



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

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## *NOTICE*

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technical information and to inform the public of technical developments which  
may form the basis for a final EPA decision, position, or regulatory action.*

## **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<sup>1</sup>. 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<sup>2</sup>. 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<sup>3</sup>. 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<sup>4</sup>, 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<sup>5</sup>.

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<sup>6</sup>. 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<sup>7</sup>. 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.

#### Procurement of High emitting vehicles with no MIL illumination

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<sup>8</sup> 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<br>#procured<br>(% of goal) | Ford         | Diamler-<br>Chrysler | Toyota     | Honda      | Nissan       | Other        | Total         |
|-------|--------------------------------|--------------|----------------------|------------|------------|--------------|--------------|---------------|
| LDV   | 45<br>(128%)                   | 31<br>(148%) | 22<br>(220%)         | 5<br>(45%) | 8<br>(73%) | 7<br>(100%)  | 14<br>(140%) | 132<br>(126%) |
| LDT   | 18<br>(66%)                    | 28<br>(96%)  | 16<br>(80%)          | 1<br>(20%) | 0<br>(0%)  | 4<br>(133%)  | 2<br>(20%)   | 69<br>(73%)   |
| Total | 63<br>(102%)                   | 59<br>(116%) | 38<br>(127%)         | 6<br>(38%) | 8<br>(67%) | 11<br>(110%) | 16<br>(80%)  | 201<br>(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<br>(# that MIL went out*) | # which failed FTP over<br>appropriate cert. standard | subset that failed over 1.5<br>times standard |
|-------|--|---|---|
| LDV   | 128 (subset of 5)                                | 40  | 21  |
| LDT   | 66 (subset of 6)                                 | 18  | 10  |
| Total | 194 (subset of 11)                               | 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<sup>9</sup>. 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<br>MIL | # which failed FTP over cert.<br>standard (includes over 1.5X) | # which failed FTP over 1.5<br>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<sup>10</sup>), 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<br>N=126                           | .138 gpm<br>n= 114 | 0.1 gpm<br>n= 111 | 2.40 gpm<br>n= 126 | 0.1 gpm<br>n=126 | 6.47 gpm<br>n=114 | -0.53 mpg<br>(increase in fuel economy)<br>n=114 |
| average reductions for OBD repairs with \$600 repair limit<br>n=118 | 0.1 gpm<br>n= 108  | 0.1 gpm<br>n= 105 | 2.42 gpm<br>n=118  | 0.1 gpm<br>n=118 | 6.21 gpm<br>n=108 | -0.53 mpg<br>n= 108                              |
| average reduction for IM240 repair<br>n=7                           | 1.04 gpm<br>n=7    | 0.9 gpm<br>n=5    | 15.4 gpm<br>n=7    | 0.6 gpm<br>n=7   | 14.71 gpm<br>n=7  | -2.36 mpg<br>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                | NO <sub>x</sub>   | CO <sub>2</sub>  | MPG               |
|--|-------------------|-------------------|-------------------|-------------------|------------------|-------------------|
| average reduction<br>for OBD repair<br>n=65                      | .11 gpm<br>n= 65  | 0.05 gpm<br>n= 49 | 1.56 gpm<br>n=65  | 0.13 gpm<br>n=65  | -2.66gpm<br>n=64 | -0.03 mpg<br>n=64 |
| average<br>reductions for<br>OBD repair with<br>\$600 limit n=60 | 0.10 gpm<br>n= 60 | 0.05 gpm<br>n= 46 | 1.62 gpm<br>n= 60 | 0.08 gpm<br>n= 60 | -3.42gpm<br>n=60 | -0.02 mpg<br>n=59 |
| average reduction<br>for IM240 repair<br>n=7                     | 0.84 gpm<br>n=7   | 0.37 gpm<br>n=5   | 10.47 gpm<br>n=7  | 0.60 gpm<br>n=7   | 8.27gpm<br>n=7   | -0.79 mpg<br>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<br>LANE IM240 failure   | As-Received<br>FTP:THC CO NOX<br>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<br>LANE IM240 failure                                      | Could not be driven on FTP<br>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<br>LAB IM240 failure                      | As-Received<br>FTP:THC CO NOX<br>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<br>MIL on prior to repair; off after repairs. | Post Repair<br>FTP:THC CO NOX<br>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<br>Am odometer 47,173<br>MIL on prior to<br>diagnostics | Post Repair<br>FTP:THC CO NOX<br>0.14 1.6 1.0 | No problem found during diagnostics<br>(HC and CO below trigger levels for<br>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<sup>11</sup>, 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<sup>12</sup>.

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 manufacturers 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](http://www.epa.gov/oms/obd.htm)". CARB documents can be found at "[www.arb.ca.gov](http://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 NO<sub>x</sub>. 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. Estimating Costs

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 (O2 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 3 <sup>rd</sup> gear on FTP   | Lab IM240 results:<br>(THC/CO/NO <sub>x</sub> )<br>11.8/147/0.02<br>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.<br>Decision made to not run FTP. | Lab IM240 results:<br>32.1/45.6/0.14<br>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 compatible 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-EPSP-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)





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

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

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

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

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