Eastern Research Group, Inc.

Estimates of Emission Reductions from Performing OBDII Tests on 1997 and Newer Diesel Vehicles up to 14,000 lbs GVW

FINAL REPORT

Prepared for:

Texas Commission on Environmental Quality (TCEQ)

Prepared by:

Eastern Research Group

October 7, 2008

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Introduction

For a number of years Texas has required gasoline powered vehicles to receive emissions inspections if they are registered in El Paso or the Dallas/Ft. Worth, Houston/Galveston or Austin metropolitan areas. In these areas, vehicles older than 1996 receive a tailpipe emission test using either the loaded Acceleration Simulation Mode (ASM) or Two-Speed Idle (TSI) test cycles, while 1996 and newer vehicles receive On-Board Diagnostic II (OBDII) inspections. All vehicles receive gas cap inspections and full safety inspections. There are currently no emissions tests performed on diesel vehicles; however, the Texas Commission on Environmental Quality (TCEQ) requested Eastern Research Group (ERG) to estimate the emissions reductions from inspecting 1997 and newer diesel vehicles up to 14,000 pounds Gross Vehicle Weight (lbs GVW). The methods used in this report are the same as those used in a similar report ERG prepared for TCEQ dated August 31, 2005. The title of this earlier report was "Estimates of Emission Reductions from Performing OBDII Tests on 1997 and Newer Light-Duty Diesel Vehicles". Although the Environmental Protection Agency's (EPA) regulations have now mandated compliance of these vehicles with OBDII requirements, it is possible that the number of these diesel vehicles in the fleet is still too small to result in any appreciable air quality benefits that could result from an Inspection and Maintenance (I/M) OBDII test. Furthermore, those states that did respond to our request for I/M OBDII do not test vehicles greater than 8,500 lbs GVW. To address this shortcoming, it was assumed that the percent reduction from I/M estimated for vehicles less than 8,500 lbs GVW would also apply to those vehicles in the 8,500-14,000 GVW lbs category.

Background

OBDII is the latest regulatory approach mandated by EPA to help reduce in-use emissions from motor vehicles. OBDII systems have been mandated for gasoline powered vehicles less than 8,500 lbs GVW, since the 1996 model year[1,2]. Diesel powered vehicles less than 8,500 lbs GVW have been equipped with OBDII systems since the 1997 model year. Vehicles between 8,500 and 14,000 lbs GVW must be equipped with OBDII systems according to the phase-in schedule outlined below[3] and additional regulations are being developed for implementing OBD on vehicles over 14,000 lbs GVW beginning with the 2010 model year (MY)[4].

- 2004 model year – 40%
- 2005 model year – 60%
- 2006-7 model years – 80%

- 2008+ model years – 100%

OBDII systems monitor all components and emission control devices that could adversely affect emission levels. For light-duty vehicles, the regulations require that the system illuminate a malfunction indicator light (MIL) when a malfunction occurs that could cause emissions to exceed a level equal to 1.5 times the emissions standard that the vehicle was certified for. For vehicles over 8,500 lbs GVW, the MIL thresholds are more complex (see Reference 4).

Inspecting vehicles by using the OBDII system is much less involved than a traditional tailpipe test. OBDII systems use standardized communication protocols and a standardized connector, termed a diagnostic link connector or DLC. The inspector must locate the standardized diagnostic connector and plug in a test system and the inspector then downloads the status of the emission control system. Additionally, it is recommended that the inspector checks for proper operation of the MIL[5]. Data from the inspection can thus be recorded automatically (with the exception of the visual inspection of the MIL), stored electronically, and then transmitted to a centralized database. Texas has been performing OBDII checks on light-duty gasoline-powered vehicles since May 2002. Given the standardization and relative simplicity of an OBD test, the inclusion of OBDII equipped diesel vehicles in the program would require minimal test method development. Similarly, in the future, medium and heavy-duty diesels could also be easily added once they are equipped with OBDII systems.

Percent Reductions in Light-Duty Diesel Vehicle Emissions from Performing OBDII Inspections

ERG estimated the emission reductions from the diesel fleet by analyzing available data from states that are currently performing OBDII tests on these vehicles. Oregon, Vermont, Delaware and Connecticut were contacted; however, Vermont does not have their data available in electronic format at this time and Connecticut Department of Motor Vehicles did not respond to our request. Therefore, ERG analyzed the data provided by Oregon and Delaware, although both of these programs only test the following vehicles:

- Light-duty diesel vehicles (LDDV – passenger cars equipped with diesel engines);
- Light-duty diesel Trucks 1 (LDDT12 – light trucks less than 6,000 lbs GVW equipped with diesel engines); and
- Light-duty diesel Trucks 2 (LDDT34 – light trucks between 6,000 and 8,500 lbs GVW equipped with diesel engines).

Percent of Vehicles with MILs Commanded-on

Table 1 presents the percent of light-duty diesel vehicles that had MILs* commanded-on in Delaware and Oregon during CY06-07. Overall, 202 of the 2,563 light-duty diesel vehicles tested (7.9%) had MILs commanded-on.

Table 1 – MIL-On Rates for Light-Duty Diesels by Model Year

	Delaware		Oregon		Combined Totals		Combined
MY	**Fail**	**Pass**	**Fail**	**Pass**	**Fail**	**Pass**	**% Mil-On**
1997	4	32	2	28	6	60	9.1%
1998	17	59	24	128	41	187	18.0%
1999	2	56	3	93	5	149	3.2%
2000	4	77	25	232	29	309	8.6%
2001	7	89	37	301	44	385	10.1%
2002	13	107	32	388	45	495	8.3%
2003	5	25	23	405	28	430	6.1%
2004	1	2	2	140	3	142	2.1%
2005	0	1	1	150	1	151	0.7%
2006	0	0	0	53	0	53	0.0%

Table 2 shows a breakdown of the percent of vehicles with MILs commanded-on by vehicle make. As shown, a majority of the vehicles (97%) that had MILs commanded-on were manufactured by Volkswagen. This makes sense since Volkswagen has dominated the light-duty diesel vehicle market. All of the Volkswagens were LDDVs (passenger cars).

Table 2 – MIL-On Rates for Light-Duty Diesels by Make

Make	MIL-Off	MIL-On	Total	% Fail	% of Failures
Chevrolet	22	2	24	8.3%	1.0%
Dodge	4	1	5	20.0%	0.5%
Ford	9	1	10	10.0%	0.5%
GMC	8	0	8	0.0%	0.0%
Jeep	24	0	24	0.0%	0.0%
Mercedes	98	2	100	2.0%	1.0%
Volkswagen	2196	196	2392	8.2%	97.0%
Totals	2361	202	2563		

* Malfunction Indicator Lamp (MIL) is a term used for the light on the instrument panel, which notifies the vehicle operator of an emission related problem. The MIL is required to display the phrase "check engine" or "service engine soon" or the ISO engine symbol. The MIL is required to illuminate when a problem has been identified that could cause emissions to exceed a specific multiple of the standards the vehicle was certified to meet. For diesel powered LDVs, this multiple is 1.5.

Table 3 shows the percent of vehicles with MILs commanded-on broken out by vehicle type. As shown, the overall percentage of vehicles with MILs commanded-on is similar for LDDVs and LDDTs. As a result, the analysis of benefits that will be discussed later in this report assumes equal benefits on a percentage basis for OBDII inspections on LDDVs and LDDTs.

Table 3 – MIL-On Rates for Light-Duty Diesels by Vehicle Type

Vehicle Type	MIL-Off	MIL-On	Total	% MIL-On
LDDV	2292	198	2490	8.0%
LDDT	69	4	73	5.5%
Total	2361	202	2563	7.9%

Estimating Benefits from OBDII Inspections

The following steps were taken to estimate the emission reductions from performing OBDII inspections on light-duty diesel vehicles:

- Diagnostic trouble codes (DTCs[*]) that were stored in vehicles with MILs commanded-on were tabulated
- Generic DTCs (those beginning with P0XXX) were interpreted using an IATN (International Automotive Technician Network) DTC look-up facility;
- Manufacturer specific DTCs (those beginning with P1XXX or P3XXX) were interpreted by contacting manufacturers and by performing internet searches based on DTC and make.

The DTCs were then grouped into one of the following categories:

- DTCs that possibly affected hydrocarbons (HC) and particulate matter (PM) emissions;
- DTCs that possibly affected nitrogen oxide (NO_x) emissions; and
- DTCs that could not be easily assigned to the HC/PM or NOx categories or were presumed to have a minimal impact on emissions.

Although grouping DTCs into the above three categories may slightly underestimate the relationship between pollutants for specific repairs (such as the relationship between HC and NOx emissions), the above groupings are believed to represent the largest emission reduction

[*] DTCs are how OBDII identifies and communicates to technicians the nature and location of on-board problems. Whenever the MIL is illuminated, a DTC should be present.

impact of certain DTC repairs. Since insufficient DTC-specific test and repair emissions information is available for diesel vehicles, DTCs were assigned to one of the above groups based on operational knowledge of the diesel engine and control system components.

Due to a lack of true DTC-specific emission information for diesel vehicles, it was assumed that problems affecting HC and PM emissions increased HC and PM emissions by 50% over their certification standards; problems affecting NO_x emissions increased NO_x emissions by 50% over their certification standard. Since the presence of a DTC may not immediately result in an emissions increase, this assumption may result in an overestimate of emissions benefit. This potential overestimate may be partially offset by those DTCs which happen to increase emissions more than 50% over certification standards. Also inherent in the above assumption is that vehicles without a set DTC will be polluting exactly at their certification standard emission level for all pollutants.

Table 4 presents a tabulation of all the DTCs that were observed in vehicles failing OBDII tests in Oregon and Delaware in descending order of DTC frequency. As shown, the most common DTC was P0380, a problem in the glow plug circuit. Glow plugs are used in diesel powered vehicles to warm up the combustion chamber when the engine is cold. By warming up the combustion chamber, the vehicle starts easier when it is cold. It is assumed the problems in the glow plug circuit primarily affected HC and PM emissions, since they could be excessive if the combustion chamber wasn't warmed up prior to a cold start. NO_x related problems such as problems in the exhaust gas recirculation (EGR) system occurred much less frequently then HC and PM problems. Overall, it was estimated that 76.1% (210 out of 276) of the DTCs affected HC and PM emissions and 6.9% (19 out of 276) of the DTCs affected NOx emissions.

Table 4 – DTCs in Light-Duty Diesel Vehicles Failing Their OBDII Inspection

DTC	Count	% of MIL-On Cases	Description	Assumed Emission Impact
P0380	92	33.3%	Glow Plug/Heater Circuit "A" Malfunction	HC, PM
P0673	28	10.1%	Cylinder 3 Glow Plug Circuit	HC, PM
P0674	24	8.7%	Cylinder 4 Glow Plug Circuit	HC, PM
P0118	19	6.9%	Engine Coolant Temperature Circuit High Input	Minimal
P0672	17	6.2%	Cylinder 2 Glow Plug Circuit	HC, PM
P0671	16	5.8%	Cylinder 1 Glow Plug Circuit	HC, PM
P0605	14	5.1%	Internal Control Module Read Only Memory (ROM) Error	Minimal

DTC	Count	% of MIL-On Cases	Description	Assumed Emission Impact
P1550	14	5.1%	Idle Speed Control	Unknown
P1403	8	2.9%	EGR Flow Deviation	NOx
P1556	5	1.8%	Symptom -- Black Smoke	Unknown
P3130	5	1.8%	EGR System Regulation Limit Exceeded	NOx
P0128	4	1.4%	Coolant Temp Below Thermostat Regulating Temperature	Minimal
P0401	3	1.1%	Exhaust Gas Recirculation Flow Insufficient Detected	NOx
P0402	2	0.7%	Exhaust Gas Recirculation Flow Excessive Detected	HC, PM
P1557	2	0.7%	Leaking Intake Hose During Boost Condition	HC, PM
P0101	1	0.4%	Mass or Volume Air Flow Circuit Performance Problem	Minimal
P0102	1	0.4%	Mass or Volume Air Flow Circuit Low Input	Minimal
P0116	1	0.4%	Engine Coolant Temperature Circuit Range/Performance Problem	Minimal
P0215	1	0.4%	Engine Shutoff Solenoid Malfunction	Minimal
P0234	1	0.4%	Engine Overboost Condition	NOx
P0236	1	0.4%	Turbocharger Boost Sensor A Circuit Range/Performance	HC, PM
P0243	1	0.4%	Turbocharger Wastegate Solenoid A Malfunction	HC, PM
P0299	1	0.4%	Turbo Underboost	HC, PM
P0300	1	0.4%	Random/Multiple Cylinder Misfire Detected	HC, PM
P0405	1	0.4%	Exhaust Gas Recirculation Sensor A Circuit Low	NOx
P0514	1	0.4%	Battery Temperature Sensor Circuit Range/Performance	Minimal
P0600	1	0.4%	Communication Link Malfunction	Minimal
P1093	1	0.4%	Unknown	Unknown
P1136	1	0.4%	O2 Sensor Heater Circuit High Voltage (Bank 1 Sensor 1)	HC, PM
P1144	1	0.4%	MAF Sensor Short To Ground	Minimal
P1145	1	0.4%	Unknown	Unknown
P1161	1	0.4%	IAT Sensor Short	Minimal
P1256	1	0.4%	ECT Sensor Short	Minimal
P1369	1	0.4%	Unknown	Unknown
P1441	1	0.4%	Unknown	Unknown
P1443	1	0.4%	Unknown	Unknown
P1619	1	0.4%	Glow Plug Relay Short To Ground	HC, PM
P1810	1	0.4%	TFP Valve Position Switch Circuit Malfunction	Minimal
Grand Total	276			

Table 5 summarizes the 100k certification standards and the average emission level for a certification test for a given pollutant, e.g. HC, PM or NOx. Prior to MY04, all vehicles were Tier 1 (T1), although this category is also dependent on MY as can be seen in Table 5. At this time, there were no diesel vehicles listed on the Office of Transportation and Air Quality web site[6] that were certified to any standard below Tier 2 Bin 9.

Table 5 –100k Vehicle Standards Obtained from Certification Records

	100k (g/mi)					
	HC or NMOG		**NOx**		**PM**	
	Std	**Cert**	**Std**	**Cert**	**Std**	**Cert**
T1						
<=MY99	0.31	0.04	1.25	0.73	0.1	0.06
>=MY00	0.31	0.03	1.25	0.64	0.1	0.05
B10						
>=MY04	0.156	0.01	0.6	0.45	0.08	0.06
B9						
>=MY04	0.09	0.02	0.3	0.25	0.06	0.04

Table 6 shows the calculated emission benefits from correcting problems in light-duty diesel powered vehicles that cause their MIL to illuminate. Because there was a range of standards in the EPA certification data, both the Low and High values were included in Table 6. However, regardless of the standard, the overall estimated "% Reduction from I/M" scales accordingly and the same result in terms of "% Reduction from I/M" is obtained. Hence, HC and PM emissions are estimated to be reduced by 3.01% and NO_x emissions are estimated to be reduced by 0.27% by performing OBDII inspections on light-duty diesel powered vehicles for both the Low and High certification standards. These estimates only apply to 1997 and newer light-duty diesel vehicle categories (LDDV, LDDT12, LDDT34). The reductions shown in Table 6 are based on the assumption that similar fail rates and DTCs would be seen in Texas as seen in Oregon and Delaware.

Table 6 – Estimated Percent Emissions Reductions from Performing OBDII Inspections on Light-Duty Diesels

	100k Std (g/mi)		Assumed Malfunction Impact				Net Emissions Increase (g/mi)		% Reduction from IM	
Pollutant	**High**	**Low**	**High**	**Low**	**% MIL-On**	**% Affected**	**High**	**Low**	**High**	**Low**
HC or NMOG	0.31	0.09	0.155	0.045	7.9%	76.1%	0.0093	0.0027	3.01%	3.01%
NOx	1.25	0.3	0.625	0.15	7.9%	6.9%	0.0032	0.0008	0.27%	0.27%
PM	0.1	0.06	0.05	0.03	7.9%	76.1%	0.0030	0.0018	3.01%	3.01%

Fleet Emissions Impact from Performing OBDII Inspections on Light-Duty Diesel Powered Vehicles

Texas counties currently participating in the Air Check Texas I/M program include nine counties in the Dallas/Forth Worth nonattainment area, five counties in the Houston/Galveston nonattainment area, El Paso County, Travis and Williamson counties.

In order to generate estimates of emissions benefits from implementing OBD testing for LDDVs and LDDTs, MOBILE6 modeling runs were performed for each county for the 2009, 2012 and 2018 calendar years. The I/M reduction factors listed above in Table 6 were then applied to emission factors obtained from these MOBILE runs for 1997 and newer model year light-duty vehicles, and the 2008 and newer heavy-duty vehicles.

MOBILE6 Input File Generation and Execution

In order to run MOBILE6 and obtain emission factors for each county and year of interest, it was necessary to first create appropriate MOBILE6 input files (SPEEDVMT, FACILITY VMT, and VMT BY HOUR). These files were created using a SAS script developed by ERG (rdtab.sas), using input files obtained from the Texas Transportation Institute (TTI). These input files contained hourly data, aggregated by roadway type and MOBILE6 vehicle type, for parameters such as vehicle miles traveled (VMT), VMT Mix, average operational speed, and other information.

The first step in the process of creating the MOBILE6 input files listed above was to read in the data for each county, as provided by TTI, and assign MOBILE 6 facility types (freeway, arterial, ramp, or local) to each roadway type, based on the description of the roadway itself.

To create the SPEEDVMT file, VMT were calculated for each roadway type by hour, regardless of MOBILE6 vehicle type. Next, using the average operational speed obtained from the TTI data, the VMT were separated into appropriate speed “bins” using the harmonic mean procedure, as outlined in the MOBILE6 guidance. At this point, the VMT, having been separated into “bins”, were converted to VMT fraction by MOBILE6 facility type and hour. A file containing this information was then created in a format readable by MOBILE6.

The FACILITY VMT file was created by separating the VMT obtained from the TTI data into “bins” based on MOBILE6 facility type (freeway, arterial, ramp, or local). This was done for each hour of the day, and for each MOBILE6 vehicle type. At this point, the VMT, having been separated into “bins”, were converted to VMT fraction by MOBILE6 facility type and hour. Again, a file containing this information was created in a format readable by MOBILE6.

The VMT BY HOUR file was created by calculating a VMT sum for each hour of the day, regardless of vehicle type or facility type. The VMT were converted to VMT fraction at this point, and once again a file containing this information was output in a format readable by MOBILE6.

Other MOBILE6 inputs, such as registration distributions, diesel fractions, and trip lengths were extracted from sample MOBILE6 files supplied by TTI. Inventory data was available for all Dallas/Fort Worth and Houston/Galveston counties; however, limited data was available for Travis, Williamson and El Paso counties. In these cases, the best available inventory data was used, and a standard VMT factor of 3% per year was applied to approximate 2009, 2012, and 2018 VMT.

Having created each of the MOBILE6 input files described above for each county of interest, three MOBILE6 runs were performed for each county - one for the 2009 calendar year one for 2012, and one for 2018. The emission factors obtained from the MOBILE6 output for each run were then used to determine the benefits of implementing an OBD program applicable to both light-duty and heavy-duty diesel vehicles based on the data in Tables 3, 4, 5 and 6.

To accomplish this, a SAS program (emproc.sas) was created to process the output from the three MOBILE6 runs performed for each county. For each vehicle type and pollutant, a travel fraction (by age) was calculated. VMT for each vehicle type were read in from TTI data processed above, and these VMT were weighted by the travel fraction to obtain an adjusted VMT value for each combination of age, vehicle type, and pollutant. This adjusted VMT was then multiplied by the applicable emission factor obtained from MOBILE6 to come up with a total number of grams for each pollutant of interest, which were then converted to tons. At this point, the I/M reduction factors in Table 6 were applied (3.01% for HC and PM, 0.27% for NOx) to calculate light duty and heavy-duty diesel OBD benefits.

MOBILE Results

Tables 7a through 7c present estimated benefits for vehicles less than 8,500 GVW lbs for each of the counties of interest. Tables 8a through 8c provide the same information for vehicles between 8,500 and 14,000 lbs GVW with the assumption that the HC/PM and NOx "% Reduction from I/M" values reported in Table 6 would be the same as that seen for the light-duty diesel fleet. As previously described, these estimated benefits are based on assumed emission reductions derived from certification standards and presumed knowledge of the OBD monitoring system. True "in-program" emission reductions could vary from these estimated benefits. Note that the primary reason the estimated reductions are so low is the relatively small number of vehicles miles traveled by LDDVs and LDDTs, e.g. VMT from these vehicle categories is sometimes three orders of magnitude less than LDGVs. Although in absolute terms the tons reduced are small, the values may or may not be significant depending on the level of reductions needed to meet State Implementation Plan requirements.

Table 7a- Estimated NOx Benefits of OBD Implementation on Diesel Vehicles < 8,500 lbs GVW

		2009			2012			2018		
County	**Pollutant**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**
Brazoria	NOx	0.000043	0.0869	0.0159	0.000048	0.0962	0.0176	0.000058	0.1169	0.0213
Chambers	NOx	0.000028	0.0563	0.0103	0.000029	0.0584	0.0107	0.000035	0.0709	0.0129
Collin	NOx	0.000311	0.6212	0.1134	0.000361	0.7218	0.1317	0.000471	0.9416	0.1718
Dallas	NOx	0.001501	3.0018	0.5478	0.001661	3.3210	0.6061	0.002159	4.3174	0.7879
Denton	NOx	0.000295	0.5895	0.1076	0.000338	0.6755	0.1233	0.000441	0.8817	0.1609
Ellis	NOx	0.000142	0.2849	0.0520	0.000192	0.3846	0.0702	0.000244	0.4874	0.0889
El Paso	NOx	0.000094	0.1884	0.0344	0.000093	0.1866	0.0341	0.000116	0.2314	0.0422
Ft.Bend	NOx	0.000068	0.1364	0.0249	0.000077	0.1533	0.0280	0.000098	0.1964	0.0359
Galveston	NOx	0.000037	0.0744	0.0136	0.000045	0.0895	0.0163	0.000058	0.1152	0.0210
Harris	NOx	0.000677	1.3530	0.2469	0.000729	1.4587	0.2662	0.000936	1.8721	0.3417
Johnson	NOx	0.000093	0.1866	0.0341	0.000127	0.2541	0.0464	0.000172	0.3449	0.0629
Kaufman	NOx	0.000116	0.2316	0.0423	0.000156	0.3124	0.0570	0.000211	0.4216	0.0769
Liberty	NOx	0.000018	0.0365	0.0067	0.000020	0.0401	0.0073	0.000026	0.0521	0.0095
Montgomery	NOx	0.000082	0.1645	0.0300	0.000088	0.1769	0.0323	0.000114	0.2275	0.0415
Parker	NOx	0.000093	0.1855	0.0338	0.000125	0.2501	0.0456	0.000169	0.3374	0.0616
Rockwall	NOx	0.000060	0.1192	0.0218	0.000068	0.1370	0.0250	0.000091	0.1819	0.0332
Tarrant	NOx	0.000962	1.9244	0.3512	0.001074	2.1489	0.3922	0.001479	2.9589	0.5400
Travis	NOx	0.000154	0.3079	0.0562	0.000172	0.3437	0.0627	0.000211	0.4217	0.0770
Waller	NOx	0.000014	0.0285	0.0052	0.000023	0.0466	0.0085	0.000029	0.0570	0.0104
Williamson	NOx	0.000055	0.1097	0.0200	0.000061	0.1225	0.0224	0.000075	0.1503	0.0274

Table 7b- Estimated HC Benefits of OBD Implementation on Diesel Vehicles < 8,500 lbs GVW

		2009			2012			2018		
County	Pollutant	Daily Benefit (tons)	Daily Benefit (lbs)	Annual Benefit (tons)	Daily Benefit (tons)	Daily Benefit (lbs)	Annual Benefit (tons)	Daily Benefit (tons)	Daily Benefit (lbs)	Annual Benefit (tons)
Brazoria	HC	0.000137	0.2738	0.0500	0.000164	0.3281	0.0599	0.000202	0.4045	0.0738
Chambers	HC	0.000061	0.1218	0.0222	0.000064	0.1277	0.0233	0.000079	0.1572	0.0287
Collin	HC	0.001320	2.6403	0.4818	0.001577	3.1550	0.5758	0.002140	4.2795	0.7810
Dallas	HC	0.006288	12.5769	2.2953	0.007239	14.4783	2.6423	0.009766	19.5326	3.5647
Denton	HC	0.001160	2.3207	0.4235	0.001395	2.7909	0.5093	0.001897	3.7930	0.6922
Ellis	HC	0.000427	0.8538	0.1558	0.000588	1.1766	0.2147	0.000770	1.5409	0.2812
El Paso	HC	0.000398	0.7952	0.1451	0.000410	0.8197	0.1496	0.000521	1.0419	0.1901
Ft.Bend	HC	0.000228	0.4558	0.0832	0.000286	0.5715	0.1043	0.000370	0.7391	0.1349
Galveston	HC	0.000129	0.2581	0.0471	0.000165	0.3303	0.0603	0.000215	0.4304	0.0786
Harris	HC	0.002425	4.8507	0.8852	0.003141	6.2811	1.1463	0.004071	8.1423	1.4860
Johnson	HC	0.000349	0.6980	0.1274	0.000486	0.9725	0.1775	0.000683	1.3665	0.2494
Kaufman	HC	0.000390	0.7797	0.1423	0.000537	1.0737	0.1959	0.000751	1.5010	0.2739
Liberty	HC	0.000052	0.1050	0.0192	0.000061	0.1219	0.0222	0.000081	0.1614	0.0295
Montgomery	HC	0.000243	0.4855	0.0886	0.000286	0.5724	0.1045	0.000373	0.7457	0.1361
Parker	HC	0.000306	0.6128	0.1118	0.000422	0.8438	0.1540	0.000589	1.1772	0.2148
Rockwall	HC	0.000187	0.3740	0.0682	0.000225	0.4492	0.0820	0.000307	0.6135	0.1120
Tarrant	HC	0.003889	7.7778	1.4194	0.004545	9.0900	1.6589	0.006497	12.9942	2.3714
Travis	HC	0.000674	1.3482	0.2461	0.000763	1.5253	0.2784	0.000956	1.9110	0.3488
Waller	HC	0.000036	0.0728	0.0133	0.000057	0.1143	0.0209	0.000071	0.1428	0.0261
Williamson	HC	0.000206	0.4125	0.0753	0.000233	0.4670	0.0852	0.000293	0.5857	0.1069

Table 7c- Estimated PM Benefits of OBD Implementation on Diesel Vehicles < 8,500 lbs GVW

		2009			2012			2018		
County	Pollutant	Daily Benefit (tons)	Daily Benefit (lbs)	Annual Benefit (tons)	Daily Benefit (tons)	Daily Benefit (lbs)	Annual Benefit (tons)	Daily Benefit (tons)	Daily Benefit (lbs)	Annual Benefit (tons)
Brazoria	PM	0.000012	0.0230	0.0042	0.000008	0.0167	0.0031	0.000005	0.0108	0.0020
Chambers	PM	0.000006	0.0116	0.0021	0.000004	0.0074	0.0013	0.000002	0.0047	0.0009
Collin	PM	0.000072	0.1443	0.0263	0.000056	0.1114	0.0203	0.000073	0.1464	0.0267
Dallas	PM	0.000341	0.6815	0.1244	0.000249	0.4971	0.0907	0.000317	0.6335	0.1156
Denton	PM	0.000068	0.1356	0.0248	0.000052	0.1031	0.0188	0.000067	0.1345	0.0245
Ellis	PM	0.000029	0.0578	0.0105	0.000023	0.0457	0.0083	0.000025	0.0491	0.0090
El Paso	PM	0.000035	0.0707	0.0129	0.000022	0.0439	0.0080	0.000014	0.0287	0.0052
Ft.Bend	PM	0.000017	0.0335	0.0061	0.000012	0.0245	0.0045	0.000009	0.0182	0.0033
Galveston	PM	0.000010	0.0201	0.0037	0.000008	0.0151	0.0028	0.000005	0.0105	0.0019
Harris	PM	0.000177	0.3546	0.0647	0.000132	0.2633	0.0480	0.000093	0.1869	0.0341
Johnson	PM	0.000025	0.0501	0.0091	0.000019	0.0389	0.0071	0.000021	0.0419	0.0076
Kaufman	PM	0.000026	0.0512	0.0093	0.000021	0.0412	0.0075	0.000025	0.0492	0.0090
Liberty	PM	0.000005	0.0095	0.0017	0.000003	0.0069	0.0013	0.000002	0.0048	0.0009
Montgomery	PM	0.000019	0.0390	0.0071	0.000014	0.0279	0.0051	0.000010	0.0199	0.0036
Parker	PM	0.000020	0.0400	0.0073	0.000016	0.0317	0.0058	0.000018	0.0369	0.0067
Rockwall	PM	0.000010	0.0209	0.0038	0.000008	0.0156	0.0028	0.000010	0.0192	0.0035
Tarrant	PM	0.000223	0.4464	0.0815	0.000161	0.3225	0.0589	0.000215	0.4302	0.0785
Travis	PM	0.000050	0.1008	0.0184	0.000033	0.0667	0.0122	0.000025	0.0490	0.0089
Waller	PM	0.000003	0.0065	0.0012	0.000003	0.0068	0.0012	0.000002	0.0043	0.0008
Williamson	PM	0.000017	0.0334	0.0061	0.000011	0.0221	0.0040	0.000008	0.0162	0.0030

Table 8a- Estimated NOx Benefits of OBD Implementation on Diesel Vehicles > 8,500 lbs GVW

		2009			2012			2018		
County	**Pollutant**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**
Brazoria	NOx	0.000193	0.3857	0.0704	0.000140	0.2806	0.0512	0.000091	0.1819	0.0332
Chambers	NOx	0.000131	0.2614	0.0477	0.000077	0.1536	0.0280	0.000050	0.0996	0.0182
Collin	NOx	0.000362	0.7240	0.1321	0.000343	0.6851	0.1250	0.000205	0.4096	0.0747
Dallas	NOx	0.000945	1.8892	0.3448	0.001064	2.1285	0.3885	0.000645	1.2899	0.2354
Denton	NOx	0.000355	0.7103	0.1296	0.000328	0.6554	0.1196	0.000196	0.3918	0.0715
Ellis	NOx	0.000191	0.3826	0.0698	0.000194	0.3871	0.0706	0.000118	0.2354	0.0430
El Paso	NOx	0.000171	0.3422	0.0625	0.000143	0.2869	0.0524	0.000113	0.2266	0.0413
Ft.Bend	NOx	0.000311	0.6222	0.1136	0.000227	0.4535	0.0828	0.000156	0.3119	0.0569
Galveston	NOx	0.000170	0.3400	0.0620	0.000131	0.2620	0.0478	0.000090	0.1802	0.0329
Harris	NOx	0.003008	6.0151	1.0977	0.002078	4.1554	0.7584	0.001429	2.8584	0.5217
Johnson	NOx	0.000118	0.2362	0.0431	0.000120	0.2398	0.0438	0.000077	0.1548	0.0282
Kaufman	NOx	0.000150	0.2993	0.0546	0.000152	0.3034	0.0554	0.000098	0.1958	0.0357
Liberty	NOx	0.000084	0.1672	0.0305	0.000061	0.1213	0.0221	0.000042	0.0834	0.0152
Montgomery	NOx	0.000371	0.7420	0.1354	0.000267	0.5331	0.0973	0.000183	0.3667	0.0669
Parker	NOx	0.000121	0.2422	0.0442	0.000122	0.2446	0.0446	0.000079	0.1578	0.0288
Rockwall	NOx	0.000076	0.1518	0.0277	0.000067	0.1331	0.0243	0.000043	0.0859	0.0157
Tarrant	NOx	0.000598	1.1968	0.2184	0.000679	1.3573	0.2477	0.000436	0.8726	0.1592
Travis	NOx	0.000646	1.2913	0.2357	0.000539	1.0779	0.1967	0.000364	0.7284	0.1329
Waller	NOx	0.000068	0.1352	0.0247	0.000066	0.1321	0.0241	0.000043	0.0857	0.0156
Williamson	NOx	0.000229	0.4581	0.0836	0.000191	0.3824	0.0698	0.000129	0.2584	0.0472

Table 8b- Estimated HC Benefits of OBD Implementation on Diesel Vehicles > 8,500 lbs GVW

		2009			2012			2018		
County	**Pollutant**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**
Brazoria	HC	0.000117	0.2335	0.0426	0.000208	0.4163	0.0760	0.000320	0.6395	0.1167
Chambers	HC	0.000050	0.1002	0.0183	0.000068	0.1350	0.0246	0.000104	0.2074	0.0379
Collin	HC	0.000296	0.5927	0.1082	0.000726	1.4530	0.2652	0.000970	1.9392	0.3539
Dallas	HC	0.000780	1.5592	0.2845	0.002044	4.0881	0.7461	0.002878	5.7562	1.0505
Denton	HC	0.000263	0.5258	0.0960	0.000644	1.2881	0.2351	0.000860	1.7192	0.3137
Ellis	HC	0.000104	0.2088	0.0381	0.000280	0.5595	0.1021	0.000372	0.7448	0.1359
El Paso	HC	0.000141	0.2828	0.0516	0.000291	0.5816	0.1061	0.000467	0.9343	0.1705
Ft.Bend	HC	0.000202	0.4048	0.0739	0.000399	0.7989	0.1458	0.000651	1.3021	0.2376
Galveston	HC	0.000116	0.2323	0.0424	0.000224	0.4487	0.0819	0.000366	0.7313	0.1335
Harris	HC	0.002227	4.4537	0.8128	0.004276	8.5529	1.5609	0.006970	13.9392	2.5439
Johnson	HC	0.000080	0.1602	0.0292	0.000215	0.4306	0.0786	0.000304	0.6081	0.1110
Kaufman	HC	0.000094	0.1875	0.0342	0.000252	0.5032	0.0918	0.000355	0.7107	0.1297
Liberty	HC	0.000045	0.0892	0.0163	0.000076	0.1516	0.0277	0.000124	0.2471	0.0451
Montgomery	HC	0.000213	0.4265	0.0778	0.000390	0.7808	0.1425	0.000636	1.2726	0.2322
Parker	HC	0.000074	0.1475	0.0269	0.000197	0.3945	0.0720	0.000279	0.5571	0.1017
Rockwall	HC	0.000045	0.0908	0.0166	0.000109	0.2184	0.0399	0.000154	0.3085	0.0563
Tarrant	HC	0.000467	0.9330	0.1703	0.001239	2.4783	0.4523	0.001851	3.7019	0.6756
Travis	HC	0.000573	1.1457	0.2091	0.001241	2.4825	0.4530	0.001851	3.7019	0.6756
Waller	HC	0.000032	0.0636	0.0116	0.000066	0.1316	0.0240	0.000101	0.2022	0.0369
Williamson	HC	0.000169	0.3382	0.0617	0.000366	0.7328	0.1337	0.000546	1.0927	0.1994

Table 8c- Estimated PM Benefits of OBD Implementation on Diesel Vehicles > 8,500 lbs GVW

		2009			2012			2018		
County	**Pollutant**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**	**Daily Benefit (tons)**	**Daily Benefit (lbs)**	**Annual Benefit (tons)**
Brazoria	PM	0.000015	0.0302	0.0055	0.000027	0.0539	0.0098	0.000041	0.0828	0.0151
Chambers	PM	0.000008	0.0152	0.0028	0.000010	0.0205	0.0037	0.000016	0.0315	0.0058
Collin	PM	0.000033	0.0659	0.0120	0.000081	0.1627	0.0297	0.000109	0.2172	0.0396
Dallas	PM	0.000083	0.1669	0.0305	0.000218	0.4357	0.0795	0.000307	0.6135	0.1120
Denton	PM	0.000031	0.0625	0.0114	0.000076	0.1518	0.0277	0.000101	0.2027	0.0370
Ellis	PM	0.000014	0.0273	0.0050	0.000036	0.0730	0.0133	0.000049	0.0972	0.0177
El Paso	PM	0.000017	0.0331	0.0060	0.000034	0.0676	0.0123	0.000054	0.1085	0.0198
Ft.Bend	PM	0.000024	0.0489	0.0089	0.000046	0.0910	0.0166	0.000074	0.1483	0.0271
Galveston	PM	0.000014	0.0281	0.0051	0.000025	0.0501	0.0091	0.000041	0.0817	0.0149
Harris	PM	0.000254	0.5074	0.0926	0.000431	0.8627	0.1574	0.000703	1.4060	0.2566
Johnson	PM	0.000010	0.0196	0.0036	0.000026	0.0526	0.0096	0.000037	0.0743	0.0136
Kaufman	PM	0.000012	0.0243	0.0044	0.000033	0.0653	0.0119	0.000046	0.0923	0.0168
Liberty	PM	0.000006	0.0127	0.0023	0.000011	0.0217	0.0040	0.000018	0.0354	0.0065
Montgomery	PM	0.000028	0.0563	0.0103	0.000050	0.1000	0.0183	0.000082	0.1631	0.0298
Parker	PM	0.000009	0.0183	0.0033	0.000025	0.0490	0.0089	0.000035	0.0692	0.0126
Rockwall	PM	0.000006	0.0116	0.0021	0.000014	0.0275	0.0050	0.000019	0.0389	0.0071
Tarrant	PM	0.000053	0.1058	0.0193	0.000139	0.2780	0.0507	0.000208	0.4154	0.0758
Travis	PM	0.000066	0.131	0.0239	0.000142	0.2840	0.0518	0.000212	0.4235	0.0773
Waller	PM	0.000004	0.0087	0.0016	0.000010	0.0195	0.0036	0.000015	0.0300	0.0055
Williamson	PM	0.000022	0.0431	0.0079	0.000047	0.0934	0.0170	0.000070	0.1393	0.0254

References

[1] Clean Air Act Amendments , Title 1- Provisions for Attainment and Maintenance of National Ambient Air Quality Standards, Public Law 101-549; Code of Federal Regulations, Sections 182(a), 182(b), 182(c), 184(b), 187(a) and 118, Title 1, 1990.

[2] Motor Vehicle Inspection/Maintenance (I/M) Program Requirements: On-board Diagnostic Checks, Final Rule. Federal Register 1996, 61, 40940.

[3] US EPA Office of Transportation and Air Quality, 40 CFR Parts 85 & 86, Emissions Control, Air Pollution From 2004 and Later Model Year Heavy-Duty Highway Engines and Vehicles; Light-Duty On-Board Diagnostics Requirements, Revision, Final Rule, October 6, 2000.

[4] US EPA Office of Transportation and Air Quality; 40 CFR Part 86, Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines- Heavy-Duty Vehicle and Engine Standards; Onboard Diagnostic Requirements; Proposed Rule; January 24, 2007.

[5] "Performing On-board Diagnostic System Checks as Part of a Vehicle Inspection and Maintenance Program", EPA420-R-01-015, June 2001.

[6] US EPA Office of Transportation and Air Quality; Annual Certification Test Results & Data; Accessed July 2008; http://www.epa.gov/oms/crttst.htm.