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New Technology Research & Development Program
Grant Contract 582-5-70807-0006

Task 3 Deliverable Report

The preparation of this report is based on work funded in part
by the State of Texas through a Grant from the
Texas Commission on Environmental Quality.

♠CES

CARNOT EMISSION SERVICES
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  - Analysis
- Development
  - Testing
  - Durability
  - Mapping
  - Emissions

Emissions

- Research
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- Compliance

Services

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- Consulting

June 21, 2007

Steve Yager
Assistant Division Director
Railroad Commission of Texas
6506 Bolm Rd.
Austin, TX 78721
Email: steve.yager@rrc.state.tx.us

Subject: **Project Number 236B Final Report, "Testing of an LPG Fueled Industrial Engine and an Aftermarket Emissions Control System"**

Dear Mr. Yager:

Project Number 236B has been completed and this constitutes the final report for the program. Thank you for the opportunity to perform this work for you at Carnot Emission Services (CES).

The program entailed procuring an older, high-hour, LPG fueled industrial engine. The engine received was a GM 4.3L V6 with an undetermined amount hours. A replacement Woodward Governor mixer, regulator and pressure lock-off were added to the base engine, and ultimately integrated with a new Engine Control Systems control module and catalyst. Testing was performed in several stages to determine baseline emissions and performance of an aged catalyst and O2 sensor on tailpipe emissions.

PROGRAM HISTORY

A GM 4.3L V6 engine was obtained with an unknown amount of hours of engine service. The engine was removed from service due to coolant leaks. Upon receiving the engine it was necessary to perform mechanical repairs to bring the engine into testable condition. Rebuilt cylinder heads and head gaskets were required and these repairs were performed at CES.

The engine was installed in a transient test cell having, full-flow dilute emission sample capabilities that meet 40 CFR 1048 and 1065 LSI LPG engine testing. The test cell setup is shown in Figure 1 with the catalyst and emissions control equipment installed.

The engine was tested over three D2 steady state cycles and three LSI transient cycles in the "as found" condition, with no cayalyst or emission control equipment. The test cycles are shown in Appendix A. A TermiNOx electronic control system provided by Engine Control Systems was installed, which consisted of an electronic control module, wiring harness, and pneumatic actuator (see Figure 2). An

aged O2 sensor and an aged 3-way stoichiometric catalyst were also part of the system (Figure 3).

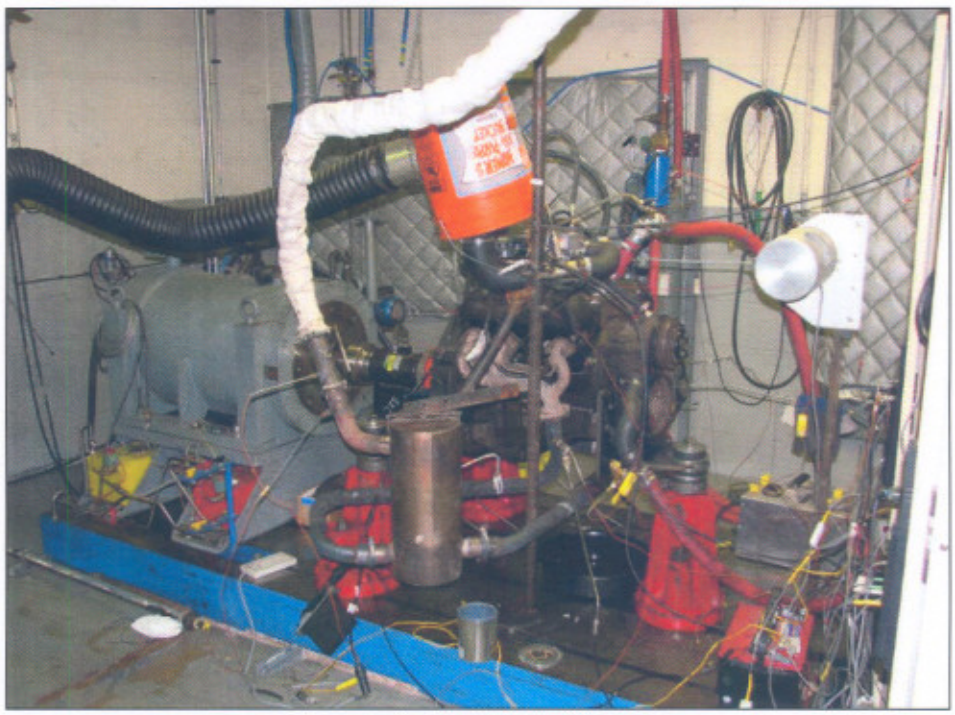


Figure 1. Test Cell Setup of GM 4.3L V6

With the emissions equipment installed, one D2 cycle was performed. Two partial D2 tests were performed over the most heavily weighted modes – 2 (25%), 3 (30%) and 4 (30%). Three additional LSI transient tests were also performed with the TermiNOx system installed.

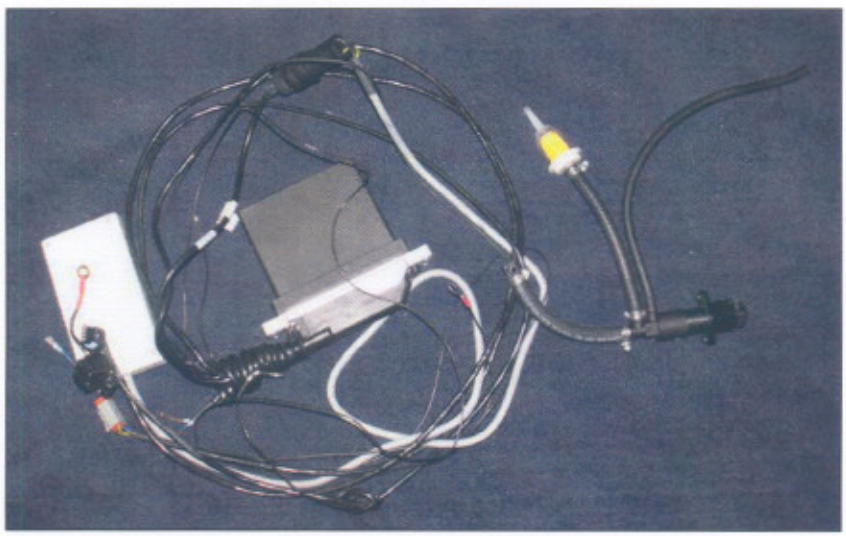


Figure 2. ECM, Wiring Harness, and Pneumatic Actuator

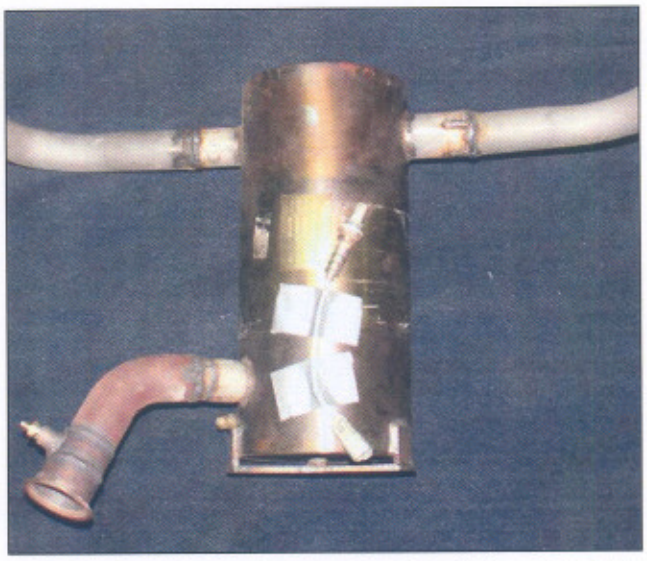


Figure 3. Oxygen Sensor and Catalyzed Muffler

The changes made with the TermiNOx system included the replacement of the mixer diaphragm valve with an IMPCO AV1-14-3 silicon valve. The Engine Control Systems program code values were set for Case #3. Table 1 shows the tests performed on each configuration.

Table 1. Summary of Hardware and Tests

HARDWARE	TESTS
As Found	Three Steady-State D2 Three Transient LSI
Aged Catalyst and Sensor with TermiNOx system	Three Steady-State D2 Three Transient LSI

PROGRAM RESULTS

In working with the ECS system, there were only two adjustments consisting of an idle and rated fuel air mixture adjustment screws. Several engine operating points, not listed in Table 1, were checked to properly set the adjustment screws.

Emission results are provided in Table 2. For multiple similar tests, the average and coefficient of variation (COV) were calculated. The COV is an indication of repeatability and is defined as a single standard deviation divided by the average and multiplied by 100 percent.

The engine in its "as found" condition had slightly varied NOx emissions over both the steady state and the transient cycle. Brake specific NOx (BSNOx) emissions ranged from 16.14 to 16.61 g/(kW-hr) for the D2 tests and 7.42 to 10.89 g/(kW-hr) for

the LSI transient tests. The average brake specific CO (BSCO) for the "as found" D2 tests was 29.73 g/(kW-hr) and 30.19 g/(kW-hr) for the "as found" transient tests.

The transient emission results with the "aged catalyst and aged O2 sensor" show lowered BSNOx numbers ranging from 2.81 to 4.54 g/(kW-hr), with a COV of 23.33%. The average BSCO results were 3.34 g/(kW-hr). Comparing the average transient results of the aged catalyst and O2 sensor to the "as found" condition, the ECS system reduced 66.5% of BSNOx emissions with a 3.3% reduction in fuel consumption. These results are summarized in Table 3. The steady state D2 results with a catalyst also show lowered BSNOx ranging from 4.70 to 5.35 g/(kW-hr) over the three tests, with a COV of 6.50%. These results are summarized in Table 4. The processed emission data sheets are included in Appendix B.

Table 2. Emission Results

Name	Date	Test	EMISSIONS [g/(kW-hr)]					BSFC [kg/(kW-hr)]
			BSCO	BSCO2	BSHC	BSNOx	BS(THC+Nox)	
As Found								
T1B 1R1	6/08/2007	D2	32.03	843.9	2.36	16.39	18.75	0.301
T1B 1R2	6/08/2007	D2	27.44	836.6	2.36	16.61	18.97	0.296
T1B 1R3	6/08/2007	D2	30.72	836.1	2.49	16.14	18.63	0.298
		Average	29.73	840.2	2.36	16.50	18.86	0.299
		COV	7.87	0.52	3.07	1.43	0.92	0.82
NI1718 T1B_1R1	6/11/2007	LSI	28.84	805.4	2.29	7.42	9.71	0.287
NI1719 T1B_1R2	6/11/2007	LSI	30.33	807.1	2.30	10.89	13.20	0.288
NI1720 T1B_1R3	6/11/2007	LSI	31.41	807.4	2.31	10.23	12.53	0.289
		Average	30.19	806.7	2.30	9.51	11.81	0.288
		COV	4.27	0.14	0.49	19.36	15.69	0.36
With TermiNOx and aged catalyst/o2 sensor								
T2B 1R1	6/13/2007	D2	0.72	821.9	0.04	5.35	5.40	0.275
T2B 1R2	6/13/2007	D2	0.83	818.1	0.06	5.09	5.15	0.274
T2B 1R3	6/13/2007	D2	.73	824.1	0.03	4.47	4.50	0.276
		Average	0.80	851.0	0.05	5.05	5.10	0.285
		COV	9.48	6.32	22.15	6.50	6.50	6.32
NI1722 T2B_1R1	6/13/2007	LSI	2.84	828.0	0.23	2.81	3.05	0.278
NI1723 T2B_1R2	6/13/2007	LSI	3.37	827.8	0.19	4.00	4.19	0.279
NI1724 T2B_1R3	6/13/2007	LSI	3.84	824.7	0.15	4.54	4.68	0.278
		Average	3.35	826.9	0.19	3.78	3.97	0.278
		COV	15.06	0.22	23.00	23.33	21.13	0.16

COV = (one standard deviation/average) x 100%

Table 3. Emission Change over Transient LSI Testing

LSI Transient Emissions		As Found	With TermiNOx System	Percent Change
BSCO	g/(kW-hr)	30.19	3.35	88.9
BSCO2	g/(kW-hr)	806.7	826.9	-2.5
BSHC	g/(kW-hr)	2.30	0.19	91.7
BSNOx	g/(kW-hr)	9.51	3.78	60.2
BS(THC+NOx)	g/(kW-hr)	11.81	3.97	66.4
BSFC	kg/(kW-hr)	0.288	0.278	3.3

Table 4. Emission Change over D2 Testing

LSI Transient Emissions		As Found	With TermiNOx System	Percent Change
BSCO	g/(kW-hr)	30.06	0.80	97.3
BSCO2	g/(kW-hr)	838.86	851.01	-1.4
BSHC	g/(kW-hr)	2.40	0.05	98.1
BSNOx	g/(kW-hr)	16.38	5.05	69.2
BS(THC+NOx)	g/(kW-hr)	18.79	5.10	72.9
BSFC	kg/(kW-hr)	.299	0.285	4.6

The first LSI transient test and the first D2 test will be used for verification of results. Both the LSI transient and the D2 test meet the reduction goals in emissions as determined for this test.

COMMENTS

The performance of the ECS system was sensitive to the two adjustment screws related to idle and rated fuel air mixture ratios. Substantial NOx and CO emission reductions were demonstrated with the ECS TermiNOx system utilizing an aged catalyst and O2 sensor. With the installation of a properly calibrated TermiNOx system it was possible to meet the emissions targets as required for this project.

CLOSURE

This report and emissions results are provided on the enclosed CD-ROM. It was a pleasure to work with the Texas Railroad Commission on this program. If there are any questions, please contact us at 210-928-1724 or by email. We look forward to working with you in the future.

Approved by:

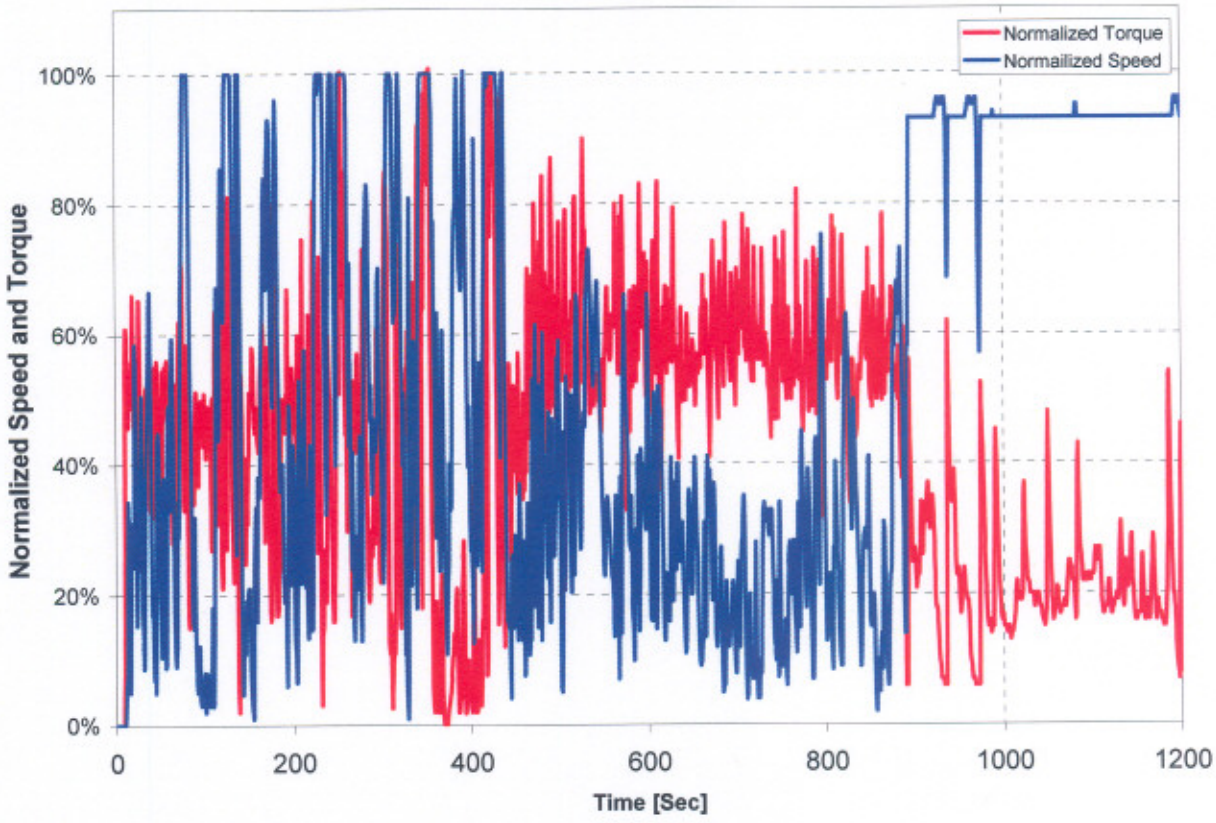
Steve E. Griffin
CEO
sgriffin@sore-aces.com

Sincerely yours,

Bradley Denton
Test Engineer
bdenton@sore-aces.com

Appendix A:

Test Cycles and Power Curve

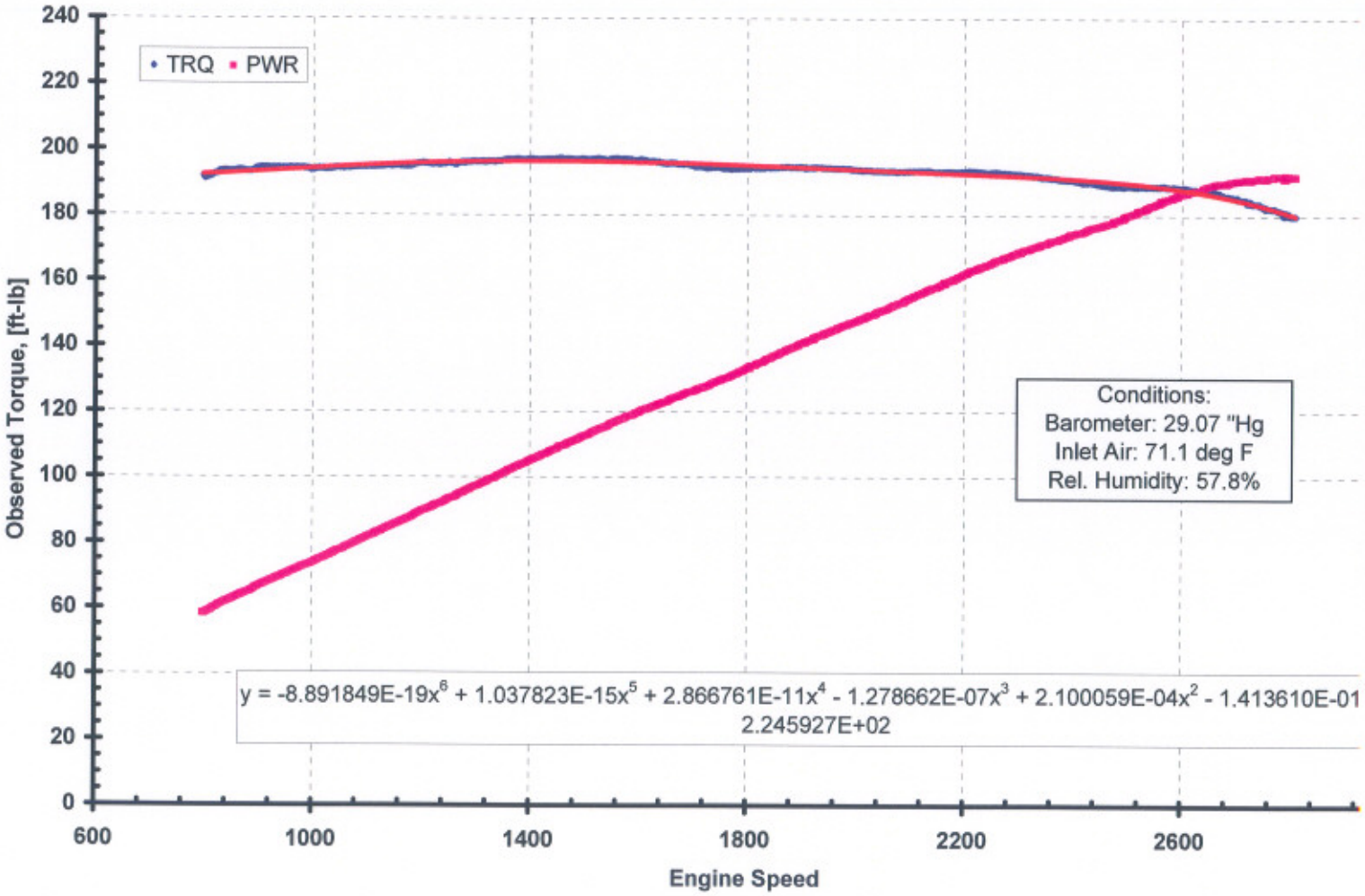


Composite Transient Test Cycle

Test Cycle	Mode Weighting Factors from B-Type ISO 8178 Test Cycle										
	1	2	3	4	5	6	7	8	9	10	11
Torque, %	100	75	50	25	10	100	75	50	25	10	0
Speed Set	Rated Speed (2600 rpm)					Intermediate Speed (1800 rpm)					Low Idle
D2 - LSI	--	--	--	--	--	0.05	0.25	0.30	0.30	0.10	--

ISO 8178 B-Type Emission Test Cycle – D2 Cycle

Texas Railroad Commission GM 4.3L V6 LPG
Base Engine As Found WOT Power Lug Curve



NI1714 TRC GM 4_3L NewEng PwrCr / LPG PwrLug CRV

Proprietary Information
of
Woodward Industrial Controls

Appendix B:

Emissions Data Sheets

CARNOT EMISSION SERVICES

EPA/CARB (ISO 8178 D2) EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TX RR Comm.		Fuel ID:	LPG	Test Cell/Stand:	4	
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/08/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Quaker State SAE 10W30	Start Test:	14:08:34	
Emission Ctrl System:	mixer				Test No:	T1B_3r1	
Rated/Idle Speed:	2800	800	Note:	D2 LPG Test	Engine Hrs. Since Rcvd/Dur:	2.50	1.08

	TARGET			MEASURED				FUEL	INLET AIR CONDITIONS			TEST FACTORS			
	Speed	Load	Torque	Time	Speed	Torque	Torque	FLOW	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]	[% Target]	[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
1	1800	100	193.6	120.0	1803	193.60	0.00	25.98	82.3	61.7	29.167	0.958	1.046	12.05	1.028
2	1800	75	145.2	120.0	1802	143.39	-1.25	22.24	83.4	63.1	29.170	0.965	1.037	12.69	1.031
3	1800	50	96.8	120.0	1802	95.34	-1.51	16.11	82.7	62.0	29.170	0.976	1.050	12.16	1.029
4	1800	25	48.4	120.0	1801	47.75	-1.35	9.98	81.1	60.0	29.168	0.979	1.021	11.33	1.026
5	1800	10	19.4	120.0	1800	19.59	1.20	6.74	79.5	57.2	29.163	0.968	0.991	10.23	1.022

	BHP	DILUTE SAMPLE EMISSIONS					DILUTION	PDP	DILUTE SAMPLE MASS FLOW				
	from Work	CO	CO2	HC	NOx	PM	RATIO	FLOW	CO	CO2	HC	NOx	PM
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]	[mg]		[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
1	66.47	2137.59	3.28	85.6	475.7	0.000	3.29	322.4	1363.1	32862.2	85.96	498.22	#DIV/0!
2	49.21	1851.61	2.76	75.4	538.1	0.000	3.90	327.4	1198.7	28064.8	76.85	572.24	#DIV/0!
3	32.70	1083.55	1.99	55.8	424.3	0.000	5.45	333.3	714.2	20572.8	57.88	459.42	#DIV/0!
4	16.37	869.27	1.76	48.8	303.3	0.000	6.17	234.2	402.5	12808.9	35.60	230.70	#DIV/0!
5	6.72	1784.21	2.53	93.4	114.8	0.000	4.23	107.6	379.8	8462.3	31.29	40.15	#DIV/0!

	WEIGHT	WEIGHTED SAMPLE MASS FLOW					WEIGHTED
	FACTOR	CO	CO2	HC	NOx	PM	POWER
MODE		[g/hr]	[g/hr]	[g/hr]	[g/hr]	[g/hr]	[hp]
1	0.05	68.15	1643.1	4.30	24.91	#DIV/0!	3.32
2	0.25	299.68	7016.2	19.21	143.06	#DIV/0!	12.30
3	0.30	214.27	6171.8	17.36	137.83	#DIV/0!	9.81
4	0.30	120.76	3842.7	10.68	69.21	#DIV/0!	4.91
5	0.10	37.98	846.2	3.13	4.01	#DIV/0!	0.67
SUM	1.00	740.85	19520.0	54.68	379.02	#DIV/0!	31.02

COMPOSITE BRAKE EMISSIONS						
BSCO	=	23.88	g/hp-hr	=	32.03	g/kW-hr
BSCO2	=	629.3	g/hp-hr	=	843.87	g/kW-hr
BSHC	=	1.76	g/hp-hr	=	2.36	g/kW-hr
BSNOx	=	12.22	g/hp-hr	=	16.39	g/kW-hr
BS(THC+NOx)	=	13.98	g/hp-hr	=	18.75	g/kW-hr
BSPM	=	#DIV/0!	g/hp-hr	=	#DIV/0!	g/kW-hr
BSFC	=	0.495	lb/hp-hr	=	0.301	kg/kW-hr

	CORR.	CORR	WATER	TEMPERATURES			TEMPERATURES	
	FACTOR	POWER	VAPOR	PRE CAT	CELL	OIL	LT BANK	RT BANK
MODE		[bhp]	["Hg]	[deg F]	[deg F]	[deg F]	[deg F]	[deg F]
1	1.0321	68.61	0.554	1132.2	90.1	260.0	1335.2	1336.5
2	1.0346	50.91	0.583	1070.9	90.8	269.6	1297.7	1306.2
3	1.0327	33.77	0.559	970.1	90.9	261.7	1229.3	1245.1
4	1.0293	16.85	0.522	783.0	87.2	244.6	1127.5	1153.3
5	1.0256	6.89	0.472	595.6	84.8	232.0	935.4	1001.5

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)						
		EPA			CARB	
BSCO	=	4.4	g/kW-hr	=	4.4	g/kW-hr
BS(THC+NOx)	=	2.7	g/kW-hr	=	2.7	g/kW-hr
BSPM	=	5000	g/kW-hr	=	5000	g/kW-hr

CORRECTED PEAK and RATED CONDITIONS				
RATED POWER	=	kW	@	rpm
PEAK TORQUE	=	N-m	@	rpm
DECLARED IDLE	=	N-m	@	rpm

CARNOT EMISSION SERVICES

EPA/CARB (ISO 8178 D2) EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TX RR Comm.		Fuel ID:	LPG	Test Cell/Stand:	4	
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/08/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Quaker State SAE 10W30	Start Test:	15:34:28	
Emission Ctrl System:	Mixer				Test No:	T1B_3r2	
Rated/Idle Speed:	2800	800	Note:	D2 LPG Test	Engine Hrs. Since Rcvd/Dur:	4.40	0.62

	TARGET			MEASURED				FUEL	INLET AIR CONDITIONS			TEST FACTORS			
	Speed	Load	Torque	Time	Speed	Torque	Torque	FLOW	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]	[% Target]	[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
1	1800	100	195.0	120.0	1803	194.98	0.00	27.47	79.8	59.1	29.151	0.957	1.009	10.98	1.024
2	1800	75	146.2	120.0	1803	144.59	-1.12	22.23	81.9	61.0	29.144	0.965	1.020	11.77	1.028
3	1800	50	97.5	120.0	1802	98.06	0.58	15.98	80.6	59.5	29.143	0.976	1.014	11.14	1.026
4	1800	25	48.7	120.0	1801	47.61	-2.33	9.70	78.5	56.6	29.145	0.980	0.977	10.00	1.021
5	1800	10	19.5	120.0	1800	18.25	-6.40	6.50	78.7	56.5	29.143	0.969	0.987	9.99	1.021

	BHP	DILUTE SAMPLE EMISSIONS					DILUTION	PDP	DILUTE SAMPLE MASS FLOW				
	from Work	CO	CO2	HC	NOx	PM	RATIO	FLOW	CO	CO2	HC	NOx	PM
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]	[mg]		[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
1	66.95	4408.49	3.22	91.1	398.8	0.000	3.15	325.7	2839.7	32542.2	92.41	421.97	#DIV/0!
2	49.63	1981.74	2.73	84.8	509.5	0.000	3.91	328.2	1286.2	27883.4	86.63	543.12	#DIV/0!
3	33.64	479.53	2.03	51.5	476.2	0.000	5.49	333.4	316.2	21029.2	53.44	515.72	#DIV/0!
4	16.32	359.42	1.76	44.9	322.1	0.000	6.34	234.2	166.5	12804.6	32.73	245.06	#DIV/0!
5	6.26	1571.15	2.45	91.9	99.4	0.000	4.39	107.8	335.0	8207.6	30.85	34.81	#DIV/0!

	WEIGHT	WEIGHTED SAMPLE MASS FLOW					WEIGHTED
	FACTOR	CO	CO2	HC	NOx	PM	POWER
MODE		[g/hr]	[g/hr]	[g/hr]	[g/hr]	[g/hr]	[hp]
1	0.05	141.99	1627.1	4.62	21.10	#DIV/0!	3.35
2	0.25	321.54	6970.8	21.66	135.78	#DIV/0!	12.41
3	0.30	94.85	6308.8	16.03	154.72	#DIV/0!	10.09
4	0.30	49.95	3841.4	9.82	73.52	#DIV/0!	4.90
5	0.10	33.50	820.8	3.08	3.48	#DIV/0!	0.63
SUM	1.00	641.83	19568.8	55.21	388.60	#DIV/0!	31.37

COMPOSITE BRAKE EMISSIONS						
BSCO	=	20.46	g/hp-hr	=	27.44	g/kW-hr
BSCO2	=	623.8	g/hp-hr	=	836.58	g/kW-hr
BSHC	=	1.76	g/hp-hr	=	2.36	g/kW-hr
BSNOx	=	12.39	g/hp-hr	=	16.61	g/kW-hr
BS(THC+NOx)	=	14.15	g/hp-hr	=	18.97	g/kW-hr
BSPM	=	#DIV/0!	g/hp-hr	=	#DIV/0!	g/kW-hr
BSFC	=	0.487	lb/hp-hr	=	0.296	kg/kW-hr

	CORR.	CORR	WATER	TEMPERATURES			TEMPERATURES	
	FACTOR	POWER	VAPOR	PRE CAT	CELL	OIL	LT BANK	RT BANK
MODE		[bhp]	["Hg]	[deg F]	[deg F]	[deg F]	[deg F]	[deg F]
1	1.0278	68.82	0.506	1120.0	85.2	238.5	1324.5	1323.5
2	1.0321	51.22	0.541	1067.6	86.6	261.8	1287.7	1301.1
3	1.0295	34.63	0.513	977.2	86.7	259.0	1238.4	1241.2
4	1.0247	16.73	0.461	789.0	84.0	245.7	1137.5	1153.6
5	1.0251	6.41	0.461	598.2	82.5	233.9	929.5	994.1

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)						
		EPA			CARB	
BSCO	=	4.4	g/kW-hr	=	4.4	g/kW-hr
BS(THC+NOx)	=	2.7	g/kW-hr	=	2.7	g/kW-hr
BSPM	=	5000	g/kW-hr	=	5000	g/kW-hr

CORRECTED PEAK and RATED CONDITIONS				
RATED POWER	=	kW	@	rpm
PEAK TORQUE	=	N-m	@	rpm
DECLARED IDLE	=	N-m	@	rpm

CARNOT EMISSION SERVICES

EPA/CARB (ISO 8178 D2) EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TX RR Comm.		Fuel ID:	LPG	Test Cell/Stand:	4	
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	BD/SG	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/08/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Quaker State SAE 10W30	Start Test:	16:12:00	
Emission Ctrl System:	mixer				Test No:	T1B_3r3	
Rated/Idle Speed:	2800	800	Note:	D2 LPG Test	Engine Hrs. Since Rcvd/Dur:	5.40	0.77

	TARGET			MEASURED				FUEL FLOW	INLET AIR CONDITIONS			TEST FACTORS			
	Speed	Load	Torque	Time	Speed	Torque	Torque		Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]	[% Target]	[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
1	1800	100	194.8	120.0	1804	194.81	0.00	27.48	82.8	61.2	29.135	0.956	1.039	11.84	1.030
2	1800	75	146.1	120.0	1803	143.91	-1.50	22.16	84.2	62.5	29.130	0.965	1.032	12.43	1.033
3	1800	50	97.4	120.0	1802	98.25	0.87	16.30	82.6	61.6	29.133	0.976	1.046	12.04	1.030
4	1800	25	48.7	120.0	1801	48.78	0.16	9.89	80.5	60.2	29.132	0.979	1.024	11.41	1.026
5	1800	10	19.5	120.0	1800	19.13	-1.81	6.56	79.7	59.3	29.126	0.969	1.007	11.07	1.025

	BHP	DILUTE SAMPLE EMISSIONS					DILUTION	PDP	DILUTE SAMPLE MASS FLOW				
	from Work	CO	CO2	HC	NOx	PM	RATIO	FLOW	CO	CO2	HC	NOx	PM
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]	[mg]		[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
1	66.90	4312.11	3.25	90.1	414.5	0.000	3.13	323.8	2761.2	32689.5	90.84	436.00	#DIV/0!
2	49.39	1784.88	2.75	89.1	533.6	0.000	3.92	327.4	1155.7	27980.6	90.79	567.54	#DIV/0!
3	33.71	1029.81	2.02	58.2	422.3	0.000	5.39	333.3	678.8	20877.8	60.34	457.24	#DIV/0!
4	16.73	470.54	1.78	47.0	325.4	0.000	6.22	234.1	217.8	12972.1	34.23	247.43	#DIV/0!
5	6.56	1181.22	2.52	84.5	110.5	0.000	4.35	107.7	251.7	8419.5	28.34	38.68	#DIV/0!

	WEIGHT	WEIGHTED SAMPLE MASS FLOW					WEIGHTED
	FACTOR	CO	CO2	HC	NOx	PM	POWER
MODE		[g/hr]	[g/hr]	[g/hr]	[g/hr]	[g/hr]	[hp]
1	0.05	138.06	1634.5	4.54	21.80	#DIV/0!	3.34
2	0.25	288.93	6995.2	22.70	141.89	#DIV/0!	12.35
3	0.30	203.64	6263.3	18.10	137.17	#DIV/0!	10.11
4	0.30	65.34	3891.6	10.27	74.23	#DIV/0!	5.02
5	0.10	25.17	841.9	2.83	3.87	#DIV/0!	0.66
SUM	1.00	721.13	19626.6	58.45	378.95	#DIV/0!	31.48

COMPOSITE BRAKE EMISSIONS						
BSCO	=	22.91	g/hp-hr	=	30.72	g/kW-hr
BSCO2	=	623.5	g/hp-hr	=	836.13	g/kW-hr
BSHC	=	1.86	g/hp-hr	=	2.49	g/kW-hr
BSNOx	=	12.04	g/hp-hr	=	16.14	g/kW-hr
BS(THC+NOx)	=	13.90	g/hp-hr	=	18.63	g/kW-hr
BSPM	=	#DIV/0!	g/hp-hr	=	#DIV/0!	g/kW-hr
BSFC	=	0.490	lb/hp-hr	=	0.298	kg/kW-hr

	CORR.	CORR	WATER	TEMPERATURES			TEMPERATURES	
	FACTOR	POWER	VAPOR	PRE CAT	CELL	OIL	LT BANK	RT BANK
MODE		[bhp]	["Hg]	[deg F]	[deg F]	[deg F]	[deg F]	[deg F]
1	1.0336	69.15	0.544	1129.3	87.5	260.4	1329.2	1328.1
2	1.0367	51.20	0.571	1070.8	88.8	268.6	1287.9	1307.2
3	1.0339	34.85	0.553	976.7	87.9	262.5	1231.6	1250.5
4	1.0303	17.23	0.525	795.7	87.1	248.5	1143.0	1157.3
5	1.0290	6.75	0.510	606.1	85.4	234.9	953.6	1004.9

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)						
		EPA			CARB	
BSCO	=	4.4	g/kW-hr	=	4.4	g/kW-hr
BS(THC+NOx)	=	2.7	g/kW-hr	=	2.7	g/kW-hr
BSPM	=	5000	g/kW-hr	=	5000	g/kW-hr

CORRECTED PEAK and RATED CONDITIONS				
RATED POWER	=	kW	@	rpm
PEAK TORQUE	=	N-m	@	rpm
DECLARED IDLE	=	N-m	@	rpm

CARNOT EMISSION SERVICES

EPA LSI TRANSIENT EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TRC		Fuel ID:	LPG	Test Cell/Stand:	4	H
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	SG/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/11/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Texaco - SAE 10W30	Test Time:	17:40	
Emission Ctrl System:	Mixer		Cycle Type:	40 CFR 1048 App.II Composite LSI	Test No:	NI1718 T1B_1R1	
Rated/Idle Speed:	2800	800	Notes:	Baseline Config - No Cat	Start/End Hrs:	7.2	0.33

Comments: 0
0.22 sec SpdCmdFilter, 760 rpm/s Max Accel/Del

	TARGET			MEASURED		
	Speed	Load	Torque	Time	Speed	Torque
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]
1	1869	n/a	82.05	1210.0	1869	82.19

FUEL FLOW	INLET AIR CONDITIONS			TEST FACTORS			
	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
13.79	80.6	64.3	29.050	0.976	1.092	13.27	1.032

	BHP	DILUTE SAMPLE EMISSIONS			
	from Work	CO	CO2	HC	NOx
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]
Cycle	29.26	1108.66	1.970	55.8	173.7

DILUTION RATIO
5.49

PDP	DILUTE SAMPLE MASS FLOW				
FLOW	CO	CO2	HC	NOx	PM
[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
287.0	629.3	17570.6	49.87	161.90	#DIV/0!

	BHP	SAMPLE INFORMATION			
	from Work	Coolant	Oil	PreCat	PostCat
MODE	[hp]	[deg F]	[deg F]	[deg F]	[deg F]
Cycle	29.26	186.70	247.000	951.5	0.0

COMPOSITE BRAKE EMISSIONS						
BSCO	=	21.51	g/hp-hr	=	28.84	g/kW-hr
BSCO2	=	600.6	g/hp-hr	=	805.40	g/kW-hr
BSHC	=	1.70	g/hp-hr	=	2.29	g/kW-hr
BSNOx	=	5.53	g/hp-hr	=	7.42	g/kW-hr
BS(THC+NOx)	=	7.24	g/hp-hr	=	9.71	g/kW-hr
BSFC	=	0.471	lb/hp-hr	=	0.287	kg/kW-hr

LSI EMISSION ISO 8178 C2 STANDARDS (2004-2006)				
	EPA		CARB	
BSCO	50.0	g/kW-hr	49.6	g/kW-hr
BS(HC+NOx)	4.0	g/kW-hr	4.0	g/kW-hr
Useful Life	5000	hrs	3500	hrs

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)				
	EPA		CARB	
BSCO	4.4	g/kW-hr	49.6	g/kW-hr
BS(THC+NOx)	2.7	g/kW-hr	4.0	g/kW-hr
BSPM	5000	g/kW-hr	5000	g/kW-hr

Engine Manufacturer:	TRC		Fuel ID:	LPG		Test Cell/Stand:	4	H
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67		Test Operator:	SG/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke		Test Date:	06/11/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Texaco - SAE 10W30		Test Time:	18:15	
Emission Ctrl System:	Mixer		Cycle Type:	40 CFR 1048 App.II Composite LSI		Test No:	NI1719 T1B_1R2	
Rated/Idle Speed:	2800	800	Notes:	Baseline Config - No Cat		Start/End Hrs:	7.6	0.33

Comments: 0
0.22 sec SpdCmdFilter, 760 rpm/s Max Accel/Del

	TARGET			MEASURED		
	Speed	Load	Torque	Time	Speed	Torque
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]
1	1870	n/a	82.09	1210.0	1871	82.25

FUEL FLOW	INLET AIR CONDITIONS		
	Temp	Dew Point	Baro
[lb/hr]	[deg F]	[deg F]	[in-hg]
13.87	82.3	65.6	29.035

TEST FACTORS			
Dry-Wet	NOx Hum.	Particulate	F Factor
Correction	Correction	Humidity	N/A
0.976	1.117	13.90	1.036

	BHP	DILUTE SAMPLE EMISSIONS			
	from Work	CO	CO2	HC	NOx
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]
Cycle	29.30	1169.42	1.980	56.5	255.6

DILUTION RATIO
5.45

PDP FLOW	DILUTE SAMPLE MASS FLOW				
	CO	CO2	HC	NOx	PM
[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
286.5	662.6	17632.3	50.35	237.94	#DIV/0!

	BHP	SAMPLE INFORMATION			
	from Work	Coolant	Oil	PreCat	PostCat
MODE	[hp]	[deg F]	[deg F]	[deg F]	[deg F]
Cycle	29.30	184.50	251.000	915.0	0.0

COMPOSITE BRAKE EMISSIONS						
BSCO	=	22.62	g/hp-hr	=	30.33	g/kW-hr
BSCO2	=	601.9	g/hp-hr	=	807.13	g/kW-hr
BSHC	=	1.72	g/hp-hr	=	2.30	g/kW-hr
BSNOx	=	8.12	g/hp-hr	=	10.89	g/kW-hr
BS(THC+NOx)	=	9.84	g/hp-hr	=	13.20	g/kW-hr
BSFC	=	0.473	lb/hp-hr	=	0.288	kg/kW-hr

LSI EMISSION ISO 8178 C2 STANDARDS (2004-2006)				
	EPA		CARB	
BSCO	50.0	g/kW-hr	49.6	g/kW-hr
BS(HC+NOx)	4.0	g/kW-hr	4.0	g/kW-hr
Useful Life	5000	hrs	3500	hrs

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)				
	EPA		CARB	
BSCO	4.4	g/kW-hr	49.6	g/kW-hr
BS(THC+NOx)	2.7	g/kW-hr	4.0	g/kW-hr
BSPM	5000	g/kW-hr	5000	g/kW-hr

CARNOT EMISSION SERVICES

EPA LSI TRANSIENT EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TRC		Fuel ID:	LPG	Test Cell/Stand:	4	H
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	SG/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/11/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Texaco - SAE 10W30	Test Time:	18:36	
Emission Ctrl System:	Mixer		Cycle Type:	40 CFR 1048 App.II Composite LSI	Test No:	NI1720 T1B_1R3	
Rated/Idle Speed:	2800	800	Notes:	Baseline Config - No Cat	Start/End Hrs:	8.0	0.33

Comments: 0
0.22 sec SpdCmdFilter, 760 rpm/s Max Accel/Del

	TARGET			MEASURED		
	Speed	Load	Torque	Time	Speed	Torque
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]
1	1869	n/a	82.05	1210.0	1870	82.20

FUEL FLOW	INLET AIR CONDITIONS			TEST FACTORS			
	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
13.89	82.3	64.7	29.044	0.976	1.101	13.49	1.035

	BHP	DILUTE SAMPLE EMISSIONS			
	from Work	CO	CO2	HC	NOx
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]
Cycle	29.26	1206.32	1.974	56.3	239.1

DILUTION RATIO
5.46

PDP FLOW	DILUTE SAMPLE MASS FLOW				
	CO	CO2	HC	NOx	PM
[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
287.3	685.3	17618.6	50.33	223.14	#DIV/0!

	BHP	SAMPLE INFORMATION			
	from Work	Coolant	Oil	PreCat	PostCat
MODE	[hp]	[deg F]	[deg F]	[deg F]	[deg F]
Cycle	29.26	189.30	253.000	911.9	0.0

COMPOSITE BRAKE EMISSIONS						
BSCO	=	23.42	g/hp-hr	=	**31.41**	g/kW-hr
BSCO2	=	602.1	g/hp-hr	=	**807.45**	g/kW-hr
BSHC	=	1.72	g/hp-hr	=	**2.31**	g/kW-hr
BSNOx	=	7.63	g/hp-hr	=	**10.23**	g/kW-hr
BS(THC+NOx)	=	9.35	g/hp-hr	=	**12.53**	g/kW-hr
BSFC	=	0.475	lb/hp-hr	=	**0.289**	kg/kW-hr

LSI EMISSION ISO 8178 C2 STANDARDS (2004-2006)				
	EPA		CARB	
BSCO	50.0	g/kW-hr	49.6	g/kW-hr
BS(HC+NOx)	4.0	g/kW-hr	4.0	g/kW-hr
Useful Life	5000	hrs	3500	hrs

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)				
	EPA		CARB	
BSCO	4.4	g/kW-hr	49.6	g/kW-hr
BS(THC+NOx)	2.7	g/kW-hr	4.0	g/kW-hr
BSPM	5000	g/kW-hr	5000	g/kW-hr

CARNOT EMISSION SERVICES

EPA/CARB (ISO 8178 D2) EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION			TEST CELL INFORMATION		
Engine Manufacturer:	TX RR Comm.		Fuel ID:	LPG		Test Cell/Stand:	4	
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67		Test Operator:	MD/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke		Test Date:	06/12/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Quaker State SAE 10W30		Start Test:	10:51:40	
Emission Ctrl System:	mixer, HO2S TWC					Test No:	T2B_3R1	
Rated/Idle Speed:	2800	800	Note:	D2 LPG Test	With Catalyst	Engine Hrs. Since Rcvd/Dur:	8.50	1.85

	TARGET			MEASURED				FUEL	INLET AIR CONDITIONS			TEST FACTORS			
	Speed	Load	Torque	Time	Speed	Torque	Torque	FLOW	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]	[% Target]	[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
1	1800	100	192.3	120.0	1803	192.26	0.00	25.70	91.3	52.8	29.221	0.959	0.938	8.69	1.033
2	1800	75	144.2	120.0	1802	142.09	-1.46	21.22	90.8	52.3	29.220	0.966	0.962	8.52	1.032
3	1800	50	96.1	120.0	1802	95.43	-0.73	14.75	90.2	53.1	29.217	0.973	0.940	8.78	1.032
4	1800	25	48.1	120.0	1801	49.20	2.37	9.09	87.1	49.9	29.216	0.981	0.912	7.78	1.026
5	1800	10	19.2	120.0	1800	18.41	-4.25	5.83	82.6	45.7	29.215	0.972	0.931	6.63	1.018

	BHP	DILUTE SAMPLE EMISSIONS					DILUTION	PDP	DILUTE SAMPLE MASS FLOW				
	from Work	CO	CO2	HC	NOx	PM	RATIO	FLOW	CO	CO2	HC	NOx	PM
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]	[mg]		[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
1	66.02	218.39	3.43	4.9	2.7	0.000	3.33	325.2	140.4	34643.6	4.94	2.84	#DIV/0!
2	48.77	11.33	2.82	0.9	10.9	0.000	4.06	328.8	7.4	28780.9	0.92	11.69	#DIV/0!
3	32.74	1.44	2.25	2.2	512.2	0.000	5.07	286.1	0.8	20004.0	1.93	476.13	#DIV/0!
4	16.87	0.77	1.69	2.1	353.8	0.000	6.71	235.0	0.4	12327.6	1.52	270.05	#DIV/0!
5	6.31	1.75	2.35	4.2	74.2	0.000	4.87	108.3	0.4	7912.4	1.41	26.12	#DIV/0!

	WEIGHT	WEIGHTED SAMPLE MASS FLOW					WEIGHTED
	FACTOR	CO	CO2	HC	NOx	PM	POWER
MODE		[g/hr]	[g/hr]	[g/hr]	[g/hr]	[g/hr]	[hp]
1	0.05	7.02	1732.2	0.25	0.14	#DIV/0!	3.30
2	0.25	1.84	7195.2	0.23	2.92	#DIV/0!	12.19
3	0.30	0.24	6001.2	0.58	142.84	#DIV/0!	9.82
4	0.30	0.11	3698.3	0.45	81.01	#DIV/0!	5.06
5	0.10	0.04	791.2	0.14	2.61	#DIV/0!	0.63
SUM	1.00	9.25	19418.1	1.65	229.53	#DIV/0!	31.01

COMPOSITE BRAKE EMISSIONS						
BSCO	=	0.30	g/hp-hr	=	0.40	g/kW-hr
BSCO2	=	626.3	g/hp-hr	=	839.86	g/kW-hr
BSHC	=	0.05	g/hp-hr	=	0.07	g/kW-hr
BSNOx	=	7.40	g/hp-hr	=	9.93	g/kW-hr
BS(THC+NOx)	=	7.46	g/hp-hr	=	10.00	g/kW-hr
BSPM	=	#DIV/0!	g/hp-hr	=	#DIV/0!	g/kW-hr
BSFC	=	0.462	lb/hp-hr	=	0.281	kg/kW-hr

	CORR.	CORR	WATER	TEMPERATURES			TEMPERATURES	
	FACTOR	POWER	VAPOR	PRE CAT	CELL	OIL	LT BANK	RT BANK
MODE		[bhp]	["Hg]	[deg F]	[deg F]	[deg F]	[deg F]	[deg F]
1	1.0335	68.23	0.403	1151.2	83.8	258.6	1363.4	1362.2
2	1.0326	50.36	0.395	1095.0	83.3	266.7	1299.7	1319.1
3	1.0325	33.80	0.407	951.2	84.2	256.8	1236.6	1249.3
4	1.0271	17.33	0.361	776.3	83.0	246.2	1147.9	1151.9
5	1.0199	6.44	0.308	591.5	80.8	234.5	954.6	1003.3

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)						
		EPA			CARB	
BSCO	=	4.4	g/kW-hr	=	4.4	g/kW-hr
BS(THC+NOx)	=	2.7	g/kW-hr	=	2.7	g/kW-hr
BSPM	=	5000	g/kW-hr	=	5000	g/kW-hr

CORRECTED PEAK and RATED CONDITIONS				
RATED POWER	=	kW	@	rpm
PEAK TORQUE	=	N-m	@	rpm
DECLARED IDLE	=	N-m	@	rpm

CARNOT EMISSION SERVICES

EPA/CARB (ISO 8178 D2) EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION			TEST CELL INFORMATION		
Engine Manufacturer:	TX RR Comm.		Fuel ID:	LPG		Test Cell/Stand:	4	
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67		Test Operator:	MD/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke		Test Date:	06/13/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Quaker State SAE 10W30		Start Test:	10:12:25	
Emission Ctrl System:	mixer, HO2S TWC					Test No:	T2B_3R2r	
Rated/Idle Speed:	2800	800	Note:	D2 LPG Test	With Catalyst	Engine Hrs. Since Rcvd/Dur:	12.40	1.00

	TARGET			MEASURED				FUEL	INLET AIR CONDITIONS			TEST FACTORS			
	Speed	Load	Torque	Time	Speed	Torque	Torque	FLOW	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]	[% Target]	[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
1	1800	100	191.5	120.0	1795	191.54	0.00	25.70	95.6	53.3	29.141	0.963	0.943	8.87	1.042
2	1800	75	143.7	120.0	1797	142.56	-0.77	19.91	96.4	52.5	29.137	0.972	0.963	8.62	1.043
3	1800	50	95.8	120.0	1800	96.78	1.05	14.83	90.6	50.4	29.132	0.975	0.917	7.96	1.034
4	1800	25	47.9	120.0	1804	47.65	-0.50	9.00	87.9	48.8	29.134	0.982	0.904	7.50	1.030
5	1800	10	19.2	120.0	1806	18.20	-4.99	5.90	84.6	45.8	29.136	0.973	0.931	6.67	1.024

	BHP	DILUTE SAMPLE EMISSIONS					DILUTION	PDP	DILUTE SAMPLE MASS FLOW				
	from Work	CO	CO2	HC	NOx	PM	RATIO	FLOW	CO	CO2	HC	NOx	PM
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]	[mg]		[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
1	65.47	370.83	3.05	7.6	0.0	0.000	3.70	362.7	266.0	34428.2	8.60	0.00	#DIV/0!
2	48.78	18.23	2.37	1.5	0.0	0.000	4.79	365.8	13.2	26987.9	1.68	0.00	#DIV/0!
3	33.17	0.00	2.10	0.0	249.9	0.000	5.43	309.1	0.0	20130.9	0.00	250.93	#DIV/0!
4	16.37	0.00	1.58	0.0	192.4	0.000	7.14	248.1	0.0	12208.3	0.00	155.05	#DIV/0!
5	6.26	0.74	2.32	4.2	49.6	0.000	4.92	110.9	0.2	7999.2	1.44	17.88	#DIV/0!

	WEIGHT	WEIGHTED SAMPLE MASS FLOW					WEIGHTED
	FACTOR	CO	CO2	HC	NOx	PM	POWER
MODE		[g/hr]	[g/hr]	[g/hr]	[g/hr]	[g/hr]	[hp]
1	0.05	13.30	1721.4	0.43	0.00	#DIV/0!	3.27
2	0.25	3.30	6747.0	0.42	0.00	#DIV/0!	12.19
3	0.30	0.00	6039.3	0.00	75.28	#DIV/0!	9.95
4	0.30	0.00	3662.5	0.00	46.52	#DIV/0!	4.91
5	0.10	0.02	799.9	0.14	1.79	#DIV/0!	0.63
SUM	1.00	16.61	18970.1	0.99	123.58	#DIV/0!	30.95

COMPOSITE BRAKE EMISSIONS						
BSCO	=	0.54	g/hp-hr	=	0.72	g/kW-hr
BSCO2	=	612.9	g/hp-hr	=	821.85	g/kW-hr
BSHC	=	0.03	g/hp-hr	=	0.04	g/kW-hr
BSNOx	=	3.99	g/hp-hr	=	5.35	g/kW-hr
BS(THC+NOx)	=	4.02	g/hp-hr	=	5.40	g/kW-hr
BSPM	=	#DIV/0!	g/hp-hr	=	#DIV/0!	g/kW-hr
BSFC	=	0.452	lb/hp-hr	=	0.275	kg/kW-hr

	CORR.	CORR	WATER	TEMPERATURES			TEMPERATURES	
	FACTOR	POWER	VAPOR	PRE CAT	CELL	OIL	LT BANK	RT BANK
MODE		[bhp]	["Hg]	[deg F]	[deg F]	[deg F]	[deg F]	[deg F]
1	1.0420	68.22	0.410	1148.6	87.7	265.2	1354.4	1360.2
2	1.0427	50.86	0.398	1095.1	87.1	269.9	1295.6	1314.8
3	1.0350	34.33	0.368	979.6	86.6	258.1	1239.6	1244.9
4	1.0310	16.88	0.347	802.2	85.4	246.2	1137.5	1151.6
5	1.0255	6.42	0.309	610.8	84.0	233.9	949.2	1004.7

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)						
		EPA			CARB	
BSCO	=	4.4	g/kW-hr	=	4.4	g/kW-hr
BS(THC+NOx)	=	2.7	g/kW-hr	=	2.7	g/kW-hr
BSPM	=	5000	g/kW-hr	=	5000	g/kW-hr

CORRECTED PEAK and RATED CONDITIONS				
RATED POWER	=	kW	@	rpm
PEAK TORQUE	=	N-m	@	rpm
DECLARED IDLE	=	N-m	@	rpm

CARNOT EMISSION SERVICES

EPA/CARB (ISO 8178 D2) EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TX RR Comm.		Fuel ID:	LPG	Test Cell/Stand:	4	
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	MD/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/13/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Quaker State SAE 10W30	Start Test:	11:17:13	
Emission Ctrl System:	mixer, HO2S TWC				Test No:	T2B_3R3	
Rated/Idle Speed:	2800	800	Note:	D2 LPG Test With Catalyst	Engine Hrs. Since Rcvd/Dur:	13.60	0.68

Note: Modes 1 & 5 from T2B_3R2r

	TARGET			MEASURED				FUEL	INLET AIR CONDITIONS			TEST FACTORS			
	Speed	Load	Torque	Time	Speed	Torque	Torque	FLOW	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]	[% Target]	[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
1	1800	100	191.5	120.0	1795	191.54	0.00	25.70	95.6	53.3	29.141	0.963	0.943	8.87	1.042
2	1800	75	143.7	120.0	1796	146.33	1.86	20.35	93.1	51.9	29.138	0.971	0.960	8.42	1.038
3	1800	50	95.8	120.0	1799	97.20	1.49	14.88	89.1	46.6	29.133	0.975	0.888	6.89	1.030
4	1800	25	47.9	120.0	1804	48.89	2.09	9.10	85.9	44.7	29.132	0.982	0.876	6.41	1.025
5	1800	10	19.2	120.0	1806	18.20	-4.99	5.90	84.6	45.8	29.136	0.973	0.931	6.67	1.024

	BHP	DILUTE SAMPLE EMISSIONS					DILUTION	PDP	DILUTE SAMPLE MASS FLOW				
	from Work	CO	CO2	HC	NOx	PM	RATIO	FLOW	CO	CO2	HC	NOx	PM
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]	[mg]		[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
1	65.47	370.83	3.05	7.6	0.0	0.000	3.70	362.7	266.0	34428.2	8.60	0.00	#DIV/0!
2	50.05	33.52	2.42	2.8	0.0	0.000	4.70	366.3	24.3	27572.9	3.20	0.00	#DIV/0!
3	33.29	0.00	2.10	0.0	236.7	0.000	5.43	309.7	0.0	20197.1	0.00	238.11	#DIV/0!
4	16.79	0.00	1.60	0.0	190.4	0.000	7.08	248.3	0.0	12344.6	0.00	153.55	#DIV/0!
5	6.26	0.74	2.32	4.2	49.6	0.000	4.92	110.9	0.2	7999.2	1.44	17.88	#DIV/0!

	WEIGHT	WEIGHTED SAMPLE MASS FLOW					WEIGHTED
	FACTOR	CO	CO2	HC	NOx	PM	POWER
MODE		[g/hr]	[g/hr]	[g/hr]	[g/hr]	[g/hr]	[hp]
1	0.05	13.30	1721.4	0.43	0.00	#DIV/0!	3.27
2	0.25	6.07	6893.2	0.80	0.00	#DIV/0!	12.51
3	0.30	0.00	6059.1	0.00	71.43	#DIV/0!	9.99
4	0.30	0.00	3703.4	0.00	46.07	#DIV/0!	5.04
5	0.10	0.02	799.9	0.14	1.79	#DIV/0!	0.63
SUM	1.00	19.39	19177.0	1.37	119.29	#DIV/0!	31.44

COMPOSITE BRAKE EMISSIONS						
BSCO	=	0.62	g/hp-hr	=	0.83	g/kW-hr
BSCO2	=	610.0	g/hp-hr	=	818.07	g/kW-hr
BSHC	=	0.04	g/hp-hr	=	0.06	g/kW-hr
BSNOx	=	3.79	g/hp-hr	=	5.09	g/kW-hr
BS(THC+NOx)	=	3.84	g/hp-hr	=	5.15	g/kW-hr
BSPM	=	#DIV/0!	g/hp-hr	=	#DIV/0!	g/kW-hr
BSFC	=	0.450	lb/hp-hr	=	0.274	kg/kW-hr

	CORR.	CORR	WATER	TEMPERATURES			TEMPERATURES	
	FACTOR	POWER	VAPOR	PRE CAT	CELL	OIL	LT BANK	RT BANK
MODE		[bhp]	["Hg]	[deg F]	[deg F]	[deg F]	[deg F]	[deg F]
1	1.0420	68.22	0.410	1148.6	87.7	265.2	1354.4	1360.2
2	1.0385	51.98	0.389	1095.4	87.5	264.6	1301.1	1318.3
3	1.0311	34.33	0.319	982.0	86.9	258.2	1236.7	1247.4
4	1.0267	17.24	0.297	790.2	85.6	243.1	1140.4	1152.0
5	1.0255	6.42	0.309	610.8	84.0	233.9	949.2	1004.7

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)						
		EPA			CARB	
BSCO	=	4.4	g/kW-hr	=	4.4	g/kW-hr
BS(THC+NOx)	=	2.7	g/kW-hr	=	2.7	g/kW-hr
BSPM	=	5000	g/kW-hr	=	5000	g/kW-hr

CORRECTED PEAK and RATED CONDITIONS				
RATED POWER	=	kW	@	rpm
PEAK TORQUE	=	N-m	@	rpm
DECLARED IDLE	=	N-m	@	rpm

CARNOT EMISSION SERVICES

EPA/CARB (ISO 8178 D2) EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TX RR Comm.		Fuel ID:	LPG	Test Cell/Stand:	4	
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	MD/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/13/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Quaker State SAE 10W30	Start Test:	12:02:30	
Emission Ctrl System:	mixer, HO2S TWC				Test No:	T2B_3R4	
Rated/Idle Speed:	2800	800	Note:	D2 LPG Test With Catalyst	Engine Hrs. Since Rcvd/Dur:	14.30	0.54

Note: Modes 1 & 5 from T2B_3R2r

	TARGET			MEASURED				FUEL	INLET AIR CONDITIONS			TEST FACTORS			
	Speed	Load	Torque	Time	Speed	Torque	Torque	FLOW	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]	[% Target]	[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
1	1800	100	191.5	120.0	1795	191.54	0.00	25.70	95.6	53.3	29.141	0.963	0.943	8.87	1.042
2	1800	75	143.7	120.0	1795	144.96	0.91	20.14	93.9	52.4	29.132	0.972	0.963	8.57	1.039
3	1800	50	95.8	120.0	1799	96.41	0.67	14.88	89.5	47.8	29.130	0.975	0.897	7.20	1.031
4	1800	25	47.9	120.0	1803	47.23	-1.37	9.04	87.3	44.6	29.129	0.982	0.876	6.39	1.027
5	1800	10	19.2	120.0	1806	18.20	-4.99	5.90	84.6	45.8	29.136	0.973	0.931	6.67	1.024

	BHP	DILUTE SAMPLE EMISSIONS					DILUTION	PDP	DILUTE SAMPLE MASS FLOW				
	from Work	CO	CO2	HC	NOx	PM	RATIO	FLOW	CO	CO2	HC	NOx	PM
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]	[mg]		[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
1	65.47	370.83	3.05	7.6	0.0	0.000	3.70	362.7	266.0	34428.2	8.60	0.00	#DIV/0!
2	49.55	19.84	2.40	0.7	0.0	0.000	4.75	365.8	14.4	27309.3	0.74	0.00	#DIV/0!
3	33.03	0.00	2.09	0.0	184.6	0.000	5.44	310.8	0.0	20190.0	0.00	186.36	#DIV/0!
4	16.22	0.21	1.57	0.0	187.4	0.000	7.19	250.9	0.1	12268.6	0.00	152.77	#DIV/0!
5	6.26	0.74	2.32	4.2	49.6	0.000	4.92	110.9	0.2	7999.2	1.44	17.88	#DIV/0!

	WEIGHT	WEIGHTED SAMPLE MASS FLOW					WEIGHTED
	FACTOR	CO	CO2	HC	NOx	PM	POWER
MODE		[g/hr]	[g/hr]	[g/hr]	[g/hr]	[g/hr]	[hp]
1	0.05	13.30	1721.4	0.43	0.00	#DIV/0!	3.27
2	0.25	3.59	6827.3	0.19	0.00	#DIV/0!	12.39
3	0.30	0.00	6057.0	0.00	55.91	#DIV/0!	9.91
4	0.30	0.03	3680.6	0.00	45.83	#DIV/0!	4.87
5	0.10	0.02	799.9	0.14	1.79	#DIV/0!	0.63
SUM	1.00	16.94	19086.2	0.76	103.53	#DIV/0!	31.06

COMPOSITE BRAKE EMISSIONS						
BSCO	=	0.55	g/hp-hr	=	0.73	g/kW-hr
BSCO2	=	614.5	g/hp-hr	=	824.05	g/kW-hr
BSHC	=	0.02	g/hp-hr	=	0.03	g/kW-hr
BSNOx	=	3.33	g/hp-hr	=	4.47	g/kW-hr
BS(THC+NOx)	=	3.36	g/hp-hr	=	4.50	g/kW-hr
BSPM	=	#DIV/0!	g/hp-hr	=	#DIV/0!	g/kW-hr
BSFC	=	0.453	lb/hp-hr	=	0.276	kg/kW-hr

	CORR.	CORR	WATER	TEMPERATURES			TEMPERATURES	
	FACTOR	POWER	VAPOR	PRE CAT	CELL	OIL	LT BANK	RT BANK
MODE		[bhp]	["Hg]	[deg F]	[deg F]	[deg F]	[deg F]	[deg F]
1	1.0420	68.22	0.410	1148.6	87.7	265.2	1354.4	1360.2
2	1.0400	51.53	0.396	1097.0	89.1	262.7	1297.7	1317.5
3	1.0323	34.10	0.333	987.2	87.7	258.9	1236.7	1247.0
4	1.0283	16.68	0.296	794.3	86.7	245.0	1133.8	1148.5
5	1.0255	6.42	0.309	610.8	84.0	233.9	949.2	1004.7

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)						
		EPA			CARB	
BSCO	=	4.4	g/kW-hr	=	4.4	g/kW-hr
BS(THC+NOx)	=	2.7	g/kW-hr	=	2.7	g/kW-hr
BSPM	=	5000	g/kW-hr	=	5000	g/kW-hr

CORRECTED PEAK and RATED CONDITIONS				
RATED POWER	=	kW	@	rpm
PEAK TORQUE	=	N-m	@	rpm
DECLARED IDLE	=	N-m	@	rpm

CARNOT EMISSION SERVICES

EPA LSI TRANSIENT EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TRC		Fuel ID:	LPG	Test Cell/Stand:	4	H
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	MD/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/13/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Texaco - SAE 10W30	Test Time:	12:58	
Emission Ctrl System:	Mixer		Cycle Type:	40 CFR 1048 App.II Composite LSI	Test No:	NI1722 T2B_1R1	
Rated/Idle Speed:	2800	800	Notes:	ECS Catalyst	Start/End Hrs:	15.1	0.33

Comments: 0
0.22 sec SpdCmdFilter, 760 rpm/s Max Accel/Del

	TARGET			MEASURED		
	Speed	Load	Torque	Time	Speed	Torque
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]
1	1869	n/a	82.04	1210.0	1868	82.24

FUEL FLOW	INLET AIR CONDITIONS			TEST FACTORS			
	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
13.39	86.6	65.3	29.110	0.978	1.111	13.75	1.039

	BHP	DILUTE SAMPLE EMISSIONS			
	from Work	CO	CO2	HC	NOx
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]
Cycle	29.25	100.54	1.868	5.3	60.7

DILUTION RATIO
6.07

PDP FLOW	DILUTE SAMPLE MASS FLOW				
	CO	CO2	HC	NOx	PM
[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
311.1	61.8	18060.9	5.11	61.33	#DIV/0!

	BHP	SAMPLE INFORMATION			
	from Work	Coolant	Oil	PreCat	PostCat
MODE	[hp]	[deg F]	[deg F]	[deg F]	[deg F]
Cycle	29.25	189.71	251.567	964.4	0.0

COMPOSITE BRAKE EMISSIONS						
BSCO	=	2.11	g/hp-hr	=	2.84	g/kW-hr
BSCO2	=	617.4	g/hp-hr	=	828.01	g/kW-hr
BSHC	=	0.17	g/hp-hr	=	0.23	g/kW-hr
BSNOx	=	2.10	g/hp-hr	=	2.81	g/kW-hr
BS(THC+NOx)	=	2.27	g/hp-hr	=	3.05	g/kW-hr
BSFC	=	0.458	lb/hp-hr	=	0.278	kg/kW-hr

LSI EMISSION ISO 8178 C2 STANDARDS (2004-2006)				
	EPA		CARB	
BSCO	50.0	g/kW-hr	49.6	g/kW-hr
BS(HC+NOx)	4.0	g/kW-hr	4.0	g/kW-hr
Useful Life	5000	hrs	3500	hrs

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)				
	EPA		CARB	
BSCO	4.4	g/kW-hr	49.6	g/kW-hr
BS(THC+NOx)	2.7	g/kW-hr	4.0	g/kW-hr
BSPM	5000	g/kW-hr	5000	g/kW-hr

CARNOT EMISSION SERVICES

EPA LSI TRANSIENT EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TRC		Fuel ID:	LPG	Test Cell/Stand:	4	H
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	MD/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/13/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Texaco - SAE 10W30	Test Time:	13:40	
Emission Ctrl System:	Mixer, HO2S, TWC		Cycle Type:	40 CFR 1048 App.II Composite LSI	Test No:	NI1723 T2B_1R2	
Rated/Idle Speed:	2800	800	Notes:	ESC Catalyst	Start/End Hrs:	15.8	0.33

Comments: 0
0.22 sec SpdCmdFilter, 760 rpm/s Max Accel/Del

	TARGET			MEASURED		
	Speed	Load	Torque	Time	Speed	Torque
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]
1	1870	n/a	82.10	1210.0	1868	82.29

FUEL FLOW	INLET AIR CONDITIONS			TEST FACTORS			
	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
13.41	85.3	65.2	29.109	0.978	1.109	13.70	1.037

	BHP	DILUTE SAMPLE EMISSIONS			
	from Work	CO	CO2	HC	NOx
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]
Cycle	29.27	119.21	1.864	4.3	86.1

DILUTION RATIO
6.08

PDP FLOW	DILUTE SAMPLE MASS FLOW				
	CO	CO2	HC	NOx	PM
[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
312.0	73.6	18069.8	4.14	87.25	#DIV/0!

	BHP	SAMPLE INFORMATION			
	from Work	Coolant	Oil	PreCat	PostCat
MODE	[hp]	[deg F]	[deg F]	[deg F]	[deg F]
Cycle	29.27	187.84	236.390	951.0	0.0

COMPOSITE BRAKE EMISSIONS						
BSCO	=	2.51	g/hp-hr	=	3.37	g/kW-hr
BSCO2	=	617.3	g/hp-hr	=	827.84	g/kW-hr
BSHC	=	0.14	g/hp-hr	=	0.19	g/kW-hr
BSNOx	=	2.98	g/hp-hr	=	4.00	g/kW-hr
BS(THC+NOx)	=	3.12	g/hp-hr	=	4.19	g/kW-hr
BSFC	=	0.458	lb/hp-hr	=	0.279	kg/kW-hr

LSI EMISSION ISO 8178 C2 STANDARDS (2004-2006)				
	EPA		CARB	
BSCO	50.0	g/kW-hr	49.6	g/kW-hr
BS(HC+NOx)	4.0	g/kW-hr	4.0	g/kW-hr
Useful Life	5000	hrs	3500	hrs

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)				
	EPA		CARB	
BSCO	4.4	g/kW-hr	49.6	g/kW-hr
BS(THC+NOx)	2.7	g/kW-hr	4.0	g/kW-hr
BSPM	5000	g/kW-hr	5000	g/kW-hr

CARNOT EMISSION SERVICES

EPA LSI TRANSIENT EMISSION TEST RESULTS
CES PROJECT: P-236B

ENGINE IDENTIFICATION			FUEL/OIL INFORMATION		TEST CELL INFORMATION		
Engine Manufacturer:	TRC		Fuel ID:	LPG	Test Cell/Stand:	4	H
Engine Model Number:	GM 4.3L		H/C Ratio:	2.67	Test Operator:	MD/BD	
Engine Serial Number:	W6W15UFD		Engine Cycle:	4 Stroke	Test Date:	06/13/07	
Engine Displacement [cc/in^3]:	4300	262.4	Oil Type:	Texaco - SAE 10W30	Test Time:	14:03	
Emission Ctrl System:	Mixer		Cycle Type:	40 CFR 1048 App.II Composite LSI	Test No:	NI1724 T2B_1R3	
Rated/Idle Speed:	2800	800	Notes:	ECS Catalyst	Start/End Hrs:	16.2	0.33

Comments: 0
0.22 sec SpdCmdFilter, 760 rpm/s Max Accel/Del

	TARGET			MEASURED		
	Speed	Load	Torque	Time	Speed	Torque
MODE	[rpm]	[%]	[ft-lb]	[sec]	[rpm]	[ft-lb]
1	1869	n/a	82.04	1210.0	1867	82.26

FUEL FLOW	INLET AIR CONDITIONS			TEST FACTORS			
	Temp	Dew Point	Baro	Dry-Wet	NOx Hum.	Particulate	F Factor
[lb/hr]	[deg F]	[deg F]	[in-hg]	Correction	Correction	Humidity	N/A
13.36	88.4	66.5	29.090	0.978	1.135	14.33	1.043

	BHP	DILUTE SAMPLE EMISSIONS			
	from Work	CO	CO2	HC	NOx
MODE	[hp]	[ppm]	[%]	[ppmC3]	[ppm]
Cycle	29.24	136.67	1.866	3.3	98.2

DILUTION RATIO
6.07

PDP FLOW	DILUTE SAMPLE MASS FLOW				
	CO	CO2	HC	NOx	PM
[scfm]	[g/hr]	[g/hr]	[g/hr C1]	[g/hr]	[g/hr]
310.1	83.8	17984.5	3.20	98.91	#DIV/0!

	BHP	SAMPLE INFORMATION			
	from Work	Coolant	Oil	PreCat	PostCat
MODE	[hp]	[deg F]	[deg F]	[deg F]	[deg F]
Cycle	29.24	186.89	246.929	890.1	0.0

COMPOSITE BRAKE EMISSIONS						
BSCO	=	2.87	g/hp-hr	=	**3.84**	g/kW-hr
BSCO2	=	615.0	g/hp-hr	=	**824.73**	g/kW-hr
BSHC	=	0.11	g/hp-hr	=	**0.15**	g/kW-hr
BSNOx	=	3.38	g/hp-hr	=	**4.54**	g/kW-hr
BS(THC+NOx)	=	3.49	g/hp-hr	=	**4.68**	g/kW-hr
BSFC	=	0.457	lb/hp-hr	=	**0.278**	kg/kW-hr

LSI EMISSION ISO 8178 C2 STANDARDS (2004-2006)				
	EPA		CARB	
BSCO	50.0	g/kW-hr	49.6	g/kW-hr
BS(HC+NOx)	4.0	g/kW-hr	4.0	g/kW-hr
Useful Life	5000	hrs	3500	hrs

LSI EMISSION ISO 8178 C2 STANDARDS (2007+)				
	EPA		CARB	
BSCO	4.4	g/kW-hr	49.6	g/kW-hr
BS(THC+NOx)	2.7	g/kW-hr	4.0	g/kW-hr
BSPM	5000	g/kW-hr	5000	g/kW-hr