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New Technology Research & Development Program
Grant Contract 582-5-70807-0008

Task 2 Deliverable

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

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TASK DELIVERABLES

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

NEW TECHNOLOGY RESEARCH & DEVELOPMENT (NTRD) PROGRAM

Task 2: Map Engine for the DF2010 Fuel System (2.2.3)

SUBMITTED BY

CLEAN AIR WORLDWIDE GP, INC.

CONTRACT NUMBER 582-5-70807-008

Texas Commission on Environmental Quality
New Technology Research & Development (NTRD) Program
Task Deliverables

Contract Number: 582-5-70807-0008

Grantee: Clean Air Worldwide GP, Inc.

Date Submitted: February 8, 2006

Report for **Article 2. Task 2: Map Engine for the DF2010 retrofit device**

Task Statement Number 2.2

Section I. Objectives

The company, Clean Air Worldwide GP, Inc, purchased a DT466 engine specifically for testing at California Environmental Engineering in California. CEE requested that we provide an engine that had not been run on any other fuel, so a remanufactured engine was purchased. Original dynamometer data is to be obtained from the manufacturer.

Engineering testing and measurements were conducted to determine the size of the DF2010 Fuel System to be installed on the DT466 remanufactured engine.

In order to prepare the DT466 to conduct the initial mapping many tasks had to be performed as listed.

Task 2, Task Statement 2.2

Mr. Henry Harness conducted the initial mapping on the OEM International DT466 mapping. In order to accomplish this, he directed Brookside Machine Inc. to perform the following tasks:
INTAKE: modification of intake manifold (measurement of air flow), modification of induction tube (measurement of discharge temperature), modification of turbo compressor housing discharge (measurement of turbo efficiency), modification of turbo charger inlet (measure ambient conditions of pressure and temperature)
EXHAUST: modification of exhaust turbine (measure exhaust velocity), modification of exhaust manifold (measure exhaust back pressure and exhaust temperature), modification of exhaust pipe for turbocharger discharge (measure temperature and pressure), modification of exhaust pipe for emission test equipment.
Mr. Henry Harness directed B&A Auto Electric to perform the following tasks: Install all sensors to measure initial engine readings, install Data Acquisition System to record all initial engine readings.

Sub-Task 2.2.1
Mr. Henry Harness conducted initial mapping on the DT466 to determine the proper size of the DF2010 Fuel System. B&A Auto Electric assisted him with the dyno work to baseline the OEM Engine.

Sub-Task 2.2.1.1
Mr. Henry Harness used the information from 2.2.1 to calculate the proper size of the DF2010 Fuel System to be applied to the DT466 engine.

Based on this information Mr. Harness directed Brookside Machine to make alterations to the evaporative module portion of the DF2010 Fuel System and modify the induction tube, after cooler, fuel pump, injector and associated hardware including the brackets to mount the fuel system (see task 2.2.1.2). They also manufactured adapters for the new turbo inlet and new turbo outlet.
Based on this information Mr. Harness directed B&A Auto Electric to modify a new power generation unit to match horsepower of the DT466 engine. Additionally the wiring harness which controls the evaporative module required extensive revisions and improvements for operation with the DT466 engine.

The following tasks are so related that Task 3 is also included in this report.

Sub-Task 2.2.1.2 and Sub-Task 2.3.1.1 regarding Brookside Machine
Mr. Henry Harness completed the design of all mounting brackets (2.2.1.2) and completed the design of The DF2010 retrofit device (2.3.1) and directed Brookside Machine to manufacture the following components:
Turbo inlet adaptor: T4 to T3
Sleeve for Turbo compressor inlet housing from 2.75 inches to 3.0 inches
Four inch turbo discharge outlet adaptor
One inch turbo drain fitting
Induction tube for front side of turbo
Auxiliary injector
Fuel pump bracket
Injector bracket
Fuel pressure regulator bracket
Induction tube mounting bracket
New turbo discharge tubes
Brackets for after cooler
Power Generation Brackets with idle pulley provisions
Idle pulley
18 tooth power generation drive sprocket
90 tooth drive sprocket
power generator support bracket
Injector cap for auxiliary injector with cooling fins
Five inch fan spacer
Exhaust manifold stud standoffs
Evaporative module
Modify inlet and outlet fuel pressure regulator
Nickel plate evaporative module
Nickel plate aluminum 18 tooth sprocket to give high Reynolds number
Nickel plate aluminum 90 tooth sprocket to give high Reynolds number
Nickel plate fan spacer for corrosion resistance
Powder coat all brackets
Ceramic coating on Turbine housing
Powder coat fuel pressure regulator to protect from elements
Powder coat injector tubes
Ceramic coat all adaptors

Section 2. Attachments:

Attachment A: Test Results from Engine Analyzer Pro v3.3 on DT466-210 Turbo D.

Section 3. Results

The Dragon Fire 2010 was sized to function on the DT466 engine. All mounting brackets and modifications needed for installation were completed.

Task 2.2 has been completed

Tom C Barna Date: 2/8/06

Authorized Project Representative's Signature

NOTE: *Please attach any additional information that you feel should be a part of your report or that may be required to meet the deliverable requirements for tasks completed during this reporting period.*

Engine Analyzer Pro v3.3
Eng: DT-466-210 TURBO D
Test Results

Horsepower Henry
281-639-7484

Date: 12-14-2005
Time: 7:31:24 pm
Page: 1

Projected Performance

Engine RPM	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500
Brk Tq, ft lb	337	334	332	329	324	319	313	304	294	523	497	469	440	408
Brake HP	77.0	82.7	88.5	94.0	98.7	103	107	110	112	209	208	205	201	194
Exh Pres, PSI	3.4	4.1	4.8	5.7	6.5	7.5	8.7	9.8	10.9	29.1	30.6	31.8	32.9	33.6
Boost, PSI	1.6	1.8	2.1	2.5	2.8	3.2	3.6	4.1	4.5	22.9	23.7	24.4	24.9	25.5
Vol Eff, %	82.3	83.2	84.2	85.2	85.9	86.8	87.6	88.1	88.2	146.2	143.6	140.5	137.0	133.5
Actual CFM	133	146	159	172	185	199	213	226	238	414	426	436	443	450
Fuel Flow, lb/hr	25.30	27.70	30.17	32.73	35.20	37.78	40.36	42.84	45.16	78.6	80.9	82.7	84.2	85.4
Nitrous, lb/hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ntrs Fuel, lb/hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BMEP, PSI	109	108	107	106	105	103	101	98.5	95.1	169	161	152	142	132
A/F Mxtr Qlty, %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
BSFC, lb/HP-hr	0.329	0.335	0.341	0.348	0.357	0.366	0.377	0.389	0.404	0.376	0.388	0.403	0.419	0.439
Thermal Eff, %	49.89	49.37	48.88	48.27	47.64	46.90	46.09	45.25	44.32	42.71	41.84	40.93	40.05	38.97
IMEP, PSI	133	133	133	133	133	132	131	129	127	203	195	186	178	169
Frctn Tq, ft-lbs	74.7	77.6	80.5	83.4	86.2	89.1	92.1	95.0	97.9	103	105	108	110	113
Frctn HP	17.08	19.21	21.45	23.81	26.27	28.86	31.55	34.36	37.28	40.99	44.01	47.12	50.3	53.7
FMEP, PSI	24.19	25.11	26.04	26.97	27.91	28.85	29.79	30.74	31.68	33.17	34.00	34.82	35.65	36.48
Mech Eff, %	81.8	81.2	80.5	79.8	79.0	78.2	77.2	76.2	75.0	83.6	82.6	81.3	80.0	78.4
Motoring HP	23.19	27.05	31.38	36.24	41.53	47.54	54.2	61.3	68.9	98.9	110	121	132	143
Pumpng Work, HP	-6.11	-7.84	-9.91	-12.44	-15.26	-18.68	-22.62	-26.96	-31.64	-57.9	-65.7	-73.6	-81.6	-89.1
Residual Exh, %	5.0	5.2	5.4	6.2	6.4	7.4	7.6	8.0	9.2	8.2	8.7	10.2	10.8	11.4
Shrt Circuit, %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exh Temp, deg F	1054	1072	1091	1112	1131	1153	1175	1197	1218	1382	1402	1420	1439	1454
Mx Cyl Pres, PSI	1357	1375	1398	1425	1445	1474	1502	1526	1545	2667	2648	2618	2580	2539
Mx Cyl Tmp, deg F	3791	3787	3788	3791	3788	3793	3798	3803	3806	3976	3977	3976	3969	3962
In Port Tmp, deg F	183	185	188	192	196	200	206	210	214	301	307	310	312	315
Piston Spd, ft/min	1050	1138	1225	1313	1400	1488	1575	1663	1750	1838	1925	2013	2100	2188
Piston Gs @ TDC	150	170	200	230	260	300	330	370	410	450	500	540	590	640
Coolant HP	33.78	36.04	38.45	41.03	43.62	46.49	49.45	52.5	55.5	68.9	72.3	75.7	79.2	82.5
Blow By, CFM	4.8	4.8	4.9	5.0	5.1	5.2	5.2	5.3	5.4	9.1	9.0	8.9	8.7	8.6
In Tun Pres, PSI	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.0	0.0
Avg In Vel, ft/sec	147	159	171	183	195	208	220	232	244	258	269	281	293	305
Avg Ex Vel, ft/sec	147	159	171	183	195	208	220	232	244	256	269	281	293	305
Mach #	0.281	0.304	0.327	0.351	0.374	0.398	0.421	0.444	0.468	0.491	0.514	0.538	0.561	0.585
Act In FlowArea,%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Act Ex FlowArea,%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Valve Toss														
Knock Index	21.4	22.0	22.8	24.0	24.7	26.2	27.8	29.2	30.2	139.6	139.2	136.4	131.9	127.5
Spark Advnc, deg	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	26.7	26.8	26.9	27.0	27.1
Primary Jet														
Secondary Jet														
Calc Error	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compressor Eff, %	35.9	35.3	35.1	35.0	35.0	35.0	35.0	35.0	35.0	68.6	68.2	67.9	67.6	67.2
Cmprssr Pres Ratio	1.12	1.14	1.16	1.19	1.22	1.25	1.28	1.32	1.35	2.87	2.95	3.01	3.07	3.13
Compressor HP	2.7	3.5	4.5	5.7	6.9	8.4	10.1	11.9	13.7	47.6	50.7	53.4	55.8	57.7
Turbo Wastegt, %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turbo Surge, %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PkTq=523@2100 Avg=373
PkHP=209@2100 Avg=135

ATTACHMENT A: TEST RESULTS

DT466 ENGINE WITHOUT THE DF2010 FUEL SYSTEM

Special Calculations

------ Valve Flow & Cam Calculations			------------------	--Int--	--Exh--
Overlap Area, deg*sq-in	0.4		Vlv Area, deg*sq-in	162.1	76.3
Total Exh/Int %	47.1		Total Avg Flow Coef	0.206	0.431
Lobe Separation, deg	112.0		Lobe Area, inch*deg	17.29	17.29
Overlap, deg	26		Duration, deg	250	250
Overlap @ .050, deg	-34		Opening Events, deg	13	57
			Closing Events, deg	57	13
------------------	--Int--	--Exh--	Duration @.050, deg	190	190
Duration @.200, deg	90	91	Opn Evnts @.050, deg	-17	27
TDC Tappet Lift, in	0.018	0.017	Cls Evnts @.050, deg	27	-17
Gross Valve Lift, in	0.390	0.390	Lobe Centerlns, deg	112.0	112.0
Net Valve Lift, in	0.384	0.384	Grss Tappet Lft, in	0.260	0.260

------ General Engine Calculations		----------	
Displacement, ccs	7637.6	Displacement, cu in	465.99
Dynamic Comp. Ratio	13.62	Compression Ratio	16.00
Theo. Crank Comprssn,PSI	419	Clearance Volume, ccs	84.9
Pk Secondary Tuning RPM	na	Idle Vacuum, ''Hg	23.2
Pk Secondary Tuning RPM	na	Idle Vacuum, ''Hg	23.2

Engine Input Specs

Short Block, File: Untitled

Block/Pistons/Rods

Bore, in	4.34
Stroke, in	5.25
# of Cylinders	6
Rings: Diesel Rings	
Rod Length, in	7
Pstn Skrt: Large Diesel Skirt	
Bearing Size	2
Pstn Top: No Coating	
Cyl Lckg: Typical Leakage	

Accessories

Fan Type: Clutch	
Wtr Pump: Production Size	

Engine Inertia/Crank Design

Inertia: Eng Only, Std Flywhl	
Crank Design: Typical Windage	

Head(s), File: Untitled

Intake Port Specs

Port Layout: 1 valve & 1 port	
Valve Diameter, in	2
Avg Port Diameter, in	1.5
Port Length, in	3
Single Flow Coef	.42
Anti-Reversion, %	0

Combustion Chamber

Compression Ratio	16
Chamber Design: Typical Wedge	

Exhaust Port Specs

Port Layout: 1 valve & 1 port	
Valve Diameter, in	.95
Avg Port Diameter, in	1.5
Port Length, in	3
Single Flow Coef	.6
Anti-Reversion, %	0

Miscellaneous

Mtrl/Coating: Cast Iron	
Burn Rating: Typical	

Intake System, File: Untitled

Manifold Specs (1 runner /cyl)

Runner Dia @ Head, in	1.5
Runner Design: Straight Runners, No	
Runner Length, in	6.
Runner Flow Coef	1.02
Runner Taper, deg	0
Type for turbo: Single Plane-carb(s)	
Int Heat: Prod (full) Heat	

Carburetor(s)

Total CFM Rating	600
Secondaries: Open @ 4000 RPM	
Air Cleaner CFM Rating	na
Air Meter CFM Rating	na
Restrictor CFM Rating	na

Plenum not used: Turbocharged

Plenum Volume, cu in	na

Exhaust System, File: Untitled

Header Primary (2 runners/cyl)

Straight Primary (no diameter change	
Section 1, Inside Dia, in	1.5
Section 1, Length, in	9.
Section 2, Inside Dia, in	na
Section 2, Length, in	na
Section 3, Inside Dia, in	na
Section 3, Length, in	na
Runner Flow Coef	1.002

Full Exhaust System

CFM Rating	360

Collector (Simple)

Collector Length, in	25
Collector Dia, in	na
Collector Taper, deg	na

Engine Input Specs

Cam/Valve Train, File: Untitled

Intake Cam Profile		Exhaust Cam Profile	
Centerline, deg ATDC	112	Cam File	
Duration @ .050"	190	Centerline, deg BTDC	112
Opening @ .050"	-17	Duration @ .050"	190
Closing @ .050"	27	Opening @ .050"	27
Max Lobe Lift, in	.26	Closing @ .050"	-17
Actual Valve Lash, in	hyd	Max Lobe Lift, in	.26
Designed Valve Lash, in	hyd	Actual Valve Lash, in	.028
Rocker Arm Ratio	1.5	Designed Valve Lash, in	.028
Profile Type: Mild Hyd Flat		Rocker Arm Ratio	1.5
Gross Valve Lift, in	.39	Profile Type: Mild Hyd Flat	
Dwell over Nose: 0 Deg-Std Profile		Gross Valve Lift, in	.39
Use a Cam File	No	Dwell over Nose: 0 Deg-Std Profile	
		Use a Cam File	No
		Overall Cam Specs	
		Total Cam Adv: Straight Up	

Valve Train Dynamics, File: Untitled

Intake Valve Train		Exhaust Valve Train	
Gen Type: Pushrod & Rocker Arm		Gen Type: Pushrod & Rocker Arm	
Eff Valve Mass, gms		Eff Valve Mass, gms	
Eff Rckr Arm Stffnss, lb/in		Eff Rckr Arm Stffnss, lb/in	
Eff Lifter Mass, gms		Eff Lifter Mass, gms	
Eff Lifter Stiffness, lb/in	guess	Eff Lifter Stiffness, lb/in	guess
Spring Rate, lb/in		Spring Rate, lb/in	
Seated Spring Force, lbs		Seated Spring Force, lbs	

Turbocharger, File: Untitled

1st Stage Turbo		General Specs	
Island CFM	500	Throttle Location: Draw Through	
Island Pressure Ratio	2.75	Max Boost Limit, PSI	30
Island Efficiency, %	70	# Turbos/Stgs: 1 Single Turbo	
Surge CFM	100	Intercooler: 0% No Intercooler	
Ex Turbine Eff: 65% Typical		Intercooler CFM Rating	100000
Turbine Nozzle Dia, in	1.025		

Calculation Conditions, File: DT-466-210 TURBO DIESEL

Test Conditions		Fuel Specs	
CorFctr: SAE Conds (77 deg, 29.6")		Fuel Type: Truck Diesel (prod. lean	
Barometric Pressure, "Hg	na	Fuel Octane (R+M)/2	
Intake Air Temp, deg F	na		
Dew Point, deg F	na	Use Nitrous Oxide	No
Elevation, feet	na		
Cooling Sys: Liquid Cooled		Program Sets Spark for Best Power	
Coolant Temp, deg F	195		
Accel Rate: 0 Steady State			
RPM to Run			
Starting RPM	1200		
Number of RPM Steps	14		
RPM Step Size	100		