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Evaluation of On Board Diagnostics for Use In Detecting Malfunctioning and High Emitting Vehicles

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Executive Summary:

In this report we describe a test program designed to give preliminary answers to the questions:

* Is there a benefit of identifying the emissions problems of vehicles with the OBD system and how does it compare to the available tailpipe tests?

* Will OBD pass any vehicles which are emitting at levels that are of concern in I/M?

A total of 201 vehicles qualified for this program, 194 with the MIL illuminated and 7 high emitters with no MIL illumination. After testing these vehicles we concluded that:

* OBD technology is a viable I/M test for 1996 and newer vehicles. The emission reductions available from basing repairs on OBD appear to be at least as large and possibly larger than emission reductions obtained from I/M tailpipe tests.

* OBD did miss some high emitters but performed better than available I/M tailpipe tests.

* Some areas of OBD technology still need to be refined and the vehicles with OBD technology should be monitored for the effect of aging.

* OBD I/M offers preventative maintenance which allows benefits previously unavailable to I/M programs to be claimed.

Background:

On August 6, 1996, under the authority of the Clean Air Act (CAA) as amended in 1990, the EPA published rules requiring the use of On-Board Diagnostics (OBD) in inspection and maintenance (I/M) programs (40 CFR parts 51 and 85). This provision required I/M programs to incorporate an OBD check of OBD equipped vehicles in addition to traditional tailpipe testing on January 1, 1998. The Agency decided to delay the mandatory startup of OBD I/M until January 1, 2001 for a variety of reasons. The primary reason was that there was little data on the performance of OBD systems in-use, given the relative newness of OBD technology. An additional concern existed over the level of understanding of the technology in the states and repair industry. During the delay period the Agency conducted a test program to evaluate the usefulness of OBD for I/M and to determine the associated emission benefits. This effort was coordinated with stakeholders through the Mobile Sources Technical Review Subcommittee, a workgroup formed by the Clean Air Act Advisory Committee (CAAAC). The CAAAC was formed under the 1972 Federal Advisory Committee Act (FACA) in order to advise the Agency on technical matters.

Under the original OBD I/M requirement (Aug. 6, 1996), the Agency intended to collect test data from all I/M programs using both the IM240 tailpipe test and OBD. Using the data collected, the Agency would determine the effectiveness of the OBD test in comparison to the IM240 test and develop emission reduction credits associated with the OBD test. Subsequent to the 1996 regulation, the I/M test environment changed significantly and the use of the IM240 test was not as prevalent as expected. Additional information came to light in the same time frame which indicated that the IM240 test as originally designed has what is known as a "preconditioning" issue[1]. Technical discussions about the appropriateness of comparing OBD to a "hot" start test (IM240) and not the Federal Test Procedure (FTP), which is a "cold" start test, were raised both internally at EPA and within the FACA. The cumulative impact of these concerns in I/M was that the comparison of OBD to I/M tailpipe testing, as conducted in the inspection lanes, became of questionable value. The test program described here was undertaken by EPA in order to alleviate the need for states to run dual tests (tailpipe and OBD) in their I/M lanes as a form of data gathering[2]. This report is the result of that test program.

Test Study Design:

It was decided (based on advice from the FACA) to conduct an FTP based test program with a minimum of 200 vehicles[3]. Vehicle numbers were limited by economics (FTP tests cost several thousand dollars per test per vehicle) and the understanding that the goal of this test program was to provide a first look at the use of OBD compared to tailpipe I/M testing. It is generally accepted that the IM240 is the most accurate I/M test[4], so we decided that the IM240 would be considered a best case scenario.

In developing the test program several questions had to be considered. First, what is the benefit of using OBD systems to identify emissions exceedences and how does it compare to available tailpipe tests in identifying emissions problems? For this question, vehicles with the malfunction indicator light (MIL) illuminated would be recruited for the test program. All the post-repair emissions evaluations would have to be based solely on the diagnosis provided by the OBD system as this is accepted industry repair practice for post 1996 model year vehicles.

Second, does OBD miss any vehicles which are emitting at levels that are of concern in I/M (i.e. high tailpipe emissions with no MIL)? For this question, vehicles with potentially high emissions that were not detected by the OBD system would have to be identified.

Because of concerns about the relatively small sample size and the ease of procurement of domestic vehicles it was decided that the sample should be weighted based on manufacturer production for the largest 6 producers. The remaining manufacturers represent a small percentage (<10%) of the entire fleet. "Other" was used to represent the remaining manufacturers. There was also concern that light-duty trucks (LDT) would not be adequately represented unless the sample was weighted for their inclusion. Table 1 below was developed for a 200 vehicle sample based on 1997 sales[5].

Table 1: Procurement Goals Based on Production

MFR	GM	Ford	Daimler-Chrysler	Toyota	Honda	Nissan	Other	Total
LDV	35	21	10	11	11	7	10	105
LDT	27	29	20	5	1	3	10	95
Total	62	50	30	16	12	10	20	200

Once identified, vehicles would receive the IM240 and FTP emissions tests and an OBD system check prior to any maintenance being performed. This would provide the "As-Received" emissions profile of the vehicle. The FTP would be considered the standard for comparing any emissions reductions and the IM240 and OBD checks would only provide information on identifying vehicles into categories (pass/fail). For vehicles that needed repairs (based on OBD or tailpipe results), a second series of tests would be run to provide information on the emission changes as a result of the repairs.

Methods:

During a two year period (9/97- 10/99) sampling was conducted at 4 labs [National Vehicles and Fuels Emissions Laboratory (NVFEL) in Ann Arbor, Michigan; Automotive Testing Laboratory (ATL) in Mesa, Arizona; Colorado Department of Health Laboratory (CDH) in Aurora, Colorado; and California Air Resources Board (CARB) in El Monte, California].

For vehicles with the MIL illuminated, any vehicle with a non-evaporative emissions related trouble code (evaporative emissions will be discussed in a separate report) commanding the MIL on was accepted into the program[6]. These vehicles were selected without knowledge of the tailpipe emissions. Vehicles with misfire codes are relatively common, therefore, an upper limit of 25% of any manufacturer's sample was established, based on a fleet survey of 100,000 vehicles in Wisconsin and the relative occurrence of misfire diagnostic trouble codes (DTC)s in the I/M lane[7]. Locating vehicles with MILs illuminated was difficult. Vehicles were solicited through newspaper ads, notices in the E-Mail of large organizations etc., but in the end, recruitment relied heavily on rental fleets, repair facilities, and used car dealers. These businesses provided a more concentrated source of new vehicles to select from and monitor for MIL illumination.

FTP testing was performed using methods described in CFR 86.130-96 with the exception that no diurnal heat build was performed and no SHED testing was conducted. IM240 testing was done in accordance with EPA Technical Guidance EPA-AA RSPD IM 98-1. OBD information was gathered using SAE compliant (SAE 1978) scan tools from various manufacturers. Maintenance on vehicles was performed at either the original manufacturer's dealership or by mechanics following the manufacturer's available service information.

Vehicles procured with the MIL illuminated were inspected for safety and OBD information then tested using the LAB240 (see definition in appendix 5) procedure with the fuel that was in the tank (fuel samples were taken and analyzed for sulfur content). The vehicles were then drained of in-use fuel and refueled with indolene test fuel. Next the vehicles received a standard FTP and a second LAB240. These FTP emissions represent the "before" level of emissions. The vehicles were then sent for repairs, if called for by either the OBD status or the FTP emissions levels. After repair it was again tested on the FTP to determine the "after" level of emissions. Any difference measured between the two FTPs represented the air quality improvement attributable to the repair. (See appendix 2 for test sequence details)

Maintenance performed in this program followed OEM published procedures and (in some cases consultation with OEM engineers augmented published information when high tailpipe emissions with no OBD problem existed). In cases where a scan of the OBD system indicated a diagnostic trouble code, but the technicians could find nothing wrong, the OBD system was reset. The OBD system was then allowed to verify the absence of any OBD problem.

Two vehicles came in with emissions extremely high and/or running so poorly that they could not be FTP tested. These were repaired and their costs were included in the cost data but since we had no initial test we could not ascertain an air quality benefit. See discussion in appendix 6, Table x2.

<u>Procurement of High emitting vehicles with no MIL illumination</u>

To recruit vehicles with high emissions and no MIL illumination we used LANE240 (see definition in appendix 5) test data. Additionally some attempts were made at identifying vehicles which experience indicated could have high emissions (e.g. high mileage, driveability problems). The most stringent IM240 standards[8] were applied even though the actual state I/M program did not fail vehicles based on these values. For testing conducted at the ATL facility an agreement was made with the contractor for one of the local IM240 lanes to test 1996 and newer vehicles using the full test (no fast pass) and applying the appropriate cut points. When a vehicle was identified, ATL personnel were notified and the owner was approached regarding the use of the vehicle in the test program. ATL also put pamphlets in all of the other Phoenix I/M lanes requesting owners to contact them if they failed the LANE240 test. At the CDH lab, LANE IM240 failing vehicles were identified using the state's computer data base. Owners were contacted via phone or mail to request the use of the vehicle in the test program. For vehicles recruited using LANE IM240, if the vehicle passed the LAB IM240 they were released because they were an error of commission by the LANE IM240. Because the NVFEL lab is not located near an operating I/M program no attempts were made using I/M as a screening tool. NVFEL, along with ATL and CDH did attempt to find vehicles which OBD may have missed by recruiting vehicles that were suspected of having high emissions even without any quantitative verification. These vehicles tended to be ones that local mechanics said were running poorly, or vehicles with very high mileage. On the vehicles which were suspected high emitters without any tailpipe data, the LAB IM240 was also used as a screening tool.

Results:

Sample

201 vehicle tests were conducted in the program, versus a target of 200 vehicles (1 vehicle procured twice). Table 2 represents the breakdown of this sample by manufacturer and vehicle type, cars (LDV) and trucks (LDT).

Table2: Description of Sample by Manufacturer and Type

MFR	GM #procured (% of goal)	Ford	Diamler-Chrysler	Toyota	Honda	Nissan	Other	Total
LDV	45 (128%)	31 (148%)	22 (220%)	5 (45%)	8 (73%)	7 (100%)	14 (140%)	132 (126%)
LDT	18 (66%)	28 (96%)	16 (80%)	1 (20%)	0 (0%)	4 (133%)	2 (20%)	69 (73%)
Total	63 (102%)	59 (116%)	38 (127%)	6 (38%)	8 (67%)	11 (110%)	16 (80%)	201 (100%)

The category of "other" is made up of the following LDVs and LDTs in the sample:

Mazda	n= 2	Kia	n= 1
VW	n= 3	Saab	n= 1
Isuzu	n=2(LDT)	Volvo	n= 1
Hyundai	n= 3	Suzuki	n= 3

Breakout by model year

	1996	1997	1998	1999	2000
LDV	28	33	38	32	1
LDT	27	22	14	6	0

Odometer readings

	LDV	LDT
MINIMUM	29	3981
AVERAGE	26440	54505
MAXIMUM	93575	245000

Of the 201 vehicles in the sample, 194 were procured with the MIL illuminated. Table 3 shows how these vehicles compared to the FTP tailpipe test.

Table 3: Vehicles with MIL illuminated

	# with MIL illuminated (# that MIL went out*)	# which failed FTP over appropriate cert. standard	subset that failed over 1.5 times standard
LDV	128 (subset of 5)	40	21
LDT	66 (subset of 6)	18	10
Total	194 (subset of11)	58	31

* denotes that MIL self-extinguished while vehicle was undergoing FTP testing

Table 3 includes two vehicles which are assumed to have failed their as-received FTP at over 1.5 times the applicable tailpipe standards[9]. These vehicles could not be driven on the FTP trace and therefore no tailpipe readings are available. A description of these vehicles is in appendix 6.

Part of the recruitment process was to find vehicles with high emissions and no MIL illumination. IM lanes or technicians identified eight (8) vehicles which ultimately qualified as having high emissions with no MIL illumination. These vehicles represent vehicles which failed a LAB240 without MIL illumination. Table 4 represents a summary of these data

Table 4: Sample of Vehicles with no MIL Illumination

	# with no MIL	# which failed FTP over cert. standard (includes over 1.5X)	# which failed FTP over 1.5 times standard
LDV	4	2	1
LDT	4*	3*	3*
Total	8	5	4

*CDH04 was recruited for no MIL but subsequent scanning of the OBD systems showed that the MIL was commanded on. This truck is not considered an OBD miss.

The ability of OBD to correctly identify vehicles which are emitting at levels significantly over their applicable certification standard (2x) was also investigated. The subgroup of vehicles making up this sample is listed in Table 5.

Table 5: Vehicles over twice their certification standard

	# over twice cert standard	# with MIL on (w/FTP over 2X)	# which failed LABIM240 (w/FTP over 2X)
LDV	15	14	7
LDT	6	5	6

The one LDV (CDH03) and one LDT (CDH33) which were missed by OBD were failed by the LAB IM240; the eight LDVs which were missed by the LAB IM240 were failed by the OBD scan.

Information on the ability to repair high emitting vehicles based solely on extinguishing the MIL was also collected. Of the 15 LDVs with emissions over twice their standard 12 (80%) retested, after repairing for the MIL illumination, to below the certification standard. For LDTs the number was 4 (80%) of 5 over twice certification standards. All the LDVs tested below 1.5X the applicable standards after repair. The vehicles remaining above their standard after repair but with no MIL are discussed in another section of this report (Table 10).

Repairs conducted in this test program provide information on the cost of repairing for MIL illuminations (Table 6). Many of the vehicles in this program were still within their warranty period and cost details were not given on the repair invoice. Costs for repairs were assigned to them based on parts costs and a labor rate of $70 per hour. Vehicles with “maintenance not required” (MNR) were charged 1 hour of labor. See appendix 3 for details on how costs were assigned.

Table 6:Average Cost of OBD Repair

	# repaired for MIL	# with MNR	Average cost of repair (includes 1 hr cost for MNR)	Average cost of repair excluding MNR
LDV	128	25	$252	$287
LDT	66	14	$284	$322
Total	194	39*		

* 29 of the 39 had misfire or fuel trim OBD codes which we believe would be repaired in the field but were not repaired for this program.

The cost of repairs varied greatly in the sample. The most costly repair was $2,150 for repair of two cylinder heads on a LDV (CDH 32). The most costly LDT (ATL 090) repair was $1,974 for replacement of a transmission (OBD transmission fault detected (see discussion in appendix 7). The median repair cost for LDV was $160 while for LDT the median was $210. Based on current waiver regulations (~$600 waiver limit[10]), at least 94% of the LDV and 91% of the LDT could be repaired for below current I/M waiver limits.

Emissions reductions attributable to OBD repairs (and LAB IM240) are in Table 7. The IM240 repair data overlap with the OBD repair information in this table based on each test's ability to identify a vehicle. It should be noted that CDH did not measure non-methane hydrocarbon (NMHC) and CARB did not measure total hydrocarbon(THC) for their respective vehicles. The THC and NMHC averages in the tables reflect averages calculated from vehicles with only these measured emissions. LDV and LDT data are presented separately because we think that there is a significant difference in the stringency of the control strategies. The reader may combine these data without hazard as they were all gathered and combined in the same fashion.

Table 7: Average Reductions from Repairs

LDV	THC	NMHC	CO	NOx	CO2	MPG
average reduction for OBD repair N=126	.138 gpm n= 114	0.1 gpm n= 111	2.40 gpm n= 126	0.1 gpm n=126	6.47 gpm n=114	-0.53 mpg (increase in fuel economy) n=114
average reductions for OBD repairs with $600 repair limit n=118	0.1 gpm n= 108	0.1 gpm n= 105	2.42 gpm n=118	0.1 gpm n=118	6.21 gpm n=108	-0.53 mpg n= 108
average reduction for IM240 repair n=7	1.04 gpm n=7	0.9 gpm n=5	15.4 gpm n=7	0.6 gpm n=7	14.71 gpm n=7	-2.36 mpg n=7

Vehicle ATL78 was not included in the calculations of for either OBD or IM240 since no FTP results were available. Vehicle ATL96 was excluded from the calculations for OBD (IM240 did not identify this vehicle) for the same reason.

Table 7 continued

LDT	THC	NMHC	CO	NOx	CO2	MPG
average reduction for OBD repair n=65	.11 gpm n= 65	0.05 gpm n= 49	1.56 gpm n=65	0.13 gpm n=65	-2.66gpm n=64	-0.03 mpg n=64
average reductions for OBD repair with $600 limit n=60	0.10 gpm n= 60	0.05 gpm n= 46	1.62 gpm n= 60	0.08 gpm n= 60	-3.42gpm n=60	-0.02 mpg n=59
average reduction for IM240 repair n=7	0.84 gpm n=7	0.37 gpm n=5	10.47 gpm n=7	0.60 gpm n=7	8.27gpm n=7	-0.79 mpg n=7

Vehicle CDH04 was not included in the calculations of for either OBD or IM240 since no FTP results were available.

Vehicles that failed the LAB240 with the MIL illuminated were repaired based mainly on the OBD codes and therefore are not completely independent of OBD effects. Another way to look at the same repair reductions is to quantify the total grams per mile reduced over the study and not on a per vehicle average. This is reflected in Table 8.

Table 8: Summation of reductions associated with OBD repairs and IM240

LDV	THC	NMHC	CO	NOx	CO2	MPG
Summation reduction for OBD repair	15.8 gpm	11.1 gpm	303 gpm	12.0 gpm	737 gpm	-60 mpg
Summation reduction for IM240 repair	7.2 gpm	4.5 gpm	108 gpm	3.9 gpm	103 gpm	-16 mpg
LDT	THC	NMHC	CO	NOx	CO2	MPG
Summation reduction for OBD repair	7.5 gpm	2.6 gpm	102 gpm	8.2 gpm	-170 gpm	-2 mpg
Summation reduction for IM240 repair	5.9 gpm	1.8 gpm	73 gpm	4.2 gpm	58 gpm	-5 mpg

The ability of OBD systems to identify components which are not functioning properly, even when the vehicle was emitting below applicable standards, was investigated in this study. Table 9 lists the result of maintenance performed on vehicles with tailpipe emissions below the applicable certification standards.

Table 9: Maintenance aspect of OBD MIL illumination identification

	MIL on/passing FTP	malfunctioning part found	Unable to duplicate malfunction (MIL extinguished)
LDV	88	63	25 (3)
LDT	48	34	14 (6)
Total	136	97	39 (9)

See appendix 4 for a list of parts replaced

During this test program 5 vehicles without MIL illuminations were found to have tailpipe emissions exceeding both their applicable standards and the 1.5 times target trigger level for MIL illumination. These vehicles are listed in Table 10 with the cause of their high emissions. Two of these vehicles are post OBD repairs for MIL illumination (ATL130 and ATL120). These two vehicle's emissions remained above the trigger level even after all reasonable diagnostics had been completed.

Table 10: Discussion of specific vehicles

Vehicle	FTP Emissions	Problem found
CDH03; 1996 Chrysler Neon, odometer 86236 LANE IM240 failure	As-Received FTP:THC CO NOX 1.73 52 0.25	OBD error of omission; unanticipated oxygen sensor failure; later model years have revised logic which would have illuminated MIL
CDH04; 1996 GM S10 Pickup Truck, odometer 27,063 LANE IM240 failure	Could not be driven on FTP Projected FTP failure (See appendix 6, table X2)	OBD commanding MIL on but electrical short caused no MIL illumination; Scan of system showed MIL commanded "On". This vehicle would be identified in an OBD I/M scenario.
CDH33; 1997 Daimler-Chrysler 1500 Pick-up truck, odometer 113,543 LAB IM240 failure	As-Received FTP:THC CO NOX 0.55 12.8 2.9	THC level is below 1.5 times certification standard (NMHC is unknown) but CO and NOx are over 1.5 times. See discussion of catalyst monitor
ATL130; 1996 Isuzu Hombre (GM certified system) 235K odometer MIL on prior to repair; off after repairs.	Post Repair FTP:THC CO NOX 0.5 17.1 0.6	OBD repair did not return vehicle to below 1.5 times certification standards (HC below CO is over) See discussion on catalyst monitor.

ATL120; 1997 GM Gr Am odometer 47,173 MIL on prior to diagnostics	Post Repair FTP:THC CO NOX 0.14 1.6 1.0	No problem found during diagnostics (HC and CO below trigger levels for OBD; NOx above OBD trigger level)

LDV CDH03 from the table above is considered an OBD error of omission due to the emissions levels and the lack of MIL illumination. The repair of the oxygen sensor returned this vehicle to acceptable emissions level. Further investigation of this problem by Daimler-Chrysler engineers found an unanticipated failure mode of the rear oxygen sensor. Daimler-Chrysler found that this failure mode would be detected by all later OBD systems in their product line. No additional examples of this type of oxygen sensor failure mode were located in this test program. LDT CDH04 is not considered an OBD error for this study since the OBD computer was commanding the MIL to be illuminated, but the nature of the problem (short in the electrical system) would not allow the MIL to illuminate. This type of problem would be caught by scanning the OBD system, as opposed to just a visual check of the MIL (as required by EPA regulations). LDT CDH33, LDT ATL130 and LDV ATL120 fall into a category of OBD error of omission that is allowable under the current OBD regulations. Each of these vehicles appears to have emissions problems (CO and NOx) due to catalyst efficiency losses (this is based on evaluation of the emission control systems on each vehicle). These vehicles do not exceed the HC trigger level, which is used as the monitor for loss of catalyst efficiency[11], therefore, these systems are not in violation of the OBD requirements. In this study, due to the lack of a detailed (complete bench analysis of each emission component) analysis of the entire emissions system, it was not possible to say for certain that these CO and NOx problems were exclusively due to loss of catalyst efficiency. Extensive engineering analysis of the engine controls and catalyst system would be required to address this area. This was beyond the scope of this study.

Recruitment of vehicles from IM lanes with excessive emissions and no MIL resulted in a very low number of vehicles in this program. As shown in Table 11, we recruited 17 vehicles that had failed the LANE240 with no MIL illumination. Fifteen (15) of the 17 passed the LAB 240. We gathered no FTP data on the 15 since the purpose of this area of the test program was to find vehicles with high emissions and no MIL illumination.

Table 11: Attempts at I/M lane procurement

Failed LANE IM240/No MIL	Passed LAB IM240
17	15

All 17 vehicles failed the LANE IM240 for CO; seven (7) failed exclusively for CO .

Discussion of results:

The vehicle sample from this test program has several aspects which should be noted. First, LDVs are over represented in comparison to LDTs (132 to 69 respectively). This may be due to the LDTs having lower emissions relative to their less stringent emissions standards. Since most of these LDT's emission control systems are very similar to LDV systems, manufacturers may have made the OBD systems less sensitive to specific component degradation. This would cause less MIL illuminations for LDTs than for similar LDVs. Also, because LDTs have higher allowable tailpipe emissions (but similar emission control systems) than LDVs, normal degradation of the emissions to high levels should take longer. How or if this impacts conclusions from this study is not known at this time. Congruent with this fact is the matter of the low age of the fleet of vehicles being evaluated. Because of the short period these vehicles have been in use, procurement for this program was difficult and average mileage low (37,000 miles). We do not believe that this should impact conclusions being drawn from this study since the OBD system is for the most part a software/solid state system and not subject to ageing impacts. The main impact of the newness of these vehicles is in the cost of procuring study vehicles and limited exposure of input and control hardware to real world effects (heat, cold, water, salt). Continued study of this fleet as it ages and accumulates mileage is recommended but little data exists to draw any meaningful conclusions regarding these impacts at this time (EPA is completing a high-mileage study of OBD vehicles in the fall of 2000). The possibility exists that synergistic effects of multiple components aging may impact the OBD systems ability to detect vehicles which have high emissions. At this time no evidence suggests this possibility will cause dramatic change in OBD's usefulness for I/M.

Within this study, the sample of Honda and Toyota are under represented due to difficulty in finding vehicles made by these manufacturers which met the acceptance criteria. One explanation for this may be that both manufacturers have a reputation of high quality and limited emissions problems. The possibility remains that the OBD systems on these manufacturers vehicles are not functioning as required and therefore MIL illuminations are limited. Given the age of the fleet being evaluated and the limited ability to find Hondas and Toyotas at I/M lanes (Hondas and Toyotas generally have a low failure rate in I/M), no real conclusion can be reached on these manufacturer's OBD systems based on these data. More targeted study of these two major manufacturers appears warranted as their products age. An additional targeted engineering study could be performed to offer a level of comfort on this matter.

Of the 194 vehicles that were accepted into the program with the MIL on, 43 or 22% were sent home without any repairs and were listed as "maintenance not required" (MNR). This segment, which some may characterize as "false failure", requires further explanation. Ten of these vehicles were sent home because the MIL extinguished before initial testing was completed. Since our repair goal was to extinguish the MIL, and self extinguishing is normal operation, we had no more interest in these vehicles and we did no further testing.

Of the 33 remaining vehicles 30 passed the FTP. Two (ATL94 and ATL98) were below 1.5 times FTP and one (ATL120) was an acknowledged dirty vehicle, for which we could not find an appropriate repair. We judge that all 43 of these vehicles had intermittent problems. Almost half (15) had misfire codes. Misfires are notoriously intermittent and in some cases we were able to make a vehicle misfire in the lab by spraying the engine compartment with water (similar to real world conditions). In at least one case we were unsuccessful with this technique even though we could plainly see where the misfire was occurring from an ignition wire that was not routed correctly. An additional 11 of the 33 had fuel trim OBD codes which OEM diagnostics failed to identify a specific cause.

While an argument can be made that these nonrepaired vehicles initially having OBD failures found in this test program represent OBD's equivalent to the tailpipe false failure, we believe that this problem is overstated in this study (due to procurement methods which solicited vehicles as soon as MIL illumination occurred) and that OBD offers a better method of dealing with these problems than traditional tailpipe I/M. The OBD technology offers the technician the ability to diagnose the I/M problem directly from the same system that was used to fail the vehicle at the inspection lane. Additionally, if the technician can not find any problem with the system and the system does not retrigger the MIL, the technician has a higher level of assurance that the vehicle will pass the retest at the inspection lane. Smooth implementation of OBD checks in I/M programs will rely on educating the public, I/M inspectors, and the automotive service industry about OBD technology.

It is believed that changes to the OBD regulations which make extinguishing MILs easier for misfire and fuel system problems should reduce this concern (intermittent MILs) on future model years. These intermittent problems that occur are no different than intermittent problems that occur on pre-OBD II vehicles and are merely a by-product of engineering applications. OBD is not designed to eliminate these intermittent problems, only to indicate and provide a possible root cause for the technician to investigate. It should be acknowledged that these intermittent problems existed prior to OBD technology and are not created by the technology. These problems may cause frustration with consumers and technicians but are believed to be a problem which is addressable through proper education of technicians and owners. Discussions with repair technicians and members of the Service Technician Society (STS) have shown that the intermittent misfire and fuel trim problems are being addressed with real field fixes. Anecdotal evidence indicates that field repairs are limiting the recurrence of these codes.

Conclusions:

From this study we conclude that the OBD technology is a viable I/M test for 1996 and newer vehicles. The magnitude of emissions reductions available from basing repairs on OBD appear at least as large, if not greater, than available I/M tailpipe tests. In direct comparison to the IM240 the OBD technology offers the ability to identify more of the vehicles with tailpipe emissions which exceed certified standards (see Tables 3, 4, and 5). With only a couple of exceptions OBD identifies the same vehicles that IM240 does and additionally identifies components which have degraded and may cause future emissions problems. While the instantaneous emissions benefits of identifying and repairing these components are small, long term durability of expensive components (catalytic converter, fuel injectors, oxygen sensors, transmissions) may be extended from this type of preventative maintenance. Additionally, we found that OBD repairs effectively returned vehicles to their proper operating conditions and that tailpipe emissions, for a majority, returned to below certification levels. The cost of repairs for extinguishing the MIL appears reasonable with a limited number of exceptions. We believe it is almost impossible to separate the cost of repairing IM240 failures from OBD failures since OBD diagnostics are the basis for almost all emission system repairs on these vehicles and in the field.

While OBD does not appear to identify all of the high emitting vehicles, including a tailpipe test as part of an I/M test program design in order to catch the small fraction of failures missed by

OBD, would be questionable due to cost and air quality benefits associated with the gain. The probability of false failure with the tailpipe test appears to be high at this time for these vehicles (model year 1996 and newer). Another problem with tandem testing would be explaining conflicting test results between the OBD test and the tailpipe test. While there exists many plausible engineering explanations for conflicting results, the perception problem created with the general public would not be easily addressed. The high level of confidence in the existing tailpipe test results could be a barrier to the acceptance of the OBD technology.

The rate of IM240 lane false failures (15 out of 17) is troubling. Further investigation concerning IM240 testing accuracy is justified before any recommendation for tailpipe testing these newer vehicles is warranted. Current revisions to the IM240 test cycle (AZ147 cycle) may offer better results but this is unknown at this time. All previous studies on tailpipe testing effectiveness have evaluated fleets in general and not the effectiveness on new vehicles specifically. The results from this test program would support further study of any tailpipe test on this specific technology group before including a tailpipe test. Other I/M tailpipe tests may have similar or worse problems with new vehicles. It should be pointed out that in its comparison of the emission reductions attributable to OBD-I/M versus IM240, the OBD tailpipe study was biased in favor of the IM240 to ensure that the conclusions drawn regarding OBD-I/M relative effectiveness were conservative. Specifically, when a vehicle was identified as a likely IM240 false failure based upon a comparison of LANE240 and LAB240 test results, that vehicle was then dismissed from further participation in the study. As a result, the gpm emission reductions attributed to IM240 were not "watered down" down by the false failures noted between the LANE- and LAB240s. Conversely, potential OBD false failures were included in the sample and were actively recruited. Therefore, the gpm reductions attributed to either test based upon this pilot really do represent the "best case" scenario for IM240 and the "worst case" scenario for OBD-I/M.

In this study the cost of performing OBD repairs to extinguish MILs appear accurate and reasonable in cost. No calculations of cost effectiveness were performed for this report due to the limited scale of this study and any comparisons would be with fleet cost effectiveness values. The average repair costs of $252 and $284 for OBD LDV and LDT respectively is higher than the CPI corrected value for IM240 repairs from the 1992 I/M regulation of $200. We believe that this is mainly due to the very small percentage of very expensive repairs found in this study. We believe that any comparison of cost effectiveness should account for the level of false failures which occur in tailpipe testing demonstrated in this study. Without adjustments for this concern and life-cycle analysis of OBD's preventative repairs any comparison is of limited application.

Recommendations:

Several areas of the OBD technology appear to justify further examination. The no malfunction found vehicles raise concerns of overly sensitive OBD systems that detect problems that cannot be repaired due to their intermittent nature. This could lead to frustration for vehicle owners and technicians and could impact acceptance of OBD technology. In this study, the prevalence of this problem may be overstated due to the nature of recruitment (vehicles were very hard to find and vehicles were recruited as soon as MILs were illuminated). In a "real world" scenario, many of these vehicles would have had the MIL extinguished naturally through normal driving (none of the vehicles which had their MIL extinguish during the test program were procured from the I/M lanes, which adds credence to this hypothesis).

The OBD catalyst efficiency monitoring requirements appear to offer somewhat of a window for vehicles to exceed their tailpipe emissions levels for CO and NOx without any MIL illumination. It is unknown from this study if the vehicles which failed for CO and NOx due to apparent catalyst problems would eventually illuminate the MIL based on loss of efficiency for HC. Further study in this area appears justified and the assumptions in monitoring catalysts should be revisited for possible refinement. Along these lines CARB has proposed OBD regulation changes which would address catalyst NOx conversion efficiency[12].

This test program was run on vehicles which are relatively new and therefore can not address the impacts of time on these systems. While care was taken not to test vehicles with little or no mileage accumulated, nothing can substitute for exposure of these systems to seasonal changes and mass of fuel through the systems which come with natural aging. Based on this we feel that further monitoring of this technology as it ages is advised. With this understood, we believe that this technology has demonstrated an ability to identify vehicles with high emissions or defective components which is as good or better than available tailpipe tests at this time. Additional study of this technology as mileage is accumulated and as time passes is advised in order to offer continuing confidence in this method of identifying vehicles in the fleet which should be repaired. Vehicles that were not adequately represented in this study, i.e. Hondas, Toyotas, and to some degree trucks, should be also be investigated further.

Appendix:

1 Regulatory Summary

The following discussion provides a summary of the regulatory history and the current regulatory requirements for EPA's OBD program. A detailed discussion of the specific EPA OBD requirements that manufactures are required to comply with are contained in the Federal Register (58 FR 9468 for '94-'97 model years, 63 FR 7081 for '98 and later model years). CARB OBDII requirements can be obtained from the California Air Resources Board. The documents cited throughout this discussion are available on EPA's OBD Web site at "www.epa.gov/oms/obd.htm". CARB documents can be found at "www.arb.ca.gov".

On February 19, 1993, the EPA published a final rulemaking (58 FR 9468) requiring manufacturers of light-duty vehicles (LDV) and light-duty trucks (LDT) to install on-board diagnostic (OBD) systems on such vehicles beginning with the 1994 model year. The regulations promulgated in that final rulemaking require manufacturers to install OBD systems that monitor emission control components for any malfunction or deterioration causing certain emission thresholds to be exceeded. The regulations also require that the driver be notified of the need for repair via a dashboard light when the diagnostic system has detected a problem. Under these regulations, a vehicle's OBD system must be capable of detecting a malfunction or deterioration of emission-related components before such a malfunction or deterioration individually causes an emission increase greater than certain thresholds. For example, the OBD system must identify catalyst deterioration before it results in both exhaust emissions greater than 0.6 g/mi THC and an exhaust emission increase of greater than 0.4 g/mi THC. As mandated by the Clean Air Act Amendments of 1990, the original Federal OBD regulations required manufacturers to monitor the catalyst, oxygen sensors and to detect misfire. The 1993 regulations also required manufacturers to monitor for evaporative system leaks and for any other component malfunction or deterioration that could impact emissions.

The 1993 regulations provided that manufacturers could certify to CARB OBDII requirements to meet Federal OBD requirements, which in most cases are at least as stringent as the Federal OBD requirements. This compliance option was available to manufacturers through the 1998 model year. The 1993 requirements are applicable to MY 1994-1998.

On December 22, 1998 (63 FR 70681), EPA promulgated a final rulemaking to update the original Federal OBD regulations finalized in 1993. One of the primary goals of the 1998 regulation was to redesign the Federal OBD requirements such that they more closely resembled the CARB OBDII requirements. As a result, EPA moved the Federal OBD program away from the additive threshold approach and adopted aspects of CARB multiplicative approach. In other words, OBD systems would be required to monitor deterioration and malfunction of emission-related components at 1.5 times the applicable standard for HC, CO, and NOx. In addition, the Federal OBD monitoring requirements were expanded from the 1993 list (this reflected EPA's requirement from the CAA to move to an OBD system check to enhance or replace traditional tail-pipe tests in Inspection/Maintenance programs).

The 1998 regulations extended indefinitely the CARB OBDII compliance option to manufacturers beyond the 1998 model year. However, EPA is required to update its regulations whenever CARB finalizes changes to their regulations. EPA will publish a Federal Register notice in these instances announcing the adoption of the latest CARB changes and will invite comment from interested parties. The changes finalized in the 1998 regulations are applicable to 1999 and later model years.

2 Test Sequence Used at Laboratories

i. Procurement and acceptance into the program

ii. LA-4 cycle (preconditioning for IM240 test)

iii. IM240 test

iv. Drain in-use fuel

v. Fill with indolene (40% fill)

vi. LA-4 cycle (preconditioning for FTP test)

vii. 12 hour soak (no diurnal heat build)

viii. FTP test (no evaporative test)

ix. IM240 test

x. Repair if necessary

xi. OBD Readiness flags cleared thru operation of vehicle

xii. Repeat starting at iv

3. <u>Estimating Costs</u>

Repair information for vehicles was reported in several different ways. Some work invoices listed the parts that were replaced or the repairs that were made with no indication of cost, others listed the cost of the parts only, while some work invoices listed only the total cost of the repair with no breakdown of parts and labor. Many of the vehicles in the test program were still under warranty and were sent to the dealers for repair. In most of those cases, since there was no charge, there was no cost information. Information was gathered from dealerships to assign repair costs in these cases.

To assign a cost to each vehicle we took the following steps:

1/ List of all the “hard” data, (labor hours, labor charge, parts charge, total charge)

2/ The miscellaneous charges were added as though they were labor or parts

3/ The labor rate was assumed to be $70 per hour. (Actual rates varied from $50 to $70)

4/ The number of labor hours can now be calculated from the labor cost data and this is added to our table of “hard” data.

5/ For multiple repairs that are similar (O_2 sensors is the best example) we averaged the parts and labor hours and assigned those values to the vehicles that have no cost data available.

6/ Where we had no “hard” data for labor hours we used the composite judgement of several people that were experienced in these repairs.

7/ All vehicles for which there were no problems found were assigned one hour labor, in the absence of other data, under the assumption that most shops would charge that amount for the DTC scan

We believe this approach to be as conservative as possible, biasing the cost data, if at all, to the high side.

4 Broken parts

A breakdown of the broken parts found for vehicles with passing FTP scores and a MIL illumination is in Table X1.

Table X1: Broken Parts Found with Passing FTP emissions

Systems/Components	LDV	LDT
O2 Sensor	11	15
EGR System	4	6
Ignition System (spark plugs, ignition wires, other)	10	1
Transmission related components	3	4
PCM, Reprogram or Replace	10	1
Wire Harness problems	6	1
Engine, Mechanical (cylinder head, harmonic balancer, valve springs)	1	1
Vacuum Leaks	4	2
Thermostat, Cooling System	1	0
Fuel Pump	2	0
Cam Sensor	2	0
Secondary Air Combo Valve	2	0
Throttle Position sensor	1	1
Exhaust Leak	0	1
Mass Air Flow sensor	1	0
Intake Air Controller	1	0
Evaporative emissions valve	1	0
Catalyst	3	1

5 Lane IM240 and Lab IM240

There are a number of differences between the way an IM240 test is conducted in an inspection lane and the way that the test is conducted in an emissions laboratory. Some of them are:

1/ quality of the test equipment

2/ frequency of calibration of test equipment

3/ skill of technician

4/ control of ambient conditions

5/ control of tire pressure

6/ operating temperature of the vehicle

The first five items are of critical importance for a certification test in the laboratory but it is our opinion that they are diminished in comparison to the last item for I/M testing.

By far the greatest importance is item six. There is a large variation in emissions between a partly warmed vehicle and a fully warmed vehicle. In the laboratory an LA4 (1372 seconds) test cycle is run before the LAB240 test to assure that the engine is fully warmed up and the catalyst hot. Vehicles arriving at I/M inspection lanes are assumed to be at operating temperature due to the driving prior to arrival at the lane (this may or may not be true). Attempts have been made in I/M systems to address this preconditioning problem through various methods.

6 Non-Testable Vehicles

Table X2 is a description of why each vehicle was not testable and why the FTP is assumed to be over the applicable standards.

Table X2: Description of Vehicles/Trucks Assumed to Fail FTP

Vehicle	FTP dynamometer concerns	Available data
CDH4, 1996 S-10 Pickup MIL off (computer commanding MIL "On")	Truck could not accelerate and would stall in 3rd gear on FTP	Lab IM240 results: (THC/CO/NOx) 11.8/147/0.02 Black plume of smoke from tailpipe
ATL78, 1999 Malibu MIL illuminated 74,000 miles	IM240 test of the vehicle caused closure of test cell due to hydrocarbon contamination of instruments. Decision made to not run FTP.	Lab IM240 results: 32.1/45.6/0.14 Raw fuel out of the tailpipe during testing

7 Vehicle ATL 90

ATL 90, a GM Cheyenne truck.- The transmission of this high mileage truck had been replaced with an incorrect transmission and so is technically a case of tampering. However the truck was clean and the difference between the two transmissions was, in our opinion, insignificant for operation or emissions but was such that the computer was not compatable with the transmission. The only possible repair was replacement of the transmission at high cost ($2,000) for no benefit and therefore no repair was performed.

Reference

1. SAE paper 962091; "Preconditioning Effects on I/M Test Results Using IM240 and ASM Procedures. Heirigs, Philip; Gordon, Jay

2. Federal Register Volume 61, No. 152; August 6, 1996; page 40940

3. Mobile Source Technical Review Subcommittee meeting of 7/16/97

4. Sierra Research Report under EPA Contract 68-C4-0056; WA 2-03; "Development of a Proposed Procedure for Determining the Equivalency of Alternative Inspection and Maintenance Programs" page 7.

5. Automotive Industries; page 17; February, 1998,.

6. "Recommended Practice for Diagnostic Trouble Code Definitions" SAE J2012; Society of Automotive Engineers, Inc.; Revision date March 1999.

7. "Analysis of the OBDII Data Collected From The Wisconsin I/M Lanes", Ted Trimble, Environmental Engineer, U.S. EPA, August, 2000.

8. "EPA I/M Briefing Book; Everything You Ever Wanted to Know About Inspection and Maintenance"; EPA-AA-EPSD-IM-94-1226, Section Four, page 10; United States Environmental Protection Agency, Office of Air and Radiation, February 1995

9. For LDVs: 40 CFR Part 86.096-8 (a)(1); for LDTs: 40 CFR Part 86.097-9 (a)(1)

10. Clean Air Act, Section 182 (c)((3)(C)(iii); July 1992

11. California Air Resources Board Regulation "Malfunction and Diagnostic System Requirements, 1968.1(b)(1.2.1 - 1.2.4)

12. California Air Resources Board, MSC 99-12, Notice of Proposed Regulation Changes to 1968.1(b)(1.2.4)

Table x 3

													POST FTP									
									F	T	P		2	4	0							
					engi																	
lab	Vehicle nu	Yr	Make	Model	Size	odometer		THC	nmHC	CO	Nox	OBD Pcod	THC	CO	Nox	repairs			hours	parts	labor	total
					liters	miles		gr/mi	gr/mi	gr/mi	gr/mi		gr/mi	gr/mi	gr/mi				labor	$	$	$
ARB	1	98	GM	Lumina	3.1	5844	initial		0.08	1.0	0.08	302	0.00	0.135	0.02	repair loose plug wire, #2 cyl			1		70	70
							final		0.09	1.4	0.06		0.01	0.152	0.18							
ARB	2	98	DC	breeze	2.4	40	initial		0.09	1.7	0.03	700	0.03	0.373	0.00	loose wire, tcm to relay			2		140	140
							final		0.08	1.4	0.03		0.01	0.202	0.01							
ARB	3	97	DC	neon	2	25148	initial		0.18	2.4	0.12	703	0.01	0.31	0.12	brake switch	new head	coil				1838
							final		0.15	3.1	0.19		0.01	0.23	0.15	new injectors	clean plugs					
ARB	4	98	ford	contour	2	29407	initial		0.06	0.9	0.09	133	0.02	0.982	0.11	mil off prep #1, fixed fuel leak			2.5	70	175	245
							final		0.07	1.0	0.10		0.01	0.242	0.11		new O2 sensor					
ARB	5	97	GM	camero	3.8	21806	initial		0.29	4.4	0.84	102	0.10	1.213	0.75	new MAF sensor,new cat			4	400	280	680
							final		0.07	1.6	0.12		0.01	0.279	0.01							
ARB	6	97	suzuki	metro	1	22779	initial		0.04	2.0	0.09	113	0.01	2.833	0.06	repair IAT circuit/sensor wires			2		140	140
							final		0.03	0.5	0.10		0.00	0.775	0.05							
ARB	7	98	honda	accord	2.3	2259	initial		0.04	0.7	0.04	135	0.01	0.323	0.01	npf; fuel trim			1		70	70
							final		0.04	0.7	0.04											
ARB	8	98	hyundai	accent	1.5	16528	initial		0.06	0.6	0.13	1614	0.01	0.176	0.12	npf;			1		70	70
							final		0.06	0.6	0.13											
ARB	9	97	ford	aspire	1.3	20702	initial		0.12	1.6	0.39	420	0.06	3.125	0.42	cat replaced, front O2 senson			3	350	210	560
							final		0.08	0.9	0.10		0.02	0.281	0.33	rear O2 sens mistakenly replaced						
ARB	10	98	honda	civic	1.6	654	initial		0.09	0.8	0.06	118	0.07	2.86	0.04	overheating on road			0.5		35	35
							final		0.11	0.7	0.05		0.06	0.674	0.06	remove plastc shield from radiator						
ARB	11	97	honda	accord	2.2	23199	initial		0.06	1.0	0.12	740	0.01	0.352	0.06	npf			1		70	70
							final		0.06	1.0	0.12											
ARB	12	97	DC	intrepid	3.5	23534	initial		0.12	1.1	0.13	306	0.03	0.115	0.16	spark plug replaced,			1	2	70	72
							final		0.12	1.3	0.23		0.02	0.023	0.11							
ATL	1	97	GM	Malibu	3.1	15386	initial	0.287	0.24	2.7	0.58	420	0.12	1.12	0.61	Replaced Ign. Module, rear O2, .			4	620	280	900
							final	0.116	0.10	1.5	0.09		0.01	0.04	0.01	cat replaced,						
ATL	2	97	GM	Grand Am	2.4	22717	initial	0.092	0.08	1.3	0.60	300	0.01	0.15	0.94	Replaced Oil Pump.			2.5	45	175	220
							final	0.091	0.08	1.3	0.54		0.02	0.2	0.81							
ATL	3	98	Nissan	Sentra	1.6	309	initial	0.072	0.07	1.3	0.17	400	0.02	0.64	0.17	Replaced EGR			2	2.5	140	142.5
							final	0.066	0.06	1.3	0.11		0.02	0.69	0.11	back pressure tube						
ATL	5	97	DC	Sebring	2.5	14036	initial	0.129	0.12	0.9	0.14	740	0.03	0.16	0.09	npf; transmission			1		70	70
							final	0.129	0.12	0.9	0.14											
ATL	6	97	DC	Neon	2	18232	initial	0.118	0.11	0.8	0.17	300	0.0	0.13	0.08	npf; misfire			1		70	70
							final	0.118	0.11	0.8	0.17											
ATL	7	97	GM	Grand Am	2.4	21729	initial	0.894	0.86	2.5	0.27	300	0.01	0.26	0.49	Replaced Oil Pump.			2.5	45	175	220
							final	0.086	0.08	1.2	0.40		0.01	0.08	0.68							
ATL	8	97	Nissan	Maxima	3	18897	initial	0.113	0.10	1.3	0.48	174	0.03	0.55	0.31	Replaced front O2 sensor			2	85	140	225
							final	0.111	0.10	0.9	0.16		0.03	0.16	0.16	replace egr tube gasket						
ATL	9	96	GM	Lumina	3.1	40698	initial	0.182	0.16	2.4	0.25	300	0.05	0.48	0.21	npf; misfire			1		70	70
							final	0.182	0.16	2.4	0.25											
ATL	10	97	SUZUKI	Metro	1.3	19764	initial	0.572	0.52	9.9	0.14	113	0.30	6.48	0.01	Repaired broken IAT wires			1.5		105	105
							final	0.071	0.06	0.7	0.07		0.03	0.16	0.16							
ATL	11	97	Hyundai	Elantra	1.8	13373	initial	0.143	0.13	0.7	0.16	136	0.02	0.1	0.09	Replaced rear O2 sensor.			1.5	70	105	175
							final	0.143	0.13	0.7	0.17		0.02	0.06	0.17							
ATL	12	98	DC	Breeze	2	2774	initial	0.174	0.15	2.0	0.35	300, 304	0.09	1.53	0.57	npf; misfire			1		70	70
							final	0.174	0.15	2.0	0.35											
ATL	13	98	Ford	Contour	2	4737	initial	0.076	0.07	2.1	0.12	302	0.02	1.75	0.14	npf; misfire			1		70	70
							final	0.076	0.07	2.1	0.12											
ATL	14	98	DC	Neon	2	9468	initial	0.083	0.07	0.8	0.07	305	0.02	0.1	0.06	npf; misfire			1		70	70
							final	0.083	0.07	0.8	0.07											
ATL	15	97	Nissan	Sentra	1.6	22470	initial	0.1	0.09	0.7	0.12	136	0.01	0.2	0.03	Replaced O2 sensor			1.5	70	105	175
							final	0.089	0.08	1.2	0.07		0.02	0.61	0.08							
ATL	16	96	Ford	Mustang	3.8	14823	initial	0.131	0.11	1.7	0.10	304	0.02	0.24	0.08	reinstall Spark plug boot on #4			1		70	70
							final	0.133	0.12	1.7	0.08		0.02	0.36	0.03							
ATL	17	96	GM	lumina	3.1	70600	initial	.20	0.17	2.5	0.56		0.05	0.45	0.45	fail state I/m	NPF					
							final	0.20	0.17	2.5	0.56											
ATL	18	98	Nissan	Altima	2.4	29	initial	0.084	0.08	0.7	0.01	300	0.01	0.13	0.01	npf; misfire			1		70	70
							final	0.084	0.08	0.7	0.01											
ATL	19	98	Hyundai	Sonata	2.4	3650	initial	0.186	0.17	1.2	0.18	400	0.00	0.08	0.07	Install vacuum signal line			1.5		105	105
							final	0.176	0.16	1.1	0.17		0.01	0.08	0.05	to egr						
ATL	21	96	Ford	Contour	2	41427	initial	0.129	0.11	1.2	0.17	301, 302, 3	0.03	0.7	0.19	repaired Capacitor wire at coil			1.5		105	105
							final	0.138	0.11	1.2	0.16		0.03	0.7	0.13							
ATL	22	97	DC	Neon	2	25862	initial	0.13	0.12	0.9	0.17	304	0.02	0.23	0.05	npf; misfire			1		70	70
							final	0.13	0.12	0.9	0.17											
ATL	24	98	DC	Stratus	2.4	3178	initial	0.091	0.08	1.8	0.07	401	0.01	0.21	0.0	New PCM			1.75	200	122.5	322.5
							final	0.07	0.06	1.7	0.09		0.00	0.2	0.1							
ATL	25	98	Ford	Taurus	3	1497	initial	0.112	0.10	1.1	0.06	500	0.01	0.06	0.0	npf; vehicle npf			1		70	70
							final	0.112	0.10	1.1	0.06											
ATL	26	98	FORD	Grand Mar	4.6	6516	initial	0.098	0.09	1.2	0.04	122, 1120	0.01	0.09	0.01	TPS had been replaced once before. Vehicle taken to a local Ford			1		70	70

							final	0.091	0.08	1.0	0.06		0.01	0.05	0.00						
ATL	27	97	Honda	Civic	1.6	10570	initial	0.068	0.05	1.6	0.04	302, 304, 1	0.04	1.07	0.03	npf; misfire		1		70	70
							final	0.068	0.05	1.6	0.04										
ATL	30	98	Ford	Taurus	3	5475	initial	3.099	2.63	122.0	0.07	172, 175	0.03	0.16	0.05	Replaced sending unit		2	50	140	190
							final	0.105	0.09	1.4	0.10		0.01	0.09	0.08						
ATL	31	96	GM	Lumina	3.1	29197	initial	0.241	0.21	3.3	0.50		0.06	1.54	0.48	failed state I/M test, npf		1		70	70
							final	0.241	0.21	3.3	0.50										
ATL	32	98	Ford	Taurus	3	6496	initial	0.121	0.10	1.2	0.07	161	0.01	0.02	0.06	Replaced Fuel Sending Unit		1	50	70	120
							final	0.104	0.09	1.2	0.08		0.02	0.42	0.02						
ATL	35	98	GM	LeSabre	3.8	15916	initial	0.08	0.07	0.9	0.16	300	0.02	0.2	0.19	npf; misfire		1.5	12	105	117
							final	0.08	0.07	0.9	0.16										
ATL	37	97	GM	Achieva	2.4	29233	initial	0.118	0.10	2.6	0.17	503				Replaced VSS & Gear	npf	1	70	70	140
							final	0.118	0.10	2.6	0.17										
ATL	40	96	niss	sentra	1.6	31366	initial	.15	0.14	0.8	0.28		0.03	0.3	0.09	fail state I/m	NPF				
							final	$0.15	0.14	0.8	0.28										
ATL	43	98	Toyota	Camry	2.2	440	initial	0.114	0.10	1.2	0.22	401	0.02	0.05	0.16	Replaced EGR vacuum line		0.5	10	35	45
							final	0.106	0.10	1.2	0.14		0.02	0.15	0.08						
ATL	44	98	GM	Camaro	3.8	20051	initial	0.174	0.14	3.0	1.31	120, 135, 1	0.00	0	0.06	Repaired Shorted Wiring		1.5		105	105
							final	0.074	0.06	1.3	0.21										
ATL	49	98	GM	Regal	3.8	27501	initial	0.071	0.06	1.1	0.24	131	0.01	0.28	0.18	npf; fuel trim		1		70	70
							final	0.07	0.06	1.3	0.24										
ATL	50	98	GM	88 LS	3.8	15239	initial	0.277	0.25	1.4	0.13	304	0.03	0.09	0.22	spark plug and wire replaced		1.5	24	105	129
							final	0.079	0.06	1.1	0.14		0.02	0.16	0.12						
ATL	53	98	Ford	Escort	2	7424	initial	0.059	0.05	1.2	0.10	171	0.01	0.58	0.11	replace manifold vac. hose		1.5	3	105	108
							final	0.078	0.07	0.7	0.09										
ATL	56	98	FORD	Tracer	2	24066	initial	0.052	0.05	0.9	0.12	1504	0.01	0.41	0.13	r/r vent sol reprogram		1.6	36	112	148
							final	0.04	0.04	0.5	0.07		0.01	0.08	0.03						
ATL	59	96	GM	Cierra	3.1	54355	initial	0.181	0.16	1.9	0.35	1406, 300	0.06	0.95	0.13	computer replaced		2	200	140	340
							final	0.171	0.15	1.9	0.33		0.04	0.41	0.29						
ATL	60	96	Ford	Taurus GL	3	91173	initial	0.167	0.13	2.6	0.51	340	0.06	2.76	0.45	replace camshaft sensor and		2	125	140	265
							final	0.146	0.12	1.4	0.34		0.04	1.06	0.32	drive shaft					
ATL	61	99	Toyota	Camry	2.2	9795	initial	0.063	0.05	0.9	0.15	1133	0.02	0.35	0.09	npf, fuel trim		1		70	70
							final	0.063	0.05	0.9	0.15										
ATL	62	96	Ford	Taurus	3	55296	initial	0.124	0.10	1.4	0.32	1504, 153	0.05	0.67	0.31	npf; fuel trim		1		70	70
							final	0.124	0.10	1.4	0.32										
ATL	63	98	Ford	Taurus	3	17567	initial	0.104	0.09	1.2	0.09	1309	0.02	0.1	0.32	R/R pcm and throttle valve		2.1	344	147	491
							final	0.103	0.09	1.2	0.08										
ATL	64	99	GM	Malibu	3.1	7834	initial	0.126	0.10	1.3	0.16	301	0.04	0.02	0.16	npf; misfire		1		70	70
							final	0.12	0.10	1.4	0.13		0.01	0.02	0.22						
ATL	65	99	DC	Breeze	2	9535	initial	0.145	0.13	1.9	0.20	136	0.04	0.59	0.16	replaced o2 sens and F.P. relay		2	100	140	240
							final	0.082	0.07	0.7	0.14		0.02	0.2	0.10						
ATL	66	99	GM	Regal	3.8	6443	initial	0.057	0.05	1.1	0.09	131	0.00	0.1	0.01	replaced o2 sens		1.5	70	105	175
							final	0.054	0.05	1.0	0.10										
ATL	68	98	GM	Camaro	3.8	9448	initial	0.085	0.07	0.9	0.06	306	0.02	0	0.06	reprogram PCM		1.2		84	84
							final	0.082	0.07	0.7	0.07		0.03	0.05	0.05						
ATL	69	99	Toyota	Camry	2.2	11508	initial	0.079	0.07	1.2	0.14	1133	0.01	0.28	0.05	npf; fuel trim		1		70	70
							final	0.079	0.07	1.2	0.14										
ATL	71	97	Kia	Sephia	1.6	32048	initial	0.103	0.08	1.3	0.30	420	0.03	0.58	0.37	replace exhaust, ox sensor		3	550	210	760
							final	0.081	0.07	0.9	0.05		0.01	0.04	0.01	and catalyst					
ATL	73	99	Nissan	Infiniti Q45	4.1	7252	initial	0.148	0.13	1.5	0.42	505	0.04	0.06	0.33	idle air control motor		1.75	95	122.5	217.5
							final	0.144	0.13	1.4	0.19										
ATL	74	98	Ford	Taurus	3	19410	initial	0.123	0.10	1.3	0.10	1309	0.02	0.04	0.05	new PCM		1.8	200	126	326
							final	0.115	0.10	1.1	0.08										
ATL	75	99	Nissan	Altima	2.4	10146	initial	0.075	0.06	1.2	0.06	740	0.01	0.27	0.01	tfans,pcm new		2	250	140	390
							final	0.072	0.07	1.0	0.05		0.01	0.06	0.03						
ATL	76	99	GM	Gr. Am	3.4	23208	initial	0.224	0.21	0.9	0.27	113	0.02	0.01	0.35	wiring at ECT		1.5		105	105
							final	0.109	0.09	1.3	0.18										
ATL	77	99	Ford	Contour	2	5860	initial	0.1	0.08	5.9	0.05	1131	0.91	73.3	0.05	light went out, battery went dead		1		70	70
							final	0.059	0.05	1.3	0.10										
ATL	78	99	gm	malibu	3.1	7400	initial					201, 301				no initial ftp wiring at #1 injector		1		70	70
							final	.08	0.1	0.8	0.09										
ATL	79	99	Toyota	Camry	2.2	12848	initial	0.083	0.1	1.2	0.15	1133	0.02	0.29	0.07	R/R MAF		1.5	110	105	215
							final	0.052	0.0	0.4	0.08		0.01	0.07	0.03						
ATL	81	99	GM	Malibu	3.1	7064	initial	0.135	0.1	1.2	0.14	131, 306	0.02	0.12	0.26	R/R O2 B1S1		1.5	70	105	175
							final	0.126	0.1	1.5	0.12		0.00	0.01	0.14						
ATL	83	99	GM	Lumina	3.1	8896	initial	0.278	0.2	2.9	0.53	420	0.21	2.4	0.61	R/R cat		2	300	140	440
							final	0.076	0.1	0.9	0.09		0.01	0	0.07						
ATL	87	96	GM	Cavalier	2.2	93575	initial	0.164	0.1	1.8	0.22	141	0.12	0.91	0.26	R/R B1S1 O2		1.5	73.08	105	178.08
							final	0.147	0.1	1.7	0.17		0.10	0.76	0.18						
ATL	89	99	GM	Cavalier	2.2	4465	initial	0.192	0.2	5.5	0.05	1133	0.10	6.34	0.01	light went out; fuel trim		1	15	70	85
							final	0.09	0.1	1.6	0.07		0.09	6.06	0.00						
ATL	91	99	GM	Intrigue	3.8	10202	initial	0.08	0.1	1.0	0.21	131, 1887	0.04	0.6	0.18	R/R O2		1.5	70	105	175
							final	0.08	0.07	1.1	0.12		0.01	0.2	0.18						
ATL	96	99	DC	Sebring	2.5	9514	initial					171				fuel pump		1.75	95	122.5	217.5

							final	0.1	0.08	1.0	0.09		0.00	0.1	0.06						
ATL	95	97	Mazda	626	2	36596	initial	0.11	0.09	1.1	0.18	421	0.04	1.1	0.18	reprogram prom		1		70	70
							final	0.11	0.09	1.1	0.17		0.03	0.8	0.22						
ATL	98	99	GM	Gr. Am	2.4	15618	initial	0.24	0.18	4.0	0.13	171, 172, 3	0.13	2.5	0.04	npf; fuel trim		1		70	70
							final	0.24	0.18	4.0	0.13										
ATL	100	97	Ford	Aspire	1.3	24936	initial	0.19	0.17	1.4	0.15	303, 505	0.06	0.9	0.13	Replaced dist.cap/rotor/plug wire		0.5	15	35	50
							final	0.17	0.16	1.2	0.21		0.03	0.3	0.30						
ATL	101	99	toyota	camray	2.2	11575	initial	0.07	0.06	0.9	0.14	1133	0.02	0.2	0.05	light went out; npf; fuel trim					
							final	0.07	0.06	0.9	0.14										
ATL	102	99	Saab	9-3	2	19237	initial	0.13	0.12	1.4	0.19	1652	0.01	0	0.11	loose connection at PCM		1.5		105	105
							final	0.14	0.12	1.8	0.15		0.02	0	0.10						
ATL	103	98	GM	Cavalier	2.2	27140	initial	0.27	0.22	5.8	0.12	118	0.06	1.74	0.08	Repair open wires at Coolant Sensor		0.25		17.5	17.5
							final	0.13	0.10	3.2	0.08		0.04	1.3	0.03						
ATL	104	97	Ford	Taurus	3	52650	initial	0.14	0.11	2.3	0.40	340	0.04	0.2	0.32	R/R cam sensor	$124 parts only	1.2	124	84	208
							final	0.13	0.10	1.5	0.21		0.03	0.1	0.22						
ATL	105	99	GM	regal	3.8	15563	initial	0.096	0.08	1.1	0.14	131	0.01	0.42	0.25	R/R O2 sensor		2.5	76	173	249
							final	0.051	0.04	0.9	0.09		0.01	0.16	0.02						
ATL	106	99	Ford	Mustang	3.8	13701	initial	0.18	0.14	6.1	0.08	190, 1132,	0.12	2.1	0.10	Replace PCM, wiring above trans broke		3	350	210	560
							final	0.077	0.07	0.7	0.05		0.01	0	0.03						
ATL	108	98	FORD	Tracer	2	20137	initial	0.052	0.05	0.5	0.19	401	0.01	0.15	0.19	Replace EGR sensor		2	140	140	280
							final	0.054	0.05	0.5	0.09		0.01	0.1	0.08						
ATL	110	98	Ford	Escort	2	26205	initial	0.073	0.07	1.0	0.14	172	0.02	0.51	0.18	Reflashed PCM		1.9		130	130
							final	0.054	0.05	0.6	0.07		0.01	0.08	0.05						
ATL	111	99	DC	Intrepid	2.7	14664	initial	0.328	0.29	4.3	0.29	161, 432, 1	0.29	6.12	0.16	Replace O2		1.5	76	105	181
							final	0.121	0.10	0.6	0.28		0.04	0.23	0.25						
ATL	113	98	Ford	Escort	2	35177	initial	0.053	0.05	0.6	0.10	172	0.01	0.19	0.07	Reflashed PCM		1.9		130	130
							final	0.047	0.04	0.5	0.09		0.01	0.08	0.12						
ATL	114	99	GM	Grand Am	3.4	12921	initial	0.328	0.30	2.4	0.47	121	0.01	0	0.27	Replaced TPS		1.571429	43	110	153
							final	0.084	0.07	1.4	0.13		0.02	0.05	0.14						
ATL	115	99	DC	Stratus	2.4	19475	initial	0.227	0.18	8.3	0.15	700, 733, 7	0.32	0.4	0.11	Replace Tr Input Sensor		1.285714	15	90	105
							final	0.067	0.06	1.0	0.09		0.02	0.33	0.05						
ATL	116	99	Ford	Escort	2	15104	initial	0.058	0.05	0.5	0.10	135	0.01	0.24	0.11	Repair Wiring to O2 Sensor		1.857143		130	130
							final	0.056	0.05	0.7	0.07		0.01	0.03	0.10						
ATL	117	99	FORD	Sable	3	5596	initial	0.28	0.25	1.4	0.18	301	0.02	0	0.34	new head		7.142857		500	500
							final	0.09	0.08	1.1	0.13		0.00	0	0.27						
ATL	118	99	GM	Cavalier	2.2	20432	initial	0.151	0.13	2.5	0.04	141	0.03	0.22	0.01	Replaced O2 sensor		1	164	70	234
							final	0.16	0.14	3.7	0.04		0.02	0.2	0.03						
ATL	119	97	SUZUKI	Metro	1.3	55195	initial	0.7	0.61	32.3	0.13	113	0.49	33.6	0.06	Fix iat wiring		1		70	70
							final	0.06	0.05	1.3	0.37		0.01	0.5	0.21						
ATL	120	97	GM	Grand Am	2.4	47,173	initial	0.14	0.12	1.6	0.97	122, 1404	0.02	0.4	0.90	npf; fuel trim		1		70	70
							final	0.14	0.12	1.6	0.97										
ATL	121	99	DC	stratus	2.4	17000	initial	0.1	0.07	1.3	0.09	700, 731, 7	0.58	22.6	0.11	R/R trans input sensor		1.5	20	105	125
							final	0.09	0.07	1.4	0.10		0.02	0.4	0.03						
ATL	122	99	GM	DeVille	4.6	18900	initial	0.21	0.18	1.6	0.21	742	0.05	0.2	0.13	R/R trans upper valve body assembly		7.3	425	511	936
							final	0.16	0.14	0.7	0.18		0.06	0.2	0.16						
ATL	123	97	ford	Escort	2	71000	initial	0.08	0.07	1.1	0.10	302	0.01	0.4	0.17	leak at purge line		2.5	60	175	235
							final	0.06	0.06	0.8	0.12		0.01	0.3	0.15	harmonic balancer bad					
ATL	124	99	honda	Accord	2.3	5000	initial	0.04	0.03	1.0	0.03	1259	0.00	0.5	0.00	npf; fuel trim		1		70	70
							final	0.04	0.03	1.0	0.03										
ATL	125	99	GM	Intrigue	3.8	28000	initial	0.07	0.05	0.8	0.43	135, 140	0.01	0.3	0.21	R/R O2 sensor		3.5	58	245	303
							final	0.08	0.07	1.1	0.22		0.01	0.5	0.17						
ATL	126	98	GM	sunfire	2.2	31606	initial	0.12	0.09	5.2	0.20	121, 404, 1	0.05	3.5	0.10	repair tps wiring		1		70	70
							final	0.12	0.09	5.1	0.07		0.05	3.8	0.02						
ATL	127	98	gm	sunfire	2.2	26000	initial	0.12	0.10	3.8	0.15	141	0.06	5.2	0.04	O2 sensor		1	125	70	195
							final	0.1	0.08	2.7	0.17		0.05	3.0	0.10						
ATL	128	96	gm	Lumina	3.1	34769	initial	0.2	0.17	2.5	0.50	141	0.11	3.0	0.65	R/R O2 sensor		1	77	70	147
							final	0.1	0.09	0.8	0.17		0.02	0.0	0.21						
ATL	131	98	gm	Cavalier	2.2	31424	initial	0.28	0.25	4.8	0.08	300	0.14	3.6	0.01	R/R plug wires 2&3 cylinders		1	17	70	87
							final	0.12	0.09	2.8	0.11		0.06	1.8	0.03						
EPA	1	98	DC	breeze	2	2405	initial	0.085	0.07	0.7	0.21	401	0.03	1.4	0.19	replace egr back pressure transducer w/sol		2	90	140	230
							final	0.071	0.06	0.5	0.13		0.02	0.3	0.05						
EPA	2	97	vw	passant	2.8	23437	initial	0.136	0.10	1.3	0.19	411	0.05	0.3	0.12	replace combo valve for secondary air		1.5	280	105	385
							final	0.118	0.10	1.2	0.09		0.03	0.3	0.02						
EPA	6	98	GM	deville	4.6	9495	initial	0.23	0.21	1.7	0.16	606, 741	0.07	0.4	0.08	dealer replaced speedsensor		1.5	80	105	185
							final	0.227	0.21	1.8	0.14		0.05	0.3	0.07						
EPA	7	97	HONDA	ACCORD	2.2	17155	initial	0.103	0.08	1.5	0.14	302	0.05	1.0	0.20	light out; misfire					
							final	0.103	0.08	1.5	0.14										
EPA	10	97	ford	aspire	1.3	38418	initial	2.093	1.77	30.3	0.03	302	0.95	34.1	0.01	replaced plugs and installed		2	20	140	160
							final	0.181	0.16	1.7	0.12		0.04	0.6	0.14	#2 plug wire					
EPA	11	98	GM	sunfire	2.2	13766	initial	0.092	0.08	1.7	0.33	1133	0.02	0.8	0.18	replace front o2 sens and thermostadt		3	75	210	285
							final	0.0872	0.07	2.1	0.13		0.02	0.8	0.10						
EPA	12	98	GM	cavalier	2.2	16660	initial	2.434	2.37	10.9	0.09	302	1.68	29.7	0.01	replace plugs and wires		2.5	40	175	215
							final	0.109	0.09	2.4	0.11		0.03	1.2	0.05						
EPA	13	97	vw	passant	2.8	38278	initial	0.163	0.13	1.7	0.17	300	0.05	0.6	0.15	replace plugs and wires		2.5	250	175	425

							final	0.163	0.13	1.7	0.17										
EPA	14	97	DC	neon	2	41449	initial	0.1515	0.14	1.0	0.19	303	0.04	0.274	0.15	npf; misfire		2	70	140	210
							final	0.1515	0.14	1.0	0.19										
EPA	17	97	ford	escort	2	35965	initial	0.087	0.07	1.2	0.29	402	0.02	0.73	0.41	R/R EGR vacuum sensor		2	65	140	205
							final	0.0639	0.06	0.8	0.15		0.01	0.256	0.21						
EPA	18	96	mazda	626	2	60615	initial	0.382	0.33	6.9	1.01	171	0.10	4.31	0.89	replace catalyst		5.5	649	242	667
							final	0.0956	0.08	1.0	0.22		0.01	0.1177	0.17						
EPA	23	96	ford	escort	1.8	31120	initial	0.346	0.31	4.3	0.20	302	0.13	2.95	0.21	Replace air filter,plugs		2	25	140	165
							final	0.305	0.27	4.4	0.16		0.13	2.55	0.22	wires and rotor					
EPA	26	0	GM	century	3.4	48	initial	0.1141	0.09	0.6	0.09	122	0.03	0.0365	0.04	assembly error; wire clamped by hose clamp.		1.5		105	105
							final	0.0797	0.07	0.6	0.07		0.02	0.0496	0.01						
EPA	28	96	volks	jetta	2	17016	initial	0.1292	0.12	1.4	0.09	303	0.02	0.24	0.02	plugs cap		1.3	170	90	260
							final	0.1292	0.12	1.4	0.09										
EPA	29	97	ford	escort	2	42038	initial	0.0614	0.06	0.9	0.14	301	0.01	0.203	0.19	ignition wires		1	32	70	102
							final	0.0599	0.06	0.8	0.09										
CDH	3	96	DC	neon	2	86236	initial	1.743		52.0	0.25		1.09	36.4	0.19	repair vacuum leak,	no lite ever	3.2	70	224	292
							final	0.224		2.1	0.13		0.07	0.5	0.19	replace downstream O2 sensor					
CDH	6	96	ford	crown viv	4.6	84848	initial	2.444		39.5	0.66	420, 301	1.28	29.1	0.88	replace coil and plugs,		4.8	152	336	488
							final	0.204		4.8	0.47		0.04	3.6	0.48	clean air flow sensor					
CDH	7	96	GM	corsica	3.1	54048	initial	0.483		8.7	0.36	301	0.29	9.3	0.27	fuel rail replace (sugar in gas)		6	1088	420	1508
							final	0.293		2.5	0.83		0.09	1.3	0.93						
CDH	15	96	FORD	continen	4.6	62517	initial	0.319		4.8	0.27	304	0.12	4.0	0.22	recalibrate pcm		0.9		66	66
							final	0.321		4.4	0.18		0.10	2.7	0.11						
CDH	18	96	volvo	850	2.4	80355	initial	0.197		1.5	4.39	410	0.06	0.8	4.35	Replace the air pump		2.1	406	145	560
							final	0.123		1.0	0.28		0.02	0.2	0.30						
CDH	20	97	honda	civic	1.6	22359	initial	0.175		1.8	0.20	302, 1300,	0.08	1.5	0.01	replace ECM		2.5	350	175	525
							final	0.18		2.4	0.20		0.10	3.3	0.15						
CDH	21	96	GM	cavalier	2.2	39483	initial	0.146		2.1	0.28	1406, 440	0.07	1.6	0.24	replace "W" valve		3.2	219	215	435
							final	0.146		2.4	0.22		0.05	1.4	0.13						
CDH	25	96	DC	neon	2	76168	initial	0.134		1.6	0.69	403	0.03	0.5	0.52	egr solenoid	scan and replace	1.2	90.83	84	175
							final	0.125		1.2	0.39		0.03	0.2	0.44						
CDH	26	97	honda		2.7	59734	initial	0.194		1.3	0.29	302, 303, 1	0.04	0.2	0.16	replace distributor cap		0.5	15.48	32	47.48
							final	0.169		1.0	0.32		0.05	0.4	0.18						
CDH	28	96	GM	camero	5.7	46607	initial	0.123		1.5	0.76	172, 175, 4	0.03	0.1	1.01	replace canister, purge valve		5.1	115.78	357.5	482.02
							final	0.164		2.0	0.32		0.03	0.3	0.41	& monitor					
CDH	29	96	DC	cirrus	2.4	82626	initial	0.231		6.3	0.32	300, 303	0.06	2.3	0.30	relace coil pack,plugs, and wires		2.9	224	202	426
							final	0.225		6.3	0.33		0.06	2.3	0.29						
CDH	31	96	DC	sebring	2.5	37620	initial	0.328		4.1	0.39	134, 133	0.09	2.4	0.52	scan,replace two o2 sensors		2.4	222.3	134.4	356.7
							final	0.244		1.6	0.34		0.03	0.1	0.35	heat 122.85	downstream 99.45				
CDH	32	96	GM	regal	3.8	78027	initial	0.394		2.7	0.45	304	0.09	1.3	0.36	$1298 R/R rear cylinder head					2150
							final	0.189		2.4	0.43		0.03	0.7	0.32	$852 R/R front cylinder head					
CDH	34	96	DC	sebring		81630	initial	0.205		2.1	0.45	134	0.04	0.1	0.35	R/R O2 sensor		1.8	100	104	204
							final	0.188		1.0	0.37		0.03	0.1	0.40						
CDH	37	96	GM	sl-2	1.9	55044	initial	0.392		3.2	0.50	300	0.36	3.0	0.98	plugs and wires		2.5	51	170	221
							final	0.14		1.5	0.51		0.02	0.2	0.45						
CDH	38	96	DC	neon		40390	initial	0.628		5.0	0.34	121, 123	0.13	1.3	0.40	r/r throttle body and reflash computer		2.828571	275	198	473
							final	0.208		2.2	0.19		0.05	0.7	0.20						
ATL	4	98	Ford	Windstar	3.8	20461	initial	0.073	0.07	0.7	0.06	135, 155	0.01	0.1	0.04	npf; fuel trim		1		70	70
							final	0.073	0.07	0.7	0.06										
ATL	23	98	Ford	Ranger	3	12819	initial	0.993	0.82	21.3	0.18	1131	0.63	11.8	0.14	Replaced O2 sensor.		1.5	70	105	175
							final	0.165	0.13	1.8	0.12		0.02	0.18	0.03						
ATL	28	98	GM	S10	4.3	18112	initial	0.305	0.26	2.6	0.21	146	0.30	2.19	0.03	repaired three wires burned by exhaust		3	70	210	280
							final	0.204	0.18	1.8	0.25		0.05	0.43	0.04	r/r rear O2 sensor	reprogram computer				
ATL	29	98	GM	Venture	3.4	7634	initial	0.2	0.18	3.4	0.20	305	0.01	0.03	0.28	npf; misfire		1		70	70
							final	0.2	0.18	3.4	0.20										
ATL	33	98	GM	Tahoe	5.7	12577	initial	0.305	0.26	2.4	0.20	131, 134, 1	0.05	0.26	0.20	Replace B1S1 O2 Sensor		1.5	70	105	175
							final	0.284	0.25	2.2	0.20		0.05	0.2	0.24						
ATL	34	98	GM	Safari	4.3	14187	initial	0.166	0.15	1.6	0.24	300	0.04	0.07	0.24	npf; misfire		1		70	70
							final	0.166	0.15	1.6	0.24										
ATL	36	98	DC	Voyager	3.3		initial	0.053	0.05	0.4	0.16	1698	0.00	0	0.40	Replace Trans. Module		1.5	100	105	205
							final	0.064	0.06	0.5	0.21		0.00	0	0.43						
ATL	38	97	Ford	F150 PU	4.6	29006	initial	0.282	0.19	7.5	0.29	141	0.23	3.7	0.37	Replaced MAF		3.5	240	245	485
							final	0.131	0.11	1.9	0.14		0.02	0.4	0.07						
ATL	39	97	Ford	E-250 Van	4.2	44125	initial	0.127	0.11	2.1	0.26	503	0.03	1.4	0.51	npf; vehicle speed sensor		1		70	70
							final	0.127	0.11	2.1	0.26										
ATL	41	97	GM	Suburban	5.7	28619	initial	0.22	0.18	2.0	0.35	102, 131, 1	0.10	0.7	0.18	two O2 sensors		2	140	140	280
							final	0.22	0.18	2.3	0.31		0.07	0.4	0.25						
ATL	42	98	GM	Suburban	5.7	18137	initial	0.21	0.15	2.4	0.66	161	0.06	0.2	0.72	O2 sensor		1.5	70	105	175
							final	0.201	0.14	2.6	0.45		0.05	0.14	0.31						
ATL	45	97	Ford	F150 PU	4.6	19721	initial	0.145	0.12	1.6	0.76	304, 305, 3	0.03	0.3	0.00	Water in fuel, replaced fuel pump		1.5	105	105	210
							final	0.144	0.13	2.3	0.10		0.02	0.12	0.02						
ATL	46	98	Ford	Windstar	3.8	25188	initial	0.081	0.07	1.1	0.20	302	0.01	0.21	0.22	Bulletin No. 98-15-13		1	100	70	170
							final	0.084	0.07	1.0	0.16		0.01	0.07	0.13						
ATL	47	96	Ford	E-250 Van	4.9	51411	initial	0.18	0.10	1.2	0.62	133, 1131	0.06	-0.02	0.84	Replaced 2 B1S1 O2 sensors		2.5	150	175	325

							final	0.136	0.08	1.3	0.41		0.07	0	0.51						
ATL	48	98	GM	Suburban	5.7	19186	initial	0.218	0.16	2.7	0.68	141	0.08	0.11	0.61	Replaced B1S2 O2 Sensor		2.5	76	173	249
							final	0.242	0.20	3.1	0.40		0.06	0.2	0.38						
ATL	51	96	DC	caravan	3	65811	initial	0.21	0.18	1.0	0.40	134	0.07	0.14	0.40	light out; fuel trim		1			70
							final														
ATL	52	96	DC	Caravan	3	73357	initial	0.251	0.22	1.1	0.46	172	0.09	0.54	0.53	npf; fuel trim		1		70	70
							final	0.251	0.22	1.1	0.46										
ATL	54	97	Ford	F-150 Pick	4.2	64735	initial	0.237	0.19	7.9	0.13	133, 1131	0.36	18.6	0.10	replace o2 sen		1.5	70	105	175
							final	0.118	0.10	1.0	0.10		0.07	0.0	0.07						
ATL	55	97	Ford	F-150 Pick	5.4	76029	initial	0.134	0.12	1.5	0.17	174	0.01	0.1	0.06	npf; fuel trim		1		70	70
							final	0.134	0.12	1.5	0.17										
ATL	57	97	Ford	Ranger	2.3	19686	initial	0.087	0.07	1.6	0.11	171	0.01	0.11	0.18	replace o2 sen		1.5	70	105	175
							final	0.076	0.07	0.6	0.14		0.01	0	0.15						
ATL	58	97	FORD	Villager	3	89615	initial	0.132	0.10	1.0	0.40	136	0.11	0.9	0.42	replace o2 sen		1.5	70	105	175
							final	0.15	0.13	1.0	0.51		0.09	0.42	0.52						
ATL	67	97	DC	Caravan	3	87889	initial	0.268	0.24	1.7	0.36	133	0.09	0.65	0.33	replaced o2 sens		1.5	70	105	175
							final	0.241	0.21	1.4	0.34										
ATL	70	96	Ford	E-150	4.9	77940	initial	0.18	0.11	1.8	0.65	174	0.11	0.24	0.80	repair exhaust leak		1		70	70
							final	0.216	0.15	2.0	0.61		0.11	0.15	0.65						
ATL	72	99	Ford	Ranger	3	8797	initial	0.237	0.20	2.9	0.62	1405	0.18	2.18	0.83	npf; EGR		1		70	70
							final	0.256	0.22	3.0	0.43		0.17	1.78	0.60						
ATL	82	96	GM	Tahoe	5.7	58661	initial	0.204	0.17	2.7	0.31	1406, 1122	0.10	1.18	0.27	R/R EGR valve		2.6	117	182	299
							final	0.237	0.20	2.6	0.33		0.08	0.89	0.18						
ATL	84	99	ford	ranger	3	11974	initial	0.17	0.14	2.3	0.19	351, 352, 3	0.06	0.2	0.08	light out; ignition system		1			70
							final														
ATL	85	97	NISSAN	Quest	3	79540	initial	0.183	0.15	1.4	0.33	733	0.10	2.32	0.38	TPS replaced		1.5	37.52	105	142.52
							final	0.164	0.14	1.5	0.37		0.06	0.41	0.47						
ATL	86	96	isuzu	Rodeo	3.2	44157	initial	0.127	0.12	1.0	0.30	502	0.01	0.2	0.35	R/R speedo gear		1.5	20.73	105	125.73
							final	0.113	0.10	1.0	0.34		0.02	0.17	0.38						
ATL	88	97	DC	Ram Van	3.9	122781	initial	0.497	0.43	6.1	1.16	305, 138, 1	0.29	4.79	1.28	new plugs		1.5	12	105	117
							final	0.414	0.35	4.9	1.07		0.38	5.2	1.34						
ATL	90	96	GM	Cheyenne	5	104689	initial	0.279	0.24	2.5	0.27	1860, 306				transmission wrong model year cost 1974 to replace				0	1974
							final	0.279	0.24	2.5	0.27										
ATL	92	97	Ford	F-150	4.2	101242	initial	0.26	0.21	8.2	0.52		0.25	21.0	1.04	R/R all four O2 sensors		4.2	232	294	526
							final	0.17	0.14	1.6	0.30		0.08	0.9	0.41						
ATL	93	99	Ford	Ranger	3	7498	initial	1.31	1.17	42.7	0.01	135, 155	1.11	53.0	0.01	Reconnect 2 front O2 sensors		1.5		105	105
							final	0.09	0.08	1.5	0.02		0.01	0.0	0.02						
ATL	94	97	Ford	F150	4.6	29698	initial	0.28	0.23	5.8	0.21	172, 175	0.03	0.3	0.27	npf; fuel trim		1		70	70
							final	0.28	0.23	5.8	0.21										
ATL	97	96	GM	Astro	4.3	91737	initial	0.33	0.30	2.2	0.66	102, 340	0.16	1.3	0.27	R/R O2 sensor, freed up EGR pintle		2	83	140	223
							final	0.18	0.15	1.9	0.27		0.08	1	0.29						
ATL	99	97	Nissan	Pickup	2.4	118117	initial	0.15	0.12	0.7	0.52	110	0.09	1	0.22	Replaced IAT and repaired wiring		2	45	140	185
							final	0.16	0.14	1.0	0.42		0.06	0.6	0.37						
ATL	107	99	DC	Caravan	3.3	22560	initial	0.182	0.13	2.4	0.26	401	0.08	0.73	0.11	Replace EGR valve		1.3	142	87	229
							final	0.161	0.12	1.5	0.12		0.05	0.25	0.13						
ATL	109	96	Ford	F-150	5.8	89443	initial	0.325	0.25	3.2	0.21	171, 174	0.07	0.62	0.87	Replace EGR solenoid		1	23	70	23
							final	0.195	0.15	2.2	0.56		0.07	0.52	1.05						
ATL	112	99	Nissan	Altima GXI	2.4	13322	initial	0.047	0.04	0.8	0.09	141	0.00	0	0.05	Replace O2 B1S2		2.5	76	173	249
							final	0.05	0.04	0.8	0.04		0.00	0.1	0.05						
ATL	129	96	gm	Astro	4.3	175000	initial	0.38	0.32	3.3	0.97	420	0.28	2.9	0.96	Replace cat and 2 O2 sensors		3	466	210	676
							final	0.1	0.09	0.8	0.17		0.02	0	0.21						
ATL	130	96	isuzu	Hombre	2.2	245000	initial	0.4	0.32	10.1	1.36	108	0.40	11.8	1.33	R/R intake air temp sensor		1	16	70	86
							final	0.5	0.39	17.1	0.57		0.33	14.7	0.86						
EPA	3	98	GM	jimmy	4.3	8750	initial	0.288	0.21	3.9	2.14	605, 300, 1	0.04	0.0051	2.08	dealer repair cpi-fuel inj.	(fuel rail)	5	450	350	800
							final	0.203	0.18	2.2	0.26		0.05	2.19	0.09						
EPA	4	98	GM	blazer	4.3	6156	initial	0.208	0.18	1.8	0.25	306, 300	0.06	0.257	0.15	npf; misfire		1		0	70
							final	0.208	0.18	1.8	0.25										
EPA	8	96	toyota	4-runner	3.4	53052	initial	0.123	0.11	1.7	0.58	130, 133	0.01	0.02	0.61	light out; fuel trim		1			70
							final	0.123	0.11	1.7	0.58										
EPA	15	98	DC	cheroke	4	26959	initial	0.128	0.10	1.2	0.11	303	0.04	0.284	0.52	replace valve springs		5	55	350	405
							final	0.103	0.02	0.9	0.09		0.01	0.005	0.41	clean combustion cxchamber					
EPA	16	99	DC	Caravan	3.3	4439	initial	0.1176	0.09	1.2	0.26	401	0.04	0.1431	0.10	replace egr valve		2	91	140	231
							final	0.1092	0.09	0.9	0.98		0.03	0.0358	0.04						
EPA	19	96	DC	cherokee	4	42253	initial	0.15	0.11	3.9	0.25	138	0.05	2.16	0.20	replace O2 sensor		1.5	105	105	210
							final	0.1299	0.10	1.9	0.22		0.05	1.2	0.19						
EPA	20	96	ford	explorer	4	46706	initial	0.1458	0.10	2.4	0.23	153	0.04	1.176	0.19	r/r left O2 sensor		2	72	140	212
							final	0.1082	0.08	1.4	0.13		0.04	0.699	0.08						
EPA	21	98	DC	CARAVAN	3.3	12241	initial	0.1128	0.09	0.8	0.22	1698	0.02	0.09	0.20	light out; PCM communications		1			70
							final	0.1128	0.09	0.8	0.22										
EPA	22	96	DC	grand voya	3	78642	initial	0.226	0.20	1.2	0.29	133	0.06	0.286	0.20	upstream O2 sensor		2	70	140	210
							final	0.1868	0.17	1.0	0.32		0.04	0.1897	0.23						
EPA	24	97	ford	ranger	4	56239	initial	0.1332	0.09	2.3	0.25	171, 174	0.04	1.621	0.16	repl upper intake manifold	&fuel rail gaskets	6	40	420	460
							final	0.1373	0.12	2.0	0.12		0.01	0.753	0.05						
CDH	2	96	GM	blazer	4.3	55439	initial	0.2		1.8	0.56	1406	0.06	0.658	0.19	replace egr valve		1.6	185	109	302

							final	0.196	1.9	0.41		0.07	0.618	0.09								
CDH	4	96	GM	s10		27063	initial				108, 123, 172, 1441				install new pcm				2.1	164	150	314
							final	0.41	4.0	0.51		0.29	5.22	0.57	ran two sulfur purge cycles							
CDH	5	96	ford	f150	4.9	30576	initial	0.196	2.2	0.35	171	0.08	1.256	0.39	replace both hego's				2	91	140	231
							final	0.169	2.0	0.39		0.06	0.265	0.38								
CDH	8	96	ford	windstar	3.8	44305	initial	.108	1.1	0.36	402	0.03	0.68	0.22	light went out;npf; EGR				1			70
							final	0.108	1.1	0.36												
CDH	9	96	ford	windstar	3.8	68870	initial	0.115	1.2	0.96	174	0.03	1.6	1.33	sealed vacuum leak				3.5		242	242
							final	0.131	1.4	0.83		0.05	1.8	1.09	(upper intake manifold)							
CDH	10	96	DC	Voyager	3.3	57820	initial	0.315	4.9	1.07	420	0.15	4.2	1.41	replaced the cat	reflash PCM			3	350	210	560
							final	0.019	0.4	0.21		0.10	1.2	0.17								
CDH	12	97	DC	gr cheroke	4	26102	initial	.193	1.2	0.25	301	0.08	0.3	0.28	light went out; npf; misfire				1			70
							final	0.193	1.2	0.25												
CDH	14	96	ford	f150	5.8	107544	initial	0.228	2.6	0.58	750	0.06	0.4	0.47	replace solenoid pack and pcm				5.6	510	395	905
							final	0.221	2.8	0.05		0.06	0.6	0.43								
CDH	16	97	FORD	F150	4.6	86654	initial	0.194	3.3	1.12	141	0.57	1.5	1.37	R/R O2 sensor				2.7	71	191	265
							final	0.17	2.8	1.08		0.05	0.8	1.23								
CDH	17	97	ford	b4000(Maz	4	24651	initial	0.152	2.5	0.28	171, 174, 7	0.03	2.4	0.07	r/r 2 O2 sensors and trans solenoid				3	210	210	420
							final	0.137	1.9	0.26		0.30	0.7	0.21								
CDH	19	96	ford	bronco	5.8	3981	initial	0.319	6.5	0.41	133	0.04	0.1	0.32	R/R O2 sens				1.9	63	133	196
							final	0.176	2.1	0.48		0.04	0.4	0.39								
CDH	22	96	GM	blazer	4.3	100853	initial	0.469	5.8	0.55	147	0.24	3.2	0.29	r/r O2 sen #2				2.5	76	173	249
							final	0.37	4.2	0.55		0.16	2.0	0.32								
CDH	23	97	ford	expedition	5.4	49036	initial	0.123	2.7	0.51	156, 171, 1	0.01	0.1	0.38	replace 2 front hego sensors				3.7	124	255.99	380
							final	0.105	1.2	0.42		0.01	0.1	0.31	rr cat efficicy monitor							
CDH	24	97	DC	ram1500	5.9	67060	initial	3.76	10.7	0.89	201, 753	10.97	32.1	1.62	bare and brocken wires due to tampering				3.4	11.85	237	249.3
							final	0.255	4.2	0.59		0.10	3.7	0.63								
CDH	27	96	GM	yukon	5.7	71905	initial	0.26	2.8	0.56	1406	0.09	0.8	0.32	replace egr				1.8	176	101	276
							final	0.281	3.1	0.47		0.10	0.6	0.46								
CDH	30	97	GM	1500	5.7	45166	initial	0.229	2.9	0.45	300, 1870	0.08	1.3	0.49	r/r transmission valve body				3.2	538	225	763
							final	0.235	2.9	0.46		0.07	1.0	0.40								
CDH	33	97	DC	ram1500	5.9	113543	initial	0.546	12.8	2.88		0.31	9.1	3.00	R/R O2 se new	cat			4.1	528	290	818
							final	0.159	2.3	0.23		0.06	0.9	0.17								
CDH	36	96	DC	caravan		80748	initial	0.366	6.8	1.67	303	0.14	5.2	1.86	plugs and wires	replace	computer	cat	5.2	240	366	608
							final	0.131	2.3	0.52		0.03	0.8	0.49								
CDH	39	96	ford	bronco	5.8	109124	initial								failed state	I/M	passed lab	no ftp				276.6993
							final															