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TESTING OF CDT BIODIESEL PLUS™ USING THE TCEQ PROCEDURE FOR CERTIFICATION OF EMISSION REDUCTIONS FOR LOW EMISSION DIESEL FUELS

FINAL REPORT

SwRI Project No. 03-05586

Prepared for:

Clean Diesel Technologies, Inc.
300 Atlantic St.
Suite 702
Stamford, CT 06901-3522

Prepared by:

E. Robert Fanick
Group Leader

May 2006

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DEPARTMENT OF ENGINE AND EMISSIONS RESEARCH
ENGINE, EMISSIONS, AND VEHICLE RESEARCH DIVISION

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Results and discussion given in this report relate only to the test items described in this report.

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1.0 INTRODUCTION

The test results reported herein were generated by the Department of Engine and Emissions Research (DEER), Division of Engine, Emissions, and Vehicle Research at Southwest Research Institute® (SwRI®), for Clean Diesel Technologies, Inc (CDTI). This study was run as SwRI Project 03.05586. The Principal Investigator and Project Leader for SwRI was Mr. E. Robert Fanick, Group Leader in DEER. SwRI technical personnel involved in engine operation, emissions sampling, and emissions analysis included Messrs. Ricky D. Frierson and Sergio M. Oseguera. Data reduction was performed by Ms. Sylvia G. Niño, Ms. Amanda L. Korzekwa, and Ms. Kathleen M. Jack. The SwRI Project Manager for this work was Dr. Lawrence R. Smith, Manager of the Chemistry and Unregulated Emissions Section.

This report contains hot-start transient emission results obtained from a 1991 Detroit Diesel Corporation (DDC) Series 60 heavy-duty diesel engine using a reference fuel, Fuel R, and a candidate fuel, Fuel C, containing bio-diesel and an additive Platinum Plus® DFX from CDTI. This candidate fuel is trademarked as CDT Biodiesel PLUS™. Fuel R met the specifications defined in the Texas Commission on Environmental Quality (TCEQ) Chapter 114 – Control of Air Pollution From Motor Vehicles, Subchapter H: Low Emission Fuels, Division 2: Low Emission Diesel. These fuels were tested following Alternative 4, as specified in the aforementioned TCEQ procedure.

2.0 EXPERIMENTAL SETUP

For testing, a 1991 DDC Series 60 (Serial No. 06R0038671) heavy-duty diesel engine was mounted in a transient-capable test cell. This engine had an inline, six-cylinder configuration rated for 365 hp at 1800 rpm. It was turbocharged and used a laboratory water-to-air heat exchanger for a charge air intercooler. Table 1 lists the engine specifications and features. The exhaust was routed to a full flow constant volume sampler (CVS) that utilizes a positive displacement pump (PDP), as illustrated in Figure 1. Total flow in the tunnel was maintained at a nominal flow rate of about 2000 SCFM. Sample zone probes for total particulate (PM), heated oxides of nitrogen (NO_x), heated hydrocarbons (HC), carbon monoxide (CO), and carbon dioxide (CO_2) measurements were connected to the main tunnel. Probes for background gas measurement were connected downstream of the dilution air filter pack, but upstream of the mixing section. The dilution system was equipped with pressure and temperature sensors at various locations in order to obtain all necessary information required by the U.S. Code of Federal Regulation (CFR 40, Part 86, Subpart N).

TABLE 1. ENGINE SPECIFICATIONS AND FEATURES

Engine Parameter	Comment
Engine Serial Number	06R0038671
Make	Detroit Diesel
Model	Series 60, 6067GU60
Engine Displacement and Configuration	12.7 L, I-6
Emission Family	MDD12.7FZAK
Rated Power	365 bhp at 1800 rpm
Electronic Control Module	DDEC-II
Aspiration	Turbocharged

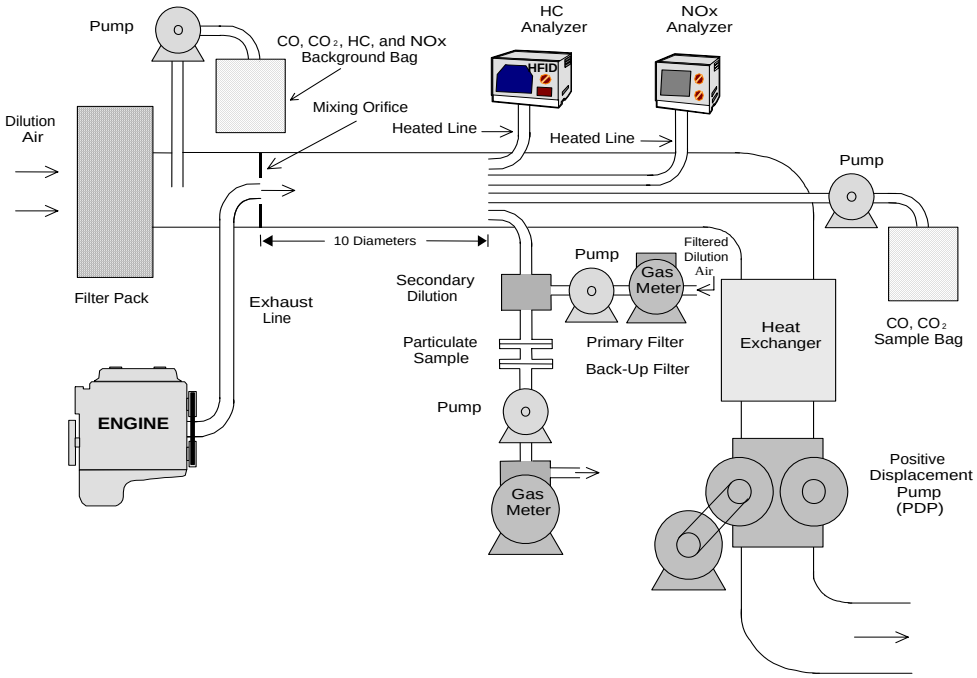

FIGURE 1. SAMPLING SYSTEM USED FOR TRANSIENT EMISSION MEASUREMENTS

3.0 DESCRIPTION OF FUELS TESTED

The reference fuel, Fuel R (SwRI Code EM-5785-F), met the compositional, chemical and physical specifications described in TCEQ Chapter 114 – Control of Air Pollution From Motor Vehicles, Subchapter H: Low Emission Fuels, Division 2: Low Emission Diesel, §114.315. Approved Test Methods. The candidate fuel, Fuel C (SwRI Code EM-5901-F), consisted of an 80 percent ultra-low sulfur diesel (ULSD) blend stock (SwRI Code EM-5444-F) and 20 percent bio-diesel (coded at SwRI as EM-5639-F) provided by CDTI, and additive, Platinum Plus® DFX (coded at SwRI as EM-3240-A) also provided by CDTI. It is our understanding that this formulation will be sold under the trademark of CDT Biodiesel PLUS™. To prepare Fuel C for this test project, 80 percent of the ULSD was blended with 20 percent bio-diesel and 2.5 ml/gallon of the concentrated additive Platinum Plus® DFX. The mixture was then stirred with an air actuated mixer for one hour. The treated fuel was analyzed for total platinum and cerium by inductively-coupled plasma/mass spectrometry (ICP/MS). Selected fuel properties for the reference fuel and for the diesel blend stock used to prepare the candidate fuel are presented in Table 2. Properties of the bio-diesel, B100, additive along with corresponding ASTM D6751 specifications are presented in Table 3. Table 4 presents the platinum and cerium concentrations for Fuel C obtained from the ICP/MS analysis.

TABLE 2. FUEL ANALYSIS RESULTS FOR FUEL R AND BLEND STOCK FOR FUEL C

Fuel Code	Test Method	Reference Fuel Specifications	Reference Fuel EM-5785-F	Diesel Blend Stock Used to Prepare Fuel C		
			1	1	2	3
Sulfur, ppm	D5453	15 max.	12.3	1.2	<0.001	<0.001
Aromatics, vol %	D5186	10 max.	9.9	6.1	6.0	6.1
Polycyclic Aromatics, weight %	D5186	1.4 max.	0.9	0.7	0.7	0.7
Nitrogen, ppm	D4629	10 Max.	7	9.8	10	9.2
Cetane Number	D613	48 min.	49.2	55.9	55.8	55.8
API Gravity	D287	33-39	39	37.1		
Viscosity @ 40°C, cSt	D445	2.0-4.1	2.7	2.966		
Ash, % mass	D482	NA[a]	ND[b]	<0.001		
Flash Point, °F	D93	130 min.	154.5	192		
Cloud Point, °C	D2500	NA	ND	-19		
Copper Strip Corrosion	D130	NA	ND	1B		
Water & Sediment, vol %	D2709	NA	ND	0.01		
Lubricity @ 60°C	D6079	NA	ND	0.365		
Ramsbottom	D524	NA	ND	0.08		
IBP, °F	D86	340-420	364.8	409		
10%, °F		400-490	410.9	438		
50%, °F		470-560	497.3	501		
90%, °F		550-610	608.2	588		
EP, °F		580-660	657.1	631		

[a]NA – Not applicable; no specification for this fuel property
[b]ND – Not determined

TABLE 3. FUEL ANALYSIS RESULTS FOR B100 ADDITIVE

Property	Test Method	Limit	EM-5639-F
Flash Point, °C	D93	130.0 min.	204
Water and Sediment, % vol.	D2709	0.050 max.	0.01
Kinematic Viscosity, mm^2/s	D445	1.9-6.0	4.196
Sulfated Ash, % mass	D874	0.020 max.	<0.001
Sulfur, ppm	D5453	15 ppm	11.2
Copper Strip Corrosion	D130	No. 3 max.	1B
Cetane Number	D613	40 min.	54
Cloud Point, °C	D2500	Report	11
Carbon Residue, % mass	D4530	0.050 max.	0.0295
Acid Number, mg KOH/g	D664	0.80 max.	0.28
Free Glycerin, % mass	D6584	0.02 max.	0.001
Total Glycerin, % mass	D6584	0.24 max.	0.029
Phosphorus, % mass	D4951	0.001 max.	<0.0005
90% Distillation Temperature, °C	D1160	360 max.	352

TABLE 4. FUEL ANALYSIS OF EM-5901-F FOR PLATINUM AND CERIUM

Sample	Cerium, mg/kg	Platinum, mg/kg
First Analysis	7.31	0.174
Second Analysis	7.78	0.171
Third Analysis	7.41	0.169
Average	7.50	0.171

4.0 TEST PLAN AND TEST PROCEDURES

A test plan utilizing alternative 4 of the TCEQ procedure for certification of emission reductions for alternative diesel fuels was submitted to TCEQ for approval and was subsequently approved by TCEQ for this work. Alternative 4 calls for the test sequence to include six (6) hot-start tests with Fuel R, a conditioning period not to exceed 72 hours of engine operation with Fuel C, nine (9) hot-start tests with Fuel C, and a final set of six (6) hot-starts with Fuel R to determine if the engine emissions and fuel consumption rates returned to their original baseline levels. For this study, only 25 hours of durability were performed with Fuel C at the request of CDTI and with the approval of TCEQ. In addition, only six (6) of the nine (9) hot-start tests were conducted with Fuel C because of insufficient fuel to complete the full sequence of tests. This change to the original test plan was discussed and confirmed with TCEQ prior to completing the test program. At the completion of testing, each individual test was considered for use in statistically comparing the two fuels. All transient emission tests were conducted according to the EPA Federal Test Procedure (FTP) specified in CFR 40, Part 86, Subpart N. The first run with Fuel R was used to generate the transient command cycle that was used for all subsequent emission tests.

The test protocol was transformed into a specific test sequence as outlined in Table 5. Regulated emissions of HC, CO, CO_2, NO_x, and PM were measured along with CO_2. Procedures for the measurements of HC, CO, CO_2, NO_x, and PM are described in Subpart N of CFR 40, Part 86. The actual pattern for running Alternative 4 is shown in Table 6.

The EPA transient cycle is described by means of percent of maximum torque and percent of rated speed for each one-second interval over a test cycle of 1199 seconds duration. To generate a transient cycle, an engine's full power curve is obtained from an engine speed below curb idle speed to maximum no-load engine speed. Data from this "power curve," or engine map, are used with the specified speed and load percentages to form a transient cycle. A graphic presentation of the speed and torque commands which constitute a transient cycle is given in Figure 2 for illustration purposes.

In general, a transient test consists of a cold-start transient cycle and a hot-start transient cycle. The same engine command cycle is used in both cases. For the cold-start, the diesel engine is operated over a "prep" cycle, and then allowed to stand overnight in an ambient soak at a temperature between 68 and 86°F. The cold-start transient cycle begins when the engine is cranked for cold start-up. Upon completion of the cold-start transient cycle, the engine is stopped and allowed to stand for 20 minutes. After this hot-soak period, a hot-start cycle begins with engine cranking. In order to determine how well the engine followed the transient command cycle, engine performance is compared to engine command, and several statistics are computed. These computed statistics must be within tolerances specified in the CFR. In addition to the statistical parameters, the cycle work actually produced should be between 5 percent above and 15 percent below the work requested by the command cycle. The first five minutes of the cycle is designated as the New York Non-Freeway (NYNF) portion of the test and represents city operation with extensive idle time. The second five minutes is called the Los Angeles Non-Freeway (LANF) portion. This part of the test also represents city operation, but without the excessive idle time. The third five minute section of the test is called the Los

TABLE 5. PROCEDURE FOR ACCUMULATING REGULATED EMISSIONS DATA USING ALTERNATIVE 4 OF THE TCEQ PROTOCOL

Step	Description
1	Install engine. Perform emission instrument calibrations as required. Calibrate torquemeter and check signal conditioning systems. Validate CVS gaseous and particulate sampling systems using propane recovery techniques.
2	Check engine condition using reference fuel, and note fault codes if any. Bring engine oil level to "full" using the manufacturer's recommended oil.
3	Perform fuel change procedure to operate on Fuel R. Change filter, purge fuel supply, etc.
4	Warm up engine, and operate at rated speed and load, then check performance.
5	Conduct transient "full-throttle" torque map from low- to high-idle. Compute and store resulting transient command cycle. (Note: The initial transient command cycle with Fuel R was used for all subsequent emission tests in this test plan. Other torque-map information generated with either Fuels R or C during this test work was included for documentation purposes.)
6	Run two 20-minute practice or conditioning transient cycles without a 20-minute soak between cycles, and adjust dynamometer controls to meet statistical limits for transient cycle operation.
7	Soak the engine for 20-minutes. Run three hot-start transient tests with a 20-minute soak between each. For each individual hot-start test, determine THC, CO, NO_x, and PM.
8	Repeat Steps 4 through 7.
9	Blend Fuel C according to written directions from CDTI. Perform fuel change to Fuel C. Operate the engine for 25 hours using repetitive transient cycles to represent normal engine operation.
10	Repeat Steps 4 through 8.
11	Perform fuel change to Fuel R. Repeat Steps 4 through 8.
12	Summarize data and prepare the final report.

TABLE 6. ACTUAL PATTERN OF RUNS USING ALTERNATIVE 4

Test Day	Hot Start Transient							
	Fuel	Test Number			Fuel	Test Number		
1	R	1	2	3	R	4	5	6
2	Engine operation for 25 hours							
3	C	7	8	9	C	10	11	12
4	R	13	14	15	R	16	17	18

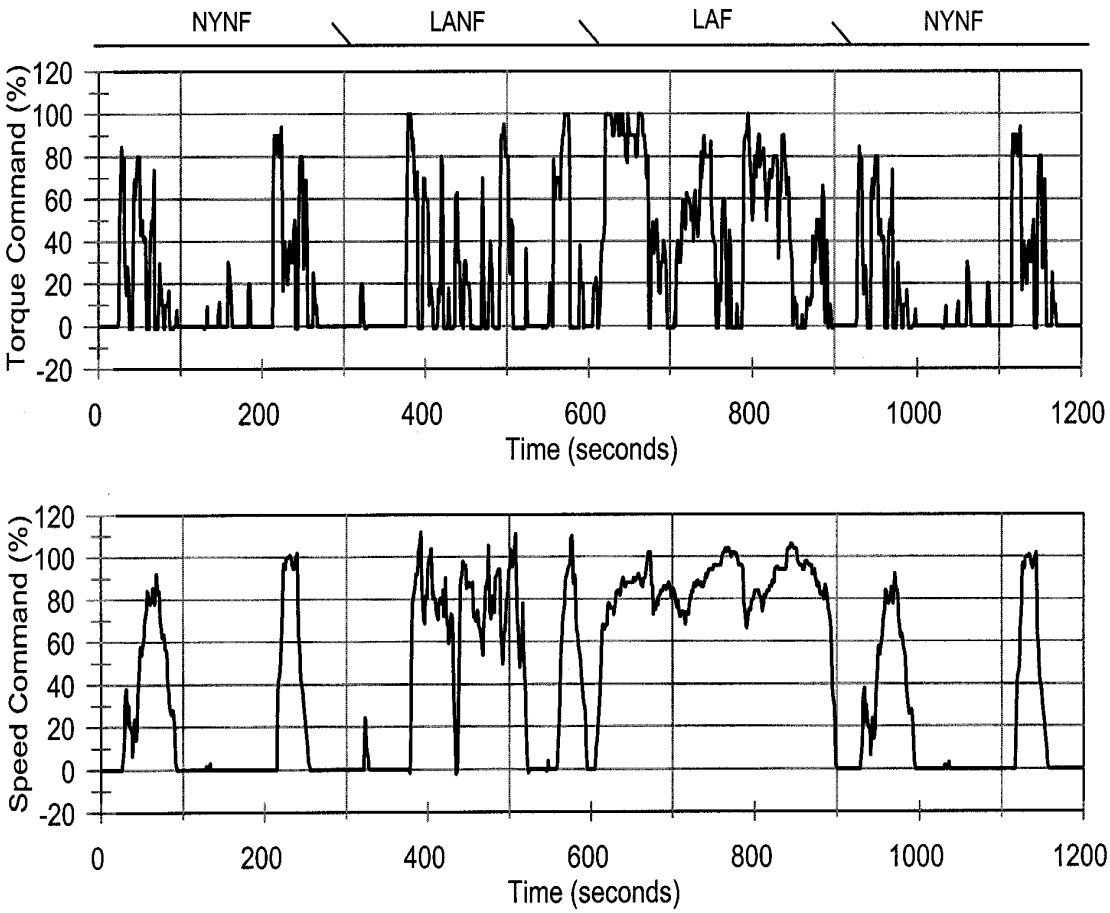

FIGURE 2. GRAPHIC REPRESENTATION OF TORQUE AND SPEED COMMANDS FOR THE TRANSIENT CYCLE FOR HEAVY-DUTY ENGINES

Angeles Freeway (LAF) portion. This part is more representative of higher speed conditions indicative of freeway operation. The final five minutes of the EPA transient cycle is a repeat of the NYNF portion. These four parts are combined to give the EPA transient cycle.

5.0 RESULTS

Results for the baseline transient torque map that was generated with Fuel R and used as the reference map for all subsequent transient runs are given in Table 7. Table 7 also contains the torque map data for Fuel C and data for the repeat maps with Fuel R. The results indicate that engine performance characteristics were consistent throughout the testing. Figure 3 shows a graphical representation of the torque map data for both fuels. More detailed data on engine performance is given in Appendix A.

TABLE 7. SUMMARY OF TRANSIENT TORQUE MAPS OBTAINED WITH THE 1991 DETROIT DIESEL SERIES 60 HEAVY-DUTY DIESEL TEST ENGINE

Engine Speed, rpm	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
Initial Tests with Fuel R													
First Map, lb-ft[a]	637	700	814	903	1022	1208	1400	1331	1258	1199	1143	1104	1051
Second Map, lb-ft	631	689	797	906	1036	1194	1409	1332	1260	1203	1153	1119	1041
Fuel C													
First Map, lb-ft	637	684	791	901	1042	1188	1386	1338	1261	1189	1151	1104	1025
Second Map, lb-ft	633	693	797	897	1045	1193	1385	1326	1240	1193	1168	1108	1042
Final Tests with Fuel R													
First Map, lb-ft	615	665	764	915	1047	1188	1383	1317	1257	1191	1143	1106	1020
Second Map, lb-ft	615	667	776	920	1048	1201	1387	1343	1251	1209	1148	1106	1036

Idle speed: 600 rpm, rated speed: 1800 rpm.
[a] This map was used as reference for all subsequent transient cycles.

During steady-state performance checks, the 1991 DDC Series 60 engine had a maximum power of 362 hp at a rated speed of 1800 rpm with Fuel R for the initial baseline, 361 hp for the repeat test with Fuel R, a maximum power of 360 hp and 361 hp with Fuel C, and a maximum power of 362 hp for both of the final baseline tests with Fuel R. Peak torque at 1200 rpm was 1420 lb-ft and 1428 lb-ft on Fuel R for the initial baselines, 1406 lb-ft and 1402 lb-ft on Fuel C, and 1402 lb-ft and 1408 lb-ft for the final baseline tests with Fuel R. No operational problems were observed.

Table 8 gives emission results for HC, non-methane hydrocarbons (NMHC), CO, NO_x, PM, and brake specific fuel consumption (BSFC) obtained for each of the tests. The average, standard deviation, and coefficient of variation for each set of six hot-start transient tests are also included for each fuel. Detailed results are given in Appendix B. (Please note that while averages, standard deviations, and coefficient of variations were calculated for the six hot-start tests with Fuel R that followed the Fuel C testing, the data were not utilized in subsequent calculations as these tests were only conducted to determine if there was any residual effect from the additive.) No residual effects from Fuel C were noted when the fuel was changed back to Fuel R, except for a slight lowering of the PM emissions.

Table 9 shows the statistical approach for comparing the emission results. With this approach, the average emissions from the six individual tests with the candidate fuel, "Fuel C"

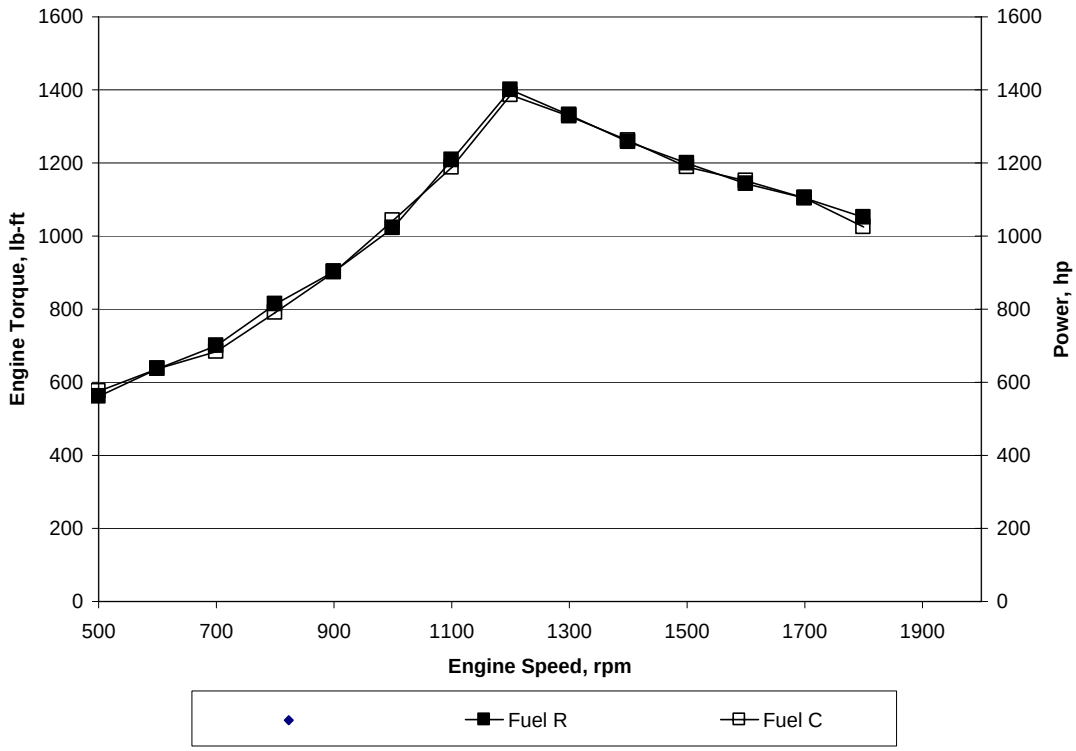

FIGURE 3. ENGINE PERFORMANCE USING FUELS R AND C

(X_C), were compared to the average emission results for six individual tests with the average reference fuel, "Fuel R" (X_R), by using the one-side t distribution as given in TCEQ Chapter 114, Control of Air Pollution From Motor Vehicles, Subchapter H: Low Emission Fuels, Division 2: Low Emission Diesel, §114.315, Approved Test Methods. The average term for the reference fuel for each emission was adjusted by the tolerance (1 percent of the average for NO_x and 2 percent of the average for HC, NMHC, CO, and PM) and by a value that included:

- Pooled standard deviation, S_p
- Square root of two divided by the number of tests, n, for both reference plus candidate (in this case, n = 12)
- One-sided upper percentage point of t distribution with a = 0.15 and 2n-2 degrees of freedom

The equation for this comparison is:

$$X_C < X_R + \delta - (S_p \times \sqrt{(2/n)} \times t(a, 2n-2))$$

Values presented in Table 9 were based on a spreadsheet calculation provided by TCEQ to CDTI and subsequently to SwRI. In this spreadsheet, the number of tests, n, was based on the sum of tests with the candidate plus the number of tests with the reference fuel, which in this evaluation

TABLE 8. SUMMARY OF REGULATED EMISSIONS

Test Number	Test Date	Transient Emissions, g/hp-hr					BSFC, lb/hp-hr	Work, hp-hr
		HC	NMHC	CO	NO_x	PM		
R1	3/3/2006	0.083	0.081	2.378	4.483	0.206	0.380	23.78
R2	3/3/2006	0.085	0.083	2.411	4.598	0.203	0.382	23.75
R3	3/3/2006	0.093	0.091	2.396	4.550	0.203	0.381	23.83
R4	3/3/2006	0.081	0.079	2.694	4.722	0.209	0.387	23.52
R5	3/3/2006	0.079	0.077	2.405	4.628	0.204	0.379	23.81
R6	3/3/2006	0.080	0.078	2.489	4.688	0.210	0.390	23.49
	Mean	0.084	0.082	2.462	4.612	0.206	0.383	23.70
	Std. Dev	0.005	0.005	0.120	0.088	0.003	0.004	0.15
	% COV	6.1%	6.1%	4.9%	1.9%	1.5%	1.1%	0.6%
C7	3/6/2006	0.076	0.074	2.184	4.642	0.164	0.367	23.69
C8	3/6/2006	0.062	0.061	2.013	4.630	0.162	0.361	23.81
C9	3/6/2006	0.062	0.061	2.172	4.622	0.162	0.364	23.87
C10	3/6/2006	0.084	0.082	2.251	4.598	0.168	0.363	23.79
C11	3/6/2006	0.065	0.064	2.086	4.647	0.170	0.356	23.80
C12	3/6/2006	0.069	0.068	2.055	4.700	0.171	0.359	23.65
	Mean	0.070	0.068	2.127	4.640	0.166	0.362	23.77
	Std. Dev	0.009	0.009	0.090	0.034	0.004	0.004	0.08
	% COV	12.6%	12.6%	4.2%	0.7%	2.4%	1.1%	0.3%
R13	3/9/2006	0.085	0.083	2.386	4.611	0.195	0.377	23.69
R14	3/9/2006	0.076	0.074	2.441	4.667	0.200	0.383	23.52
R15	3/9/2006	0.094	0.092	2.358	4.576	0.191	0.383	23.80
R16	3/9/2006	0.081	0.079	2.429	4.595	0.196	0.376	23.76
R17	3/9/2006	0.049	0.048	2.395	4.652	0.194	0.373	23.73
R18	3/9/2006	0.081	0.079	2.589	4.679	0.200	0.380	23.85
	Mean	0.078	0.076	2.433	4.630	0.196	0.379	23.73
	Std. Dev	0.015	0.015	0.082	0.042	0.004	0.004	0.12
	% COV	26.3%	26.3%	4.2%	0.9%	1.6%	0.9%	0.3%

is 12 (six reference tests plus six candidate test). This value was used as opposed to using the number of tests for each of the sets of data. The number of tests used in the calculation affects the degrees of freedom, the square root term, and the student's t test. If the average for the candidate fuel is less than the adjusted average for the reference fuel, then the candidate fuel is comparable or better than the reference fuel. While reductions were noted for HC, NMHC, CO, and PM with Fuel C; an increase of 0.2 percent was observed for the NO_x emissions.

TABLE 9. COMPARISON OF EMISSIONS USING TCEQ STATISTICAL CRITERIA

	HC	NMHC	CO	NO_x	PM
Number of Test Points, n [a]	12	12	12	12	12
R Average, X_R [b]	0.084	0.082	2.462	4.612	0.206
C Average, X_c [b]	0.070	0.068	2.127	4.640	0.166
Pooled Std. Dev., Sp [b]	0.007	0.007	0.106	0.067	0.004
Degrees of Freedom, df [c]	22	22	22	22	22
Student's t, t [d]	1.061	1.061	1.061	1.061	1.061
Tolerance Level [e]	0.002	0.002	0.049	0.004	0.008
Adjusted R Average , Adj. X_R [f]	0.082	0.080	2.465	4.629	0.208
Is X_c < Adj. X_R	Yes	Yes	Yes	No	Yes
Percent Reduction, r [g]	15.1	15.1	13.7	-0.2	20.3

[a] For Alternative 4, n = number of tests (reference plus candidate)
[b] Units are in g/hp-hr
[c] df = 2(n - 1)
[d] One-sided student's t for 2n - 2 degrees of freedom and significance level of 0.15.
[e] Tolerance level is 1 percent for NO_x and 2 percent for HC, NMHC, CO, and PM
[f] Adj. $X_R = X_R + \delta - (S_p \times \sqrt{(2/n)} \times t(a, 2n\text{-}2))$ where t(a,2n - 2) is 1.061
[g] Negative values indicate greater emissions

6.0 SUMMARY

This test program was conducted for CDTI by the DEER at SwRI. The reference fuel (Fuel R) and the candidate fuel (Fuel C) were compared using hot-start transient tests run on a 1991, DDC Series 60 heavy-duty diesel engine following Alternative 4 (with the exception that only six (6) hot-start tests were run with Fuel C) as specified in the (TCEQ) Chapter 114 – Control of Air Pollution From Motor Vehicles, Subchapter H: Low Emission Fuels, Division 2: Low Emission Diesel.

The average emission results for PM and NO_x using the candidate alternative diesel fuel were compared to the adjusted average emission results using the reference diesel fuel. The candidate fuel was found to decrease PM emissions by 20.3 percent and to increase NO_x emissions by 0.2 percent when compared to the reference fuel. Average HC and CO emissions were lower with the candidate fuel than with the reference fuel (15 and 14 percent lower, respectively).

APPENDIX A

Power Validation and Torque Map Data for a 1991 Detroit Diesel Series 60 Running with Reference Fuel and with CDT Biodiesel PLUS™ from

Clean Diesel Technologies, Inc

08-5586-001
Project Number

REF-1
Test or ID Number

POWER VALIDATION
HEAVY-DUTY DIESEL ENGINE

Cell No.: 4	Date: 03/03/2006	Start Time: 8:37	Finish Time: 9:05
Engine S/N or ID: S60 38671		[X] As-Received	[ ] Modified
Operator: RDF	Project Leader: Robert Fanick		Fuel Code: EM-5785-F
Low Idle rpm (no load): 0	Low Idle rpm @ 0	lb-ft CITT: 0	High Idle rpm (governed): 1,922
Notes:			

Parameters	Rated Power	Peak Torque
Torque (lb-ft)	1,057	1,420
Speed (rpm)	1,800	1,200
Power (bhp)	362.0	324.0
Fuel Flow (lb/hr)	116.3	107.2
Water Out (°F)	200.0	204
Water In (°F)	182	185
Oil (°F)	218	224
Inlet Air (°F)	78.0	78
Fuel (°F)	90	90
Exhaust (°F)	833	1,003
Intercooler In (°F)	274	270
Intercooler Out (°F)	110	104
IC Coolant Supply (°F)		
Inlet Air Dewpoint (°F)	61.6	60.6
Chiller Water (°F)	61.0	60.0
Barometer ("Hg)	29.32	29.32
Inlet Air Restriction ("H2O)	-16.1	-7.60
Exhaust Restriction ("Hg)	3.2	1.80
Boost Pres. Before IC ("Hg)	38.00	35.50
Boost Pres. After IC ("Hg)	34.4	33.4
Intercooler ÐP ("H2O)	49.0	29.0
Oil Pressure (psig)	52.0	46.0
Fuel Pressure (psig)	15.2	17.0
Engine Water Pres. (psig)		
Hour Meter (hours)	689.2	689.3

08-5586-001	REF 1 PM
Project Number	Test Number

POWER MAP
HEAVY-DUTY DIESEL ENGINE

Date: 03/03/2006 Time: 8:37	Engine Model: S60		
Cell No.: 4	Serial No. or ID: 38671		
Operator: RDF	Hour Meter: 688.8	Dura. Hours:	0.00
Project Leader: Robert Fanick	Fuel Code: EM-5785-F	Baro., "Hg:	29.32

MAP PRECONDITIONING

Parameter	Rated Speed	RatedTorque
Power (bhp)	362.00	324.00
Torque (lb-ft)	1,057.00	1,420.00
Speed (rpm)	1,800.00	1,200.00
Fuel Flow (lb/hr)	116.30	107.20
Inlet Air Restriction ("H2O)	-16.10	-7.60
Exhaust Restriction ("Hg)	3.20	1.80
Intake Air (°F)	78.00	78.00
Intake Air Dewpoint (°F)	61.60	60.60
ÐP Across Intercooler ("H2O)	49.00	29.00
Temperature After Intercooler (°F)	110.00	104.00

Map @ [X] 8 rpm/sec sweep [ ] Other: Idle Speed, rpm Low: 600 High: 1,922

RESULTS

Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft
100		1100	1,208	2100		3100	
200		1200	1,400	2200		3200	
300		1300	1,331	2300		3300	
400		1400	1,258	2400		3400	
500	561	1500	1,199	2500		3500	
600	637	1600	1,143	2600		3600	
700	700	1700	1,104	2700		3700	
800	814	1800	1,051	2800		3800	
900	903	1900		2900		3900	
1000	1,022	2000		3000		4000	

Speed Ramp Rate 8.0 rpm/sec RATED SPEED, rpm: Manufacturer 1,800 Measured 1,715

Calculated Maximum Speed = 1.13*[Highest RATED SPEED - Curb Idle Speed] + Curb Idle Speed = 1,956 rpm

TRANSIENT CYCLE INPUTS

CITT: 0 lb-ft

Idle Speed: 600 rpm Rated Speed 1,800 rpm Max. Power 363.0 hp Max. Torque 1,431 lb-ft

DIESEL ENGINE SET-UP DATA

Required Information as per CFR 86-1344-94 (c) CERTD1.DER Rev. 8-95

1. Engine Manufacturer: **Detroit Diesel**
2. Engine system combination: **heavy-duty diesel engine**
3. Engine Model: **Series 60** Engine Displacement (in^3): **775**
4. Engine identification number: **06R0038671**
5. Applicable engine model year: **1991**
6. Engine fuel type: **TxLED ULSD Reference Fuel**
7. Recommended lubricating oil type: **SAE 15W-40**
8. Exhaust pipe configuration, pipe sizes, etc: **see item 17 below**
9. Curb or low idle speed (RPM): **600**
10. Dynamometer idle speed. (Automatic transmission engines only.) **NA**
11. Engine parameter specifications (such as injection timing or injector height setting, operating temperature, etc): **NA**
12. Engine performance data:
    - Manufacturer's advertised maximum power (BHP) **365**
    - Manufacturer's rated engine speed (RPM) **1800**
    - Manufacturer's measured fuel rate at maximum power (lb_m/hr) **116.3**
    - Manufacturer's maximum governed engine speed (RPM) **1956**
13. Recommended start-up procedure: **NA**
14. Maximum safe engine operating speed (RPM): **NA**
15. Number of hours of operation accumulated on engine (prior to installation): **NA**
16. Manufacturer's recommended inlet depression (in. H_2O): **-16**

    Typical in-use inlet depression (in. H_2O): **-16.1**
17. Exhaust system:
    - Header pipe inside diameter (inches) **4**
    - Tailpipe inside diameter (inches) **5**
    - Minimum distance in-use between the exhaust manifold and the exit of the chassis exhaust system: _____
    - Other: _____

Diesel Engine Pre-Test Data

Required Information as per CFR 86-1244-94 (d) CERTD2.DER Rev. 8-95

1. Engine-system combination: **heavy-duty diesel fueled engine**
2. Engine identification number: **06R0038671**
3. Instrument operator(s): **R. Cortez**
4. Engine operator(s): **Ricky Frierson**
5. Number of hours of operation accumulated on the engine prior to beginning the test sequence: **NA**
6. Identification and specification of test fuel: **TxLED Ultra-Low Sulfur Diesel**
   SwRI Fuel Code: EM-5785-F
7. Emission Analyzers and Equipment:

Emission Analyzers	Serial No.	Verification Date	Operator
HC continuous	1000139	2/7/06	Sergio Oseguera
CO bag	56314704	2/13/06	R. Guerra
CO2 bag	2000173	2/8/06	R. Guerra
NO_X continuous	1000448	2/8/06	Sergio Oseguera
NO_X converter	1000448	2/7/06	Sergio Oseguera
Equipment			
CVS	5	3/2/06	Sergio Oseguera
Torquemeter	RF 12	2/27/06	Ricky Frierson

DIESEL ENGINE TEST DATA

Required Information as per CFR 86-1344-94 (e) CERTD3.DER Rev. 8-95

1. Date and time of day: **3/3/06 11:00 am, 11:40 am, 12:29 pm**
2. Test number: **R1, R2, R3**
3. Engine intake air or test cell temperature (°F): **76, 75, 77**
4. Barometric pressure (in. Hg): **29.33, 29.33, 29.31**
5. Engine intake or test cell humidity (% RH): **59, 58, 56** CVS dilution air humidity (%RH): **46, 49, 40**
6. Maximum torque verses speed curve as determined in 86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used: **see attached**
7. Measured maximum horsepower engine speed (RPM): **1800** Maximum torque speed (RPM): **1200**
8. Measured maximum horsepower (BHP): **362** Maximum measured torque (ft-lb): **1420**
9. Measured high idle engine speed (RPM): **---1956**
10. Measured fuel consumption rate (lb_m/hr) at maximum power: **116.3** and at peak torque: **107.2**
11. Cold-soak time interval and cool down procedures: **NA**
12. Temperature set point of the heated continuous analysis system components (°F): **375**
13. Test cycle validation statistics as specified in 86.1341 for each test phase (cold and hot): **see attached**
14. Total CVS flow rate and dilution factor for each test phase (cold and hot):
    CVS Flow Rate (scfm): **2165.20, 2159.06, 2151.25** Dilution Factor: **21.56, 21.37, 21.23**
15. Dilute exhaust mixture temperature at gas meter (°F): **78, 77, 77**
    Secondary dilution air temperature at gas meter (°F): **82, 83, 82**
16. Maximum temperature at 90mm particulate filter sample zone (°F): **117, 116, 116**
17. Dilute exhaust sample concentrations (background corrected):
    HC (ppmC) **2.74, 2.83, 3.10** CO (ppmC) **39.20, 39.74, 39.78**
    CO_2 (%) **0.5652, 0.5682, 0.5712** NO_X (ppm) **44.34, 45.91, 45.49**
19. Diesel fuel composition: **see attached**
21. The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter:
    Pre-Test Primary (mg) **437.436, 440.788, 450.460**
    Post-test Primary (mg) **441.075, 444.451, 454.152**
    Pre-test Backup (mg) **weighed as pair** Post-test Backup (mg) **weighed as pair**
22. Brake specific emissions (g/BHP-hr) for HC, CO, NO_X for each test phase (cold and hot):
    HC **0.083, 0.085, 0.093** CO **2.378, 2.411, 2.386**
    NO_X **4.483, 4.598, 4.550** Part. **0.206, 0.203, 0.203**
23. The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test:
    HC **---NA---** CO **-NA-----** NO_X **-NA-----** Part. **-NA-----**
24. The carbon balance brake specific fuel consumption (lb/BHP-hr) for the total test: **0.381**
25. The number of hours of operation accumulated on the engine after completing the test sequence: **NA**

08-5586-001
Project Number

POWER VALIDATION
HEAVY-DUTY DIESEL ENGINE

030306 PV2
Test or ID Number

Cell No.: 4	Date: 03/03/2006	Start Time: 13:10	Finish Time: 13:18
Engine S/N or ID: S60		[X] As-Received	[ ] Modified
Operator: RDF	Project Leader: Robert Fanick		Fuel Code: EM-5785-F
Low Idle rpm (no load): 600	Low Idle rpm @ 0	lb-ft CITT: 0	High Idle rpm (governed): 1,922
Notes:			

Parameters	Rated Power	Peak Torque
Torque (lb-ft)	1,056	1,428
Speed (rpm)	1,800	1,200
Power (bhp)	361.0	326.0
Fuel Flow (lb/hr)	115.9	103.6
Water Out (°F)	196.0	203
Water In (°F)	183	181
Oil (°F)	203	218
Inlet Air (°F)	76.0	77
Fuel (°F)	92	92
Exhaust (°F)	808	992
Intercooler In (°F)	271	270
Intercooler Out (°F)	113	107
IC Coolant Supply (°F)		
Inlet Air Dewpoint (°F)	61.0	60.5
Chiller Water (°F)	60.0	61.0
Barometer ("Hg)	29.30	29.30
Inlet Air Restriction ("H2O)	-16.1	-7.80
Exhaust Restriction ("Hg)	3.0	1.70
Boost Pres. Before IC ("Hg)	38.00	36.00
Boost Pres. After IC ("Hg)	34.4	33.9
Intercooler ÐP ("H2O)	48.4	28.6
Oil Pressure (psig)	53.0	46.0
Fuel Pressure (psig)	15.8	16.6
Engine Water Pres. (psig)		
Hour Meter (hours)	691.7	691.7

08-5586-001
Project Number

PMAP 2
Test Number

POWER MAP
HEAVY-DUTY DIESEL ENGINE

Date: 03/03/2006 Time: 13:10	Engine Model: S60		
Cell No.: 4	Serial No. or ID: 38671		
Operator: RDF	Hour Meter: 691.6	Dura. Hours:	0.00
Project Leader: Robert Fanick	Fuel Code: EM-5785-F	Baro., "Hg:	29.30

MAP PRECONDITIONING

Parameter	Rated Speed	RatedTorque
Power (bhp)	361.00	326.00
Torque (lb-ft)	1,056.00	1,428.00
Speed (rpm)	1,800.00	1,200.00
Fuel Flow (lb/hr)	115.90	103.60
Inlet Air Restriction ("H2O)	-16.10	-7.80
Exhaust Restriction ("Hg)	3.00	1.70
Intake Air (°F)	76.00	77.00
Intake Air Dewpoint (°F)	61.00	60.50
ÐP Across Intercooler ("H2O)	48.40	28.60
Temperature After Intercooler (°F)	113.00	107.00

Map @ [X] 8 rpm/sec sweep [ ] Other: 600 Idle Speed, rpm Low: 600 High: 1,922

RESULTS

Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft
100		1100	1,194	2100		3100	
200		1200	1,409	2200		3200	
300		1300	1,332	2300		3300	
400		1400	1,260	2400		3400	
500	572	1500	1,203	2500		3500	
600	631	1600	1,153	2600		3600	
700	689	1700	1,119	2700		3700	
800	797	1800	1,041	2800		3800	
900	906	1900		2900		3900	
1000	1,039	2000		3000		4000	

Speed Ramp Rate 0.0 rpm/sec RATED SPEED, rpm: Manufacturer 0 Measured 0

Calculated Maximum Speed = 1.13*[Highest RATED SPEED - Curb Idle Speed] + Curb Idle Speed = 0 rpm

TRANSIENT CYCLE INPUTS

CITT: 8 lb-ft

Idle Speed: 600 rpm Rated Speed 1,800 rpm Max. Power 365.0 hp Max. Torque 1,413 lb-ft

DIESEL ENGINE SET-UP DATA

Required Information as per CFR 86-1344-94 (c) CERTD1.DER Rev. 8-95

1. Engine Manufacturer: **Detroit Diesel**
2. Engine system combination: **heavy-duty diesel engine**
3. Engine Model: **Series 60** Engine Displacement (in^3): **775**
4. Engine identification number: **06R0038671**
5. Applicable engine model year: **1991**
6. Engine fuel type: **TxLED ULSD Reference Fuel**
7. Recommended lubricating oil type: **SAE 15W-40**
8. Exhaust pipe configuration, pipe sizes, etc: **see item 17 below**
9. Curb or low idle speed (RPM): **600**
10. Dynamometer idle speed. (Automatic transmission engines only.) **NA**
11. Engine parameter specifications (such as injection timing or injector height setting, operating temperature, etc): **NA**
12. Engine performance data:
    - Manufacturer's advertised maximum power (BHP) **365**
    - Manufacturer's rated engine speed (RPM) **1800**
    - Manufacturer's measured fuel rate at maximum power (lb_m/hr) **115.9**
    - Manufacturer's maximum governed engine speed (RPM) **1922**
13. Recommended start-up procedure: **NA**
14. Maximum safe engine operating speed (RPM): **NA**
15. Number of hours of operation accumulated on engine (prior to installation): **NA**
16. Manufacturer's recommended inlet depression (in. H_2O): **-16**

    Typical in-use inlet depression (in. H_2O): **-16.1**
17. Exhaust system:
    - Header pipe inside diameter (inches) **4**
    - Tailpipe inside diameter (inches) **5**
    - Minimum distance in-use between the exhaust manifold and the exit of the chassis exhaust system: _____
    - Other: _____

Diesel Engine Pre-Test Data

Required Information as per CFR 86-1244-94 (d) CERTD2.DER Rev. 8-95

1. Engine-system combination: **heavy-duty diesel fueled engine**
2. Engine identification number: **06R0038671**
3. Instrument operator(s): **R. Cortez**
4. Engine operator(s): **Ricky Frierson**
5. Number of hours of operation accumulated on the engine prior to beginning the test sequence: **NA**
6. Identification and specification of test fuel: **TxLED Ultra-Low Sulfur Diesel**
   SwRI Fuel Code: EM-5785-F
7. Emission Analyzers and Equipment:

Emission Analyzers	Serial No.	Verification Date	Operator
HC continuous	1000139	2/7/06	Sergio Oseguera
CO bag	56314704	2/13/06	R. Guerra
CO2 bag	2000173	2/8/06	R. Guerra
NO_x continuous	1000448	2/8/06	Sergio Oseguera
NO_x converter	1000448	2/7/06	Sergio Oseguera
Equipment			
CVS	5	3/2/06	Sergio Oseguera
Torquemeter	RF 12	2/27/06	Ricky Frierson

DIESEL ENGINE TEST DATA

Required Information as per CFR 86-1344-94 (e) CERTD3.DER Rev. 8-95

1. Date and time of day: 3/3/06 2:28 pm, 3:08 pm, 3:48 pm
2. Test number: R4, R5, R6
3. Engine intake air or test cell temperature (°F): 76, 76, 78
4. Barometric pressure (in. Hg): 29.25, 29.24, 29.24
5. Engine intake or test cell humidity (% RH): 57, 55, 53 CVS dilution air humidity (%RH): 41, 41, 43
6. Maximum torque verses speed curve as determined in 86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used: see attached
7. Measured maximum horsepower engine speed (RPM): 1800 Maximum torque speed (RPM): 1200
8. Measured maximum horsepower (BHP): 361 Maximum measured torque (ft-lb): 1428
9. Measured high idle engine speed (RPM): ---1922
10. Measured fuel consumption rate (lb_m/hr) at maximum power: 115.9 and at peak torque: 103.6
11. Cold-soak time interval and cool down procedures: NA
12. Temperature set point of the heated continuous analysis system components (°F): 375
13. Test cycle validation statistics as specified in 86.1341 for each test phase (cold and hot): see attached
14. Total CVS flow rate and dilution factor for each test phase (cold and hot):
    CVS Flow Rate (scfm): 2155.99, 2148.92, 2148.59 Dilution Factor: 21.22, 21.28, 21.10
15. Dilute exhaust mixture temperature at gas meter (°F): 78, 78, 78
    Secondary dilution air temperature at gas meter (°F): 84, 84, 84
16. Maximum temperature at 90mm particulate filter sample zone (°F): 116, 118, 119
17. Dilute exhaust sample concentrations (background corrected):
    HC (ppmC) 2.67, 2.64, 2.64 CO (ppmC) 44.04, 39.95, 40.78
    CO_2 (%) 0.5706, 0.5681, 0.5768 NO_X (ppm) 46.53, 46.70, 46.39
19. Diesel fuel composition: see attached
21. The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter:
    Pre-Test Primary (mg) 449.693, 445.580, 436.156
    Post-test Primary (mg) 453.375, 444.197, 439.874
    Pre-test Backup (mg) weighed as pair Post-test Backup (mg) weighed as pair
22. Brake specific emissions (g/BHP-hr) for HC, CO, NO_X for each test phase (cold and hot):
    HC 0.081, 0.079, 0.080 CO 2.694, 2.405, 2.489
    NO_X 4.722, 4.628, 4.688 Part. 0.209, 0.204, 0.210
23. The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test:
    HC ---NA--- CO -NA----- NO_X -NA----- Part. -NA-----
24. The carbon balance brake specific fuel consumption (lb/BHP-hr) for the total test: 0.385
25. The number of hours of operation accumulated on the engine after completing the test sequence: NA

08-5586-001
Project Number

PV-C1
Test or ID Number

POWER VALIDATION
HEAVY-DUTY DIESEL ENGINE

Cell No.: 4	Date: 03/06/2006	Start Time: 10.27	Finish Time: 10.46
Engine S/N or ID: S60 38671		[X] As-Received	[ ] Modified
Operator: RDF	Project Leader: Robert Fanick		Fuel Code: 5901
Low Idle rpm (no load): 600	Low Idle rpm @ 0	lb-ft CITT: 0	High Idle rpm (governed): 0
Notes:			

Parameters	Rated Power	Peak Torque
Torque (lb-ft)	1,056	1,406
Speed (rpm)	1,800	1,200
Power (bhp)	360.0	322.0
Fuel Flow (lb/hr)	120.3	107.2
Water Out (°F)	199.0	203
Water In (°F)	180	183
Oil (°F)	206	213
Inlet Air (°F)	78.0	77
Fuel (°F)	96	96
Exhaust (°F)	823	997
Intercooler In (°F)	271	264
Intercooler Out (°F)	110	104
IC Coolant Supply (°F)		
Inlet Air Dewpoint (°F)	58.9	57.9
Chiller Water (°F)	56.0	56.0
Barometer ("Hg)	29.36	29.36
Inlet Air Restriction ("H2O)	-15.9	-7.40
Exhaust Restriction ("Hg)	3.1	1.60
Boost Pres. Before IC ("Hg)	37.20	35.00
Boost Pres. After IC ("Hg)	33.6	32.9
Intercooler ÐP ("H2O)	49.0	28.6
Oil Pressure (psig)	54.0	47.0
Fuel Pressure (psig)	14.2	
Engine Water Pres. (psig)		
Hour Meter (hours)	718.9	718.9

08-5586-001
Project Number

Map-C1
Test Number

POWER MAP
HEAVY-DUTY DIESEL ENGINE

Date: 03/06/2006 Time: 10.27	Engine Model: S60		
Cell No.: 4	Serial No. or ID: 38671		
Operator: RDF	Hour Meter: 718.6	Dura. Hours:	0.00
Project Leader: Robert Fanick	Fuel Code: 5901	Baro., "Hg:	29.36

MAP PRECONDITIONING

Parameter	Rated Speed	RatedTorque
Power (bhp)	360.00	322.00
Torque (lb-ft)	1,056.00	1,406.00
Speed (rpm)	1,800.00	1,200.00
Fuel Flow (lb/hr)	120.30	107.20
Inlet Air Restriction ("H2O)	-15.90	-7.40
Exhaust Restriction ("Hg)	3.10	1.60
Intake Air (°F)	78.00	77.00
Intake Air Dewpoint (°F)	58.90	557.90
ÐP Across Intercooler ("H2O)	49.00	28.60
Temperature After Intercooler (°F)	110.00	104.00

Map @ [X] 8 rpm/sec sweep [ ] Other: Idle Speed, rpm Low: 600 High: 1,922

RESULTS

Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft
100		1100	1,188	2100		3100	
200		1200	1,386	2200		3200	
300		1300	1,328	2300		3300	
400	575	1400	1,261	2400		3400	
500	575	1500	1,189	2500		3500	
600	637	1600	1,151	2600		3600	
700	684	1700	1,104	2700		3700	
800	791	1800	1,025	2800		3800	
900	901	1900		2900		3900	
1000	1,042	2000		3000		4000	

Speed Ramp Rate 8.0 rpm/sec RATED SPEED, rpm: Manufacturer 1,800 Measured 1,720

Calculated Maximum Speed = 1.13*[Highest RATED SPEED - Curb Idle Speed] + Curb Idle Speed = 1,956 rpm

TRANSIENT CYCLE INPUTS

CITT: 0 lb-ft

Idle Speed: 600 rpm Rated Speed 1,800 rpm Max. Power 363.2 hp Max. Torque 1,412 lb-ft

DIESEL ENGINE SET-UP DATA

Required Information as per CFR 86-1344-94 (c) CERTD1.DER Rev. 8-95

1. Engine Manufacturer: **Detroit Diesel**
2. Engine system combination: **heavy-duty diesel engine**
3. Engine Model: **Series 60** Engine Displacement (in^3): **775**
4. Engine identification number: **06R0038671**
5. Applicable engine model year: **1991**
6. Engine fuel type: **CDTI Candidate Fuel**
7. Recommended lubricating oil type: **SAE 15W-40**
8. Exhaust pipe configuration, pipe sizes, etc: **see item 17 below**
9. Curb or low idle speed (RPM): **600**
10. Dynamometer idle speed. (Automatic transmission engines only.) **NA**
11. Engine parameter specifications (such as injection timing or injector height setting, operating temperature, etc): **NA**
12. Engine performance data:
    - Manufacturer's advertised maximum power (BHP) **365**
    - Manufacturer's rated engine speed (RPM) **1800**
    - Manufacturer's measured fuel rate at maximum power (lb_m/hr) **116.3**
    - Manufacturer's maximum governed engine speed (RPM) **1922**
13. Recommended start-up procedure: **NA**
14. Maximum safe engine operating speed (RPM): **NA**
15. Number of hours of operation accumulated on engine (prior to installation): **NA**
16. Manufacturer's recommended inlet depression (in. H_2O): **-16**

    Typical in-use inlet depression (in. H_2O): **-15.9**
17. Exhaust system:
    - Header pipe inside diameter (inches) **4**
    - Tailpipe inside diameter (inches) **5**
    - Minimum distance in-use between the exhaust manifold and the exit of the chassis exhaust system: _____
    - Other: _____

Diesel Engine Pre-Test Data

Required Information as per CFR 86-1244-94 (d) CERTD2.DER Rev. 8-95

1. Engine-system combination: **heavy-duty diesel fueled engine**
2. Engine identification number: **06R0038671**
3. Instrument operator(s): **R. Cortez**
4. Engine operator(s): **Ricky Frierson**
5. Number of hours of operation accumulated on the engine prior to beginning the test sequence: **NA**
6. Identification and specification of test fuel: **CDTI Candidate Fuel**

   SwRI Fuel Code: EM-5901-F
7. Emission Analyzers and Equipment:

Emission Analyzers	Serial No.	Verification Date	Operator
HC continuous	1000139	3/6/06	Sergio Oseguera
CO bag	56314704	2/13/06	R. Guerra
CO2 bag	2000173	2/8/06	R. Guerra
NO_x continuous	1000448	2/8/06	Sergio Oseguera
NO_x converter	1000448	2/7/06	Sergio Oseguera
Equipment			
CVS	5	3/2/06	Sergio Oseguera
Torquemeter	RF 12	3/6/06	Ricky Frierson

DIESEL ENGINE TEST DATA

Required Information as per CFR 86-1344-94 (e) CERTD3.DER Rev. 8-95

1. Date and time of day: 3/6/06 11:55 am, 12:35 pm, 1:15 pm
2. Test number: C7, C8, C9
3. Engine intake air or test cell temperature (°F): 77, 75, 76
4. Barometric pressure (in. Hg): 29.34, 29.32, 29.29
5. Engine intake or test cell humidity (% RH): 55, 60, 63 CVS dilution air humidity (%RH): 47, 50, 48
6. Maximum torque verses speed curve as determined in 86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used: see attached
7. Measured maximum horsepower engine speed (RPM): 1800 Maximum torque speed (RPM): 1200
8. Measured maximum horsepower (BHP): 360 Maximum measured torque (ft-lb): 1406
9. Measured high idle engine speed (RPM): ---1956
10. Measured fuel consumption rate (lb_m/hr) at maximum power: 120.3 and at peak torque: 107.2
11. Cold-soak time interval and cool down procedures: NA
12. Temperature set point of the heated continuous analysis system components (°F): 375
13. Test cycle validation statistics as specified in 86.1341 for each test phase (cold and hot): see attached
14. Total CVS flow rate and dilution factor for each test phase (cold and hot):
    CVS Flow Rate (scfm): 2156.51, 2151.79, 2149.53 Dilution Factor: 22.88, 23.14, 22.88
15. Dilute exhaust mixture temperature at gas meter (°F): 78, 78, 79
    Secondary dilution air temperature at gas meter (°F): 84, 84, 84
16. Maximum temperature at 90mm particulate filter sample zone (°F): 118, 119, 119
17. Dilute exhaust sample concentrations (background corrected):
    HC (ppmC) 2.52, 2.07, 2.06 CO (ppmC) 35.94, 33.41, 36.12
    CO_2 (%) 0.5361, 0.5319, 0.5371 NO_X (ppm) 46.09, 45.93, 45.44
19. Diesel fuel composition: see attached
21. The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter:
    Pre-Test Primary (mg) 429.704, 428.467, 434.122
    Post-test Primary (mg) 432.615, 431.413, 437.052
    Pre-test Backup (mg) weighed as pair Post-test Backup (mg) weighed as pair
22. Brake specific emissions (g/BHP-hr) for HC, CO, NO_X for each test phase (cold and hot):
    HC 0.076, 0.062, 0.062 CO 2.184, 2.013, 2.172
    NO_X 4.642, 4.630, 4.622 Part. 0.164, 0.162, 0.162
23. The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test:
    HC ---NA--- CO -NA----- NO_X -NA----- Part. -NA-----
24. The carbon balance brake specific fuel consumption (lb/BHP-hr) for the total test: 0.364
25. The number of hours of operation accumulated on the engine after completing the test sequence: NA

08-5586-001
Project Number

PV-C2
Test or ID Number

POWER VALIDATION
HEAVY-DUTY DIESEL ENGINE

Cell No.: 4	Date: 03/06/2006	Start Time: 13.42	Finish Time: 13.50
Engine S/N or ID: S60 38671		[X] As-Received	[ ] Modified
Operator: RDF	Project Leader: Robert Fanick		Fuel Code: 5901
Low Idle rpm (no load): 600	Low Idle rpm @ 0	lb-ft CITT: 0	High Idle rpm (governed): 1,922
Notes:			

Parameters	Rated Power	Peak Torque
Torque (lb-ft)	1,045	1,402
Speed (rpm)	1,800	1,200
Power (bhp)	361.0	321.0
Fuel Flow (lb/hr)	115.5	108.2
Water Out (°F)	199.0	204
Water In (°F)	182	184
Oil (°F)	218	224
Inlet Air (°F)	76.0	76
Fuel (°F)	100	99
Exhaust (°F)	827	1,002
Intercooler In (°F)	271	264
Intercooler Out (°F)	116	110
IC Coolant Supply (°F)		
Inlet Air Dewpoint (°F)	64.5	64.0
Chiller Water (°F)	64.0	64.0
Barometer ("Hg)	29.28	29.28
Inlet Air Restriction ("H2O)	-16.0	-7.30
Exhaust Restriction ("Hg)	3.1	1.60
Boost Pres. Before IC ("Hg)	37.80	34.80
Boost Pres. After IC ("Hg)	34.2	32.9
Intercooler ÐP ("H2O)	49.0	25.8
Oil Pressure (psig)	52.0	46.0
Fuel Pressure (psig)	15.0	16.0
Engine Water Pres. (psig)		
Hour Meter (hours)	720.9	720.9

08-5586-001
Project Number

Map-C2
Test Number

POWER MAP
HEAVY-DUTY DIESEL ENGINE

Date: 03/06/2006 Time: 13.42	Engine Model: S60		
Cell No.: 4	Serial No. or ID: 38671		
Operator: RDF	Hour Meter: 720.8	Dura. Hours:	0.00
Project Leader: Robert Fanick	Fuel Code: 5901	Baro., "Hg:	29.28

MAP PRECONDITIONING

Parameter	Rated Speed	RatedTorque
Power (bhp)	361.00	321.00
Torque (lb-ft)	1,045.00	1,402.00
Speed (rpm)	1,800.00	1,200.00
Fuel Flow (lb/hr)	115.50	108.20
Inlet Air Restriction ("H2O)	-16.00	-7.30
Exhaust Restriction ("Hg)	3.00	1.60
Intake Air (°F)	76.00	76.00
Intake Air Dewpoint (°F)	64.50	64.00
ÐP Across Intercooler ("H2O)	49.00	25.80
Temperature After Intercooler (°F)	116.00	110.00

Map @ [X] 8 rpm/sec sweep [ ] Other: Idle Speed, rpm Low: 600 High: 1,922

RESULTS

Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft
100		1100	1,193	2100		3100	
200		1200	1,385	2200		3200	
300		1300	1,326	2300		3300	
400		1400	1,240	2400		3400	
500	573	1500	1,193	2500		3500	
600	633	1600	1,168	2600		3600	
700	693	1700	1,108	2700		3700	
800	797	1800	1,042	2800		3800	
900	897	1900		2900		3900	
1000	1,045	2000		3000		4000	

Speed Ramp Rate 8.0 rpm/sec RATED SPEED, rpm: Manufacturer 1,800 Measured 1,703

Calculated Maximum Speed = 1.13*[Highest RATED SPEED - Curb Idle Speed] + Curb Idle Speed = 1,956 rpm

TRANSIENT CYCLE INPUTS

CITT: 0 lb-ft

Idle Speed: 600 rpm Rated Speed 1,800 rpm Max. Power 363.0 hp Max. Torque 1,409 lb-ft

DIESEL ENGINE SET-UP DATA

Required Information as per CFR 86-1344-94 (c) CERTD1.DER Rev. 8-95

1. Engine Manufacturer: **Detroit Diesel**
2. Engine system combination: **heavy-duty diesel engine**
3. Engine Model: **Series 60** Engine Displacement (in^3): **775**
4. Engine identification number: **06R0038671**
5. Applicable engine model year: **1991**
6. Engine fuel type: **CDTI Candidate Fuel**
7. Recommended lubricating oil type: **SAE 15W-40**
8. Exhaust pipe configuration, pipe sizes, etc: **see item 17 below**
9. Curb or low idle speed (RPM): **600**
10. Dynamometer idle speed. (Automatic transmission engines only.) **NA**
11. Engine parameter specifications (such as injection timing or injector height setting, operating temperature, etc): **NA**
12. Engine performance data:
    - Manufacturer's advertised maximum power (BHP) **365**
    - Manufacturer's rated engine speed (RPM) **1800**
    - Manufacturer's measured fuel rate at maximum power (lb_m/hr) **116.3**
    - Manufacturer's maximum governed engine speed (RPM) **1922**
13. Recommended start-up procedure: **NA**
14. Maximum safe engine operating speed (RPM): **NA**
15. Number of hours of operation accumulated on engine (prior to installation): **NA**
16. Manufacturer's recommended inlet depression (in. H_2O): **-16**

    Typical in-use inlet depression (in. H_2O): **-15.9**
17. Exhaust system:
    - Header pipe inside diameter (inches) **4**
    - Tailpipe inside diameter (inches) **5**
    - Minimum distance in-use between the exhaust manifold and the exit of the chassis exhaust system: _____
    - Other: _____

Diesel Engine Pre-Test Data

Required Information as per CFR 86-1244-94 (d) CERTD2.DER Rev. 8-95

1. Engine-system combination: **heavy-duty diesel fueled engine**
2. Engine identification number: **06R0038671**
3. Instrument operator(s): **R. Cortez**
4. Engine operator(s): **Ricky Frierson**
5. Number of hours of operation accumulated on the engine prior to beginning the test sequence: **NA**
6. Identification and specification of test fuel: **CDTI Candidate Fuel**

   SwRI Fuel Code: EM-5901-F
7. Emission Analyzers and Equipment:

Emission Analyzers	Serial No.	Verification Date	Operator
HC continuous	1000139	3/6/06	Sergio Oseguera
CO bag	56314704	2/13/06	R. Guerra
CO2 bag	2000173	2/8/06	R. Guerra
NO_x continuous	1000448	2/8/06	Sergio Oseguera
NO_x converter	1000448	2/7/06	Sergio Oseguera
Equipment			
CVS	5	3/2/06	Sergio Oseguera
Torquemeter	RF 12	3/6/06	Ricky Frierson

DIESEL ENGINE TEST DATA

Required Information as per CFR 86-1344-94 (e)

CERTD3.DER Rev. 8-95

1. Date and time of day: 3/6/06 3:00 pm, 3:40 pm, 4:20 pm
2. Test number: C10, C11, C12
3. Engine intake air or test cell temperature (°F): 75, 75, 77
4. Barometric pressure (in. Hg): 29.24, 29.23, 29.22
5. Engine intake or test cell humidity (% RH): 75, 76, 72 CVS dilution air humidity (%RH): 44, 43, 44
6. Maximum torque verses speed curve as determined in 86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used: see attached
7. Measured maximum horsepower engine speed (RPM): 1800 Maximum torque speed (RPM): 1200
8. Measured maximum horsepower (BHP): 361 Maximum measured torque (ft-lb): 1402
9. Measured high idle engine speed (RPM): ---1922
10. Measured fuel consumption rate (lb_m/hr) at maximum power: 115.5 and at peak torque: 108.2
11. Cold-soak time interval and cool down procedures: NA
12. Temperature set point of the heated continuous analysis system components (°F): 375
13. Test cycle validation statistics as specified in 86.1341 for each test phase (cold and hot): see attached
14. Total CVS flow rate and dilution factor for each test phase (cold and hot):
    CVS Flow Rate (scfm): 2152.15, 2148.21, 2150.58 Dilution Factor: 22.82, 23.18, 23.18
15. Dilute exhaust mixture temperature at gas meter (°F): 78, 78, 78
    Secondary dilution air temperature at gas meter (°F): 84, 84, 84
16. Maximum temperature at 90mm particulate filter sample zone (°F): 118, 119, 120
17. Dilute exhaust sample concentrations (background corrected):
    HC (ppmC) 2.80, 2.17, 2.30 CO (ppmC) 37.33, 34.64, 33.86
    CO_2 (%) 0.5346, 0.5239, 0.5251 NO_X (ppm) 43.38, 43.68, 43.74
19. Diesel fuel composition: see attached
21. The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter:
    Pre-Test Primary (mg) 451.303, 435.901, 439.131
    Post-test Primary (mg) 454.324, 438.970, 442.203
    Pre-test Backup (mg) weighed as pair Post-test Backup (mg) weighed as pair
22. Brake specific emissions (g/BHP-hr) for HC, CO, NO_X for each test phase (cold and hot):
    HC 0.084, 0.065, 0.069 CO 2.252, 2.087, 2.055
    NO_X 4.602, 4.651, 4.700 Part. 0.168, 0.170, 0.171
23. The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test:
    HC ---NA--- CO -NA----- NO_X -NA----- Part. -NA-----
24. The carbon balance brake specific fuel consumption (lb/BHP-hr) for the total test: 0.359
25. The number of hours of operation accumulated on the engine after completing the test sequence: NA

08-5586-001
Project Number

POWER VALIDATION
HEAVY-DUTY DIESEL ENGINE

030906 PV
Test or ID Number

Cell No.: 4	Date: 03/09/2006	Start Time: 8:52	Finish Time: 9:10
Engine S/N or ID: S60 38671		[X] As-Received	[ ] Modified
Operator: RDF	Project Leader: Robert Fanick		Fuel Code: EM-5785-F
Low Idle rpm (no load): 600	Low Idle rpm @ 0	lb-ft CITT: 0	High Idle rpm (governed): 1,922
Notes:			

Parameters	Rated Power	Peak Torque
Torque (lb-ft)	1,052	1,402
Speed (rpm)	1,800	1,200
Power (bhp)	362.0	321.0
Fuel Flow (lb/hr)	116.2	103.6
Water Out (°F)	198.0	203
Water In (°F)	182	180
Oil (°F)	199	210
Inlet Air (°F)	80.0	79
Fuel (°F)	99	96
Exhaust (°F)	819	994
Intercooler In (°F)	273	271
Intercooler Out (°F)	106	100
IC Coolant Supply (°F)		
Inlet Air Dewpoint (°F)	49.1	49.0
Chiller Water (°F)	50.0	50.0
Barometer ("Hg)	28.82	28.82
Inlet Air Restriction ("H2O)	-16.1	-7.70
Exhaust Restriction ("Hg)	3.0	1.60
Boost Pres. Before IC ("Hg)	37.30	35.00
Boost Pres. After IC ("Hg)	33.9	33.0
Intercooler ÐP ("H2O)	46.0	27.0
Oil Pressure (psig)	55.0	48.0
Fuel Pressure (psig)		
Engine Water Pres. (psig)		
Hour Meter (hours)	723.0	723.0

SwRI - Department of Emissions Research
FORM 07-001A

03/18/2006

08-5586-001
Project Number

030906 PM
Test Number

POWER MAP
HEAVY-DUTY DIESEL ENGINE

Date: 03/09/2006 Time: 8:52	Engine Model: S60		
Cell No.: 4	Serial No. or ID: 38671		
Operator: RDF	Hour Meter: 722.8	Dura. Hours:	0.00
Project Leader: Robert Fanick	Fuel Code: EM-5785-F	Baro., "Hg:	28.82

MAP PRECONDITIONING

Parameter	Rated Speed	RatedTorque
Power (bhp)	362.00	321.00
Torque (lb-ft)	1,052.00	1,402.00
Speed (rpm)	1,800.00	1,200.00
Fuel Flow (lb/hr)	116.20	103.60
Inlet Air Restriction ("H2O)	-16.10	-7.70
Exhaust Restriction ("Hg)	3.00	1.60
Intake Air (°F)	80.00	79.00
Intake Air Dewpoint (°F)	49.10	49.00
ÐP Across Intercooler ("H2O)	46.00	27.00
Temperature After Intercooler (°F)	106.00	100.00

Map @ [X] 8 rpm/sec sweep [ ] Other: Idle Speed, rpm Low: 600 High: 1,922

RESULTS

Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft
100		1100	1,188	2100		3100	
200		1200	1,383	2200		3200	
300		1300	1,317	2300		3300	
400		1400	1,257	2400		3400	
500	556	1500	1,191	2500		3500	
600	615	1600	1,143	2600		3600	
700	665	1700	1,106	2700		3700	
800	764	1800	1,020	2800		3800	
900	915	1900		2900		3900	
1000	1,047	2000		3000		4000	

Speed Ramp Rate 8.0 rpm/sec RATED SPEED, rpm: Manufacturer 1,800 Measured 1,703

Calculated Maximum Speed = 1.13*[Highest RATED SPEED - Curb Idle Speed] + Curb Idle Speed = 1,956 rpm

TRANSIENT CYCLE INPUTS

CITT: 0 lb-ft

Idle Speed: 600 rpm Rated Speed 1,800 rpm Max. Power 360.4 hp Max. Torque 1,402 lb-ft

SwRI - Department of Emissions Research
FORM 07-001B

DIESEL ENGINE SET-UP DATA

Required Information as per CFR 86-1344-94 (c) CERTD1.DER Rev. 8-95

1. Engine Manufacturer: **Detroit Diesel**
2. Engine system combination: **heavy-duty diesel engine**
3. Engine Model: **Series 60** Engine Displacement (in^3): **775**
4. Engine identification number: **06R0038671**
5. Applicable engine model year: **1991**
6. Engine fuel type: **TxLED ULSD Reference Fuel**
7. Recommended lubricating oil type: **SAE 15W-40**
8. Exhaust pipe configuration, pipe sizes, etc: **see item 17 below**
9. Curb or low idle speed (RPM): **600**
10. Dynamometer idle speed. (Automatic transmission engines only.) **NA**
11. Engine parameter specifications (such as injection timing or injector height setting, operating temperature, etc): **NA**
12. Engine performance data:
    - Manufacturer's advertised maximum power (BHP) **365**
    - Manufacturer's rated engine speed (RPM) **1800**
    - Manufacturer's measured fuel rate at maximum power (lb_m/hr) **116.3**
    - Manufacturer's maximum governed engine speed (RPM) **1956**
13. Recommended start-up procedure: **NA**
14. Maximum safe engine operating speed (RPM): **NA**
15. Number of hours of operation accumulated on engine (prior to installation): **NA**
16. Manufacturer's recommended inlet depression (in. H_2O): **-16**

    Typical in-use inlet depression (in. H_2O): **-16.1**
17. Exhaust system:
    - Header pipe inside diameter (inches) **4**
    - Tailpipe inside diameter (inches) **5**
    - Minimum distance in-use between the exhaust manifold and the exit of the chassis exhaust system: _____
    - Other: _____

Diesel Engine Pre-Test Data

Required Information as per CFR 86-1244-94 (d) CERTD2.DER Rev. 8-95

1. Engine-system combination: **heavy-duty diesel fueled engine**
2. Engine identification number: **06R0038671**
3. Instrument operator(s): **R. Cortez**
4. Engine operator(s): **Ricky Frierson**
5. Number of hours of operation accumulated on the engine prior to beginning the test sequence: **NA**
6. Identification and specification of test fuel: **TxLED Ultra-Low Sulfur Diesel**
   SwRI Fuel Code: EM-5785-F
7. Emission Analyzers and Equipment:

Emission Analyzers	Serial No.	Verification Date	Operator
HC continuous	1000139	3/6/06	Sergio Oseguera
CO bag	56314704	2/13/06	R. Guerra
CO2 bag	2000173	3/8/06	R. Guerra
NO_x continuous	1000448	3/7/06	Sergio Oseguera
NO_x converter	1000448	3/7/06	Sergio Oseguera
Equipment			
CVS	5	3/8/06	Sergio Oseguera
Torquemeter	RF 12	3/6/06	Ricky Frierson

DIESEL ENGINE TEST DATA

Required Information as per CFR 86-1344-94 (e) CERTD3.DER Rev. 8-95

1. Date and time of day: 3/9/06 10:20 am, 11:00 am, 11:40 pm
2. Test number: R13, R14, R15
3. Engine intake air or test cell temperature (°F): 77, 77, 78
4. Barometric pressure (in. Hg): 28.83, 28.82, 28.81
5. Engine intake or test cell humidity (% RH): 37, 36, 37 CVS dilution air humidity (%RH): 18, 16, 26
6. Maximum torque verses speed curve as determined in 86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used: see attached
7. Measured maximum horsepower engine speed (RPM): 1800 Maximum torque speed (RPM): 1200
8. Measured maximum horsepower (BHP): 362 Maximum measured torque (ft-lb): 1402
9. Measured high idle engine speed (RPM): ---1922
10. Measured fuel consumption rate (lb_m/hr) at maximum power: 116.2 and at peak torque: 103.6
11. Cold-soak time interval and cool down procedures: NA
12. Temperature set point of the heated continuous analysis system components (°F): 375
13. Test cycle validation statistics as specified in 86.1341 for each test phase (cold and hot): see attached
14. Total CVS flow rate and dilution factor for each test phase (cold and hot):
    CVS Flow Rate (scfm): 2123.95, 2116.93, 2115.89 Dilution Factor: 21.46, 21.28, 21.10
15. Dilute exhaust mixture temperature at gas meter (°F): 78, 79, 78
    Secondary dilution air temperature at gas meter (°F): 84, 85, 83
16. Maximum temperature at 90mm particulate filter sample zone (°F): 116, 117, 117
17. Dilute exhaust sample concentrations (background corrected):
    HC (ppmC) 2.86, 2.55, 3.17 CO (ppmC) 39.87, 40.66, 39.75
    CO_2 (%) 0.5689, 0.5764, 0.5823 NO_X (ppm) 49.58, 50.19, 49.39
19. Diesel fuel composition: see attached
21. The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter:
    Pre-Test Primary (mg) 434.862, 429.781, 434.642
    Post-test Primary (mg) 438.260, 433.258, 438.080
    Pre-test Backup (mg) weighed as pair Post-test Backup (mg) weighed as pair
22. Brake specific emissions (g/BHP-hr) for HC, CO, NO_X for each test phase (cold and hot):
    HC 0.083, 0.085, 0.093 CO 2.378, 2.411, 2.386
    NO_X 4.483, 4.598, 4.550 Part. 0.206, 0.203, 0.203
23. The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test:
    HC ---NA--- CO -NA----- NO_X -NA----- Part. -NA-----
24. The carbon balance brake specific fuel consumption (lb/BHP-hr) for the total test: 0.381
25. The number of hours of operation accumulated on the engine after completing the test sequence: NA

08-5586-001
Project Number

030906 PMAP
Test Number

POWER MAP
HEAVY-DUTY DIESEL ENGINE

Date: 03/09/2006 Time: 12:56	Engine Model: DDC S60		
Cell No.: 4	Serial No. or ID: 06R0038671		
Operator: RDF	Hour Meter: 724.9	Dura. Hours:	0.00
Project Leader: Robert Fanick	Fuel Code: EM-5785-F	Baro., "Hg:	28.78

MAP PRECONDITIONING

Parameter	Rated Speed	RatedTorque
Power (bhp)	362.00	321.00
Torque (lb-ft)	1,050.00	1,402.00
Speed (rpm)	1,800.00	1,200.00
Fuel Flow (lb/hr)	0.00	0.00
Inlet Air Restriction ("H2O)	-16.00	-7.60
Exhaust Restriction ("Hg)	3.10	1.60
Intake Air (°F)	78.00	78.00
Intake Air Dewpoint (°F)	51.20	51.20
ÐP Across Intercooler ("H2O)	49.00	27.00
Temperature After Intercooler (°F)	115.00	110.00

Map @ [X] 8 rpm/sec sweep [ ] Other: Idle Speed, rpm Low: 600 High: 1,922

RESULTS

Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft	Speed, rpm	Torque lb-ft
100		1100	1,201	2100		3100	
200		1200	1,387	2200		3200	
300		1300	1,343	2300		3300	
400		1400	1,251	2400		3400	
500	563	1500	1,209	2500		3500	
600	615	1600	1,148	2600		3600	
700	667	1700	1,106	2700		3700	
800	776	1800	1,036	2800		3800	
900	920	1900		2900		3900	
1000	1,048	2000		3000		4000	

Speed Ramp Rate 8.0 rpm/sec RATED SPEED, rpm: Manufacturer 1,800 Measured 1,703

Calculated Maximum Speed = 1.13*[Highest RATED SPEED - Curb Idle Speed] + Curb Idle Speed = 1,956 rpm

TRANSIENT CYCLE INPUTS

CITT: 0 lb-ft

Idle Speed: 600 rpm Rated Speed 1,800 rpm Max. Power 362.0 hp Max. Torque 1,408 lb-ft

DIESEL ENGINE SET-UP DATA

Required Information as per CFR 86-1344-94 (c) CERTD1.DER Rev. 8-95

1. Engine Manufacturer: **Detroit Diesel**
2. Engine system combination: **heavy-duty diesel engine**
3. Engine Model: **Series 60** Engine Displacement (in^3): **775**
4. Engine identification number: **06R0038671**
5. Applicable engine model year: **1991**
6. Engine fuel type: **TxLED ULSD Reference Fuel**
7. Recommended lubricating oil type: **SAE 15W-40**
8. Exhaust pipe configuration, pipe sizes, etc: **see item 17 below**
9. Curb or low idle speed (RPM): **600**
10. Dynamometer idle speed. (Automatic transmission engines only.) **NA**
11. Engine parameter specifications (such as injection timing or injector height setting, operating temperature, etc): **NA**
12. Engine performance data:
    - Manufacturer's advertised maximum power (BHP) **365**
    - Manufacturer's rated engine speed (RPM) **1800**
    - Manufacturer's measured fuel rate at maximum power (lb_m/hr) **116.3**
    - Manufacturer's maximum governed engine speed (RPM) **1922**
13. Recommended start-up procedure: **NA**
14. Maximum safe engine operating speed (RPM): **NA**
15. Number of hours of operation accumulated on engine (prior to installation): **NA**
16. Manufacturer's recommended inlet depression (in. H_2O): **-16**

    Typical in-use inlet depression (in. H_2O): **-16**
17. Exhaust system:
    - Header pipe inside diameter (inches) **4**
    - Tailpipe inside diameter (inches) **5**
    - Minimum distance in-use between the exhaust manifold and the exit of the chassis exhaust system: _____
    - Other: _____

Diesel Engine Pre-Test Data

Required Information as per CFR 86-1244-94 (d) CERTD2.DER Rev. 8-95

1. Engine-system combination: **heavy-duty diesel fueled engine**
2. Engine identification number: **06R0038671**
3. Instrument operator(s): **R. Cortez**
4. Engine operator(s): **Ricky Frierson**
5. Number of hours of operation accumulated on the engine prior to beginning the test sequence: **NA**
6. Identification and specification of test fuel: **TxLED Ultra-Low Sulfur Diesel**
   SwRI Fuel Code: EM-5785-F
7. Emission Analyzers and Equipment:

Emission Analyzers	Serial No.	Verification Date	Operator
HC continuous	1000139	3/6/06	Sergio Oseguera
CO bag	56314704	2/13/06	R. Guerra
CO2 bag	2000173	3/8/06	R. Guerra
NO_x continuous	1000448	3/7/06	Sergio Oseguera
NO_x converter	1000448	3/7/06	Sergio Oseguera
Equipment			
CVS	5	3/8/06	Sergio Oseguera
Torquemeter	RF 12	3/6/06	Ricky Frierson

DIESEL ENGINE TEST DATA

Required Information as per CFR 86-1344-94 (e) CERTD3.DER Rev. 8-95

1. Date and time of day: **3/9/06 2:20 pm, 3:00 pm, 3:40 pm**
2. Test number: **R16, R17, R18**
3. Engine intake air or test cell temperature (°F): **78, 78, 77**
4. Barometric pressure (in. Hg): **28.73, 28.73, 28.73**
5. Engine intake or test cell humidity (% RH): **39, 38, 41** CVS dilution air humidity (%RH): **39, 38, 41**
6. Maximum torque verses speed curve as determined in 86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used: **see attached**
7. Measured maximum horsepower engine speed (RPM): **1800** Maximum torque speed (RPM): **1200**
8. Measured maximum horsepower (BHP): **362** Maximum measured torque (ft-lb): **1408**
9. Measured high idle engine speed (RPM): **---1922**
10. Measured fuel consumption rate (lb_m/hr) at maximum power: _____ and at peak torque: _____
11. Cold-soak time interval and cool down procedures: **NA**
12. Temperature set point of the heated continuous analysis system components (°F): **375**
13. Test cycle validation statistics as specified in 86.1341 for each test phase (cold and hot): **see attached**
14. Total CVS flow rate and dilution factor for each test phase (cold and hot):
    CVS Flow Rate (scfm): **2109.75, 2106.79, 2109.81** Dilution Factor: **21.37, 21.60, 21.27**
15. Dilute exhaust mixture temperature at gas meter (°F): **80, 80, 80**
    Secondary dilution air temperature at gas meter (°F): **84, 84, 85**
16. Maximum temperature at 90mm particulate filter sample zone (°F): **121, 121, 121**
17. Dilute exhaust sample concentrations (background corrected):
    HC (ppmC) **2.74, 1.67, 2.75** CO (ppmC) **41.01, 40.44, 43.62**
    CO_2 (%) **0.5731, 0.5677, 0.5770** NO_X (ppm) **49.26, 50.07, 49.97**
19. Diesel fuel composition: **see attached**
21. The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter:
    Pre-Test Primary (mg) **441.228, 447.858, 451.845**
    Post-test Primary (mg) **444.717, 451.285, 454.845**
    Pre-test Backup (mg) **weighed as pair** Post-test Backup (mg) **weighed as pair**
22. Brake specific emissions (g/BHP-hr) for HC, CO, NO_X for each test phase (cold and hot):
    HC **0.081, 0.049, 0.081** CO **2.249, 2.395, 2.589**
    NO_X **4.595, 4.652, 4.679** Part. **0.196, 0.194, 0.200**
23. The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test:
    HC **---NA---** CO **-NA-----** NO_X **-NA-----** Part. **-NA-----**
24. The carbon balance brake specific fuel consumption (lb/BHP-hr) for the total test: **0.376**
25. The number of hours of operation accumulated on the engine after completing the test sequence: **NA**

APPENDIX B

Transient Regulated Emissions Data for a 1991 Detroit Diesel Series 60 Running with Reference Fuel and with CDT Biodiesel PLUS™ from Clean Diesel Technologies, Inc. Fuel

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R1	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/03/2006	Time: 11:00	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.33	in Hg	99.3 kPa
Engine Inlet Air			
Temperature:	76.0	°F	24.4 °C
Dew Point:	60.5	°F	15.8 °C
Abs. Humidity:	80.6	gr/lb	11.5 g/kg
Rel. Humidity:	59	%	
Dilution Air:			
Temperature:	78.0	°F	25.6 °C
Abs. Humidity	67.8	gr/lb	9.7 g/kg
Rel. Humidity:	46	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.75	ppm	
HC Bckgrd	n/a		4.20	ppm	
CO Sample	41.6	2	40.47	ppm	(Dry)
CO Bckgrd	0.2	2	0.19	ppm	
NOx Sample	n/a		45.58	ppm	(Dry)
NOx Bckgrd	1.1	1	0.28	ppm	
CO2 Sample	72.5	1	0.6095	%	(Wet)
CO2 Bckgrd	8.5	1	0.0465	%	

Corrected Concentrations

HC	2.74	ppm
CO	39.20	ppm
NOx	44.34	ppm
CO2	0.5652	%

Mass Emissions

HC		1.974	grams	
CO		56.537	grams	
NOx		106.616	grams	
Particulate		4.888	grams	
CO2		12.809	kg	
Fuel	9.03 lb		4.10	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,160.6	61.19
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.88	0.05
Gas Meter 2:	3.49	0.10
Sample Rate:	1.61	0.05
Total Flow Rate:	2,162.20	61.23

Particulate Data

Filter Number:	5058.0 (pair)	
Weight Gain:	3.639	mg
Sample Multiplier:	1.343	

Correction Factors

NOx Humidity CF:	1.015
Dry-to-Wet CF, Sample:	0.979
Dry-to-Wet CF, Bckgrd:	0.985
Dilution Factor:	21.56

Test Cycle Data

Sample Time:	1,213.90	sec		
Work:	23.78	hp-hr	17.73	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,744.9	scf	1,238.88	scm

Brake-Specific Emission Results

BSHC (Cell)	0.083	g/hp-hr	0.111	g/kW-hr
CO	2.378	g/hp-hr	3.188	g/kW-hr
NOx (Cell)	4.483	g/hp-hr	6.012	g/kW-hr
Particulate	0.206	g/hp-hr	0.276	g/kW-hr
CO2	538.6	g/hp-hr	722.33	g/kW-hr
BSFC	0.380	lb/hp-hr	0.231	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R2	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/03/2006	Time: 11:40	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.33	in Hg	99.3 kPa
Engine Inlet Air			
Temperature:	75.0	°F	23.9 °C
Dew Point:	59.2	°F	15.1 °C
Abs. Humidity:	76.9	gr/lb	11.0 g/kg
Rel. Humidity:	58	%	
Dilution Air:			
Temperature:	77.0	°F	25.0 °C
Abs. Humidity	69.5	gr/lb	9.9 g/kg
Rel. Humidity:	49	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		7.01	ppm	
HC Bckgrd	n/a		4.39	ppm	
CO Sample	42.1	2	40.97	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		47.20	ppm	(Dry)
NOx Bckgrd	1.1	1	0.28	ppm	
CO2 Sample	72.9	1	0.6148	%	(Wet)
CO2 Bckgrd	8.9	1	0.0489	%	

Corrected Concentrations

HC	2.83	ppm
CO	39.74	ppm
NOx	45.91	ppm
CO2	0.5682	%

Mass Emissions

HC		2.030	grams	
CO		57.261	grams	
NOx		109.204	grams	
Particulate		4.824	grams	
CO2		12.865	kg	
Fuel	9.07 lb		4.11	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,157.4	61.10
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.88	0.05
Gas Meter 2:	3.52	0.10
Sample Rate:	1.64	0.05
Total Flow Rate:	2,159.06	61.15

Particulate Data

Filter Number:	5059.0 (pair)	
Weight Gain:	3.663	mg
Sample Multiplier:	1.317	

Correction Factors

NOx Humidity CF:	1.005
Dry-to-Wet CF, Sample:	0.978
Dry-to-Wet CF, Bckgrd:	0.984
Dilution Factor:	21.37

Test Cycle Data

Sample Time:	1,214.50	sec		
Work:	23.75	hp-hr	17.71	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,702.9	scf	1,237.69	scm

Brake-Specific Emission Results

BSHC (Cell)	0.085	g/hp-hr	0.115	g/kW-hr
CO	2.411	g/hp-hr	3.233	g/kW-hr
NOx (Cell)	4.598	g/hp-hr	6.166	g/kW-hr
Particulate	0.203	g/hp-hr	0.272	g/kW-hr
CO2	541.7	g/hp-hr	726.42	g/kW-hr
BSFC	0.382	lb/hp-hr	0.232	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R3	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/03/2006	Time: 12:20	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.31	in Hg	99.2 kPa
Engine Inlet Air			
Temperature:	77.0	°F	25.0 °C
Dew Point:	60.0	°F	15.6 °C
Abs. Humidity:	79.2	gr/lb	11.3 g/kg
Rel. Humidity:	56	%	
Dilution Air:			
Temperature:	78.0	°F	25.6 °C
Abs. Humidity	58.3	gr/lb	8.3 g/kg
Rel. Humidity:	40	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		7.42	ppm	
HC Bckgrd	n/a		4.53	ppm	
CO Sample	42.2	2	41.07	ppm	(Dry)
CO Bckgrd	0.3	2	0.28	ppm	
NOx Sample	n/a		46.75	ppm	(Dry)
NOx Bckgrd	1.5	1	0.38	ppm	
CO2 Sample	73.2	1	0.6188	%	(Wet)
CO2 Bckgrd	9.1	1	0.0500	%	

Corrected Concentrations

HC	3.10	ppm
CO	39.78	ppm
NOx	45.49	ppm
CO2	0.5712	%

Mass Emissions

HC		2.221	grams	
CO		57.088	grams	
NOx		108.435	grams	
Particulate		4.843	grams	
CO2		12.881	kg	
Fuel	9.08 lb		4.12	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,149.6	60.88
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.87	0.05
Gas Meter 2:	3.51	0.10
Sample Rate:	1.64	0.05
Total Flow Rate:	2,151.25	60.92

Particulate Data

Filter Number:	5060.0 (pair)	
Weight Gain:	3.692	mg
Sample Multiplier:	1.312	

Correction Factors

NOx Humidity CF:	1.011
Dry-to-Wet CF, Sample:	0.981
Dry-to-Wet CF, Bckgrd:	0.987
Dilution Factor:	21.23

Test Cycle Data

Sample Time:	1,214.10	sec		
Work:	23.83	hp-hr	17.77	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,530.5	scf	1,232.81	scm

Brake-Specific Emission Results

BSHC (Cell)	0.093	g/hp-hr	0.125	g/kW-hr
CO	2.396	g/hp-hr	3.213	g/kW-hr
NOx (Cell)	4.550	g/hp-hr	6.102	g/kW-hr
Particulate	0.203	g/hp-hr	0.273	g/kW-hr
CO2	540.6	g/hp-hr	724.89	g/kW-hr
BSFC	0.381	lb/hp-hr	0.232	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R4	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/03/2006	Time: 14:28	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.25	in Hg	99.0 kPa
Engine Inlet Air			
Temperature:	76.0	°F	24.4 °C
Dew Point:	59.8	°F	15.4 °C
Abs. Humidity:	78.8	gr/lb	11.3 g/kg
Rel. Humidity:	57	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	61.5	gr/lb	8.8 g/kg
Rel. Humidity:	41	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		7.16	ppm	
HC Bckgrd	n/a		4.71	ppm	
CO Sample	46.8	2	45.64	ppm	(Dry)
CO Bckgrd	0.5	2	0.47	ppm	
NOx Sample	n/a		47.82	ppm	(Dry)
NOx Bckgrd	1.4	1	0.35	ppm	
CO2 Sample	73.2	1	0.6188	%	(Wet)
CO2 Bckgrd	9.2	1	0.0506	%	

Corrected Concentrations

HC	2.67	ppm
CO	44.04	ppm
NOx	46.53	ppm
CO2	0.5706	%

Mass Emissions

HC		1.917	grams	
CO		63.360	grams	
NOx		111.066	grams	
Particulate		4.924	grams	
CO2		12.899	kg	
Fuel	9.10 lb		4.13	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,154.4	61.01
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.86	0.05
Gas Meter 2:	3.47	0.10
Sample Rate:	1.61	0.05
Total Flow Rate:	2,155.99	61.06

Particulate Data

Filter Number:	5061.0 (pair)	
Weight Gain:	3.682	mg
Sample Multiplier:	1.337	

Correction Factors

NOx Humidity CF:	1.010
Dry-to-Wet CF, Sample:	0.980
Dry-to-Wet CF, Bckgrd:	0.986
Dilution Factor:	21.22

Test Cycle Data

Sample Time:	1,214.30	sec		
Work:	23.52	hp-hr	17.54	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,633.7	scf	1,235.73	scm

Brake-Specific Emission Results

BSHC (Cell)	0.081	g/hp-hr	0.109	g/kW-hr
CO	2.694	g/hp-hr	3.613	g/kW-hr
NOx (Cell)	4.722	g/hp-hr	6.333	g/kW-hr
Particulate	0.209	g/hp-hr	0.281	g/kW-hr
CO2	548.4	g/hp-hr	735.45	g/kW-hr
BSFC	0.387	lb/hp-hr	0.235	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R5	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/03/2006	Time: 15:08	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.24	in Hg	99.0 kPa
Engine Inlet Air			
Temperature:	76.0	°F	24.4 °C
Dew Point:	58.7	°F	14.8 °C
Abs. Humidity:	75.7	gr/lb	10.8 g/kg
Rel. Humidity:	55	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	61.5	gr/lb	8.8 g/kg
Rel. Humidity:	41	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		7.29	ppm	
HC Bckgrd	n/a		4.88	ppm	
CO Sample	42.3	2	41.17	ppm	(Dry)
CO Bckgrd	0.2	2	0.19	ppm	
NOx Sample	n/a		48.12	ppm	(Dry)
NOx Bckgrd	1.9	1	0.48	ppm	
CO2 Sample	73.1	1	0.6175	%	(Wet)
CO2 Bckgrd	9.4	1	0.0518	%	

Corrected Concentrations

HC	2.64	ppm
CO	39.95	ppm
NOx	46.70	ppm
CO2	0.5681	%

Mass Emissions

HC		1.887	grams	
CO		57.275	grams	
NOx		110.201	grams	
Particulate		4.861	grams	
CO2		12.799	kg	
Fuel	9.02 lb		4.09	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,147.3	60.81
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.87	0.05
Gas Meter 2:	3.47	0.10
Sample Rate:	1.60	0.05
Total Flow Rate:	2,148.92	60.86

Particulate Data

Filter Number:	5062.0-848 (pair)	
Weight Gain:	3.617	mg
Sample Multiplier:	1.344	

Correction Factors

NOx Humidity CF:	1.002
Dry-to-Wet CF, Sample:	0.980
Dry-to-Wet CF, Bckgrd:	0.986
Dilution Factor:	21.28

Test Cycle Data

Sample Time:	1,214.10	sec		
Work:	23.81	hp-hr	17.76	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,483.4	scf	1,231.48	scm

Brake-Specific Emission Results

BSHC (Cell)	0.079	g/hp-hr	0.106	g/kW-hr
CO	2.405	g/hp-hr	3.226	g/kW-hr
NOx (Cell)	4.628	g/hp-hr	6.207	g/kW-hr
Particulate	0.204	g/hp-hr	0.274	g/kW-hr
CO2	537.6	g/hp-hr	720.88	g/kW-hr
BSFC	0.379	lb/hp-hr	0.231	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R6	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/03/2006	Time: 15:48	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.24	in Hg	99.0 kPa
Engine Inlet Air			
Temperature:	78.0	°F	25.6 °C
Dew Point:	59.5	°F	15.3 °C
Abs. Humidity:	78.0	gr/lb	11.1 g/kg
Rel. Humidity:	53	%	
Dilution Air:			
Temperature:	78.0	°F	25.6 °C
Abs. Humidity	63.2	gr/lb	9.0 g/kg
Rel. Humidity:	43	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		7.04	ppm	
HC Bckgrd	n/a		4.64	ppm	
CO Sample	43.1	2	41.96	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		47.72	ppm	(Dry)
NOx Bckgrd	1.5	1	0.38	ppm	
CO2 Sample	73.5	1	0.6228	%	(Wet)
CO2 Bckgrd	8.8	1	0.0483	%	

Corrected Concentrations

HC	2.62	ppm
CO	40.78	ppm
NOx	46.39	ppm
CO2	0.5768	%

Mass Emissions

HC		1.873	grams	
CO		58.474	grams	
NOx		110.127	grams	
Particulate		4.925	grams	
CO2		12.998	kg	
Fuel	9.16 lb		4.16	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,147.0	60.80
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.86	0.05
Gas Meter 2:	3.48	0.10
Sample Rate:	1.62	0.05
Total Flow Rate:	2,148.59	60.85

Particulate Data

Filter Number:	5063.0 (pair)	
Weight Gain:	3.718	mg
Sample Multiplier:	1.325	

Correction Factors

NOx Humidity CF:	1.008
Dry-to-Wet CF, Sample:	0.980
Dry-to-Wet CF, Bckgrd:	0.986
Dilution Factor:	21.10

Test Cycle Data

Sample Time:	1,214.60	sec		
Work:	23.49	hp-hr	17.52	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,494.7	scf	1,231.79	scm

Brake-Specific Emission Results

BSHC (Cell)	0.080	g/hp-hr	0.107	g/kW-hr
CO	2.489	g/hp-hr	3.338	g/kW-hr
NOx (Cell)	4.688	g/hp-hr	6.287	g/kW-hr
Particulate	0.210	g/hp-hr	0.281	g/kW-hr
CO2	553.3	g/hp-hr	742.03	g/kW-hr
BSFC	0.390	lb/hp-hr	0.237	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.: C7		DIESEL 2D, EM-5901-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/06/2006	Time: 11:55	HCR: 1.904	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.135 C= 0.845 O= 0.020 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.34	in Hg	99.3 kPa
Engine Inlet Air			
Temperature:	77.0	°F	25.0 °C
Dew Point:	59.8	°F	15.4 °C
Abs. Humidity:	78.6	gr/lb	11.2 g/kg
Rel. Humidity:	55	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	71.0	gr/lb	10.1 g/kg
Rel. Humidity:	47	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.74	ppm	
HC Bckgrd	n/a		4.41	ppm	
CO Sample	38.1	2	37.01	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		47.23	ppm	(Dry)
NOx Bckgrd	0.5	1	0.13	ppm	
CO2 Sample	70.3	1	0.5811	%	(Wet)
CO2 Bckgrd	8.6	1	0.0471	%	

Corrected Concentrations

HC	2.52	ppm
CO	35.94	ppm
NOx	46.09	ppm
CO2	0.5361	%

Mass Emissions

HC	1.806	grams		
CO	51.731	grams		
NOx	109.972	grams		
Particulate	3.880	grams		
CO2	12.123	kg		
Fuel	8.70	lb	3.94	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,154.9	61.03
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.88	0.05
Gas Meter 2:	3.50	0.10
Sample Rate:	1.62	0.05
Total Flow Rate:	2,156.51	61.07

Particulate Data

Filter Number:	5064.0-860 (pair)	
Weight Gain:	2.911	mg
Sample Multiplier:	1.333	

Correction Factors

NOx Humidity CF:	1.009
Dry-to-Wet CF, Sample:	0.978
Dry-to-Wet CF, Bckgrd:	0.984
Dilution Factor:	22.88

Test Cycle Data

Sample Time:	1,214.50	sec		
Work:	23.69	hp-hr	17.67	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,651.4	scf	1,236.23	scm

Brake-Specific Emission Results

BSHC (Cell)	0.076	g/hp-hr	0.102	g/kW-hr
CO	2.184	g/hp-hr	2.928	g/kW-hr
NOx (Cell)	4.642	g/hp-hr	6.225	g/kW-hr
Particulate	0.164	g/hp-hr	0.220	g/kW-hr
CO2	511.8	g/hp-hr	686.27	g/kW-hr
BSFC	0.367	lb/hp-hr	0.223	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	C8	DIESEL 2D, EM-5901-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/06/2006	Time: 12:35	HCR: 1.904	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.135 C= 0.845 O= 0.020 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.32	in Hg	99.3 kPa
Engine Inlet Air			
Temperature:	76.0	°F	24.4 °C
Dew Point:	60.9	°F	16.1 °C
Abs. Humidity:	81.8	gr/lb	11.7 g/kg
Rel. Humidity:	60	%	
Dilution Air:			
Temperature:	78.0	°F	25.6 °C
Abs. Humidity	72.8	gr/lb	10.4 g/kg
Rel. Humidity:	50	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.19	ppm	
HC Bckgrd	n/a		4.31	ppm	
CO Sample	35.5	2	34.43	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		47.14	ppm	(Dry)
NOx Bckgrd	0.7	1	0.18	ppm	
CO2 Sample	69.8	1	0.5748	%	(Wet)
CO2 Bckgrd	8.2	1	0.0448	%	

Corrected Concentrations

HC	2.07	ppm
CO	33.41	ppm
NOx	45.93	ppm
CO2	0.5319	%

Mass Emissions

HC		1.474	grams	
CO		47.938	grams	
NOx		110.230	grams	
Particulate		3.863	grams	
CO2		11.995	kg	
Fuel	8.60 lb		3.90	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,150.2	60.89
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.87	0.05
Gas Meter 2:	3.51	0.10
Sample Rate:	1.64	0.05
Total Flow Rate:	2,151.79	60.94

Particulate Data

Filter Number:	5065.0 (pair)	
Weight Gain:	2.946	mg
Sample Multiplier:	1.311	

Correction Factors

NOx Humidity CF:	1.018
Dry-to-Wet CF, Sample:	0.978
Dry-to-Wet CF, Bckgrd:	0.984
Dilution Factor:	23.14

Test Cycle Data

Sample Time:	1,213.60	sec		
Work:	23.81	hp-hr	17.76	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,523.6	scf	1,232.61	scm

Brake-Specific Emission Results

BSHC (Cell)	0.062	g/hp-hr	0.083	g/kW-hr
CO	2.013	g/hp-hr	2.700	g/kW-hr
NOx (Cell)	4.630	g/hp-hr	6.208	g/kW-hr
Particulate	0.162	g/hp-hr	0.218	g/kW-hr
CO2	503.8	g/hp-hr	675.58	g/kW-hr
BSFC	0.361	lb/hp-hr	0.220	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.: C9		DIESEL 2D, EM-5901-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/06/2006	Time: 13:15	HCR: 1.904	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.135 C= 0.845 O= 0.020 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.29	in Hg	99.2 kPa
Engine Inlet Air			
Temperature:	76.0	°F	24.4 °C
Dew Point:	62.3	°F	16.8 °C
Abs. Humidity:	86.1	gr/lb	12.3 g/kg
Rel. Humidity:	63	%	
Dilution Air:			
Temperature:	80.0	°F	26.7 °C
Abs. Humidity	74.6	gr/lb	10.7 g/kg
Rel. Humidity:	48	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.09	ppm	
HC Bckgrd	n/a		4.21	ppm	
CO Sample	38.3	2	37.20	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		46.61	ppm	(Dry)
NOx Bckgrd	0.5	1	0.13	ppm	
CO2 Sample	70.3	1	0.5811	%	(Wet)
CO2 Bckgrd	8.4	1	0.0460	%	

Corrected Concentrations

HC	2.06	ppm
CO	36.12	ppm
NOx	45.44	ppm
CO2	0.5371	%

Mass Emissions

HC	1.473	grams		
CO	51.839	grams		
NOx	110.325	grams		
Particulate	3.869	grams		
CO2	12.113	kg		
Fuel	8.69 lb		3.94	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,147.9	60.83
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.87	0.05
Gas Meter 2:	3.50	0.10
Sample Rate:	1.63	0.05
Total Flow Rate:	2,149.53	60.88

Particulate Data

Filter Number:	5066.0 (pair)	
Weight Gain:	2.930	mg
Sample Multiplier:	1.320	

Correction Factors

NOx Humidity CF:	1.030
Dry-to-Wet CF, Sample:	0.978
Dry-to-Wet CF, Bckgrd:	0.983
Dilution Factor:	22.88

Test Cycle Data

Sample Time:	1,215.00	sec		
Work:	23.87	hp-hr	17.80	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,528.1	scf	1,232.74	scm

Brake-Specific Emission Results

BSHC (Cell)	0.062	g/hp-hr	0.083	g/kW-hr
CO	2.172	g/hp-hr	2.912	g/kW-hr
NOx (Cell)	4.622	g/hp-hr	6.198	g/kW-hr
Particulate	0.162	g/hp-hr	0.217	g/kW-hr
CO2	507.5	g/hp-hr	680.50	g/kW-hr
BSFC	0.364	lb/hp-hr	0.221	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	C10	DIESEL 2D, EM-5901-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/06/2006	Time: 15:00	HCR: 1.904	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.135 C= 0.845 O= 0.020 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.24	in Hg	99.0 kPa
Engine Inlet Air			
Temperature:	75.0	°F	23.9 °C
Dew Point:	66.5	°F	19.2 °C
Abs. Humidity:	100.2	gr/lb	14.3 g/kg
Rel. Humidity:	75	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	66.4	gr/lb	9.5 g/kg
Rel. Humidity:	44	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.61	ppm	
HC Bckgrd	n/a		3.98	ppm	
CO Sample	39.5	2	38.39	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		44.61	ppm	(Dry)
NOx Bckgrd	1.3	1	0.33	ppm	
CO2 Sample	70.4	1	0.5824	%	(Wet)
CO2 Bckgrd	9.1	1	0.0500	%	

Corrected Concentrations

HC	2.80	ppm
CO	37.33	ppm
NOx	43.38	ppm
CO2	0.5346	%

Mass Emissions

HC	2.002	grams		
CO	53.584	grams		
NOx	109.478	grams		
Particulate	4.005	grams		
CO2	12.060	kg		
Fuel	8.65	lb	3.92	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,150.5	60.90
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.87	0.05
Gas Meter 2:	3.49	0.10
Sample Rate:	1.62	0.05
Total Flow Rate:	2,152.15	60.95

Particulate Data

Filter Number:	5221.0-863 (pair)	
Weight Gain:	3.021	mg
Sample Multiplier:	1.326	

Correction Factors

NOx Humidity CF:	1.070
Dry-to-Wet CF, Sample:	0.979
Dry-to-Wet CF, Bckgrd:	0.985
Dilution Factor:	22.82

Test Cycle Data

Sample Time:	1,213.90	sec		
Work:	23.79	hp-hr	17.74	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,541.7	scf	1,233.13	scm

Brake-Specific Emission Results

BSHC (Cell)	0.084	g/hp-hr	0.113	g/kW-hr
CO	2.252	g/hp-hr	3.020	g/kW-hr
NOx (Cell)	4.602	g/hp-hr	6.171	g/kW-hr
Particulate	0.168	g/hp-hr	0.226	g/kW-hr
CO2	506.9	g/hp-hr	679.80	g/kW-hr
BSFC	0.364	lb/hp-hr	0.221	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	C11	DIESEL 2D, EM-5901-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/06/2006	Time: 15:40	HCR: 1.904	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.135 C= 0.845 O= 0.020 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.23	in Hg	99.0 kPa
Engine Inlet Air			
Temperature:	75.0	°F	23.9 °C
Dew Point:	67.0	°F	19.4 °C
Abs. Humidity:	102.1	gr/lb	14.6 g/kg
Rel. Humidity:	76	%	
Dilution Air:			
Temperature:	78.0	°F	25.6 °C
Abs. Humidity	63.2	gr/lb	9.0 g/kg
Rel. Humidity:	43	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.50	ppm	
HC Bckgrd	n/a		4.53	ppm	
CO Sample	36.7	2	35.62	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		44.74	ppm	(Dry)
NOx Bckgrd	0.7	1	0.18	ppm	
CO2 Sample	69.7	1	0.5735	%	(Wet)
CO2 Bckgrd	9.4	1	0.0518	%	

Corrected Concentrations

HC	2.17	ppm
CO	34.64	ppm
NOx	43.68	ppm
CO2	0.5239	%

Mass Emissions

HC	1.544	grams		
CO	49.674	grams		
NOx	110.692	grams		
Particulate	4.045	grams		
CO2	11.807	kg		
Fuel	8.47	lb	3.84	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,146.6	60.79
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.87	0.05
Gas Meter 2:	3.50	0.10
Sample Rate:	1.63	0.05
Total Flow Rate:	2,148.21	60.84

Particulate Data

Filter Number:	5222.0 (pair)	
Weight Gain:	3.069	mg
Sample Multiplier:	1.318	

Correction Factors

NOx Humidity CF:	1.076
Dry-to-Wet CF, Sample:	0.980
Dry-to-Wet CF, Bckgrd:	0.986
Dilution Factor:	23.18

Test Cycle Data

Sample Time:	1,214.80	sec		
Work:	23.80	hp-hr	17.75	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,494.1	scf	1,231.78	scm

Brake-Specific Emission Results

BSHC (Cell)	0.065	g/hp-hr	0.087	g/kW-hr
CO	2.087	g/hp-hr	2.799	g/kW-hr
NOx (Cell)	4.651	g/hp-hr	6.237	g/kW-hr
Particulate	0.170	g/hp-hr	0.228	g/kW-hr
CO2	496.1	g/hp-hr	665.24	g/kW-hr
BSFC	0.356	lb/hp-hr	0.216	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	C12	DIESEL 2D, EM-5901-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/06/2006	Time: 16:20	HCR: 1.904	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.135 C= 0.845 O= 0.020 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	29.22	in Hg	98.9 kPa
Engine Inlet Air			
Temperature:	77.0	°F	25.0 °C
Dew Point:	67.2	°F	19.6 °C
Abs. Humidity:	102.8	gr/lb	14.7 g/kg
Rel. Humidity:	72	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	66.4	gr/lb	9.5 g/kg
Rel. Humidity:	44	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.88	ppm	
HC Bckgrd	n/a		4.79	ppm	
CO Sample	35.9	2	34.83	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		44.85	ppm	(Dry)
NOx Bckgrd	0.8	1	0.20	ppm	
CO2 Sample	69.7	1	0.5735	%	(Wet)
CO2 Bckgrd	9.2	1	0.0506	%	

Corrected Concentrations

HC	2.30	ppm
CO	33.86	ppm
NOx	43.74	ppm
CO2	0.5251	%

Mass Emissions

HC	1.639	grams		
CO	48.597	grams		
NOx	111.157	grams		
Particulate	4.047	grams		
CO2	11.842	kg		
Fuel	8.49	lb	3.85	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,148.9	60.86
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.87	0.05
Gas Meter 2:	3.50	0.10
Sample Rate:	1.63	0.05
Total Flow Rate:	2,150.58	60.91

Particulate Data

Filter Number:	5223.0-865 (pair)	
Weight Gain:	3.072	mg
Sample Multiplier:	1.317	

Correction Factors

NOx Humidity CF:	1.078
Dry-to-Wet CF, Sample:	0.980
Dry-to-Wet CF, Bckgrd:	0.985
Dilution Factor:	23.18

Test Cycle Data

Sample Time:	1,214.40	sec		
Work:	23.65	hp-hr	17.64	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	43,527.7	scf	1,232.73	scm

Brake-Specific Emission Results

BSHC (Cell)	0.069	g/hp-hr	0.093	g/kW-hr
CO	2.055	g/hp-hr	2.756	g/kW-hr
NOx (Cell)	4.700	g/hp-hr	6.303	g/kW-hr
Particulate	0.171	g/hp-hr	0.229	g/kW-hr
CO2	500.7	g/hp-hr	671.45	g/kW-hr
BSFC	0.359	lb/hp-hr	0.218	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R13	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/09/2006	Time: 10:20	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	28.83	in Hg	97.6 kPa
Engine Inlet Air			
Temperature:	77.0	°F	25.0 °C
Dew Point:	48.8	°F	9.3 °C
Abs. Humidity:	53.2	gr/lb	7.6 g/kg
Rel. Humidity:	37	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	27.3	gr/lb	3.9 g/kg
Rel. Humidity:	18	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.06	ppm	
HC Bckgrd	n/a		3.36	ppm	
CO Sample	44.1	2	42.95	ppm	(Dry)
CO Bckgrd	2.6	2	2.44	ppm	
NOx Sample	n/a		50.41	ppm	(Dry)
NOx Bckgrd	0.9	1	0.23	ppm	
CO2 Sample	72.7	1	0.6122	%	(Wet)
CO2 Bckgrd	8.3	1	0.0454	%	

Corrected Concentrations

HC	2.86	ppm
CO	39.87	ppm
NOx	49.58	ppm
CO2	0.5689	%

Mass Emissions

HC	2.019	grams		
CO	56.515	grams		
NOx	109.240	grams		
Particulate	4.626	grams		
CO2	12.672	kg		
Fuel	8.93	lb	4.05	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,122.4	60.11
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.83	0.05
Gas Meter 2:	3.39	0.10
Sample Rate:	1.56	0.04
Total Flow Rate:	2,123.95	60.15

Particulate Data

Filter Number:	5472.0 (pair)	
Weight Gain:	3.398	mg
Sample Multiplier:	1.361	

Correction Factors

NOx Humidity CF:	0.946
Dry-to-Wet CF, Sample:	0.988
Dry-to-Wet CF, Bckgrd:	0.994
Dilution Factor:	21.46

Test Cycle Data

Sample Time:	1,214.50	sec		
Work:	23.69	hp-hr	17.67	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	42,992.4	scf	1,217.57	scm

Brake-Specific Emission Results

BSHC (Cell)	0.085	g/hp-hr	0.114	g/kW-hr
CO	2.386	g/hp-hr	3.199	g/kW-hr
NOx (Cell)	4.611	g/hp-hr	6.184	g/kW-hr
Particulate	0.195	g/hp-hr	0.262	g/kW-hr
CO2	534.9	g/hp-hr	717.34	g/kW-hr
BSFC	0.377	lb/hp-hr	0.229	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R14	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/09/2006	Time: 11:00	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	28.82	in Hg	97.6 kPa
Engine Inlet Air			
Temperature:	77.0	°F	25.0 °C
Dew Point:	48.0	°F	8.9 °C
Abs. Humidity:	51.6	gr/lb	7.4 g/kg
Rel. Humidity:	36	%	
Dilution Air:			
Temperature:	80.0	°F	26.7 °C
Abs. Humidity	25.7	gr/lb	3.7 g/kg
Rel. Humidity:	16	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.58	ppm	
HC Bckgrd	n/a		4.23	ppm	
CO Sample	42.7	2	41.56	ppm	(Dry)
CO Bckgrd	0.2	2	0.19	ppm	
NOx Sample	n/a		50.89	ppm	(Dry)
NOx Bckgrd	0.4	1	0.10	ppm	
CO2 Sample	73.1	1	0.6175	%	(Wet)
CO2 Bckgrd	7.9	1	0.0431	%	

Corrected Concentrations

HC	2.55	ppm
CO	40.66	ppm
NOx	50.19	ppm
CO2	0.5764	%

Mass Emissions

HC		1.795	grams	
CO		57.413	grams	
NOx		109.758	grams	
Particulate		4.693	grams	
CO2		12.792	kg	
Fuel	9.02 lb		4.09	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,115.4	59.91
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.83	0.05
Gas Meter 2:	3.40	0.10
Sample Rate:	1.57	0.04
Total Flow Rate:	2,116.93	59.95

Particulate Data

Filter Number:	5473.0-870 (pair)	
Weight Gain:	3.477	mg
Sample Multiplier:	1.350	

Correction Factors

NOx Humidity CF:	0.943
Dry-to-Wet CF, Sample:	0.988
Dry-to-Wet CF, Bckgrd:	0.994
Dilution Factor:	21.28

Test Cycle Data

Sample Time:	1,214.00	sec		
Work:	23.52	hp-hr	17.54	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	42,832.6	scf	1,213.04	scm

Brake-Specific Emission Results

BSHC (Cell)	0.076	g/hp-hr	0.102	g/kW-hr
CO	2.441	g/hp-hr	3.273	g/kW-hr
NOx (Cell)	4.667	g/hp-hr	6.258	g/kW-hr
Particulate	0.200	g/hp-hr	0.268	g/kW-hr
CO2	543.9	g/hp-hr	729.34	g/kW-hr
BSFC	0.383	lb/hp-hr	0.233	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R15	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/09/2006	Time: 11:40	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	28.81	in Hg	97.6 kPa
Engine Inlet Air			
Temperature:	78.0	°F	25.6 °C
Dew Point:	49.7	°F	9.8 °C
Abs. Humidity:	55.1	gr/lb	7.9 g/kg
Rel. Humidity:	37	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	40.0	gr/lb	5.7 g/kg
Rel. Humidity:	26	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		5.93	ppm	
HC Bckgrd	n/a		2.90	ppm	
CO Sample	41.9	2	40.77	ppm	(Dry)
CO Bckgrd	0.2	2	0.19	ppm	
NOx Sample	n/a		50.23	ppm	(Dry)
NOx Bckgrd	0.3	1	0.08	ppm	
CO2 Sample	73.5	1	0.6228	%	(Wet)
CO2 Bckgrd	7.8	1	0.0425	%	

Corrected Concentrations

HC	3.17	ppm
CO	39.75	ppm
NOx	49.39	ppm
CO2	0.5823	%

Mass Emissions

HC		2.230	grams	
CO		56.120	grams	
NOx		108.919	grams	
Particulate		4.553	grams	
CO2		12.920	kg	
Fuel	9.11 lb		4.13 kg	

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,114.3	59.88
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.84	0.05
Gas Meter 2:	3.43	0.10
Sample Rate:	1.60	0.05
Total Flow Rate:	2,115.89	59.92

Particulate Data

Filter Number:	5474.0-871 (pair)	
Weight Gain:	3.438	mg
Sample Multiplier:	1.324	

Correction Factors

NOx Humidity CF:	0.951
Dry-to-Wet CF, Sample:	0.985
Dry-to-Wet CF, Bckgrd:	0.991
Dilution Factor:	21.10

Test Cycle Data

Sample Time:	1,214.40	sec		
Work:	23.80	hp-hr	17.75	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	42,825.7	scf	1,212.85	scm

Brake-Specific Emission Results

BSHC (Cell)	0.094	g/hp-hr	0.126	g/kW-hr
CO	2.358	g/hp-hr	3.162	g/kW-hr
NOx (Cell)	4.576	g/hp-hr	6.137	g/kW-hr
Particulate	0.191	g/hp-hr	0.257	g/kW-hr
CO2	542.9	g/hp-hr	728.00	g/kW-hr
BSFC	0.383	lb/hp-hr	0.233	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R16	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/09/2006	Time: 14:20	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	28.73	in Hg	97.3 kPa
Engine Inlet Air			
Temperature:	78.0	°F	25.6 °C
Dew Point:	51.2	°F	10.7 °C
Abs. Humidity:	58.4	gr/lb	8.3 g/kg
Rel. Humidity:	39	%	
Dilution Air:			
Temperature:	81.0	°F	27.2 °C
Abs. Humidity	32.6	gr/lb	4.7 g/kg
Rel. Humidity:	20	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.27	ppm	
HC Bckgrd	n/a		3.70	ppm	
CO Sample	43.2	2	42.06	ppm	(Dry)
CO Bckgrd	0.3	2	0.28	ppm	
NOx Sample	n/a		49.98	ppm	(Dry)
NOx Bckgrd	0.2	1	0.05	ppm	
CO2 Sample	72.9	1	0.6148	%	(Wet)
CO2 Bckgrd	8.0	1	0.0437	%	

Corrected Concentrations

HC	2.74	ppm
CO	41.01	ppm
NOx	49.26	ppm
CO2	0.5731	%

Mass Emissions

HC	1.925	grams		
CO	57.724	grams		
NOx	109.188	grams		
Particulate	4.653	grams		
CO2	12.676	kg		
Fuel	8.94	lb	4.05	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,108.2	59.70
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.82	0.05
Gas Meter 2:	3.40	0.10
Sample Rate:	1.58	0.04
Total Flow Rate:	2,109.75	59.75

Particulate Data

Filter Number:	5475.0 (pair)	
Weight Gain:	3.489	mg
Sample Multiplier:	1.334	

Correction Factors

NOx Humidity CF:	0.959
Dry-to-Wet CF, Sample:	0.987
Dry-to-Wet CF, Bckgrd:	0.993
Dilution Factor:	21.37

Test Cycle Data

Sample Time:	1,214.00	sec		
Work:	23.76	hp-hr	17.72	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	42,687.4	scf	1,208.93	scm

Brake-Specific Emission Results

BSHC (Cell)	0.081	g/hp-hr	0.109	g/kW-hr
CO	2.429	g/hp-hr	3.258	g/kW-hr
NOx (Cell)	4.595	g/hp-hr	6.163	g/kW-hr
Particulate	0.196	g/hp-hr	0.263	g/kW-hr
CO2	533.5	g/hp-hr	715.43	g/kW-hr
BSFC	0.376	lb/hp-hr	0.229	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R17	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/09/2006	Time: 15:00	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	28.73	in Hg	97.3 kPa
Engine Inlet Air			
Temperature:	78.0	°F	25.6 °C
Dew Point:	50.5	°F	10.3 °C
Abs. Humidity:	56.9	gr/lb	8.1 g/kg
Rel. Humidity:	38	%	
Dilution Air:			
Temperature:	80.0	°F	26.7 °C
Abs. Humidity	30.0	gr/lb	4.3 g/kg
Rel. Humidity:	19	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		6.31	ppm	
HC Bckgrd	n/a		4.86	ppm	
CO Sample	42.4	2	41.27	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		50.76	ppm	(Dry)
NOx Bckgrd	0.2	1	0.05	ppm	
CO2 Sample	72.4	1	0.6082	%	(Wet)
CO2 Bckgrd	7.8	1	0.0425	%	

Corrected Concentrations

HC	1.67	ppm
CO	40.44	ppm
NOx	50.07	ppm
CO2	0.5677	%

Mass Emissions

HC		1.174	grams	
CO		56.836	grams	
NOx		110.401	grams	
Particulate		4.605	grams	
CO2		12.538	kg	
Fuel	8.84 lb		4.01	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,105.2	59.62
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.83	0.05
Gas Meter 2:	3.39	0.10
Sample Rate:	1.57	0.04
Total Flow Rate:	2,106.79	59.67

Particulate Data

Filter Number:	5476.0 (pair)	
Weight Gain:	3.427	mg
Sample Multiplier:	1.344	

Correction Factors

NOx Humidity CF:	0.955
Dry-to-Wet CF, Sample:	0.987
Dry-to-Wet CF, Bckgrd:	0.993
Dilution Factor:	21.60

Test Cycle Data

Sample Time:	1,214.10	sec		
Work:	23.73	hp-hr	17.70	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	42,630.8	scf	1,207.33	scm

Brake-Specific Emission Results

BSHC (Cell)	0.049	g/hp-hr	0.066	g/kW-hr
CO	2.395	g/hp-hr	3.212	g/kW-hr
NOx (Cell)	4.652	g/hp-hr	6.239	g/kW-hr
Particulate	0.194	g/hp-hr	0.260	g/kW-hr
CO2	528.4	g/hp-hr	708.55	g/kW-hr
BSFC	0.373	lb/hp-hr	0.227	kg/kW-hr

Southwest Research Institute - Department of Emissions Research
EPA Hot Transient Emission Test Results
Project No. 08-5586-001

Engine Model:	1991 Series 60	Test No.:	R18	DIESEL 2D, EM-5785-F	
Engine Desc.:	12.7 L (775 CID) 6	Date: 03/09/2006	Time: 15:40	HCR: 1.940	FID Resp: 1.00
Engine Cycle:	Diesel	Program HDT:	4.12-R	H= 0.140 C= 0.860 O= 0.000 X= 0.000	
Engine S/N:	06R0038671	Cell: 4	Bag Cart: 1		

Ambient/Test Cell Conditions

Barometer:	28.73	in Hg	97.3 kPa
Engine Inlet Air			
Temperature:	77.0	°F	25.0 °C
Dew Point:	51.5	°F	10.8 °C
Abs. Humidity:	59.1	gr/lb	8.4 g/kg
Rel. Humidity:	41	%	
Dilution Air:			
Temperature:	79.0	°F	26.1 °C
Abs. Humidity	31.7	gr/lb	4.5 g/kg
Rel. Humidity:	21	%	

Measured Gaseous Data

	Meter	Range	Concentration		
HC Sample	n/a		5.93	ppm	
HC Bckgrd	n/a		3.34	ppm	
CO Sample	45.7	2	44.54	ppm	(Dry)
CO Bckgrd	0.1	2	0.09	ppm	
NOx Sample	n/a		50.72	ppm	(Dry)
NOx Bckgrd	0.3	1	0.08	ppm	
CO2 Sample	73.1	1	0.6175	%	(Wet)
CO2 Bckgrd	7.8	1	0.0425	%	

Corrected Concentrations

HC	2.75	ppm
CO	43.62	ppm
NOx	49.97	ppm
CO2	0.5770	%

Mass Emissions

HC		1.928	grams	
CO		61.406	grams	
NOx		110.985	grams	
Particulate		4.752	grams	
CO2		12.766	kg	
Fuel	9.01 lb		4.08	kg

Sample Flows

	scfm	scmm
Blower 1 Rate:	2,108.2	59.71
Blower 2 Rate:	0.0	0.00
90 mm System:		
Gas Meter 1:	1.83	0.05
Gas Meter 2:	3.41	0.10
Sample Rate:	1.58	0.04
Total Flow Rate:	2,109.81	59.75

Particulate Data

Filter Number:	5477.0 (pair)	
Weight Gain:	3.567	mg
Sample Multiplier:	1.332	

Correction Factors

NOx Humidity CF:	0.960
Dry-to-Wet CF, Sample:	0.987
Dry-to-Wet CF, Bckgrd:	0.993
Dilution Factor:	21.27

Test Cycle Data

Sample Time:	1,214.40	sec		
Work:	23.72	hp-hr	17.69	kW-hr
Reference Work:	23.85	hp-hr	17.78	kW-hr
Total Volume (Vmix):	42,702.6	scf	1,209.36	scm

Brake-Specific Emission Results

BSHC (Cell)	0.081	g/hp-hr	0.109	g/kW-hr
CO	2.589	g/hp-hr	3.472	g/kW-hr
NOx (Cell)	4.679	g/hp-hr	6.275	g/kW-hr
Particulate	0.200	g/hp-hr	0.269	g/kW-hr
CO2	538.2	g/hp-hr	721.71	g/kW-hr
BSFC	0.380	lb/hp-hr	0.231	kg/kW-hr