test run are included in Appendix D. CEM data and process data as provided by Carbon Green BioEnergy, LLC are also included in Appendix E.

The following methodologies were used during the test program:

Method 3A Oxygen (O_2) Determination

Stack gas O_2 concentrations and emission rates were determined in accordance with USEPA Method 3A. A California Analytical Instruments 700 LX analyzer was were used to determine the O_2 concentrations in the manner specified in the Method. The instrument has a paramagnetic detector and the O_2 operates in the nominal range of 0% to 25% with the specific range determined by the high-level calibration gas of 22.10%. High-range calibrations were performed using USEPA Protocol gas. Zero nitrogen (a low ppm pollutant in balance nitrogen calibration gases) was introduced during other instrument calibrations to check instrument zero. High- and a mid-range % O_2 levels in balance nitrogen were also introduced. Zero and mid-range calibrations were performed using USEPA Protocol gas after each test run. Copies of the gas cylinder certifications are found in Appendix G. This testing met the performance specifications as outlined in the Method.

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Method 7E Nitrogen Oxide (NO_X) Determination

Stack gas NO_X concentrations and emission rates were determined in accordance with USEPA Method 7E, 40CFR60, Appendix A. A California Analytical Instruments 700 LX Chemiluminescence Nitrogen Oxides Analyzer was used to determine nitrogen oxides concentrations, in the manner specified in the Method. The instrument operated in the nominal range of 0 ppm to 200 ppm with the specific range determined by the high-level span calibration gas of 124.1 ppm.

The Model 700 LX operates on the principle that nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. Specifically,

$$NO+O_3 \rightarrow NO_2+O_2+hv$$

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a stainless steel NO_2-to-NO converter heated to about 589°C. The flue gas sample is drawn into the Model 700 LX through the sample bulkhead. The sample flows through a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO_2-to-NO converter and then to the reaction chamber (NO_X mode). A flow sensor prior to the reaction chamber measures the sample flow. Dry air enters the Model 700 LX through the dry air bulkhead, passes through a flow switch, and then through a silent discharge ozonator. The ozonator generates the ozone needed for the chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO_2 molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence generated during this reaction. From the reaction chamber, the exhaust travels through the ozone (O_3) converter to the pump, and is released through the vent.

The NO and NO_X concentrations calculated in the NO and NO_X modes are stored in memory. The difference between the concentrations is used to calculate the NO_2 concentration. The Model 700 LX outputs NO, NO_2, and NO_X concentrations to the front panel display, the analog outputs, and also makes the data available over the serial or ethernet connection.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 250°F. Excess moisture in the stack gas was removed using a refrigerated condenser. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run. This testing met the performance specifications as outlined in the Method.

A list of calibration gases used and the results of all calibration and other required quality assurance checks are found in Appendix F. Copies of the gas cylinder certifications are found in Appendix G. The NO_2 to NO converter test can be found in Appendix H. This testing met the performance specifications as outlined in the Method.

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3.0 TEST RESULT SUMMARIES

Client: Carbon Green Bioenergy, LLC
Facility: Woodbury Facility
Project #: M243706
Fuel Type: Natural Gas

Location: Thermal Oxidizer Stack (C10)
Date: 9/12/24
Test Method: 7E, 3A
Fuel Factor: 8710

O2 based NOx lb/mmBtu RATA

CEM Analyzer Information

NO_x Monitor/Model:	Thermo 42iQLS	**NO_x Serial # :**	12129913717
O2 Monitor/Model:	Thermo 42iQLS	**O2 Serial # :**	12129913717

1=accept 0=reject	Test Run	Test Date	Start Time	End Time	RM NO_x lb/MMBtu	CEM NO_x lb/MMBtu	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	09/12/24	09:40	10:00	0.086	0.084	0.002	0.000004
1	2	09/12/24	10:08	10:28	0.085	0.084	0.001	0.000001
1	3	09/12/24	10:37	10:57	0.085	0.084	0.001	0.000001
1	4	09/12/24	11:06	11:26	0.085	0.083	0.002	0.000004
1	5	09/12/24	11:35	11:55	0.085	0.083	0.002	0.000004
1	6	09/12/24	12:03	12:23	0.085	0.086	-0.001	0.000001
1	7	09/12/24	12:30	12:50	0.085	0.086	-0.001	0.000001
0	8	09/12/24	12:58	13:18	0.084	0.087	-0.003	0.000009
1	9	09/12/24	13:27	13:47	0.085	0.087	-0.002	0.000004
1	10	09/12/24	13:55	14:15	0.085	0.087	-0.002	0.000004

n	**9**	
t(0.025)	**2.306**	
Mean Reference Method Value	**0.085**	**RM avg**
Mean CEM Value	**0.085**	**CEM avg**
Sum of Differences	**0.002**	**di**
Mean Difference	**0.000**	**d**
Sum of Differences Squared	**0.000**	**di^2**
Standard Deviation	**0.002**	**sd**
Confidence Coefficient 2.5% Error (1-tail)	**0.001**	**cc**
Relative Accuracy	**1.81**	**RA**

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Client: Carbon Green Bioenergy, LLC
Facility: Woodbury Facility
Project #: M243706

Location: Thermal Oxidizer Stack (C10)
Date: 9/12/24
Test Method: 7E

NO_x ppmvd RATA

CEM Analyzer Information

NO_x Monitor/Model:			Thermo 42iQLS		NO_x Serial # :		12129913717	
1=accept 0=reject	Test Run	Test Date	Start Time	End Time	RM NO_x ppmvd	CEM NO_x ppmvd	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	09/12/24	09:40	10:00	64.7	63.8	0.9	0.81
1	2	09/12/24	10:08	10:28	64.7	64.1	0.6	0.36
1	3	09/12/24	10:37	10:57	65.4	64.2	1.2	1.44
0	4	09/12/24	11:06	11:26	64.6	63.2	1.4	1.96
1	5	09/12/24	11:35	11:55	64.6	63.3	1.3	1.69
1	6	09/12/24	12:03	12:23	64.9	65.0	-0.1	0.01
1	7	09/12/24	12:30	12:50	64.9	65.0	-0.1	0.01
1	8	09/12/24	12:58	13:18	64.4	65.6	-1.2	1.44
1	9	09/12/24	13:27	13:47	64.5	65.6	-1.1	1.21
1	10	09/12/24	13:55	14:15	64.7	65.4	-0.7	0.49
				n	9			
				t(0.975)	2.306			
				Mean Reference Method Value	64.756		RM avg	
				Mean CEM Value	64.667		CEM avg	
				Sum of Differences	0.800		di	
				Mean Difference	0.089		d	
				Sum of Differences Squared	7.460		di^2	
				Standard Deviation	0.961		sd	
				Confidence Coefficient 2.5% Error (1-tail)	0.739		cc	
				Relative Accuracy	1.28		RA	

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Client: Carbon Green Bioenergy, LLC **Location:** Thermal Oxidizer Stack (C10)
Facility: Woodbury Facility **Date:** 9/12/24
Project #: M243706 **Test Method:** 7E, 2

NO_x lb/hr RATA

CEM Analyzer Information

NO_x Monitor/Model:		Thermo 42iQLS			NO_x Serial # :		12129913717	
1=accept 0=reject	Test Run	Test Date	Start Time	End Time	RM NO_x lb/hr	CEM NO_x lb/hr	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	09/12/24	09:40	10:00	7.37	7.23	0.14	0.0196
1	2	09/12/24	10:08	10:28	7.44	7.37	0.07	0.0049
1	3	09/12/24	10:37	10:57	7.46	7.33	0.13	0.0169
1	4	09/12/24	11:06	11:26	7.41	7.26	0.15	0.0225
1	5	09/12/24	11:35	11:55	7.32	7.18	0.14	0.0196
1	6	09/12/24	12:03	12:23	7.40	7.48	-0.08	0.0064
1	7	09/12/24	12:30	12:50	7.36	7.45	-0.09	0.0081
0	8	09/12/24	12:58	13:18	7.28	7.51	-0.23	0.0529
1	9	09/12/24	13:27	13:47	7.34	7.53	-0.19	0.0361
1	10	09/12/24	13:55	14:15	7.33	7.50	-0.17	0.0289
				n	9			
				t(0.975)	2.306			
				Mean Reference Method Value	7.381		RM avg	
				Mean CEM Value	7.370		CEM avg	
				Sum of Differences	0.100		di	
				Mean Difference	0.011		d	
				Sum of Differences Squared	0.163		di^2	
				Standard Deviation	0.142		sd	
				Confidence Coefficient 2.5% Error (1-tail)	0.109		cc	
				Relative Accuracy	1.63		RA	

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Client: Carbon Green Bioenergy, LLC **Location:** Thermal Oxidizer Stack (C10)
Facility: Woodbury Facility **Date:** 9/12/24
Project #: M243706 **Test Method:** 3A

O_2 % (dry) RATA

CEM Analyzer Information

O_2 Monitor/Model:			Thermo 42iQLS		O_2 Serial # :		12129913717	
1=accept 0=reject	Test Run	Test Date	Start Time	End Time	RM O_2 % (dry)	CEM O_2 % (dry)	(RM-CEM) Difference (di)	(RM-CEM) Difference^2 (di^2)
1	1	09/12/24	09:40	10:00	4.5	4.4	0.1	0.01
1	2	09/12/24	10:08	10:28	4.3	4.3	0.0	0.00
1	3	09/12/24	10:37	10:57	4.3	4.4	-0.1	0.01
1	4	09/12/24	11:06	11:26	4.3	4.3	0.0	0.00
1	5	09/12/24	11:35	11:55	4.3	4.4	-0.1	0.01
1	6	09/12/24	12:03	12:23	4.3	4.4	-0.1	0.01
1	7	09/12/24	12:30	12:50	4.3	4.5	-0.2	0.04
0	8	09/12/24	12:58	13:18	4.3	4.5	-0.2	0.04
1	9	09/12/24	13:27	13:47	4.4	4.4	0.0	0.00
1	10	09/12/24	13:55	14:15	4.4	4.5	-0.1	0.01
				n	9			
				t(0.025)	2.306			
				Mean Reference Method Value	4.344		RM avg	
				Mean CEM Value	4.400		CEM avg	
				Sum of Differences	-0.500		di	
				Mean Difference	-0.056		d	
				Sum of Differences Squared	0.090		di^2	
				Standard Deviation	0.088		sd	
				Confidence Coefficient 2.5% Error (1-tail)	0.068		cc	
				Relative Accuracy	2.84		RA	

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4.0 CERTIFICATION

Mostardi Platt is pleased to have been of service to Carbon Green BioEnergy, LLC. If you have any questions regarding this test report, please do not hesitate to contact us at 630-993-2100.

As the program manager, I hereby certify that this test report represents a true and accurate summary of emissions test results and the methodologies employed to obtain those results. The test program was performed in accordance with the test methods and the Mostardi Platt Quality Manual, as applicable.

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Christopher C. Yarman — Program Manager

Jeffrey M. Crivlare — Quality Assurance

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APPENDICES

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Appendix A - Test Section Diagram

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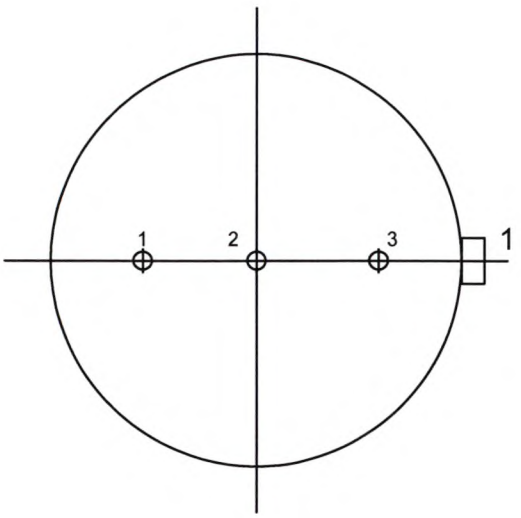
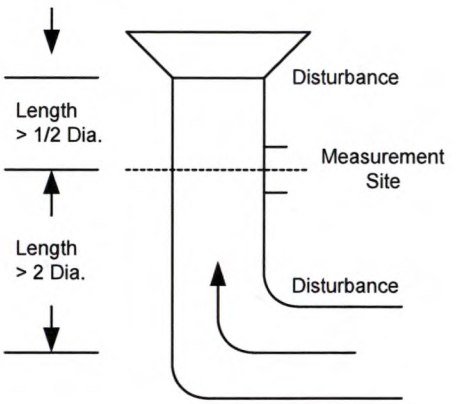
GASEOUS TRAVERSE FOR ROUND DUCTS





Job: Carbon Green BioEnergy, LLC
Woodbury, Illinois

Date: September 12, 2024

Test Location: Thermal Oxidizer Stack (C10)

Stack Diameter (Feet): 6.0

Stack Area (Square Feet): 28.27

No. Sample Points: 3

No of Ports: 1

Port Length (Inches): 8.0

Distance from inside wall
at port to traverse point:

1. 5.0 Feet (83.3 % of diameter)
2. 3.0 Feet (50.0 % of diameter)
3. 1.0 Feet (16.7 % of diameter)

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Appendix B - Sample Train Diagram

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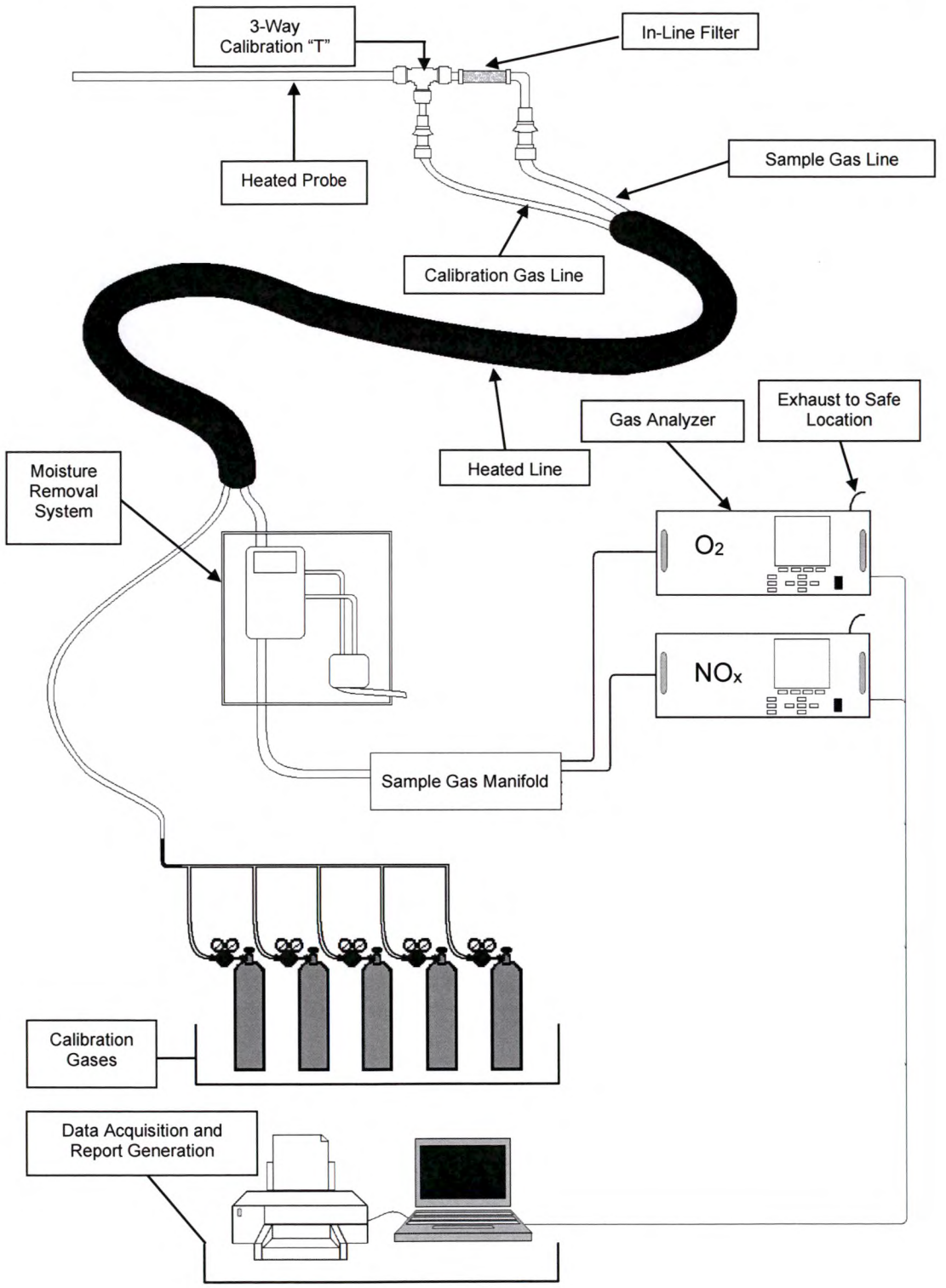
USEPA Methods 3A and 7E Extractive Gaseous Sampling Diagram



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