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ORYXE Energy International, Inc. Emissions Tests

Texas TCEQ Data Report

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Introduction

The West Virginia University (WVU) Engine and Emissions Research Laboratory (EERL) evaluated the emission from a 1992 DDC S60 diesel engine for a Texas reference diesel fuel untreated (termed untreated or TX-Base) and the same Texas reference diesel fuel treated (termed treated or TX-Treat). The objective of this study was to examine the emissions of the treated diesel fuel relative to the untreated diesel fuel. The regulated brake-specific mass emissions of oxides of nitrogen (NOx), total particulate matter (TPM), carbon monoxide (CO), and total hydrocarbon (THC), and the unregulated emission of carbon dioxide (CO_2) along with fuel consumption (FC) were measured with the engine exercised over the Federal Test Procedure (FTP) cycle. The evaluation of the fuels followed the procedures outlined in the Code of Federal Regulations (CFR) Title 40 Part 86 [1]. However, only hot start tests were used throughout the entire test protocol.

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.

Laboratory Description

Evaluation of the emissions was conducted using a 1992 Detroit Diesel Series 60 engine connected to a 550 hp GE dynamometer located in the EERL at WVU. The engine model number was 6067GU60 and engine serial number was 06R0105610.

Engine exhaust was ducted to a full-scale dilution tunnel (18 inches in diameter and 20 feet long) based on the critical flow venturi-constant volume sampler (CFV-CVS) concept. Three feet from the tunnel entrance was a 10-inch diameter orifice. This ensured that the dilute exhaust was thoroughly mixed by the time it reached the sampling zone, ten diameters downstream of the orifice. The exhaust was mixed with air and the quantity of diluted exhaust was measured precisely using critical flow venturis. These venturis were placed upstream of a blower that pulled the diluted air at constant mass flowrate once the venturis are under sonic or choked flow conditions at a nominal 3000 scfm. Temperature in the venturi was measured with an exposed fast-respond thermocouple and pressure was measured by an absolute pressure transducer. Heated sampling probes and lines conduct diluted exhaust to a number of different gas analysis instruments. The engine test cell was equipped with a pre-conditioning system for intake air. Microprocessor controlled heated probes and sampling lines were used to draw gaseous samples into the gas analysis bench.

Continuous sampling and analysis of the exhaust stream was done by non-dispersive infrared analyzers (NDIR) for CO and CO_2; wet chemiluminescent analyzer for NOx and heated flame ionization detector (HFID) for THC. The gas analysis bench was equipped with exhaust sample conditioning and analysis systems following CFR 40 Part 86 requirements. Data from the exhaust analyzers, sampling trains, double dilution tunnel, and the engine were acquired and archived at a rate of 5 Hz.

A double dilution system was used to measure TPM. A proportional sample was drawn from the main dilution tunnel into a stainless steel 4-inch diameter by 30-inch long secondary dilution tunnel. The dilute TPM sample was pulled through a stainless steel filter holder that contained two Pallflex 70mm diameter Model T60A20 fluorocarbon-coated glass microfiber filters in series. Two filters, a primary and a secondary, were used in the filter holder to maximize filter trapping efficiency. The diluted sample stream was maintained at temperatures below 125 ºF, measured at the inlet of the PM filter holder. The sample filters were conditioned in an environmentally controlled room to a nominal 70 ºF and 50%

relative humidity, in compliance with requirements of CFR Title 40 Part 86 [1], and weighed before and after sample collection using a Mettler Toledo UMX2 microbalance. All dilution air was HEPA filtered to minimize the background particulate contribution entering the tunnel. Two, 2400 cfm capacity, HEPA filters were placed in parallel to provide up to 4800 cfm dilution air capacity to the primary tunnel.

Calibration procedures and intervals were followed according to CFR 40 Part 86 requirements. A laboratory checkout following the procedures listed in CFR 40 Part 86 was performed prior to the collection of the data.

Additionally, the engine was instrumented for speed, torque, throttle position, manifold air pressure, air intake restriction, total exhaust backpressure, manifold intake temperature, coolant temperature, oil temperature, and exhaust temperature according to CFR Title 40 Part 86 requirements.

Test Fuels and Oil

Number 2 diesel fuel was shipped from a Texas refinery directly to WVU in ten (10), 55 gallon drums. This diesel fuel was labeled Neat No 2 diesel for Texas testing. Initial analysis of the No. 2 diesel fuel indicated that the Cetane Number, ASTM D-613, was below 40, and therefore, outside the specifications required by Texas and the EPA for use as “over the road” No. 2 diesel fuel. WVU and ORYXE Energy International also recognized that small variations of specifications existed from drum to drum. To minimize these barrel-to-barrel variations, four (4) drums were selected from the entire lot and were used to blend a final test batch of fuel. Each of the new barrels contained approximately 90 pounds of No. 2 diesel from the four different selected barrels. Additionally 7.0% by weight of n-Hexadecane (a natural component of Diesel fuel with a Cetane number above 60) was then admixed into the new blended four barrels of No. 2 diesel to elevate the Cetane number above forty (40). This blended fuel was analyzed to insure it met Texas and EPA specifications as “over the road” No. 2 diesel as shown in the independent laboratory specifications analysis in Table 5. Once the final fuel was blended and admixed with 7.0% by weight of n-Hexadecane, these four barrels were labeled TX-Base and TX-Treat testing fuel. This fuel was then used to run eight (8) hot FTP runs with two (2) sets each day for four (4) days to establish a baseline emission profile for Texas, over-the-road, No. 2 diesel fuel. This same fuel was then run with OR-D2. ORYXE Energy International personnel treated each batch with WVU personnel observing. The same treat rate was used by ORYXE Energy International, Inc. personnel for each of the calculated treat runs. A replicate of nine (9) hot FTP runs with two (2) sets each day for four (4) days, except for the fourth day where a third set of tests were conducted, was used to evaluate the OR-D2-treated fuel. The ninth run for the treated fuel was performed to determine if there were any changes in the treated fuel emissions profile with the modified blend fuel stock as described in the next paragraph.

It is noted that the TX-Base and TX-Treat fuels from the first batch of blended fuels were consumed before the end of the test. A new batch of fuel was made for the last day of TX-Treat tests runs only (Treat7* through Treat9*). This fuel was again blended from the original Texas refinery shipment, admixed with 7.0% n-Hexadecane, and treated with OR-D2. After the test was completed, the Cetane number was analyzed for this new TX-Treat fuel with the result of 49.7 and 48.2 for the two samples.

The engine’s fuel system was directly connected to the relevant barrel for each test. The fuel filters were changed prior to the start of this study. Multiple fuel samples were collected from the fuel containers with samples of the TX-Base and TX-Treat fuels shipped to Saybolt LP for analysis. The analyses from Saybolt are summarized in Appendix A for the triplicate analyses for the TX-Base and TX-Treat fuels. The remaining samples were retained at WVU for future analysis, if warranted. The engine oil and oil

filters were also changed prior to the commencement of this study. Typical 15W-40 diesel specification engine oil was used at the oil change prior to the commencement of the work. WVU did collect and retain an oil sample but did not have the oil analyzed.

Test Procedure

Evaluation of the emissions was conducted using the 1992 Detroit Diesel Series 60 engine described above and was inspected prior to use in this program. The inspection included visual examination and measurement of engine parameters and review of data from the engine control unit. A Detroit Diesel (ProLink) monitor was used to display the engine control unit data and to display any potential problems (error codes) during this testing. There were no error codes generated during this testing campaign.

The engine operating parameters were set to within the specifications listed in CFR 40 Part 86 or listed by the engine manufacturer for engine dynamometer testing. An ascending speed engine map (lug curve) was then generated using the TX-Base fuel. The engine description is listed in Table 1 and the engine map used for the engine load setpoint is shown in Figure 1.

Table 1 Test engine specifications.

Engine Manufacturer	Detroit Diesel Corp.
Engine Model	Series 60
Model Year	1992
Displacement (liters)	12.7
Power Rating (hp)	360 @ 1810 rpm
Configuration	Inline 6
Bore (in.) x Stroke (in.)	5.12 x 6.30
Induction	Turbocharger with Aftercooler
Fuel Type	Diesel
Engine Strokes per Cycle	Four
Injection	Direct, Electronic

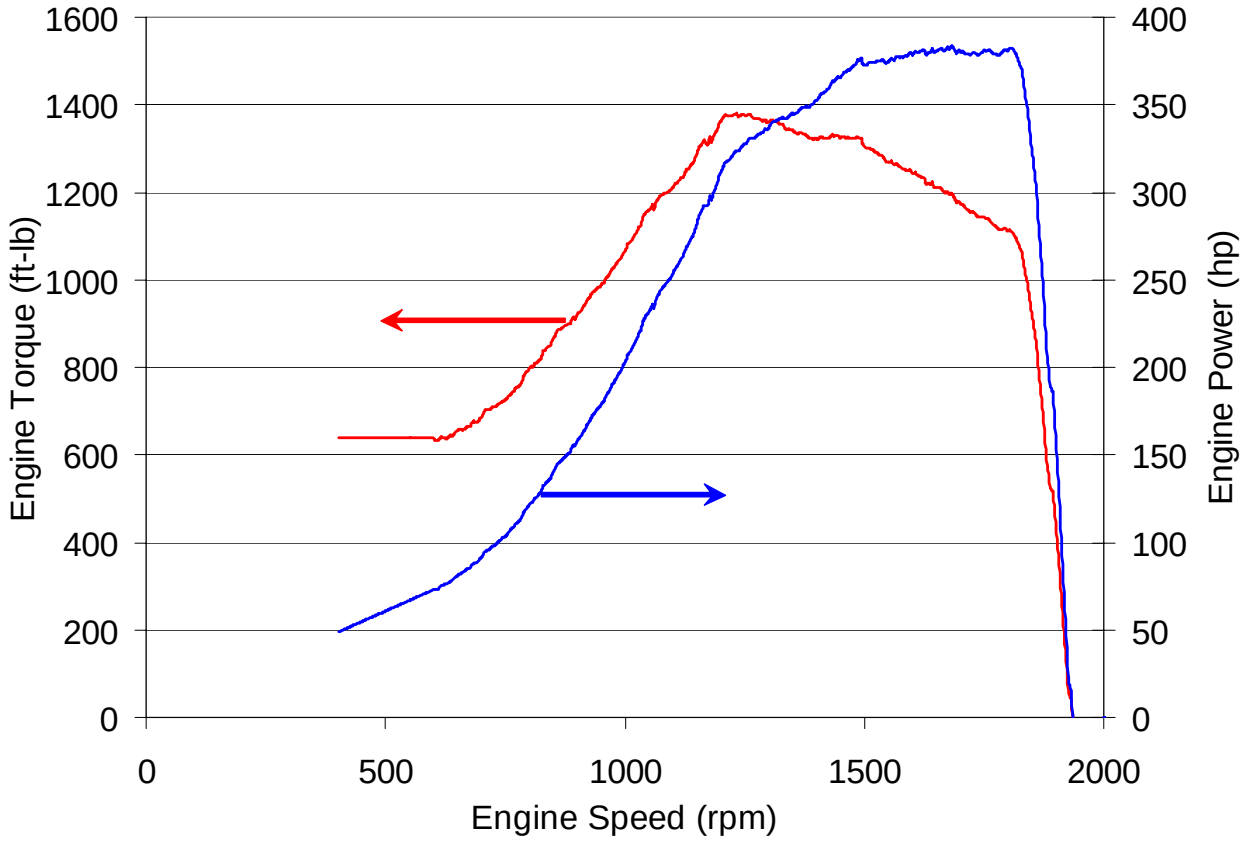


Figure 1 1992 DDC S60 engine lug curve. Note that the last TX-Base fuel engine map during the first day testing was used to generate this curve and that this curve was used for all FTP evaluations.

Prior to the start of the first FTP for each fuel evaluation, the analyzers were zeroed and spanned. At the end of each FTP test, the analyzers were checked for zero and span readings. The post test zero and span readings were recorded in the test data sheet prior to adjusting, if required, the analyzers' zero and or span value. It is noted that there were no significant (greater than two percent) drift problems encountered in the analyzers or sampling system during this work. However, prior to the last set of TX-Base fuel FTP tests, the THC analyzer exhibited large variations in the zero and span readings. The reason for the variation could not be determined and the analyzer was removed from the sampling system. A similar analyzer, same make and model, was placed into the sampling system and used for the last TX-Base evaluation set and the entire TX-Treat runs.

At the completion of each test day, a 20-minute tunnel TPM background was collected to correct the TPM test data. It is noted that the HEPA filters significantly reduced the ambient TPM contribution. However, HEPA filters are only 99.97% efficient at 0.3 μm and their efficiencies at other particle sizes are dependant upon the filter loading history. Also, tunnel shedding and hydrocarbon outgassing does still occur and is most likely the largest contributor to the tunnel background.

When the fuel was switched from the TX-Base to TX-Treat fuel, the laboratory's fuel system was purged. The laboratory incorporates a Max Machinery 710 fuel meter system. This system incorporates a primary loop to circulate fuel from the supply drum and a secondary loop to circulate fuel to the engine. The fuel transferred from the primary to secondary side was the measured fuel to the engine. The primary loop was purged by pulling two gallons of TX-Treat fuel from the supply drum and returning it

to a waste drum. After the primary side was purged, the return line was placed into the TX- Treat fuel supply drum. The secondary loop was purged in a similar manner in that the return line to the fuel meter was removed and the fuel emptied into a waste container. However, for the secondary loop, a bypass system around the engine's lift pump was incorporated from the outlet of the primary fuel filter to the inlet of the secondary fuel filter. During testing, this bypass was disengaged from the fuel system with a quarter-turn valve located at the secondary filter inlet and a quick disconnect fitting at the primary filter outlet. After two gallons of fuel was extracted from the secondary loop, the return line to the fuel meter was connected. The engine was then started and run to insure that the fuel system was functioning properly and any remaining fuel from the previous runs was sufficiently purged.

The order of the evaluation and a description of the testing are given in Table 2. A warm start, not reported, and three hot starts, reported, were used to evaluate the fuels for each set of FTP tests.

Table 2 Test history.

Fuel Name	Test Date	Test Name	Description
TX-Base/ Untreated	Aug. 28, 2004	TX-Base1 TX-Base2	Engine intake and exhaust parameters checked, engine mapped, and hot-start FTP test conducted.
	Aug. 29, 2004	TX-Base3 TX-Base4	Two sets of hot-start FTP test conducted.
	Aug. 30, 2004		Rest day, no testing conducted.
	Aug. 31, 2004	TX-Base5 TX-Base6	Two sets of hot-start FTP test conducted.
	Sept. 1, 2004	TX-Base7 TX-Base8	Two sets of hot-start FTP test conducted.
TX-Treat/ Treated	Sept. 2, 2004		Rest day, fuel switched to TX-Treat, purging runs performed.
	Sept. 3, 2004	TX-Treat1 TX-Treat2	Two sets of hot-start FTP test conducted.
	Sept. 4, 2004	TX-Treat3 TX-Treat4	Two sets of hot-start FTP test conducted.
	Sept. 5, 2004	TX-Treat5 TX-Treat6	Two sets of hot-start FTP test conducted.
	Sept. 6, 2004	TX-Treat7* TX-Treat8* TX-Treat9*	Three sets of hot-start FTP test conducted. Additional test conducted due to fuel change.

* A different neat blend stock was used for these tests.

Results

The results for the evaluation are summarized in the graphs below and in tabular format in Appendix B. The tables in the Appendix contain the run number, test date, test time, start type, comments, integrated work, fuel consumption, THC, CO, CO_2, NOx, TPM, hot-start average, hot start standard deviation, and the coefficient of variation (COV) for each set of tests. Table 7 to Table 14 contain the summary data for

the eight TX-Base fuel runs and Table 15 to Table 23 summarizes the nine TX-Treat fuel runs. Note that Table 18 to Table 23 contains the data for the last six treated tests.

Comparison of All Base and Last Six Treated Runs

The primary constituent of interest is NOx and is illustrated in Figure 2 as the average of three hot starts for each test. The bars represent one standard deviation of the data for each test. The NOx averaged 5.58 g/bhp-hr for the TX-Base fuel and 5.26 g/bhp-hr for the TX-Treat fuel, resulting in a 5.8% reduction in NOx using the TX-Treat fuel. As illustrated in this figure, the TX-Base fuel brake-specific NOx was consistent over the five calendar days that testing occurred.

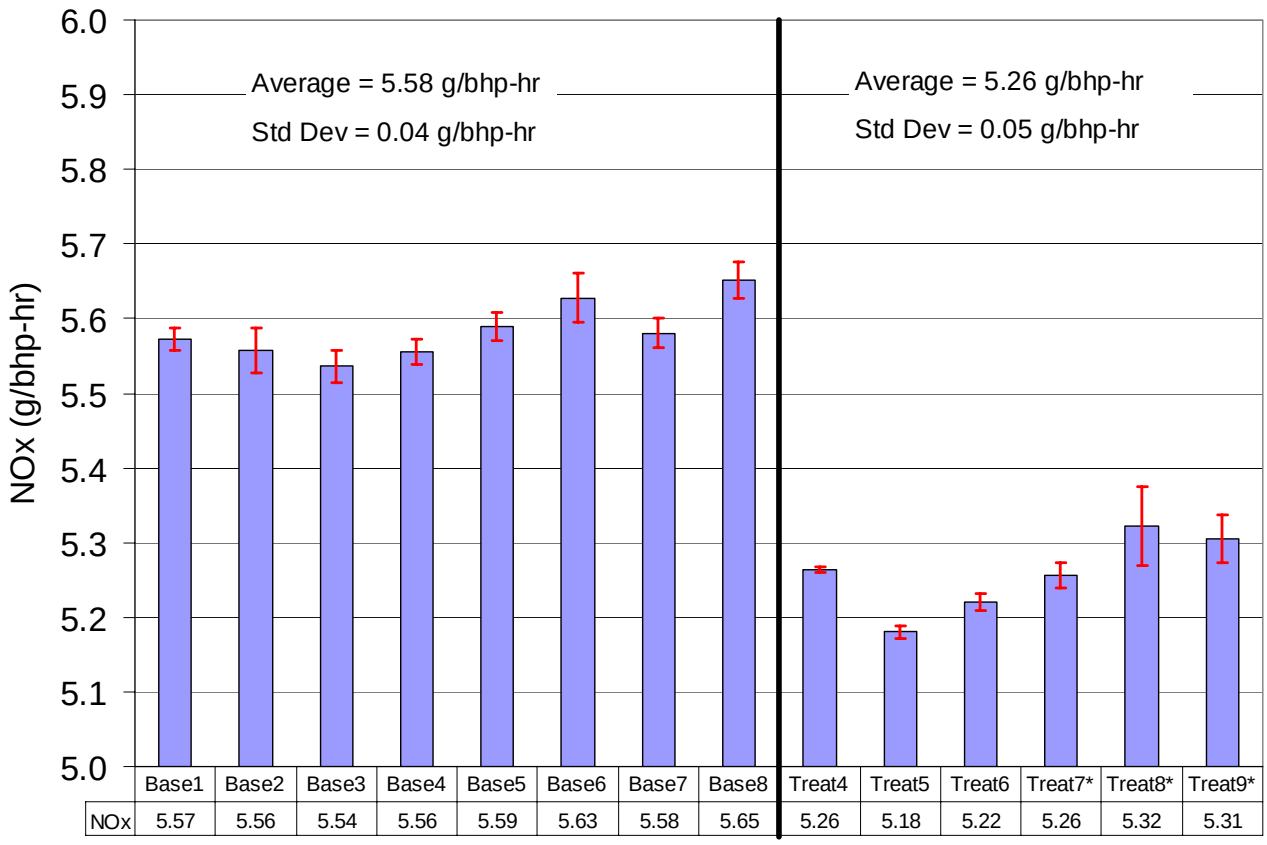


Figure 2 Average NOx from three hot-start FTP runs excluding TX-Treat1 to TX-Treat3. Bars represent one standard deviation of the data for that set of tests. Note the expanded emissions axis.

The average TX-Base fuel brake-specific NOx value is then compared against the average of six TX-Treat fuel brake-specific NOx values (or TX-Treat4 through TX-Treat9*). According to ORYXE Energy International, Inc. personnel, the first three TX-Treat fuel brake-specific NOx values (or TX-Treat1 through TX-Treat3) show the 'cumulative' effect of the OR-D2 additive and are therefore not taken into consideration or calculated in Table 3.

Table 3 Summary of all hot-start FTP runs for the TX-Base fuel and six hot-start FTP runs for the TX-Treat fuel.

	All TX-Base Fuel		Last 6 TX-Treat Fuel		Difference
	Average	Std Dev	Average	Std Dev	(%)
Work (bhp-hr)	25.3	0.1	25.3	0.1	-0.1
BSFC (lb/bhp-hr)	0.379	0.002	0.379	0.003	0.0
Fuel Cons. (lb)	9.61	0.03	9.60	0.05	-0.1
Fuel Rec. (lb)	9.80	0.03	9.87	0.04	0.7
THC (g/bhp-hr)	0.124	0.006	0.094	0.003	-23.7
CO (g/bhp-hr)	3.22	0.07	2.90	0.05	-9.7
CO2 (g/bhp-hr)	555	3	556	4	0.3
NOx (g/bhp-hr)	5.58	0.04	5.26	0.05	-5.8
TPM (g/bhp-hr)	0.233	0.004	0.241	0.006	3.5

Note that this same calculation model, comparing the average respective values of all eight TX-Base fuel runs to the average respective values of the last six TX-Treat fuel runs, will be used consistently in Figure 3 to Figure 7 only.

The average results for THC are shown in Figure 3 for the three hot start tests. The bars represent one standard deviation of the data for each test. The THC averaged 0.124 g/bhp-hr for the TX-Base fuel and 0.094 g/bhp-hr for the TX-Treat fuel, resulting in a 23.7% reduction in the THC using the TX-Treat fuel. The THC remained constant throughout the testing for each fuel. It is noted that the THC analyzer was changed between TX-Base7 and TX-Base8. The last set of evaluations for the TX-Treat fuel, TX-Treat7* through TX-Treat9*, shows consistent THC data with the prior three set of TX-Treat tests. It does not appear as though there was any impact on the THC emissions from the different treated fuel blends.

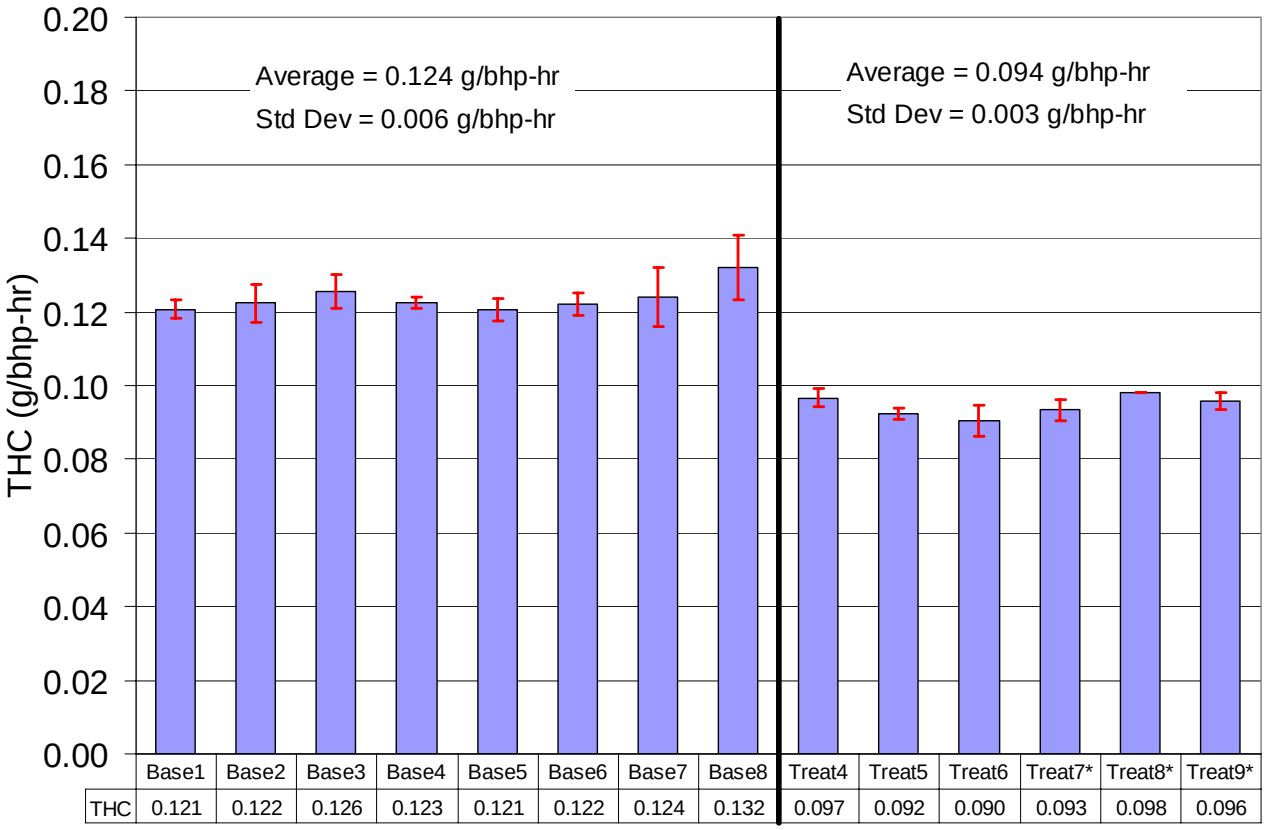


Figure 3 Average THC from three hot-start FTP runs excluding TX-Treat1 to TX-Treat3. Bars represent one standard deviation of the data for that fuel.

The average results for CO are shown in Figure 4 for the three hot start tests. The bars represent one standard deviation of the data for each test. The CO averaged 3.22 g/bhp-hr for the TX-Base fuel and 2.90 g/bhp-hr for the TX-Treat fuel, resulting in a 9.7% reduction in the CO using the TX-Treat fuel. There was a 5.5% difference in the CO for the TX-Base fuel between TX-Base1 and TX-Base5 whereas there were minor variations in the CO from test-to-test for the TX-Treat fuel. The last set of evaluations for the TX-Treat fuel, TX-Treat7* through TX-Treat9*, shows consistent CO data with the prior three set of TX-Treat tests. It does not appear as though there was any impact on the CO emissions from the different treated fuel blends.

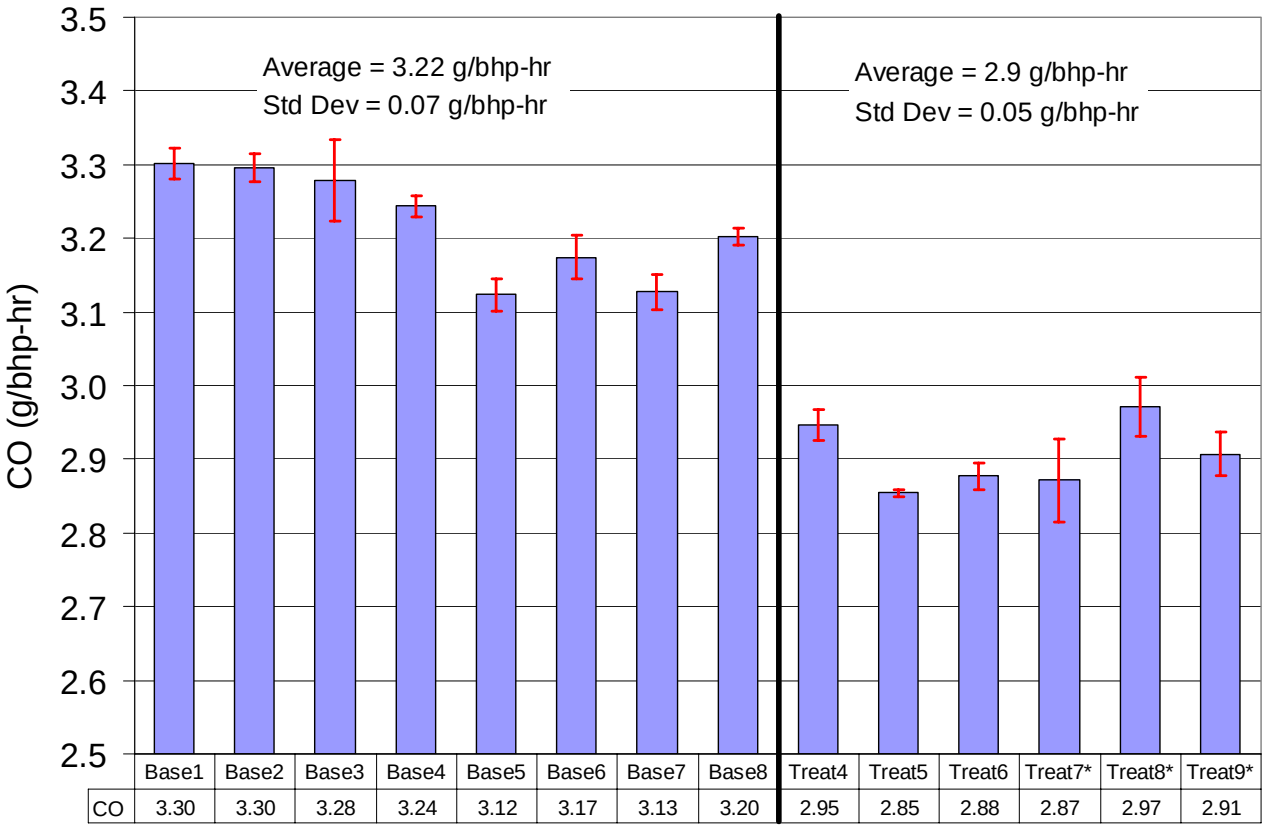


Figure 4 Average CO from three hot-start FTP runs excluding TX-Treat1 to TX-Treat3. Bars represent one standard deviation of the data for that fuel. Note the expanded emissions axis.

The average results for TPM are shown in Figure 5 for each set of tests. The bars represent one standard deviation of the data for each test. The TPM averaged 0.233 g/bhp-hr for the TX-Base fuel and 0.241 g/bhp-hr for the TX-Treat fuel, resulting in a 3.5% increase in the TPM using the TX-Treat fuel. As illustrated in this figure, the TX-Base fuel brake-specific TPM was consistent over the five calendar days that testing occurred whereas there was a slightly larger variation in the brake-specific TPM for the TX-Treat fuel. The last set of evaluations for the TX-Treat fuel, TX-Treat7* through TX-Treat9*, shows high run-to-run variability in the data but is within the variability of other TX-Base and TX-Treat tests. It does not appear as though there was any impact on the TPM emissions from the different treated fuel blends.

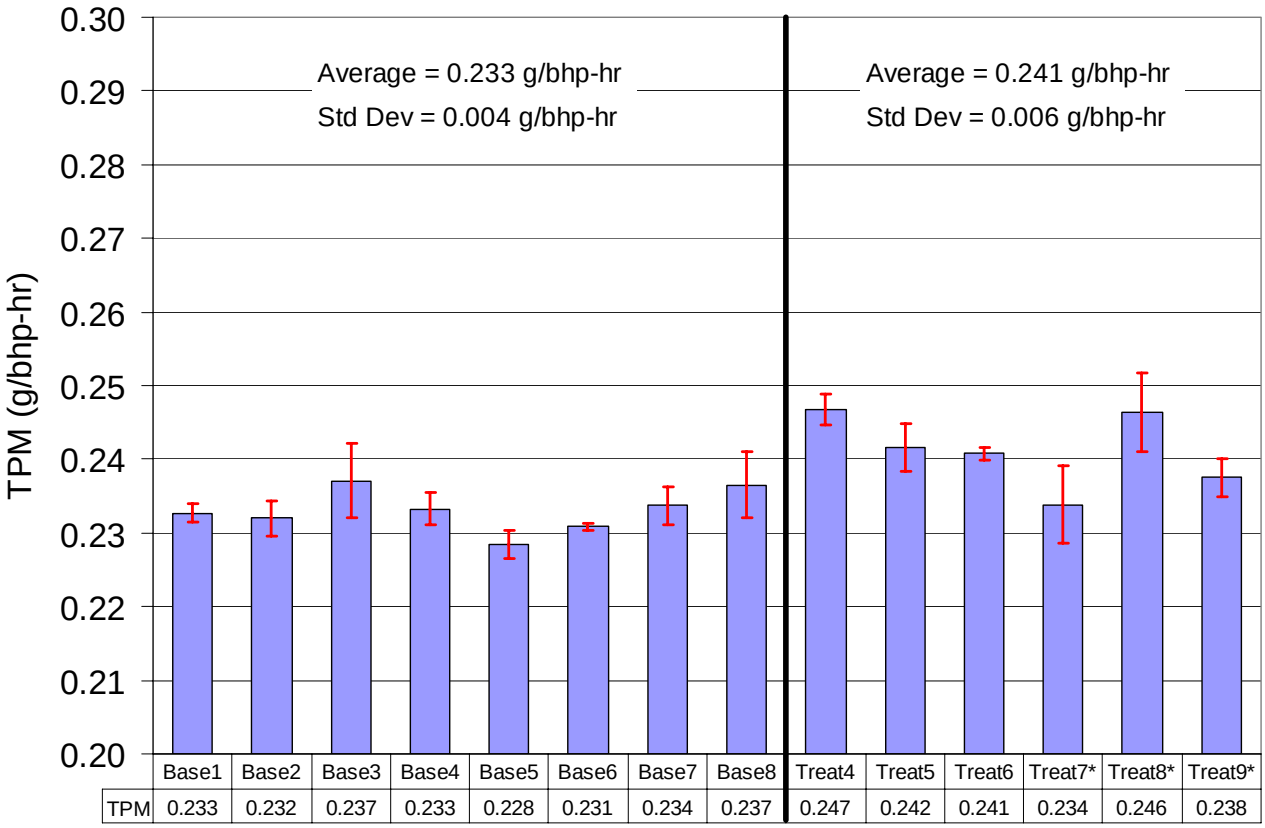
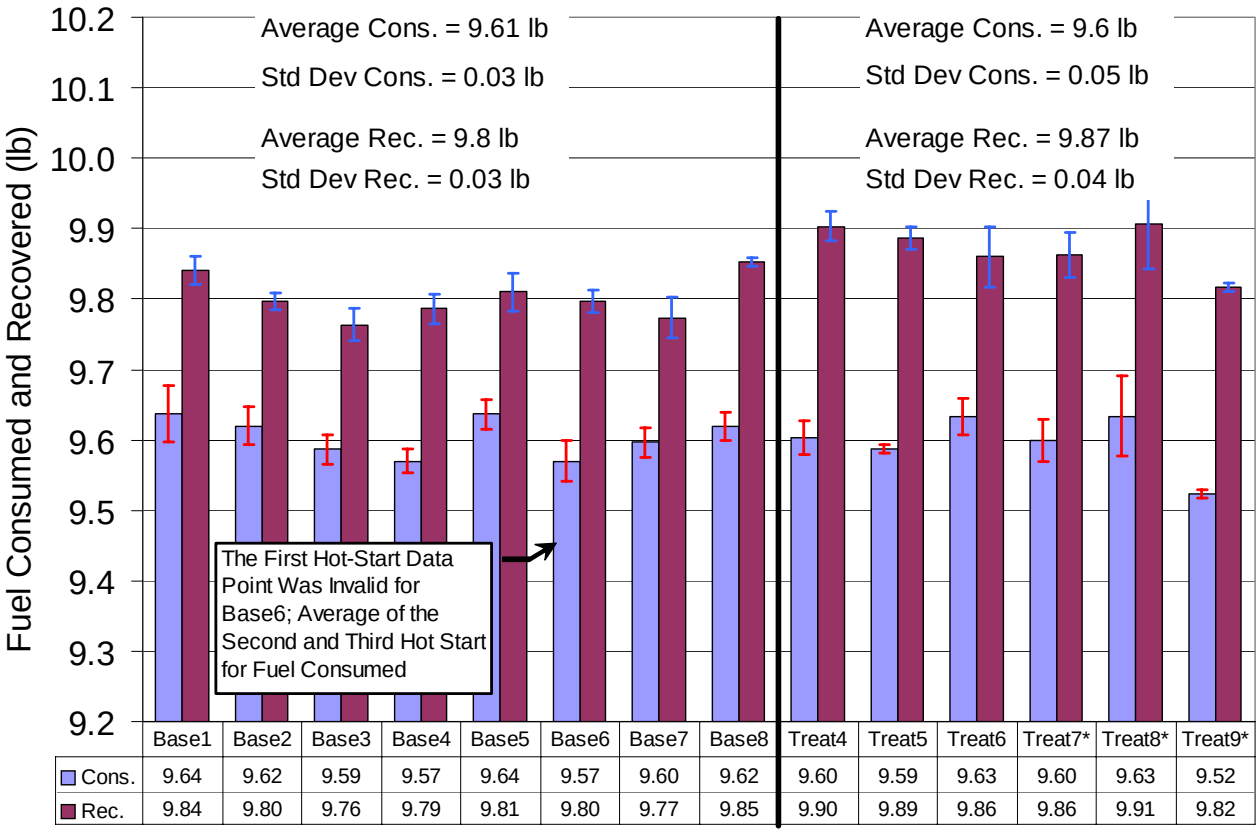


Figure 5 Average TPM from three hot-start FTP runs excluding TX-Treat1 to TX-Treat3. Bars represent one standard deviation of the data for that fuel. Note the expanded emissions axis.

The results for fuel consumption are shown in Figure 6 and in Figure 7 for the fuel consumption and BSFC, respectively, for the hot starts. The bars represent one standard deviation of the data for that fuel. The fuel consumed was the direct measurement from the fuel meter whereas the fuel recovered was the inferred value using a carbon balance from the emissions results. The BSFC values use the consumed measurement. The data uses specific gravity and the hydrogen-to-carbon ratio in the determination of these values. As shown in the fuel consumption and BSFC data, there is no significant difference in the amount of fuel required to exercise the engine over hot-start FTP cycles. The average BSFC is 0.379 lb/bhp-hr for the TX-Base and TX-Treat fuels. It is noted that there is no significant difference in the integrated work between the TX-Base and TX-Treat FTP runs.



	Base1	Base2	Base3	Base4	Base5	Base6	Base7	Base8	Treat4	Treat5	Treat6	Treat7*	Treat8*	Treat9*
Cons.	9.64	9.62	9.59	9.57	9.64	9.57	9.60	9.62	9.60	9.59	9.63	9.60	9.63	9.52
Rec.	9.84	9.80	9.76	9.79	9.81	9.80	9.77	9.85	9.90	9.89	9.86	9.86	9.91	9.82

Figure 6 Comparison of the average fuel consumption data from three hot-start FTP runs excluding TX-Treat1 to TX-Treat3. Bars represent one standard deviation of the data for that fuel. Note the expanded axes.

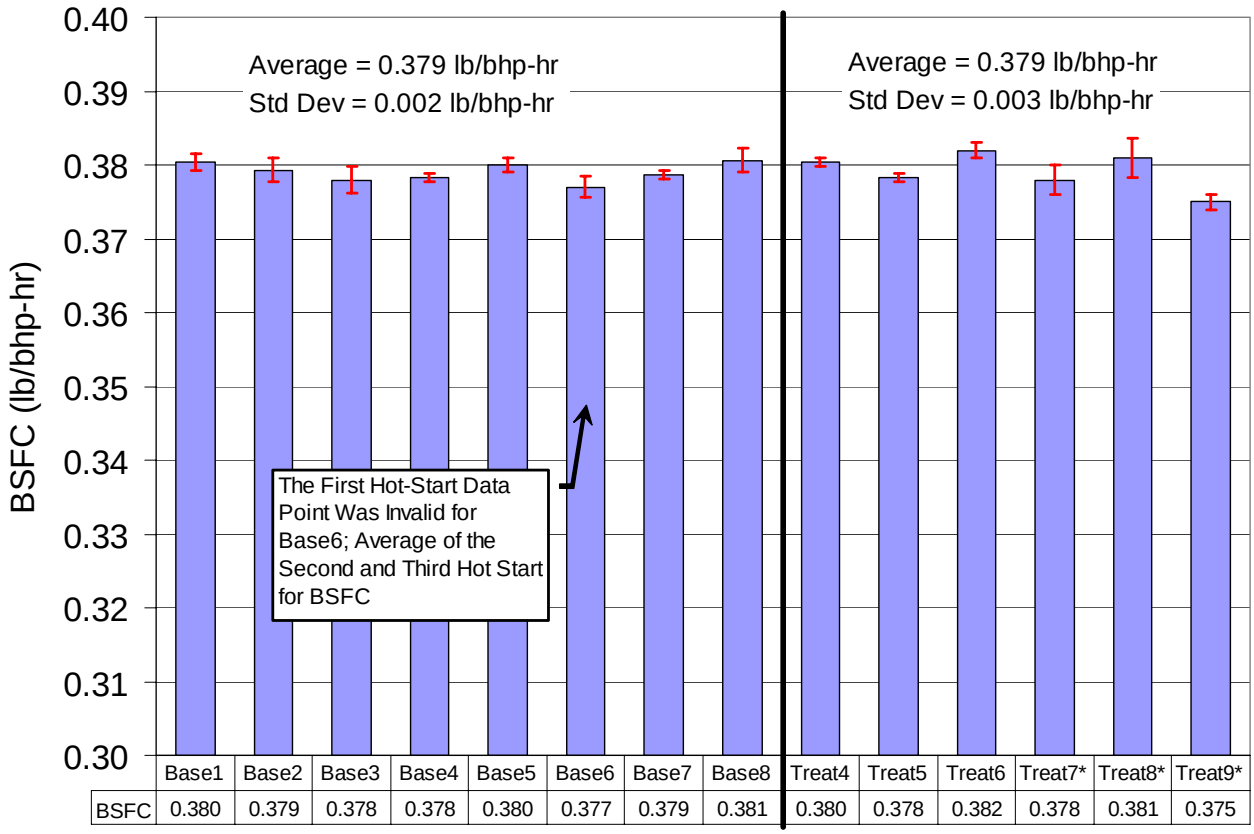


Figure 7 Comparison of the brake specific fuel consumption data from three hot-start FTP runs excluding TX-Treat1 to TX-Treat3. Bars represent one standard deviation of the data for that fuel. Note the expanded axes.

Comparison of All Base and All Treated Runs

For all runs included in the average, the NOx averaged 5.58 g/bhp-hr for the TX-Base fuel and 5.31 g/bhp-hr for the TX-Treat fuel, resulting in a 4.8% reduction in the NOx using the TX-Treat fuel. As illustrated in Figure 8 and summarized in Table 4, the TX-Base fuel brake-specific NOx was consistent over the five calendar days that testing occurred. However, there is a large initial change in the brake-specific NOx for the TX-Treat fuel.

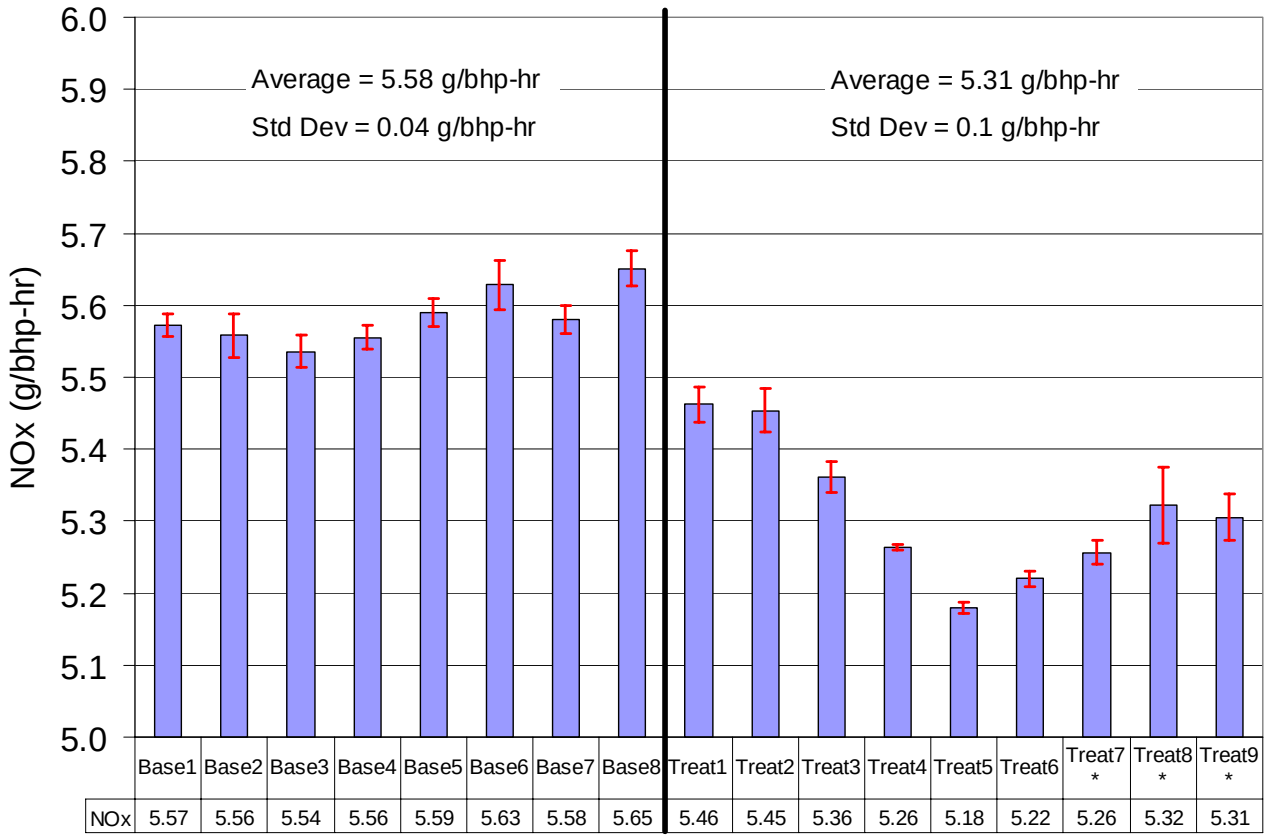


Figure 8 Average NOx from three hot-start FTP runs. Bars represent one standard deviation of the data for that set of tests. Note the expanded emissions axis.

Table 4 Summary of all hot-start FTP runs for the TX-Base and TX-Treat fuels.

	All TX-Base Fuel		All TX-Treat Fuel		Difference
	Average	Std Dev	Average	Std Dev	(%)
Work (bhp-hr)	25.3	0.1	25.3	0.1	-0.1
BSFC (lb/bhp-hr)	0.379	0.002	0.379	0.003	0.0
Fuel Cons. (lb)	9.61	0.03	9.59	0.04	-0.1
Fuel Rec. (lb)	9.80	0.03	9.88	0.04	0.8
THC (g/bhp-hr)	0.124	0.006	0.095	0.003	-23.5
CO (g/bhp-hr)	3.22	0.07	2.91	0.05	-9.6
CO2 (g/bhp-hr)	555	3	557	3	0.3
NOx (g/bhp-hr)	5.58	0.04	5.31	0.10	-4.8
TPM (g/bhp-hr)	0.233	0.004	0.239	0.006	2.6

The average results for THC are shown in Figure 9 for the three hot start tests for all runs included in the TX-Treat average. The bars represent one standard deviation of the data for each test. The THC averaged 0.124 g/bhp-hr for the TX-Base fuel and 0.095 g/bhp-hr for the TX-Treat fuel, resulting in a 23.5% reduction in the THC using the TX-Treat fuel. The THC remained constant throughout the testing for each fuel. It is noted that the THC analyzer was changed between TX-Base7 and TX-Base8. The last set of evaluations for the TX-Treat fuel, TX-Treat7* through TX-Treat9*, shows consistent THC data

with the prior six set of TX-Treat tests. It does not appear as though there was any impact on the THC emissions from the different treated blend fuels.

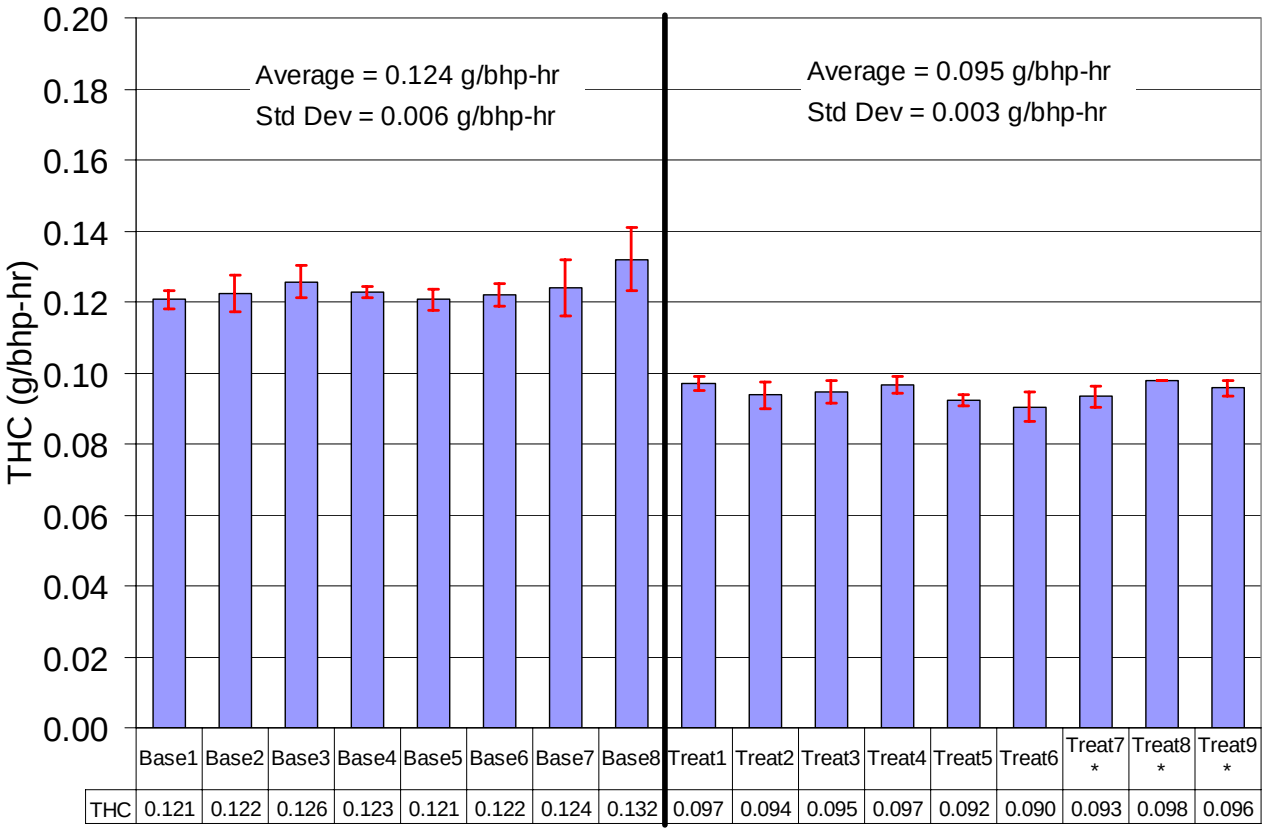


Figure 9 Average THC from three hot-start FTP runs. Bars represent one standard deviation of the data for that fuel.

The average results for CO are shown in Figure 10 for the three hot start tests. The bars represent one standard deviation of the data for each test. The CO averaged 3.22 g/bhp-hr for the TX-Base fuel and 2.91 g/bhp-hr for the TX-Treat fuel, resulting in a 9.6% reduction in the CO using the TX-Treat fuel. There was a 5.5% difference in the CO for the TX-Base fuel between TX-Base1 and TX-Base5 whereas there were minor variations in the CO from test-to-test for the TX-Treat fuel. The last set of evaluations for the TX-Treat fuel, TX-Treat7* through TX-Treat9*, shows consistent CO data with the prior six set of TX-Treat tests. It does not appear as though there was any impact on the CO emissions from the different treated blend fuels.

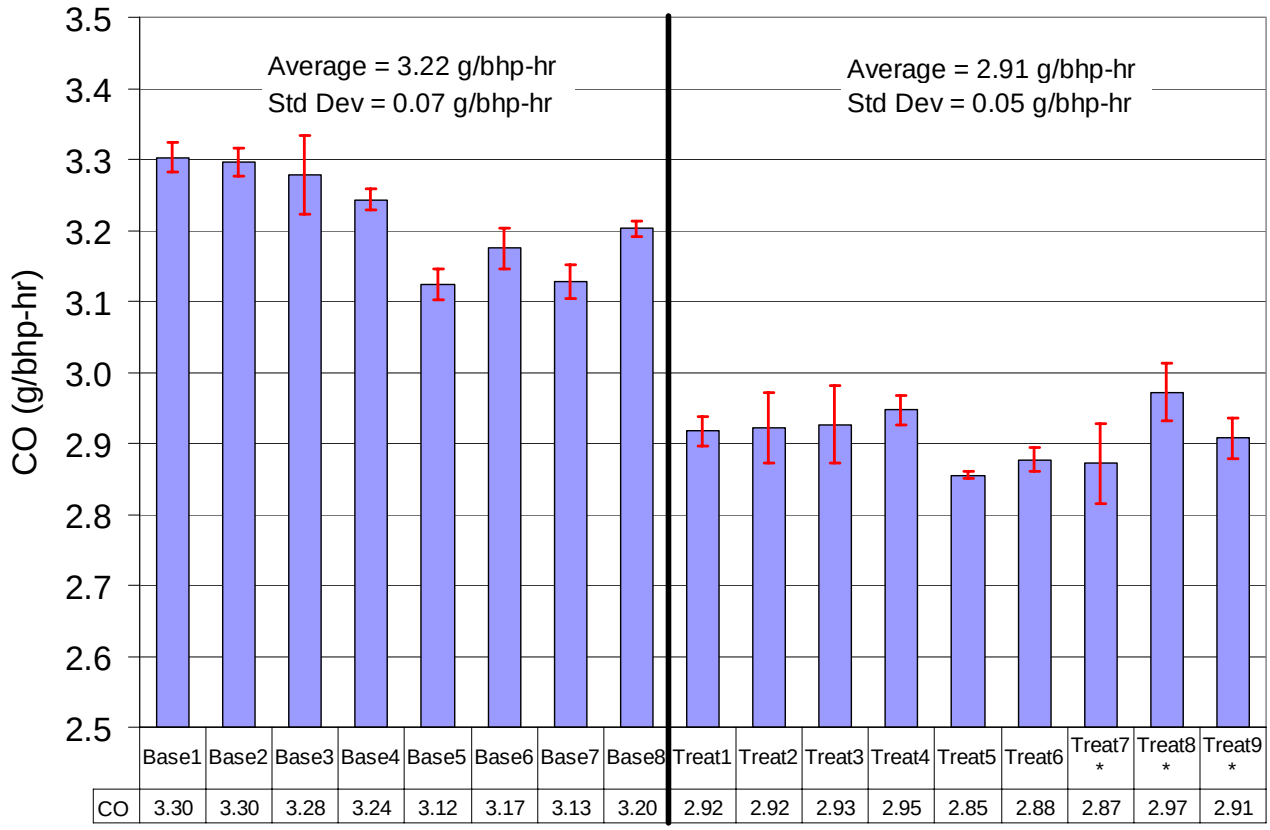


Figure 10 Average CO from three hot-start FTP runs. Bars represent one standard deviation of the data for that fuel. Note the expanded emissions axis.

The average results for TPM are shown in Figure 11 for each set of tests. The bars represent one standard deviation of the data for each test. The TPM averaged 0.233 g/bhp-hr for the TX-Base fuel and 0.239 g/bhp-hr for the TX-Treat fuel, resulting in a 2.6% increase in the TPM using the TX-Treat fuel. As illustrated in this figure, the TX-Base fuel brake-specific TPM was consistent over the five calendar days that testing occurred whereas there was a slightly larger variation in the brake-specific TPM for the TX-Treat fuel. The last set of evaluations for the TX-Treat fuel, TX-Treat7* through TX-Treat9*, shows high run-to-run variability in the data but is within the variability of other TX-Base and TX-Treat tests. It does not appear as though there was any impact on the TPM emissions from the different treated blend fuels.

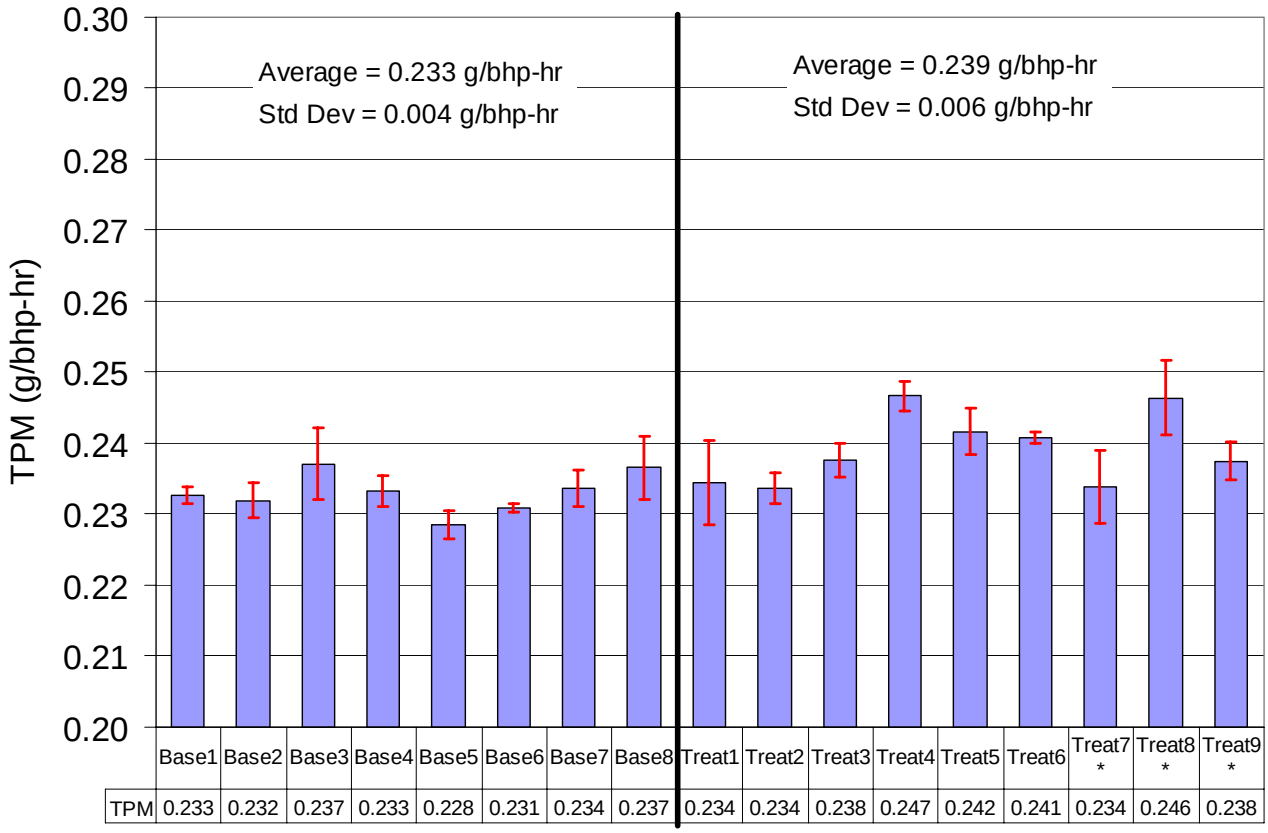
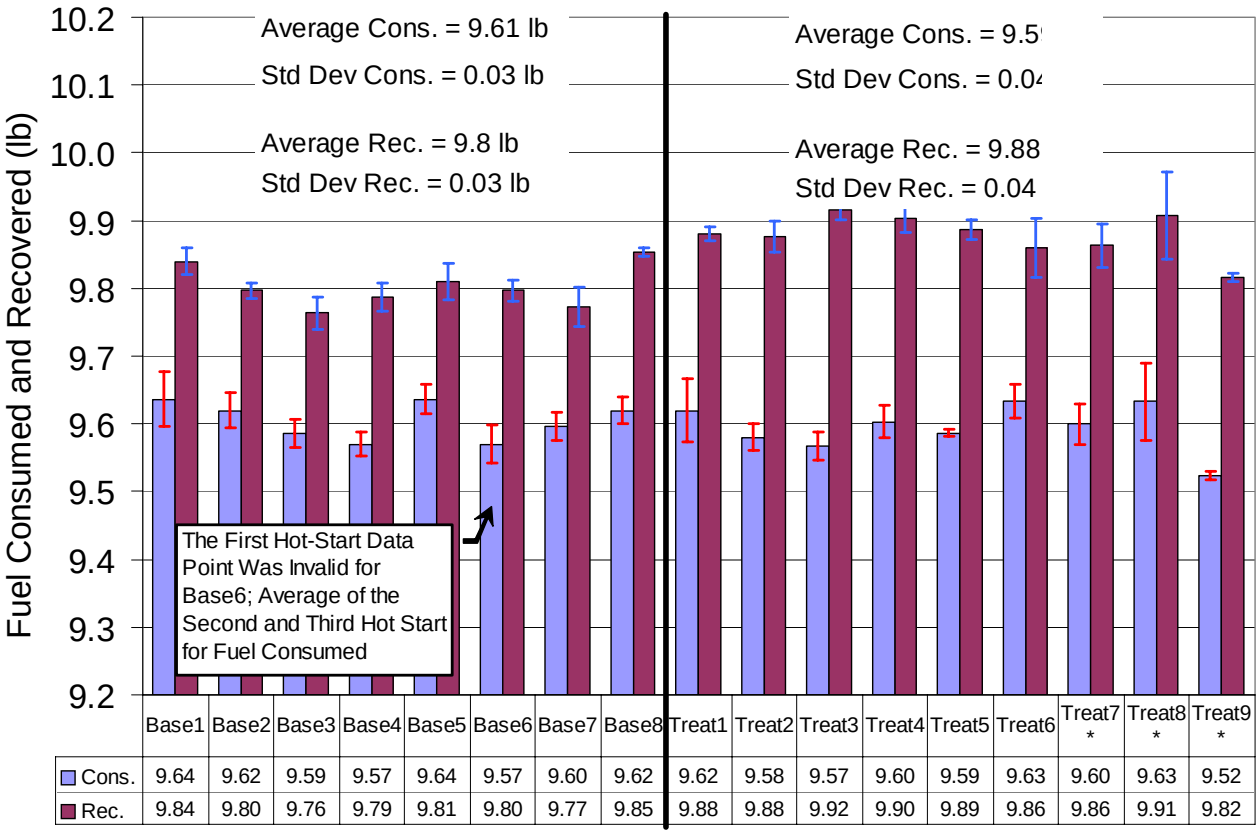


Figure 11 Average TPM from three hot-start FTP runs. Bars represent one standard deviation of the data for that fuel. Note the expanded emissions axis.

The results for fuel consumption are shown in Figure 12 and BSFC in Figure 13 for the hot starts. The bars represent one standard deviation of the data for that fuel. The fuel consumed was the direct measurement from the fuel meter whereas the fuel recovered was the inferred value using a carbon balance from the emissions results. The BSFC value uses the consumed measurement. The data uses specific gravity and the hydrogen-to-carbon ratio in the determination of these values. As shown in the fuel consumption and BSFC data, there is no difference in the amount of fuel required to exercise the engine over hot-start FTP cycles. The average BSFC is 0.379 lb/bhp-hr for the TX-Base and TX-Treat fuels. It is noted that there is no significant difference in the integrated work between the TX-Base and TX-Treat FTP runs.



	Base1	Base2	Base3	Base4	Base5	Base6	Base7	Base8	Treat1	Treat2	Treat3	Treat4	Treat5	Treat6	Treat7 *	Treat8 *	Treat9 *
Cons.	9.64	9.62	9.59	9.57	9.64	9.57	9.60	9.62	9.62	9.58	9.57	9.60	9.59	9.63	9.60	9.63	9.52
Rec.	9.84	9.80	9.76	9.79	9.81	9.80	9.77	9.85	9.88	9.88	9.92	9.90	9.89	9.86	9.86	9.91	9.82

Figure 12 Comparison of the average fuel consumption data from three hot-start FTP. Bars represent one standard deviation of the data for that fuel. Note the expanded axes.

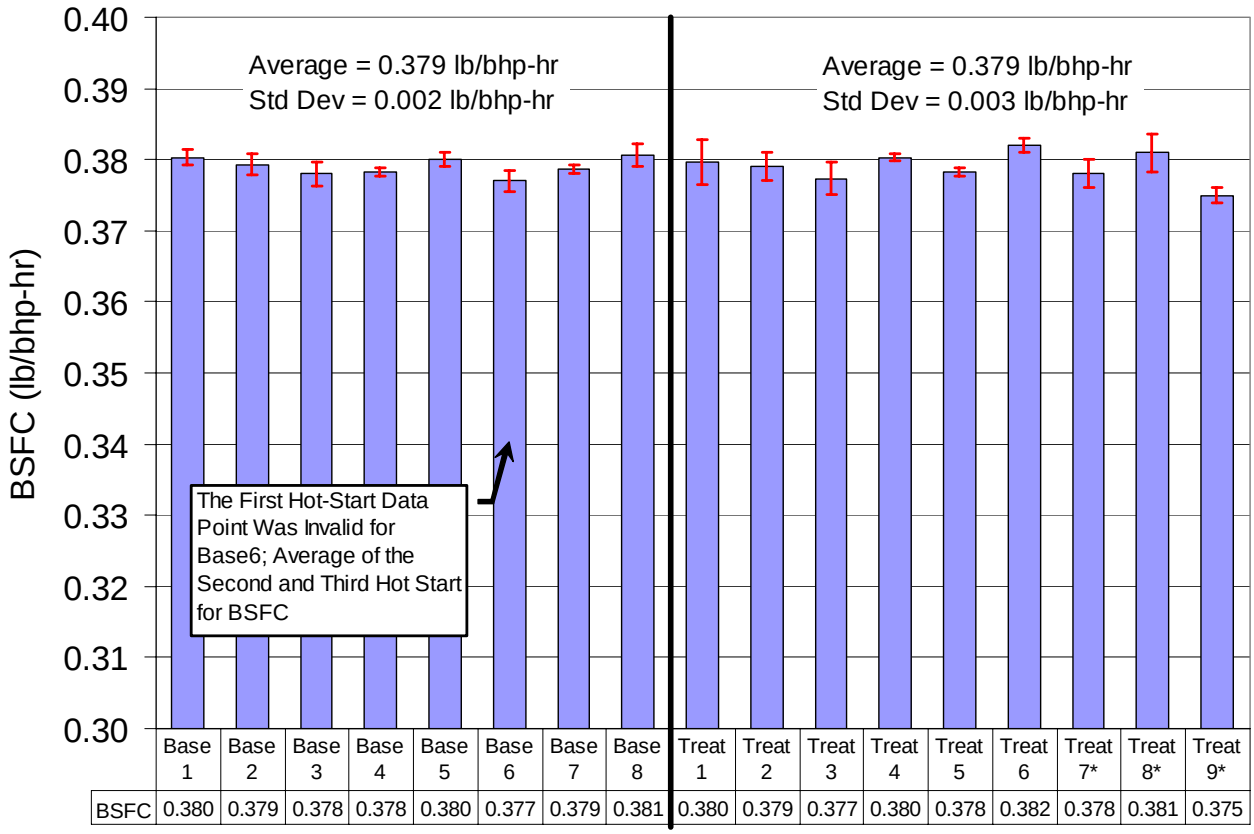


Figure 13 Comparison of the brake specific fuel consumption data from three hot-start FTP. Bars represent one standard deviation of the data for that fuel. Note the expanded axes.

References

1 *Title 40 Code of Federal Regulations, Part 86*, U.S. Government Printing Office, Washington, DC, 2000.

Appendix A – Fuel Analyses

Table 5 TX-Base fuel analysis.

Test	Units	Method	Run #1	Run #2	Run #3	Average	Std Dev
API Gravity	deg.API	ASTM D-1298	31.9	31.9	31.9	31.9	0.0
Aromatics by Supercritical Fluid Chromatography							
Monoaromatics	wt%	ASTM D-5186	29.2	29.3	29.2	29.2	0.1
Polynuclear Aromatic Hydrocarbons	wt%		9.4	9.3	9.4	9.4	0.0
Total Aromatics	wt%		38.6	38.6	38.6	38.6	0.0
Cetane Number		ASTM D-613	41.3	41.6	41.6	41.5	0.2
Distillation							
IBP	deg.F	ASTM D-86	340	318	322	327	11
5% Rec	deg.F		403	401	398	400	3
10% Rec	deg.F		436	439	435	437	2
20% Rec	deg.F		472	472	471	472	1
30% Rec	deg.F		491	491	491	491	0
40% Rec	deg.F		510	510	509	509	1
50% Rec	deg.F		528	528	526	527	1
60% Rec	deg.F		546	547	546	546	0
70% Rec	deg.F		568	568	568	568	0
80% Rec	deg.F		598	597	596	597	1
90% Rec	deg.F		641	640	640	640	1
95% Rec	deg.F		682	679	678	680	2
FBP	deg.F		689	688	685	687	2
Recovery	%		97.2	97.4	97.2	97.3	0.1
Residue	%		1.3	1.2	1.3	1.3	0.1
Loss	%		1.5	1.4	1.5	1.5	0.1
Flash Point, PMCC	deg.F	ASTM D-93	150	150	150	150	0
Kinematic Viscosity @ 40 deg. C	cSt	ASTM D-445	3.03	3.03	3.03	3.03	0.00
Nitrogen, Total	ppm wt	ASTM D-4629	207	205	207	206	1
Sulfur, Total by X-Ray Spec	wt%	ASTM D-2622	0.0409	0.0415	0.0408	0.0411	0.0004
Carbon	wt%	ASTM D-5291	87.15	87.22	87.10	87.16	0.06
Hydrogen Content	wt%	ASTM D-5291	12.91	12.70	12.91	12.84	0.12

Table 6 TX-Treat fuel analysis.

Test	Units	Method	Run #1	Run #2	Run #3	Average	Std Dev
API Gravity	deg.API	ASTM D-1298	32.7	32.8	32.1	32.5	0.3
Aromatics by Supercritical Fluid Chromatography							
Monoaromatics	wt%	ASTM D-5186	28.3	28.1	29.2	28.5	0.6
Polynuclear Aromatic Hydrocarbons	wt%		8.6	8.9	9.1	8.9	0.3
Total Aromatics	wt%		36.9	37.0	38.3	37.4	0.8
Cetane Number		ASTM D-613	51.5	54.4	49.8	51.9	2.3
Distillation							
IBP	deg.F	ASTM D-86	317	307	316	313	5
5% Rec	deg.F		405	404	402	404	1
10% Rec	deg.F		442	438	438	439	2
20% Rec	deg.F		475	475	473	474	1
30% Rec	deg.F		491	493	491	492	1
40% Rec	deg.F		513	512	510	511	1
50% Rec	deg.F		528	528	529	528	0
60% Rec	deg.F		546	545	547	546	1
70% Rec	deg.F		565	565	566	565	1
80% Rec	deg.F		592	593	596	594	2
90% Rec	deg.F		640	640	643	641	2
95% Rec	deg.F		682	684	684	683	1
FBP	deg.F		688	688	688	688	0
Recovery	%		97.3	97.1	97.0	97.1	0.2
Residue	%		1.3	1.3	1.3	1.3	0.0
Loss	%		1.4	1.6	1.7	1.6	0.2
Flash Point, PMCC	deg.F	ASTM D-93	150	148	152	150	2
Kinematic Viscosity @ 40 deg. C	cSt	ASTM D-445	2.98	2.98	2.97	2.98	0.00
Nitrogen, Total	ppm wt	ASTM D-4629	513	486	477	492	19
Sulfur, Total by X-Ray Spec	wt%	ASTM D-2622	0.0330	0.0331	0.0342	0.0334	0.0007
Carbon	wt%	ASTM D-5291	86.17	86.19	86.33	86.23	0.09
Hydrogen Content	wt%	ASTM D-5291	13.46	13.31	13.26	13.34	0.10

Appendix B – Emissions Summary Tables

Table 7 Summary of untreated fuel TX-Base1 emissions data.

Test ID	E00008-02	E00008-03	E00008-04		Base1		
Test Date	8/28/04	8/28/04	8/28/04				
Test Time	10:17	10:57	11:37				
Start Type	Hot Start	Hot Start	Hot Start				
Comment	Hot Start	Hot Start	Hot Start		Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.4	25.3	25.3		25.3	0.0	0.1
BSFC (lb/bhp-hr)	0.381	0.381	0.379		0.380	0.001	0.3
Fuel Cons. (lb)	9.68	9.63	9.60		9.64	0.04	0.4
Fuel Rec. (lb)	9.84	9.86	9.82		9.84	0.02	0.2
THC (g/bhp-hr)	0.118	0.121	0.123		0.121	0.003	2.1
CO (g/bhp-hr)	3.28	3.32	3.30		3.30	0.02	0.6
CO_2 (g/bhp-hr)	556	558	556		557	1	0.3
NOx (g/bhp-hr)	5.59	5.56	5.57		5.57	0.02	0.3
TPM (g/bhp-hr)	0.232	0.234	0.232		0.233	0.001	0.5

Table 8 Summary of untreated fuel TX-Base2 emissions data.

Test ID	E00009-02	E00009-03	E00009-04	Base2		
Test Date	8/28/04	8/28/04	8/28/04			
Test Time	14:02	14:42	15:23			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.4	25.3	25.4	25.4	0.0	0.1
BSFC (lb/bhp-hr)	0.379	0.381	0.378	0.379	0.002	0.4
Fuel Cons. (lb)	9.61	9.65	9.60	9.62	0.03	0.3
Fuel Rec. (lb)	9.81	9.79	9.79	9.80	0.01	0.1
THC (g/bhp-hr)	0.127	0.117	0.123	0.122	0.005	4.1
CO (g/bhp-hr)	3.28	3.29	3.32	3.30	0.02	0.6
CO2 (g/bhp-hr)	554	554	553	554	1	0.2
NOx (g/bhp-hr)	5.54	5.59	5.54	5.56	0.03	0.5
TPM (g/bhp-hr)	0.230	0.231	0.235	0.232	0.002	1.0

Table 9 Summary of untreated fuel TX-Base3 emissions data.

Test ID	E00010-02	E00010-03	E00010-04	Base3		
Test Date	8/29/04	8/29/04	8/29/04			
Test Time	9:37	10:18	10:58			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.3	25.4	25.4	25.4	0.1	0.2
BSFC (lb/bhp-hr)	0.380	0.377	0.377	0.378	0.002	0.5
Fuel Cons. (lb)	9.61	9.57	9.58	9.59	0.02	0.2
Fuel Rec. (lb)	9.79	9.75	9.75	9.76	0.02	0.2
THC (g/bhp-hr)	0.130	0.126	0.121	0.126	0.005	3.6
CO (g/bhp-hr)	3.34	3.26	3.23	3.28	0.06	1.7
CO2 (g/bhp-hr)	555	551	550	552	3	0.5
NOx (g/bhp-hr)	5.56	5.52	5.53	5.54	0.02	0.4
TPM (g/bhp-hr)	0.243	0.233	0.236	0.237	0.005	2.1

Table 10 Summary of untreated fuel TX-Base4 emissions data.

Test ID	E00011-02	E00011-03	E00011-04	Base4		
Test Date	8/29/04	8/29/04	8/29/04			
Test Time	13:28	14:08	14:48			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.3	25.3	25.3	25.3	0.0	0.1
BSFC (lb/bhp-hr)	0.379	0.378	0.378	0.378	0.001	0.2
Fuel Cons. (lb)	9.59	9.56	9.56	9.57	0.02	0.2
Fuel Rec. (lb)	9.81	9.78	9.77	9.79	0.02	0.2
THC (g/bhp-hr)	0.123	0.121	0.124	0.123	0.002	1.2
CO (g/bhp-hr)	3.25	3.23	3.25	3.24	0.02	0.5
CO2 (g/bhp-hr)	556	555	553	555	1	0.2
NOx (g/bhp-hr)	5.54	5.57	5.55	5.56	0.02	0.3
TPM (g/bhp-hr)	0.234	0.231	0.235	0.233	0.002	1.0

Table 11 Summary of untreated fuel TX-Base5 emissions data.

Test ID	E00012-02	E00012-03	E00012-04	Base5		
Test Date	8/31/04	8/31/04	8/31/04			
Test Time	9:07	9:47	10:27			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.3	25.4	25.3	25.3	0.1	0.2
BSFC (lb/bhp-hr)	0.381	0.379	0.380	0.380	0.001	0.3
Fuel Cons. (lb)	9.66	9.63	9.62	9.64	0.02	0.2
Fuel Rec. (lb)	9.83	9.82	9.78	9.81	0.03	0.3
THC (g/bhp-hr)	0.124	0.120	0.118	0.121	0.003	2.5
CO (g/bhp-hr)	3.15	3.11	3.12	3.12	0.02	0.7
CO2 (g/bhp-hr)	557	554	555	555	1	0.2
NOx (g/bhp-hr)	5.57	5.59	5.61	5.59	0.02	0.3
TPM (g/bhp-hr)	0.227	0.227	0.231	0.228	0.002	0.8

Table 12 Summary of untreated fuel TX-Base6 emissions data. Note that the fuel consumed and BSFC were invalid for the first hot start.

Test ID	E00013-02	E00013-03	E00013-04			
Test Date	8/31/04	8/31/04	8/31/04	Base6		
Test Time	13:47	14:27	15:07			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.5	25.4	25.4	25.4	0.1	0.2
BSFC (lb/bhp-hr)	**	0.378	0.376	0.377	0.001	0.4
Fuel Cons. (lb)	**	9.59	9.55	9.57	0.03	0.3
Fuel Rec. (lb)	9.80	9.81	9.78	9.80	0.02	0.2
THC (g/bhp-hr)	0.119	0.122	0.125	0.122	0.003	2.5
CO (g/bhp-hr)	3.21	3.15	3.17	3.17	0.03	0.9
CO2 (g/bhp-hr)	552	555	552	553	2	0.3
NOx (g/bhp-hr)	5.59	5.66	5.63	5.63	0.03	0.6
TPM (g/bhp-hr)	0.231	0.230	0.231	0.231	0.001	0.2

** An Error in the Fuel Consumed Measurement Occurred; the BSFC Uses the Consumed Measurement.

Table 13 Summary of untreated fuel TX-Base7 emissions data.

Test ID	E00014-02	E00014-03	E00014-04	Base7		
Test Date	9/1/04	9/1/04	9/1/04			
Test Time	10:47	11:27	12:07			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.4	25.4	25.3	25.3	0.0	0.1
BSFC (lb/bhp-hr)	0.379	0.378	0.379	0.379	0.001	0.2
Fuel Cons. (lb)	9.62	9.59	9.58	9.60	0.02	0.2
Fuel Rec. (lb)	9.74	9.79	9.79	9.77	0.03	0.3
THC (g/bhp-hr)	0.132	0.124	0.116	0.124	0.008	6.5
CO (g/bhp-hr)	3.15	3.14	3.10	3.13	0.02	0.8
CO2 (g/bhp-hr)	551	554	555	553	2	0.4
NOx (g/bhp-hr)	5.57	5.57	5.60	5.58	0.02	0.3
TPM (g/bhp-hr)	0.237	0.232	0.232	0.234	0.003	1.1

Table 14 Summary of untreated fuel TX-Base8 emissions data.

Test ID	E00015-02	E00015-03	E00015-04	Base8		
Test Date	9/1/04	9/1/04	9/1/04			
Test Time	17:41	18:22	19:02			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.3	25.3	25.3	25.3	0.0	0.1
BSFC (lb/bhp-hr)	0.379	0.382	0.381	0.381	0.002	0.4
Fuel Cons. (lb)	9.60	9.64	9.62	9.62	0.02	0.2
Fuel Rec. (lb)	9.85	9.86	9.85	9.85	0.01	0.1
THC (g/bhp-hr)	0.129	0.142	0.125	0.132	0.009	6.7
CO (g/bhp-hr)	3.19	3.21	3.20	3.20	0.01	0.3
CO2 (g/bhp-hr)	558	560	559	559	1	0.1
NOx (g/bhp-hr)	5.66	5.63	5.67	5.65	0.02	0.4
TPM (g/bhp-hr)	0.233	0.242	0.234	0.237	0.004	1.9

Table 15 Summary of treated fuel TX-Treat1 emissions data.

Test ID	E00020-02	E00020-03	E00020-04			
Test Date	9/3/04	9/3/04	9/3/04	Treat1		
Test Time	14:01	14:41	15:21			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.2	25.3	25.4	25.3	0.1	0.4
BSFC (lb/bhp-hr)	0.382	0.381	0.376	0.380	0.003	0.8
Fuel Cons. (lb)	9.63	9.66	9.57	9.62	0.05	0.5
Fuel Rec. (lb)	9.89	9.88	9.87	9.88	0.01	0.1
THC (g/bhp-hr)	0.097	0.099	0.095	0.097	0.002	2.1
CO (g/bhp-hr)	2.94	2.91	2.90	2.92	0.02	0.7
CO2 (g/bhp-hr)	559	556	554	556	3	0.5
NOx (g/bhp-hr)	5.49	5.46	5.44	5.46	0.02	0.5
TPM (g/bhp-hr)	0.241	0.232	0.231	0.234	0.006	2.5

Table 16 Summary of treated fuel TX-Treat2 emissions data.

Test ID	E00021-02	E00021-03	E00021-04	Treat2		
Test Date	9/3/04	9/3/04	9/3/04			
Test Time	16:50	17:30	18:11			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.4	25.2	25.3	25.3	0.1	0.3
BSFC (lb/bhp-hr)	0.377	0.381	0.379	0.379	0.002	0.5
Fuel Cons. (lb)	9.56	9.60	9.58	9.58	0.02	0.2
Fuel Rec. (lb)	9.85	9.89	9.89	9.88	0.02	0.2
THC (g/bhp-hr)	0.092	0.091	0.098	0.094	0.004	4.0
CO (g/bhp-hr)	2.87	2.94	2.96	2.92	0.05	1.7
CO2 (g/bhp-hr)	554	560	559	558	3	0.5
NOx (g/bhp-hr)	5.43	5.49	5.45	5.45	0.03	0.6
TPM (g/bhp-hr)	0.231	0.234	0.236	0.234	0.002	1.0

Table 17 Summary of treated fuel TX-Treat3 emissions data.

Test ID	E00022-02	E00022-03	E00022-04	Treat3		
Test Date	9/4/04	9/4/04	9/4/04			
Test Time	10:19	10:59	11:39			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.5	25.4	25.2	25.4	0.1	0.5
BSFC (lb/bhp-hr)	0.376	0.376	0.380	0.377	0.002	0.6
Fuel Cons. (lb)	9.56	9.55	9.59	9.57	0.02	0.2
Fuel Rec. (lb)	9.90	9.92	9.93	9.92	0.02	0.2
THC (g/bhp-hr)	0.097	0.096	0.091	0.095	0.003	3.4
CO (g/bhp-hr)	2.87	2.92	2.98	2.93	0.05	1.9
CO2 (g/bhp-hr)	555	557	561	558	3	0.6
NOx (g/bhp-hr)	5.34	5.36	5.39	5.36	0.02	0.4
TPM (g/bhp-hr)	0.235	0.240	0.238	0.238	0.002	1.0

Table 18 Summary of treated fuel TX-Treat4 emissions data.

Test ID	E00023-02	E00023-03	E00023-04			
Test Date	9/4/04	9/4/04	9/4/04	Treat4		
Test Time	13:28	14:08	14:48			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.3	25.3	25.3	25.3	0.0	0.1
BSFC (lb/bhp-hr)	0.380	0.380	0.381	0.380	0.001	0.2
Fuel Cons. (lb)	9.59	9.59	9.63	9.60	0.02	0.2
Fuel Rec. (lb)	9.91	9.88	9.92	9.90	0.02	0.2
THC (g/bhp-hr)	0.099	0.097	0.094	0.097	0.003	2.6
CO (g/bhp-hr)	2.92	2.95	2.96	2.95	0.02	0.7
CO2 (g/bhp-hr)	559	558	560	559	1	0.2
NOx (g/bhp-hr)	5.27	5.26	5.26	5.26	0.00	0.1
TPM (g/bhp-hr)	0.244	0.249	0.247	0.247	0.002	0.8

Table 19 Summary of treated fuel TX-Treat5 emissions data.

Test ID	E00024-02	E00024-03	E00024-04		Treat5		
Test Date	9/5/04	9/5/04	9/5/04				
Test Time	10:12	10:52	11:32				
Start Type	Hot Start	Hot Start	Hot Start				
Comment	Hot Start	Hot Start	Hot Start		Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.4	25.4	25.3		25.3	0.0	0.1
BSFC (lb/bhp-hr)	0.378	0.378	0.379		0.378	0.001	0.2
Fuel Cons. (lb)	9.59	9.59	9.58		9.59	0.01	0.1
Fuel Rec. (lb)	9.90	9.87	9.89		9.89	0.02	0.2
THC (g/bhp-hr)	0.092	0.094	0.091		0.092	0.002	1.7
CO (g/bhp-hr)	2.86	2.85	2.85		2.85	0.01	0.2
CO2 (g/bhp-hr)	557	555	558		557	1	0.3
NOx (g/bhp-hr)	5.17	5.18	5.19		5.18	0.01	0.2
TPM (g/bhp-hr)	0.245	0.238	0.242		0.242	0.003	1.4

Table 20 Summary of treated fuel TX-Treat6 emissions data.

Test ID	E00025-02	E00025-03	E00025-04	Treat6		
Test Date	9/5/04	9/5/04	9/5/04			
Test Time	13:16	13:57	14:37			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.2	25.2	25.2	25.2	0.0	0.1
BSFC (lb/bhp-hr)	0.381	0.383	0.382	0.382	0.001	0.3
Fuel Cons. (lb)	9.61	9.66	9.63	9.63	0.03	0.3
Fuel Rec. (lb)	9.84	9.91	9.83	9.86	0.04	0.4
THC (g/bhp-hr)	0.089	0.095	0.087	0.090	0.004	4.6
CO (g/bhp-hr)	2.88	2.89	2.86	2.88	0.02	0.6
CO2 (g/bhp-hr)	557	561	556	558	3	0.5
NOx (g/bhp-hr)	5.23	5.21	5.23	5.22	0.01	0.2
TPM (g/bhp-hr)	0.241	0.240	0.242	0.241	0.001	0.4

Table 21 Summary of treated fuel TX-Treat7* emissions data. Note that the treated fuel blend for this set of tests was different.

Test ID	E00026-02	E00026-03	E00026-04	Treat7*		
Test Date	9/6/04	9/6/04	9/6/04			
Test Time	9:56	10:36	11:16			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.5	25.3	25.4	25.4	0.1	0.3
BSFC (lb/bhp-hr)	0.376	0.380	0.378	0.378	0.002	0.5
Fuel Cons. (lb)	9.57	9.63	9.60	9.60	0.03	0.3
Fuel Rec. (lb)	9.84	9.90	9.85	9.86	0.03	0.3
THC (g/bhp-hr)	0.090	0.095	0.095	0.093	0.003	3.1
CO (g/bhp-hr)	2.81	2.92	2.89	2.87	0.06	1.9
CO2 (g/bhp-hr)	552	558	553	554	3	0.6
NOx (g/bhp-hr)	5.24	5.27	5.26	5.26	0.02	0.3
TPM (g/bhp-hr)	0.228	0.237	0.237	0.234	0.005	2.2

Table 22 Summary of treated fuel TX-Treat8* emissions data. Note that the treated fuel blend for this set of tests was different.

Test ID	E00027-02	E00027-03	E00027-04			
Test Date	9/6/04	9/6/04	9/6/04	Treat8*		
Test Time	12:53	13:33	14:13			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.2	25.3	25.4	25.3	0.1	0.3
BSFC (lb/bhp-hr)	0.384	0.379	0.380	0.381	0.003	0.7
Fuel Cons. (lb)	9.68	9.57	9.65	9.63	0.06	0.6
Fuel Rec. (lb)	9.98	9.86	9.88	9.91	0.06	0.6
THC (g/bhp-hr)	0.098	0.098	0.098	0.098	0.000	0.0
CO (g/bhp-hr)	3.02	2.94	2.96	2.97	0.04	1.4
CO2 (g/bhp-hr)	564	556	555	558	5	0.9
NOx (g/bhp-hr)	5.35	5.35	5.26	5.32	0.05	1.0
TPM (g/bhp-hr)	0.252	0.242	0.245	0.246	0.005	2.1

Table 23 Summary of treated fuel TX-Treat9* emissions data. Note that the treated fuel blend for this set of tests was different.

Test ID	E00028-02	E00028-03	E00028-04	Treat9*		
Test Date	9/6/04	9/6/04	9/6/04			
Test Time	15:59	16:39	17:19			
Start Type	Hot Start	Hot Start	Hot Start			
Comment	Hot Start	Hot Start	Hot Start	Hot Start Average	Hot Start Std Dev	Hot Start COV (%)
Work (bhp-hr)	25.3	25.4	25.5	25.4	0.1	0.3
BSFC (lb/bhp-hr)	0.376	0.375	0.374	0.375	0.001	0.3
Fuel Cons. (lb)	9.52	9.53	9.52	9.52	0.01	0.1
Fuel Rec. (lb)	9.82	9.82	9.81	9.82	0.01	0.1
THC (g/bhp-hr)	0.097	0.097	0.093	0.096	0.002	2.4
CO (g/bhp-hr)	2.90	2.88	2.94	2.91	0.03	1.0
CO2 (g/bhp-hr)	554	551	550	552	2	0.4
NOx (g/bhp-hr)	5.27	5.33	5.32	5.31	0.03	0.6
TPM (g/bhp-hr)	0.239	0.234	0.239	0.238	0.003	1.1