

Chrysler Group, LLC. - SHAP
38111 Van Dyke
Sterling Heights, Michigan 48312

Report

Performed Velocity, Moisture, Temperature, Volumetric Flow Rate,
Nitrogen Oxide, Oxygen, Carbon Dioxide, Volatile Organic Compounds and
Carbon Monoxide Emissions Testing

Sampling performed on the Cummins Model GTA28CC Engine Outlet

Sterling Heights, MI

Test Date: 11/27/13

12/27/2013

X *Brian E. Lemasters*

Signed by: customstack

Brian E. Lemasters
Custom Stack Analysis, LLC.

REPORT CERTIFICATION

Custom Stack Analysis, LLC. has used its professional experience and best professional efforts in performing this compliance test. I have reviewed the results of these tests and to the best of my knowledge and belief they are true and correct.

12/27/2013

X *Brian E. Lemasters*

Signed by: customstack
Brian E. Lemasters

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EXECUTIVE SUMMARY

Custom Stack Analysis, LLC. conducted emissions sampling using USEPA Methods 1-4, 7E, 10 and 25A. Testing was conducted on the Cummins Model GTA28CC Engine Outlet on November 27th, 2013 for compliance purposes. The Custom Stack Analysis, LLC. test crew consisted of Mr. Aaron Wervey and Mr. Brian Lemasters. The testing procedures were coordinated by Mr. Fred Klemm and Ms. Elizabeth Hoover of Cummins Bridgeway, LLC. and Mr. Adekunle Sanni, Ms. Sandra Walker and Mr. Nick Chlaub of Chrysler Group, LLC. – SHAP. All testing procedures were witnessed by Mr. Thomas Maza of the Michigan Department of Environmental Quality Air Quality Division.

Pollutant	Emission Limitations	Test Result Average	Compliance Demonstrated
Nitrogen Oxide	2.0 g/bhp-hr 160 ppm @ 15% O ²	0.28 g/bhp-hr 21.57 ppm @ 15% O ²	Yes Yes
Volatile Organic Compounds	1.0 g/bhp-hr 86 ppm @ 15% O ²	0.28 g/bhp-hr 19.96 ppm @ 15% O ²	Yes Yes
Carbon Monoxide	4.0 g/bhp-hr 540 ppm @ 15% O ²	1.51 g/bhp-hr 175.97 ppm @ 15% O ²	Yes Yes

Mr. Thomas Maza of the Michigan Department of Environmental Quality Air Quality Division advised that it was not necessary to determine the methane content as the total VOC concentration was well below the allowable limit and to report the emissions as VOC.

A description of the testing protocol is included on pages 3-6. All testing calculations are located on pages 12-17. Appendix 1 includes field test data. Appendix 2 contains laboratory data from Custom Stack Analysis, LLC. Appendix 3 contains calibration data for the equipment used on test day. Appendix 4 contains monitoring data. Appendix 5 contains process data. Test results are located on page 2.

Test Results

Chrysler Group, LLC. SHAP - Cummins Model GTA28CC Outlet
11/27/2013

	<u>Run #1</u>	<u>Run #2</u>	<u>Run #3</u>	<u>Avg.</u>
Stack Gas Velocity (ft/sec)	212.87	210.99	87.57	170.48
Standard Cubic Feet an Hour	68,900	67,949	27,233	54,694
Actual Cubic Feet per Minute	3,918	3,884	1,612	3,138
Moisture %	16.82%	17.58%	18.07%	17.49%
Carbon Dioxide %	18.00%	18.00%	18.00%	18.00%
Oxygen %	1.78%	1.78%	1.56%	1.71%
Nitrogen %	80.22%	80.22%	80.44%	80.29%
CO (ppm)	550.66	631.63	534.33	572.21
CO (ppm @ 15%)	169.91	194.94	163.05	175.97
CO (lbs/hr)	2.75	3.12	1.06	2.31
CO (tons/yr)	12.06	13.65	4.63	10.11
CO (g/hp-hr)	1.80	2.03	0.69	1.51
CO (lbs/Meg-hr)	6.16	6.97	2.36	5.17
Nox (ppm)	60.96	63.62	86.04	70.21
Nox (ppm @ 15%)	18.81	19.64	26.26	21.57
Nox (lbs/hr)	0.50	0.52	0.28	0.43
Nox (tons/yr)	2.20	2.26	1.23	1.89
Nox (g/hp-hr)	0.33	0.34	0.18	0.28
Nox (lbs/Meg-hr)	1.12	1.15	0.63	0.97
VOC* (total ppm)	74.08	71.65	48.86	64.86
VOC* (methane ppm)	0.00	0.00	0.00	0.00
VOC** (ppm)	74.08	71.65	48.86	64.86
VOC** (ppm @ 15%)	22.86	22.11	14.91	19.96
VOC** (lbs/hr Carbon)	0.40	0.38	0.10	0.29
VOC** (tons/yr)	1.74	1.64	0.45	1.28
VOC** (g/hp-hr)	0.38	0.36	0.10	0.28
VOC** (lbs/Meg-hr)	0.89	0.84	0.23	0.65
Operating Engine Horsepower	696	696	696	696
Max Engine Horsepower	701	701	701	701
Load %	99.33%	99.33%	99.33%	99.33%
Megawatt	0.4470	0.4470	0.4470	0.4470

METHOD 1

Sample and velocity traverses for stationary sources.

To aid in the representative measurement of pollutant emissions and/ or total volumetric flow rate from a stationary source, a measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. A traverse point is then located within each of these equal areas.

METHOD 2

Determination of stack gas velocity and volumetric flow rate.

The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Stausscheibe or reverse type) pitot tube.

METHOD 3

Gas analysis for the determination of dry molecular weight.

This method is applicable for determining carbon dioxide and oxygen concentrations and dry molecular weight of a sample from a gas stream of a fossil-fuel combustion process.

METHOD 4

Determination of moisture content in stack gases.

A gas sample is extracted at a constant rate from the source. It is determined either volumetrically or gravimetrically.

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METHOD 7E TESTING DESCRIPTION

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A gas sample is continuously extracted from the stack, and a portion of the sample is conveyed to an instrumental analyzer for determination of NO_x gas concentration using a chemiluminescence analyzer. The gases pass through a heated sampling probe and filter to prevent condensation. The gases then pass through a calibration valve to a heated sampling line. After the heated sampling line is a condenser for moisture removal. The sample is then passed through to a Thermo Environmental Instruments Model 42 chemiluminescence analyzer where the gases are analyzed for NO_x concentrations. Before the testing procedures commence the analyzer is left to warm up for a 90 minute period. It is then calibrated according to Method 7E specifications. To the extent practicable, the measured emissions should be between 20 to 100 percent of the selected calibration span. Three calibration gases are selected. The High-Level gas concentrations shall be equivalent to 20 to 100 percent of the calibration span. Mid-Level concentrations shall be equivalent to 40 to 60 percent of the calibration span. The Low-Level Gas concentrations of less than 20 percent of the span. Before the first run an analyzer calibration error check is conducted. If the low-level, mid, or high cal gases expected concentrations differ by more than $\pm 2\%$ of the span then the procedure needs to be repeated until an acceptable 3 point calibration is obtained. After the analyzer calibration check the upscale and low level calibration gases are introduced to the sampling calibration valve and recorded. System bias calibration must be within 5.0% of the analyzer calibration span for low-scale and upscale calibration gases. At the conclusion of each of the test runs the low-level gas and an upscale gas closest to the concentrations are introduced to the calibration valve assembly. If either the low-level or upscale value exceeds $\pm 3\%$ of the span, then the run is considered invalid.

METHOD 10 TESTING DESCRIPTION

A gas sample is continuously extracted from the stack, and a portion of the sample is conveyed to an instrumental analyzer for determination of CO gas concentration using a Luft-type nondispersive infrared analyzer. The gases pass through a heated sampling probe and filter to prevent condensation. The gases then pass through a calibration valve to a heated sampling line. After the heated sampling line is a Universal Analyzers Model 530 air cooled single sample thermoelectric water condenser with a peristolic pump for moisture removal. The sample is then passed through an ascarite tube to a Thermo Environmental Instruments Model 48 Luft-type analyzer where the gases are analyzed for CO concentrations. Before the testing procedures commence the analyzer is left to warm up for a 90 minute period. It is then calibrated according to Method 7E specifications. To the extent practicable, the measured emissions should be between 20 to 100 percent of the selected calibration span. Three calibration gases are selected.

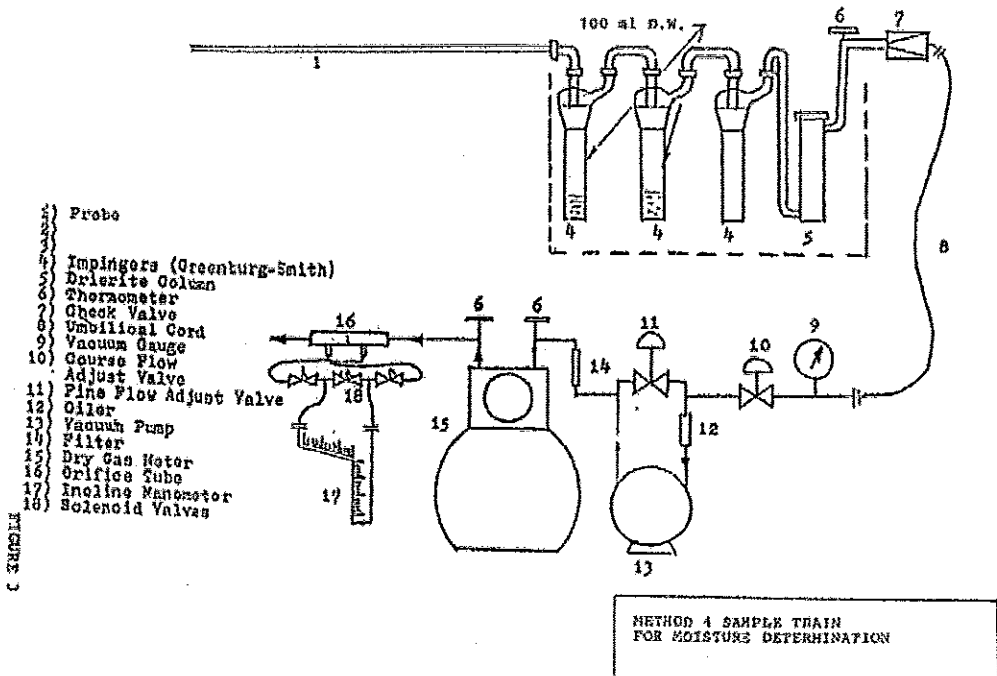
The High-Level gas concentrations shall be equivalent to 20 to 100 percent of the calibration span. Mid-Level concentrations shall be equivalent to 40 to 60 percent of the calibration span. The Low-Level Gas concentrations of less than 20 percent of the span.

Before the first run an analyzer calibration error check is conducted. If the low-level, mid, or high cal gases expected concentrations differ by more than $\pm 2\%$ of the span then the procedure needs to be repeated until an acceptable 3 point calibration is obtained. After the analyzer calibration check the upscale and low level calibration gases are introduced to the sampling calibration valve and recorded. System bias calibration must be within 5.0% of the analyzer calibration span for low-scale and upscale calibration gases. At the conclusion of each of the test runs the low-level gas and an upscale gas closest to the concentrations are introduced to the calibration valve assembly. If either the low-level or upscale value exceeds $\pm 3\%$ of the span, then the run is considered invalid.

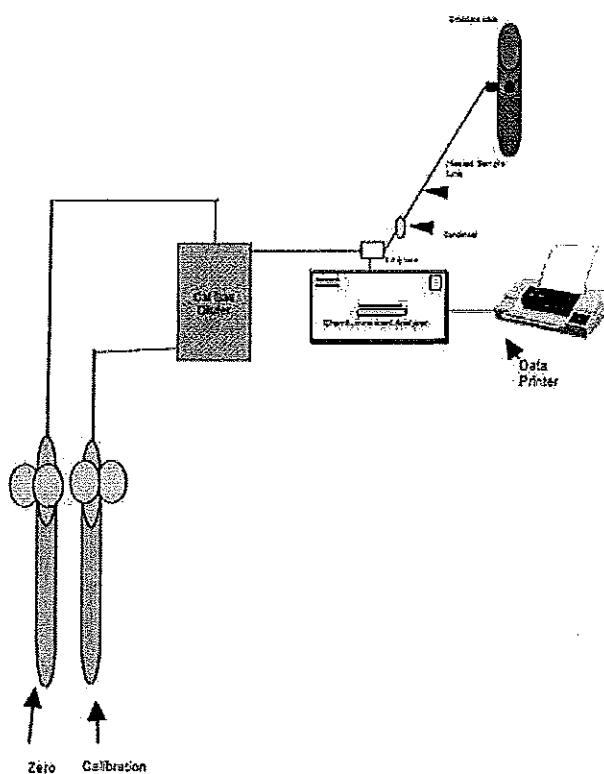
METHOD 25A TESTING DESCRIPTION

This method will be used to measure the total VOC concentration expressed in terms of ppm propane. A gas sample is extracted from the source through a stainless steel probe, through a heated sample line (teflon), to a flame ionization analyzer. The main components of Method 25A are the same as Method 204B with the exception of a non heated sample probe.

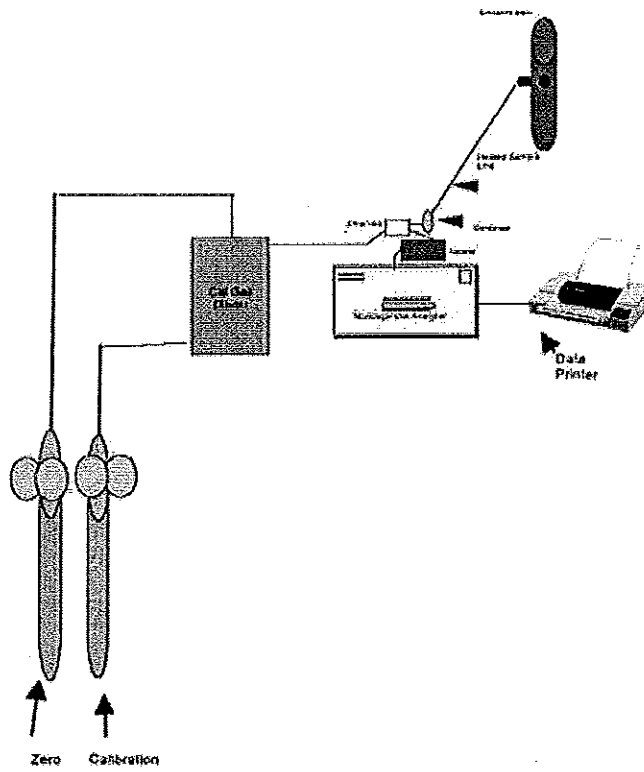
The sampling system is heated up to the proper operating temperature. Within two hours of the start of the test the FIA is calibrated. The calibration range or span is selected to be from 1.5 to 2.5 times the expected concentration. Three calibration ranges are then selected as follows: Low level 25-35% of the span, Mid level 45-55% of the span, and a High level 80-90% of the span. A zero and a high level calibration gas is then injected at the valve assembly and the FIA is adjusted to these levels. Then all four gases are introduced into the analyzer and recorded. If the responses are within 5% of the expected values then the analyzer is responding correctly. The sample probe is located in the center of the stack and sealed in place and the test is started. The test lasts for 60 minutes. At the end of the test run a drift check is run. The zero gas and the mid level calibration gas is injected at the valve assembly. The analyzer responses are then recorded. The drift check is acceptable if the results are within 3% of the span value. These checks are performed before and after each test run.



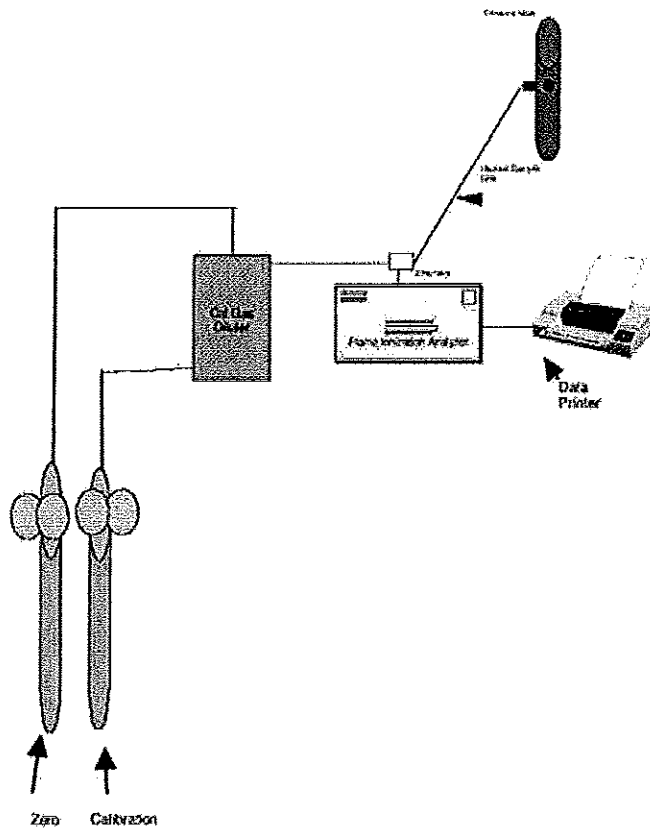
7E Sampling System



10 Sampling System



25A Sampling System

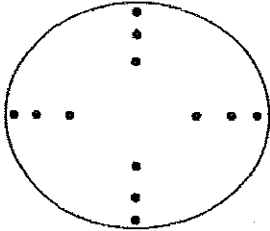


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Location of Sampling Points



Location:	Cummins Model	Engine Outlet	
	GTA28CC		
Upstream		12"	
Downstream		18"	
Stack Diameter		7.5"	Inches
Sample Point #			
	1	0.33	Inches
	2	1.1	
	3	2.22	
	4	5.28	
	5	6.41	
	6	7.17	

CALCULATIONS

Outlet

		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	
1.	Vm (std)	44.14	43.31	44.58	=

$$VM * 17.64 * \frac{PBAR + 13.6}{Tm} * Y$$

		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>
Vm (std)	= Volume of gas collected, corrected to standard conditions, cuft.	44.14	43.31	44.58
Vm	= Volume of gas sampled at meter box, cuft.	45.23	44.68	46.18
17.64	= Standard temperature, 528 Rankine / std pressure, 29.92.	17.64	17.64	17.64
Tm	= Average dry gas meter temperature, + 460 Rankine.	530.75	534.25	536.54167
Pbar	= Barometric pressure, inches of mercury (Hg)	29.29	29.29	29.29
^H	= Average pressure differential across orifice.	1.8504	1.8504	1.8504
13.6	= Specific gravity of mercury.	13.6	13.6	13.6
Y	= Callbration factor of meter box.	0.9978	0.9978	0.9978

		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	
2.	Vw (std)	8.93	9.24	9.83	=

$$Vlc * \frac{P H20}{Mh20} * \frac{R Tstd}{Pstd} = K2 * Vlc$$

		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>
Vlc	= Volume of water and silica collected.	189.4	196.1	208.6
P H20	= Density of water, 0.002201 lb/ml.	0.002201	0.002201	0.002201
M H20	= Molecular weight of water, 18.01 lb/lb-mole.	18.01	18.01	18.01
R	= Ideal gas constant, 21.85 in. hg - ft ³ /R-lb-mole.	21.85	21.85	21.85
Tstd	= Standard absolute temperature, 528 R.	528	528	528
Pstd	= Standard absolute pressure, 29.92 in. Hg.	29.92	29.92	29.92
K2	= 0.0471 ft ³ / ml.	0.0471	0.0471	0.0471

		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	
3.	Bws	0.16819	0.17583	0.18066	=

$$\frac{Vw(std)}{Vm(std) + Vw(std)}$$

		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>
Bws	= Water vapor in the gas stream, proportion.	0.16819	0.17583	0.18066
Vw(std)	= Volume of water vapor in the gas sample, scf.	8.93	9.24	9.83
Vm(std)	= Volume of gas sampled at meter box, scf.	44.14	43.31	44.58

	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>			<u>Tstd</u>	<u>Ps</u>	
8	SCFH	68900	67949	27233	=	$3600 * (1 - Bws) * Vs * A * \frac{Tstd}{Ts} * \frac{Ps}{Pstd}$		
						<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>
	3600	=	Seconds per hour.	=		3600	3600	3600
	Bws	=	Water vapor in the gas stream, proportion.	=		0.1681851	0.1758327	0.1806611
	A	=	Area of stack in sq ft.	=		0.31	0.31	0.31
	Tstd	=	Standard absolute temperature, 528 R.	=		528	528	528
	Pstd	=	Standard absolute pressure, 29.92 in. Hg.	=		29.92	29.92	29.92
	Ts	=	Temperature of stack gas, + 460 (Rankine).			1468.74	1462	1505
	Ps	=	Absolute stack gas pressure, barometric + static.			29.29	29.29	29.29
	Vs	=	Average stack gas velocity, ft / sec.			212.87	210.99	87.57

CALCULATIONS

		<u>VOC</u>										
		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>								
1.	Lbs/Hr Propane	0.48582	0.45914	0.12475	=	0.11443 * SCFH * PPM * 10 ⁻⁶						
	scfh	=	Standard stack volumetric flow rate.		=	<table border="0" style="width: 100%;"> <tr> <td style="width: 33%;"><u>RUN #1</u></td> <td style="width: 33%;"><u>RUN #2</u></td> <td style="width: 33%;"><u>RUN #3</u></td> </tr> <tr> <td style="text-align: center;">68900</td> <td style="text-align: center;">67949</td> <td style="text-align: center;">27233</td> </tr> </table>	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	68900	67949	27233
<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>										
68900	67949	27233										
	PPM	=	PPM		=	<table border="0" style="width: 100%;"> <tr> <td style="width: 33%; text-align: center;">61.62</td> <td style="width: 33%; text-align: center;">59.05</td> <td style="width: 33%; text-align: center;">40.03</td> </tr> </table>	61.62	59.05	40.03			
61.62	59.05	40.03										
2.	Lbs/Hr Carbon	0.39716	0.37534	0.10198	=	0.031182 * SCFH * PPM * 3 * 10 ⁻⁶						
	scfh	=	Standard stack volumetric flow rate.		=	<table border="0" style="width: 100%;"> <tr> <td style="width: 33%;"><u>RUN #1</u></td> <td style="width: 33%;"><u>RUN #2</u></td> <td style="width: 33%;"><u>RUN #3</u></td> </tr> <tr> <td style="text-align: center;">68900</td> <td style="text-align: center;">67949</td> <td style="text-align: center;">27233</td> </tr> </table>	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	68900	67949	27233
<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>										
68900	67949	27233										
	PPM	=	PPM		=	<table border="0" style="width: 100%;"> <tr> <td style="width: 33%; text-align: center;">61.62</td> <td style="width: 33%; text-align: center;">59.05</td> <td style="width: 33%; text-align: center;">40.03</td> </tr> </table>	61.62	59.05	40.03			
61.62	59.05	40.03										
	3	=	Carbon equivalent correction factor for propane.		=	<table border="0" style="width: 100%;"> <tr> <td style="width: 33%; text-align: center;">3</td> <td style="width: 33%; text-align: center;">3</td> <td style="width: 33%; text-align: center;">3</td> </tr> </table>	3	3	3			
3	3	3										
3.	PPM @ 15% O ₂	19.01	18.22	12.21	=	PPM * 5.9 / (20.9 - O ₂)						
	O ₂	=	Oxygen		=	<table border="0" style="width: 100%;"> <tr> <td style="width: 33%;"><u>RUN #1</u></td> <td style="width: 33%;"><u>RUN #2</u></td> <td style="width: 33%;"><u>RUN #3</u></td> </tr> <tr> <td style="text-align: center;">1.78</td> <td style="text-align: center;">1.78</td> <td style="text-align: center;">1.56</td> </tr> </table>	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	1.78	1.78	1.56
<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>										
1.78	1.78	1.56										
	PPM	=	PPM		=	<table border="0" style="width: 100%;"> <tr> <td style="width: 33%; text-align: center;">61.62</td> <td style="width: 33%; text-align: center;">59.05</td> <td style="width: 33%; text-align: center;">40.03</td> </tr> </table>	61.62	59.05	40.03			
61.62	59.05	40.03										

CALCULATIONS

NOX

		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>					
1.	Lbs/Hr	0.50151	0.51619	0.27978	=	1.194 * SCFH * PPM * 10 ⁻⁷			
	scfh	=	Standard stack volumetric flow rate.			=	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>
						68900	67949	27233	
	PPM	=	PPM corrected			=	60.96	63.62	86.04
		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>					
2.	PPM Corr.	60.96	63.62	86.04	=	$C_{gas} = (C - C_o) \frac{C_{ma}}{C_m - C_o}$			
	Co	=	Average of initial and final system calibration bias check responses for the zero gas, ppm.			=	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>
						1.27	0.72	0.6	
	C	=	Effluent gas concentration, dry basis, ppm.			=	60.53	63.1	84.36
	Cm	=	Average of initial and final system calibration bias check responses for the upscale gas, ppm.			=	43.75	43.565	43.14
	Cma	=	Actual concentration of the upscale calibration gas, ppm.			=	43.7	43.7	43.7
		<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>					
3.	PPM @ 15% O2	18.81	19.64	26.26	=	PPM * 5.9 / (20.9 - O2)			
	O2	=	Oxygen			=	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>
						1.7794549	1.78	1.56	
	PPM	=	PPM			=	60.961911	63.624834	86.044006

CALCULATIONS

CO

1	Lbs/Hr	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	=	.726 * SCFH * PPM * 10 ⁻⁷	
	scfh	=	Standard stack volumetric flow rate.			=	<u>RUN #1</u> <u>RUN #2</u> <u>RUN #3</u> 68900 67949 27233
	PPM	=	PPM			=	550.66 631.63 534.33

2	PPM Corr.	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	=	$C_{gas} = (C - C_o) \frac{C_{ma}}{C_m - C_o}$
		550.655	631.63	534.33		

	Co	=	Average of initial and final system calibration bias check responses for the zero gas			=	<u>RUN #1</u> <u>RUN #2</u> <u>RUN #3</u> 0.185 0.245 0.12
	C	=	Effluent gas concentration, dry basis,			=	551.83 630.31 533.2
	Cm	=	Average of initial and final system calibration bias check responses for the upscale			=	471.13 469.18 469.12
	Cma	=	Actual concentration of the upscale calibration gas, ppm.			=	470.1 470.1 470.1

3	PPM @ 15% O2	<u>RUN #1</u>	<u>RUN #2</u>	<u>RUN #3</u>	=	PPM * 5.9 / (20.9 - O2)	
	O2	=	Oxygen			=	<u>RUN #1</u> <u>RUN #2</u> <u>RUN #3</u> 1.7795 1.78 1.56
	PPM	=	PPM			=	550.66 631.63 534.33