# FINAL REPORT

# CHARACTERISTICS AND IMPACT OF ELECTRONIC AUTOMOTIVE EMISSION CONTROL SYSTEMS

ARB CONTRACT NO. A0-144-32

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ABSTRACT

A test program was conducted using ten 1981 or 1982 model year vehicles equipped with state-of-the-art closed loop electronic emission control systems (EECS). The purpose of the test program included determining the effect of disconnecting or disabling selected components of the electronic control system and whether the disconnected/disabled components could be detected during field repairs. Tests performed included the U.S. Environmental Protection Agency's (EPA) 1975 Federal Test Procedure (FTP) and Highway Fuel Economy Test (HFET); and a steady state test and driveability test specified by the California Air Resources Board (CARB). At least ten disablements were induced in each vehicle. One disablement for each vehicle was implanted before the vehicle was sent for diagnosis and repair. The test program showed that the impact of disabling components upon emissions, fuel economy and driveability ranged from negligible to dramatic, depending on the component and system. Closed-loop systems which incorporated on-board diagnostic and driver warning systems provided better detection of disablements than systems without on-board diagnostics and were more likely to result in correct diagnosis and repair of the vehicle.

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The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board.

The mention of commercial products, their source or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

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# Section 1

## SUMMARY

This report describes the conduct and findings of ARB Contract No. AO-144-32, "Characteristics and Impact of Electronic Automotive Emission Control Systems". This section presents an overview of the program objectives and approach; summarizes the salient results; states the conclusions from the program; and makes recommendation for future action. Section 2 describes the Test Program Methodology. Section 3 discusses the Results.

### 1.1 PROGRAM OVERVIEW

#### 1.1.1 Objectives

There were two fundamental objectives in this program. The first objective was to quantify the impact of defects in components of the electronic emissions control systems (EECS) used for closed-loop automotive engine control. The impacts included exhaust emissions, fuel economy, and vehicle performance. The second objective was to determine the effectiveness of dealerships in detecting, correctly diagnosing, and repairing the implanted defects. Underlying both objectives was a desire to determine similarities or differences between various electronic control systems used by car manufacturers.

#### 1.1.2 Scope

The program was divided into three tasks, as follows:

- Task 1: Determination of Impacts of EECS Malfunctions
- Task 2: Evaluation of Field Service and Diagnosis
- Task 3: Assessment of the Benefits of Standardized Diagnostic Systems and Equipment

Task 1 included the exhaust emissions, fuel economy and driveability tests. ARB selected ten 1981 and 1982 model year cars representing the current state-of-the-art sophistication of sensors, actuators, and computer functions. Each vehicle received an initial baseline test, at least ten implanted disablements, and a final baseline test. Some disablements prevented the car from starting or running well enough to drive. Therefore, not all cars completed ten disablement tests. A total of 125 disablements were implanted and 88 tests were completed.

Based on the test results of Task 1, one disablement was selected to be implanted in each vehicle for Task 2. Each vehicle was taken to three dealerships with a typical owner/driver complaint. After the vehicle was picked up from the dealer it was inspected to determine what had been done. The selected disablement was then reimplanted, if necessary, and the vehicle sent to the next dealer.

Results from Tasks 1 and 2 were analyzed in Task 3 to determine whether one type of electronic control system performed better than others and whether on-board vehicle diagnostic capability was better than remote diagnostic capability.

### 1.1.3 Approach

The characterization of impacts included measurements of exhaust emissions during the Federal Test Procedure (FTP), the Highway Fuel Economy Test (HFET) and an ARB 3 mode steady-state test; converter efficiency during the FTP; fuel economy during the FTP and HFET; and driveability as measured by the ARB cold and hot start test procedures. The effect of the disablements were measured as the percent increase (decrease) compared to the average of the initial and final baseline tests. The significance of the change was evaluated based on the 90% confidence limits of the baseline tests without regard to magnitude of the change or absolute level of the parameter.

The field service evaluation was based on the effectiveness of fault detection. Each vehicle was presented to three dealerships with the implanted disablement. All but the one employee-owned car were represented as SC cars with the appropriate symptom for the disablement. The employee-owned car was taken to the dealerships by the owner. The driver contacting dealerships described the symptom but did not suggest any possible cause. Symptoms included driveability complaints, warning lights, poor fuel economy and failed vehicle inspection reports. All symptoms were represented as having developed suddenly within the last few days. The field service evaluation was conducted by reviewing work orders and inspecting the vehicle to determine what work had actually been performed. The effectiveness of each dealer was evaluated by a point score based on the correctness of the diagnosis.

An evaluation of electronic control system performance was made on the basis of impact of disablements, detectability of disablements by the vehicle operator, and diagnostic effectiveness by dealerships.

## 1.2 RESULTS

### 1.2.1 Effects of Disabling Electronic Emission Controls

The average baseline emissions of the ten cars was 0.30 grams per mile HC, 2.81 grams per mile CO and 0.60 grams per mile $NO_x$. Fifty component disablements resulted in a statistically significant increase in emissions. The average emissions level of a disabled EECS component was 2.3 grams per mile HC, (+667%), 49 grams per mile CO (+1644%) and 0.77 grams per mile $NO_x$ (+28%). The effect of individual components ranged from negligible to emission levels many times the baseline levels, i.e. 16 grams/mile HC, 400 grams/mile CO, 8 grams/mile $NO_x$.

Of the 88 disablement tests completed, 70 resulted in failure of one or more CVS emission standards compared to 37 which failed one or more vehicle inspection standards. The inspection test was most effective in detecting CO failures (26 out of 32), moderately effective in detecting HC failures (31 out of 51) and ineffective in detecting $NO_x$ failures (1 out of 32). There were errors of commission as well as errors of omission for HC and CO CVS failures.

Baseline FTP catalytic converter efficiency was 88%, 84% and 68% respectively for HC, CO, and $NO_x$. Average converter efficiency of a disabled component was 66%, 62% and 58% for HC, CO, and $NO_x$, respectively. Converter efficiency generally decreased as emission levels increased. However, the decrease in converter efficiency was proportionately less than the increase in emissions levels which was due to increased engine out emission levels occuring during most disablements.

The average baseline fuel economy of the 10 cars was 19.9 miles per gallon on the FTP and 29.5 miles per gallon on the HFET. The average fuel economy of a disabled EECS component was 17.9 miles per gallon (-10%) on the FTP and 27.1 miles per gallon (-9%) on HFET. Three component disablements resulted in a statistically significant increase in fuel economy relative to baseline tests. Thirty-nine component disablements resulted in a statistically significant decrease in fuel economy relative to baseline tests. The effect of individual components varied from negligible to 50% reduction in fuel economy.

The average ARB driveability rating of a disabled EECS component was 70 demerits compared to 36 demerits for the baseline tests. Two component disablements resulted in a statistically significant improvement in driveability compared to baseline. Forty-one disablements resulted in a statistically significant degradation in driveability compared to baseline. Of these forty-one disablements, thirty-six were no-start or no-run conditions and could not be tested.

### 1.2.2 Effectiveness of Field Diagnosis and Repairs

The effectiveness of field diagnosis and repair was evaluated quantitatively using indices which expressed actual performance as a percentage of ideal performance. Separate indices were defined for driver detection of faults, mechanic diagnosis of faults and repair of faults. The indices were determined for each of the ten test cars and then combined for those cars with on-board and those with remote diagnostic systems.

On-board systems provided indices of detection, diagnosis and repair nearly twice as high as remote diagnostic systems. In many cases the only overt indication of component disablement was the warning light provided with on-board diagnostic systems or the inability to start or operate the car which occured primarily on those cars equipped with fuel injection. However, even with on-board diagnostic systems, not all component disablements resulted in warnings to the driver nor were mechanics always able to diagnose and correct the disablements.

## 1.3 CONCLUSIONS

- Malfunctions of EECS components can severely degrade emissions, fuel economy, and driveability in late model cars.

- On-board diagnostic systems were effective in alerting the driver to a malfunction and in directing the mechanic to a correct diagnosis and repair of EECS components.

- Remote diagnostic systems were effective in directing the mechanic to a correct diagnosis and repair of EEC components but did not alert the vehicle operator to the presence of a malfunction.

- On-board diagnostic systems provided better overall detection, diagnosis, and repair of EECS component malfunctions than remote diagnostic systems.

## 1.4 RECOMMENDATIONS

- Universal remote diagnostic systems should not be required due to fundamental differences between electronic emission control systems from different manufacturers.

- On-board diagnostic and driver warning systems should be required on future vehicles.

- State regulations should require self-test continuity and range limit checks of all sensor and actuator circuits with driver warning (light or buzzed) for out-of-limit condition.

- Diagnostic messages and troubleshooting aides should be coordinated so that specific circuits and components can be isolated by any trained mechanic.

Section 2

# TEST PROGRAM METHODOLOGY

This section describes the methodology used for vehicle preparation and testing, the field service evaluation and the assessment of diagnosis and repair.

## 2.1 TEST VEHICLES

### 2.1.1 Selection

The ARB selected ten passenger cars with state-of-the-art closed loop electronic emissions control systems. The vehicles represented different design technologies, including carburetors, electronic fuel injection, mechanical fuel injection, central fuel injection, port fuel injection, vacuum motor operated controls, servo motor operated controls, domestic and foreign cars. All cars were production vehicles certified to meet California emission standards. All vehicles were initially specified as 1981 models, however, due to availability at time of procurement, three 1982 models were procured. The vehicle fleet was not intended to be statistically representative of the current vehicle population.

One privately-owned car was procured from an SC employee. One SC executive car was used. Of the remaining eight cars, four were rented from new car dealers and four were rented from car rental companies. Table 2-1 describes the test vehicles.

### 2.1.2 Preparation

The ten vehicles each underwent an acceptance inspection of mechanical and emission control components to ensure that they met manufacturer's specifications. The procedures for this inspection were obtained from the manufacturer of each vehicle, and included the following specific items:

- General Component Inspection
    - Exhaust System
    - Fuel System
    - Belts and Hoses Condition

Table 2-1

TEST VEHICLE DESCRIPTION

| CAR NO. | YEAR | CODE | MAKE | MODEL | ENGINE | ENGINE FAMILY | FUEL SYSTEM | EMISSION SYSTEMS |
|---|---|---|---|---|---|---|---|---|
| 103 | 1981 | (OLD) | Oldsmobile | Cutlass | 3.8L-6 | 14E2TM | CC | TWC-CL/EGR/AIP |
| 130 | 1981 | (GRA) | Ford | Granada | 2.3L-4 | 2.3AX | CC | TWC-CL/EGR/AIP |
| 131 | 1981 | (LTD) | Ford | LTD | 5.8L-8 | 5.8WAXC | VVC | TWC-CL/EGR/AIP |
| 133 | 1981 | (PLY) | Plymouth | Reliant | 2.2L-4 | BCR2.2V2HE8 | CC | TWC-CL/EGR/AIP |
| 136 | 1981 | (LIN) | Lincoln | Mark VI | 5.0L-8 | 5.0 CCC | CFI | TWC-CL/EGR/AIP |
| 137 | 1981 | (CIT) | Chevrolet | Citation | 2.5L-4 | 12X2NN | CC | TWC-CL/EGR/AIP |
| 139 | 1982 | (TOY) | Toyota | Celica Supra | 2.8L-6 | CTY2.8V5HBG3 | EFI | TWC-CL/EGR |
| 140 | 1982 | (CAD) | Cadillac | Sedan deVille | 4.1L-8 | C6G4.1V5AGA3 | CFI | TWC-CL/EGR/AIP |
| 143 | 1982 | (BMW) | BMW | 528e | 2.7L-6 | CBM2.7V5 | EFI | TWC-CL/EGR |
| 144 | 1981 | (DAT) | Datsun | 280ZX | 2.8L-6 | BNS2.8V5FE6 | EFI | TWC-CL/EGR/TC |

EFI - Electronic Fuel Injection
CFI - Central Fuel Injection (Throttle Body)
CC - Conventional Carburetor
VVC - Variable Venturi Carburetor
TC - Turbocharged

AIP - Air Injection Pump
CL - Closed Loop Control
EGR - Exhaust Gas Recirculation
TWC - Three-way Catalyst

- Air Cleaner
- Positive Crankcase Ventilation Valve
- Exhaust Gas Recirculation Valve
- Vacuum Hose Routing

o <u>Cold Engine Functional Checks</u>

- Choke Cap Setting
- Choke Pull Off
- Electric Choke Operation
- Carburetor Linkage
- Early Fuel Evaporative System Activated
- Exhaust Gas Recirculation System Inoperative
- Heated Air Inlet Functioning
- High Idle Speed
- Correct Vacuum Routing Through Thermal Switches
- Secondary Air System Correctly Switched

o <u>Warm Engine Functional Checks</u>

- Heated Air Inlet Closed
- Early Fuel Evaporation System Inoperative
- Exhaust Gas Recirculation System Operative
- Secondary Air System Operative and Correctly Switched (Manifold versus Catalyst)
- Evaporative Emission Canister Purge
- $O_2$ System Operative
- Spark Delay Valve Operative
- Correct Vacuum Routing Through Thermal Switches
- Curb Idle Speed
- Initial Timing Advance
- Mechanical Timing Advance Operative
- Vacuum Advance Operative
- Spark Plug Firing Voltage at Idle and 40 MPH
- Idle Mixture Setting

In addition to the acceptance inspection, a vacuum gauge and tachometer were installed in each vehicle for the driveability tests. An engine out emission sampling probe was also installed in each vehicle to permit measurement of engine out mass emissions during the FTP and HFET, and undiluted emissions during the ARB steady state test.

Three vehicles failed the initial baseline test even though they passed the visual and functional inspection. These vehicles were subsequently diagnosed and repaired. Two vehicles were accepted for testing even though they continued to have marginal emission failures. The third vehicle passed the baseline test after replacement of its catalytic converter.

## 2.2 TESTING

### 2.2.1 Test Sequence

An initial baseline test, up to 10 disablement tests, and a final baseline test were performed on each vehicle. Each test consisted of the following sequence:

- o Induce Disablement
- o Precondition Vehicle
- o 12-24 Hour Soak
- o Cold Start FTP
- o HFET
- o ARB Loaded Mode Test
- o ARB Driveability Test

The emission tests were always run as one sequence. The ARB driveability test, however, was often performed at a different time than the emission test due to scheduling conflicts.

### 2.2.2 Test Procedure

Emission tests included the 1975 Federal Test Procedure (FTP) without evaporative emissions. These tests were performed in accordance with requirements

Table 2-2

SC COMMERCIAL FUEL ANALYSIS

| PARAMETER | SC COMMERCIAL FUEL* | INDOLENE SPECIFICATION |
|---|---|---|
| Reid Vapor Pressure | 9.0 | 8.7 - 9.2 |
| Research Octane Number | 93.1 | ≥93.0 |
| D86 Distillation Data | | |
| Initial Boiling Point (°F) | 96 | 75 - 95 |
| 5% Point (°F) | 116 | - |
| 10% Point (°F) | 132 | - |
| 20% Point (°F) | 162 | - |
| 30% Point (°F) | 188 | - |
| 40% Point (°F) | 214 | - |
| 50% Point (°F) | 236 | 200 - 230 |
| 60% Point (°F) | 257 | - |
| 70% Point (°F) | 282 | - |
| 80% Point (°F) | 301 | - |
| 90% Point (°F) | 345 | 300 - 325 |
| 95% Point (°F) | 371 | - |
| End Boiling Point (°F) | 406 | 415 |
| Recovery (%) | 97.5 | - |
| Residue (%) | 1.5 | - |
| Loss (%) | 1.0 | - |

*Analysis by E.W. Saybolt and Company, Inc., Wilmington, California, on August 6, 1981.

defined in the Federal Register, Volume 42, Number 12, Part 86, except that engine out emission measurements were performed and tests were run using a single batch of commercially available unleaded regular fuel rather than Indolene. Table 2-2 presents the analysis of the fuel.

Following the FTP, the Highway Fuel Economy Test (HFET) was performed. The measured test was preceded by a 3.1-minute 50-mph cruise to check and reset the horsepower and one HFET cycle without exhaust sampling.

Following the HFET, the ARB loaded mode test was performed. This 3 mode steady state test included measurements of undiluted HC, CO and $NO_x$ ahead of and after the catalyst. The test consisted of a high cruise at 55 mph using the FTP dynamometer loading followed by a low cruise at 40 mph using the dynamometer loading shown in Table 2-3. The two cruise modes were followed by an idle mode in neutral. The cruise modes were performed in the normal drive gear for vehicles with an automatic transmission and in the highest gear for vehicles with a manual transmission.

Table 2-3. ARB 3-MODE STEADY-STATE TEST

| NO. OF CYLINDERS | VEHICLE WEIGHT (lbs) | SPEED (mph) | LOADING (Road hp) |
|---|---|---|---|
| Any | Any | 55 ±1 | Set to FTP Load at 50 mph |
| 4 or less | Any | 40 ±1 | 10± 1.0 |
| 5 or 6 | Any | 40 ±1 | 15 ±1.5 |
| 7 or more | Less than 3250 | 40 ±1 | 17.5 ±1.5 |
| 7 or more | 3250 or more | 40 +1 | 20 ±1.5 |
| Any | Any | 0 (neutral) | 0 |

The failure standards for the cars in this program were 80 ppm HC, 1.0% CO, and 1000 ppm $NO_x$ at 40 mph; and 80 ppm HC and 1.0% CO at idle.

The ARB driveability test was performed on a road route originating from SC. Each test consisted of one cold start evaluation and 3 hot start evaluations using different drivers. The cold start and hot start evaluations were not necessarily performed on the same day and could either precede or follow the emission test sequence. All cold start tests were performed by one driver.

Most hot start evaluations were performed by the same three drivers with ocasional substitutions of 2 other drivers who were experienced in performing driveability ratings. Figures 2-1 and 2-2 show the ARB driveability test data sheets.

### 2.2.3 Quality Assurance

Periodic calibration and performance checks were performed throughout the program. Additional unscheduled calibrations and performance checks were also performed after unscheduled instrument maintenance activities, or if unreasonable calibration or emission data were obtained. A summary of these calibration checks is presented in Table 2-4.

Calibration and test data were recorded on data sheets and strip charts. The data for each test were compiled into a data packet by test personnel and submitted to SC Quality Control (QC). Data were audited, approved, and processed by QC in accordance with procedures used on emission test programs. The criteria were generally based on requirements contained in the Code of Federal Regulations (CFR) and specifically reflected procedures required of EPA contract laboratories. Data audit criteria are summarized in Table 2-5.

### 2.2.4 Laboratory Equipment

SC's Anaheim facility had over 4,000 square feet of soak area and was capable of maintaining 11 vehicles in soak at one time. The soak and test temperatures were maintained by 130,000 Btu gas-fired heaters and 70 tons of air conditioning. Temperatures in the soak area could be monitored continuously at nine points. In addition to temperature control, the laboratory had a humidification system comprised of 15 Maid of the Mist compressed air driven spray nozzels and a reverse osmosis desalination unit to provide demineralized water. This environmental-control system maintained soak and test cell temperatures between 68$^{o}$ and 74$^{o}$F and absolute humidity in the test cell between 30 and 60 grains of water per pound of air.

Figure 2-1 COLD START AND DRIVEAWAY EVALUATION

Sheet 1 of 2

Vehicle No. ______________ License No. ______________

Date: ______________ Time: Start ______ Finish ______ Odo.: Start ______ Finish ______

| Vehicle | Engine | Weather | Crew |
|---|---|---|---|
| Make ______ | Disp. ______ Type ______ | Temp.: Start °F ______ | Driver: ______ |
| Model ______ | Nom. C.R. ______ | End °F ______ | Recorder: ______ |
| Year ______ | Carb.: Mfg. ______ | Road Conditions: | Observer(s): ______ |
| Trans. ______ A/C ______ | Model ______ | Wet ______ Dry ______ | ______ |
| P/B P/S | Choke: | Soak Time (hrs.) ______ | ______ |

Remarks: ______________

Start Time (sec.) ______ ______ Attempts ______

| Miles | Mode | | RPM | Idle: Satis. | Idle: Rough* | Idle: Stall | Accel.: Satis. | Accel.: Hesit.* | Accel.: Stumble* | Accel.: Stall | | Back Fire |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | Hi-Cam | | | | | | | | | | | |
| | Tap | N | | | | | | | | | | |
| | Throttle | Dr | | | | | | | | | | |
| 0 | PT D/A (0-25) | | | | | | | | | | | |
| .2 | WOT Accel (25-35) | | | | | | | | | | | |
| .3 | PT Accel (25-30) | | | | | | | | | | | |
| .4 | PT Accel (25-30) | | | | | | | | | | | |
| .5 | Idle (30 sec.) | | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | | |
| .6 | WOT Accel (25-35) | | | | | | | | | | | |
| .7 | PT Accel (25-30) | | | | | | | | | | | |
| .8 | PT Accel (25-30) | | | | | | | | | | | |
| .9 | PT Accel (25-30) | | | | | | | | | | | |
| 1.0 | Idle (30 sec.) | | | | | | | | | | | |
| | WOT D/A (0-25) | | | | | | | | | | | |
| 1.1 | WOT Accel (25-35) | | | | | | | | | | | |
| 1.2 | PT Accel (25-30) | | | | | | | | | | | |
| 1.3 | PT Accel (25-30) | | | | | | | | | | | |
| 1.4 | PT Accel (25-30) | | | | | | | | | | | |
| 1.5 | Idle (30 sec.) | | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | | |
| 1.6 | WOT Accel (25-35) | | | | | | | | | | | |
| 1.7 | PT Accel (25-30) | | | | | | | | | | | |
| 1.8 | PT Accel (25-30) | | | | | | | | | | | |
| 1.9 | PT Accel (25-30) | | | | | | | | | | | |
| 2.0 | Idle (30 sec.) | | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | | |
| 2.1 | WOT Accel (25-35) | | | | | | | | | | | |
| 2.2 | PT Accel (25-30) | | | | | | | | | | | |
| 2.3 | PT Accel (25-30) | | | | | | | | | | | |
| 2.4 | PT Accel (25-30) | | | | | | | | | | | |

| Miles | Mode | RPM | Idle: Satis. | Idle: Rough* | Idle: Stall | Accel.: Satis. | Accel.: Hesit.* | Accel.: Stumble* | Accel.: Stall | Lean | Back Fire |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.5 | Idle (30 sec.) | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | |
| 2.6 | WOT Accel (25-35) | | | | | | | | | | |
| 2.7 | PT Accel (25-30) | | | | | | | | | | |
| 2.8 | PT Accel (25-30) | | | | | | | | | | |
| 2.9 | PT Accel (25-30) | | | | | | | | | | |
| 3.0 | Idle (30 sec.) | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | |
| 3.1 | WOT Accel (25-35) | | | | | | | | | | |
| 3.2 | PT Accel (25-30) | | | | | | | | | | |
| 3.3 | PT Accel (25-30) | | | | | | | | | | |
| 3.4 | PT Accel (25-30) | | | | | | | | | | |
| 3.5 | Idle (30 sec.) | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | |
| 3.6 | WOT Accel (25-35) | | | | | | | | | | |
| 3.7 | PT Accel (25-30) | | | | | | | | | | |
| 3.8 | PT Accel (25-30) | | | | | | | | | | |
| 3.9 | PT Accel (25-30) | | | | | | | | | | |
| 4.0 | Idle (30 sec.) | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | |
| 4.1 | WOT Accel (25-35) | | | | | | | | | | |
| 4.2 | PT Accel (25-30) | | | | | | | | | | |
| 4.3 | PT Accel (25-30) | | | | | | | | | | |
| 4.4 | PT Accel (25-30) | | | | | | | | | | |
| 4.5 | Idle (30 sec.) | | | | | | | | | | |
| | PT D/A (0-25) | | | | | | | | | | |
| 4.6 | WOT Accel (25-35) | | | | | | | | | | |
| 4.7 | PT Accel (25-30) | | | | | | | | | | |
| 4.8 | PT Accel (25-30) | | | | | | | | | | |
| 4.9 | PT Accel (25-30) | | | | | | | | | | |
| 5.0 | Idle (30 sec.) | | | | | | | | | | |

*T - Trace; M - Moderate; H - Heavy

Vehicle ______________________ License ______________________

Date ____________ Time: Start ________ a.m./p.m. Finish ________ a.m./p.m.

Odometer Reading: Start ____________ Finish ____________

Temperature: Start ____________ Finish ____________

Test Driver: ____________ Observer ____________

Remarks: (overheating, vapor lock, dieseling, stall at start or driving, etc)

| MODE | | RPM | Hg | Idle: Satisfactory | Idle: Rough* | Idle: Stall | Drive Mode: Satisfactory | Detonation* | Hesitation* | Stumble* | Stretchiness* | Backfire | Surge* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Idle | N | | | | | | | | | | | | |
| | D | | | | | | | | | | | | |
| Road Load | 20 mph | | | | | | | | | | | | |
| | 30 mph | | | | | | | | | | | | |
| | 40 mph | | | | | | | | | | | | |
| | 50 mph | | | | | | | | | | | | |
| | 55 mph | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| WOT Accel. | 20-30 Manual Transmission or 0-30 Auto Transmission | | | | | | | | | | | | |
| | Sudden Throttle Opening | | | | | | | | | | | | |
| | Moderate Throttle Opening | | | | | | | | | | | | |
| | Slow Throttle Opening | | | | | | | | | | | | |
| PT Accel. | 20-30 Manual Transmission or 0-30 Auto Transmission | | | | | | | | | | | | |
| | 1/4 Throttle | | | | | | | | | | | | |
| | 1/2 Throttle | | | | | | | | | | | | |
| | 3/4 Throttle | | | | | | | | | | | | |
| PT Crowd | 20-55 | | | | | | | | | | | | |
| | 15" Hg | | | | | | | | | | | | |
| | 10" Hg | | | | | | | | | | | | |
| | 5" Hg | | | | | | | | | | | | |
| PT Tip In From 20 mph | 1 | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | |
| From 30 mph | 1 | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | |
| Accel. Time 0-55 mph | | | sec. | | | | | | | | | | |
| Decel. Time 70-30 mph | | | sec. | | | | | | | | | | |
| Soak | Number of Start Attempts | | | | | | | | | | | | |
| | Total cranking time | | sec. | | | | | | | | | | |
| Idle | Neutral | RPM | Hg | | | | | | | | | | |
| | Drive | RPM | Hg | | | | *T-Trace | | | M-Moderate | | | |

Table 2-4. CALIBRATION SCHEDULE

| CALIBRATION CHECK | ANNUAL | MONTHLY | WEEKLY | DAILY | PER TEST |
|---|---|---|---|---|---|
| Constant Volume Sampler | | | | | |
| 1. Calibrate CVS pump | X | | | | |
| 2. Obtain two valid propane recovery tests | X | | | (1) | |
| Mini CVS | | | | | |
| 1. Calibrate Flow | X | | | | |
| Dynamometer | | | | | |
| 1. Calibrate actual vs. indicated hp for each required inertia weight | X | | | | |
| 2. Verify actual vs. indicated hp for all required inertia weights | | | X (biweekly) | | |
| 3. Calibrate speed and load meters | X | | X (biweekly) | | |
| Instrument System | | | | | |
| 1. Calibrate instrument with gravimetric named gases (mass analyzers only) | X | | X | | |
| 2. Perform curve fit for all instruments (mass analyzers only) | X | | X | | |
| 3. Perform system leak test | X | | | X | X |
| 4. Calibrate temperature recorders | X | X | | | |
| 5. Calibrate driver's aid<br>o speed vs. time<br>o 0 and 50 mph | X | | | | |
| 6. Calibrate drivers aid speed and load | | | | | X |
| 7. Span instruments with "working" gases (pre- and post-test cal) | | | | | X |
| SHED | | | | | |
| 1. Background and volume calibration | X | X | | | |
| 2. HC retention check | X | X | | | |
| Analytical Laboratory Equipment | | | | | |
| 1. Standardize GCs | X | | | | X |
| 2. Verify spectrophotometer using stock solutions | X | | | | |

Table 2-5. TEST ABORT AND REJECTION CRITERIA

| CATEGORY | REASON FOR REJECTION |
|---|---|
| Test Condition | -Background HC or CO concentrations exceed 10 ppm.<br>-Test or soak temperatures exceed the prescribed 20-30°C (68-86°F).<br>-Soak time (key-off to key-on) ≥12 hrs or ≤24 hrs. |
| Equipment Failure | -Unstable instrument traces.<br>-Unstable dynamometer load (post cal exceeds ±1 HP).<br>-Unstable zero or span calibrations (post cal exceeds ±1.0 deflection).<br>-CVS or bag leaks (propane recovery of ≤98%).<br>-Test cell computer.<br>-Driver's aid recorder (post cal exceeds ±1 mph).<br>-Instrument recorders.<br>-Power or other utility. |
| Operator/Driver Procedure | -Incorrect calibration procedure including calibrating to incorrect standard, failing to perform calibration, or failing to adequately document calibration.<br>-Incorrect test procedures including driver trace violations and shift points not attributable to vehicle operation, failure to use correct starting procedure, wrong fuel or fuel hook-up, and failing to use prescribed procedures. |
| Vehicle Operation | -Brake failure.<br>-Mechanical failure, i.e., cooling system, electrical, etc. |
| Emission Data | -Obvious incorrect data not traceable to clerical error.<br>-Diurnal time versus temperature limits exceeded. |
| Miscellaneous | -Running out of bag sample (maybe due to instrument failure or procedure).<br>-Incorrect vehicle maintenance procedure or part installation. |

There were two emission test cells within the facility, each totally independent of the other. Each was equipped with exhaust gas analyzers, dynamometers, and constant volume samplers which are herein described. A fan in each cell with a combined capacity of 12,000 CFM provided one air change every 3 minutes in each cell. A vehicle turntable facilitated rapid vehicle movement into and out of the test cells.

In addition to the two emission test cells, SC had a vehicle preparation and preconditioning cell. This cell was equipped with a ECE-50 dynamometer, Horiba Mexa 300A HC/CO analyzers, and a Sun Model TUT 1015 engine analyzer. This cell was equipped with heating and cooling capacity to maintain temperatures between $68^{O}F$ and $86^{O}F$. An air curtain was used to isolate the closely controlled soak environment from the preconditioning cell.

Both mass emissions instrument systems conformed to the requirements of 40 CFR 86.177-16. All sample-wetted components in the system were either of stainless steel or Teflon except for the gas cylinder valves and regulators on gases other than nitric oxide (NO) which were brass. Each instrument system was equipped with the following instruments:

- Two Beckman Model 400 Flame Ionization Analyzers with ranges of 0-50 ppmC, 0-100 ppmC, 0-300 ppmC, 0-1000 ppmC, 0-3000 ppmC and 0-10,000 ppmC.

- One Bendix 8501-5C Analyzer with ranges of 0-100 ppm CO and 0-500 ppm CO.

- One Beckman 315B CO Analyzer with ranges of 0-3000 ppm CO, and 0-3 percent CO.

- One Beckman 315B CO Analyzer with ranges of 0-2.5 percent and 0-4.0 percent $CO_2$.

- One TECO Chemiluminescence Analyzer with ranges of 0-100 ppm $NO_x$, 0-250 ppm $NO_x$, and 0-1000 ppm $NO_x$.

- Two Texas Instrument Servo-riter II dual-channel recorders for recording instrument signals.

Each of the two CVS systems conformed to the description of 40 CFR 86.177-16 and included a Mini CVS system for engine out mass emission measurements. All sample-wetted components were either stainless steel, Teflon, or Tedlar. The CVS air dilution filter cart was interconnected to both the CVS and to the vehicle tail pipe using stainless steel convoluted tubing. Adaptors of silicon rubber/fiberglass were used to seal the tubing to the tail pipe. A water-to-air type heat exchanger maintained the CVS pump inlet temperature to within $\pm 10^{0}$F of the nominal set point ($110^{0}$F). Both CVS systems contained nine Tedlar sample collection bags (three were utilized for the engine-out samples) each with a usable volume of 10 cubic feet. Filling of the sample bags was remotely controlled by computer.

The chassis dynamometer in each test cell was a Clayton Model ECE-50-0 utilizing a 1,750-pound Direct Drive Variable Inertia Flywheel (DDVIF) unit. The roll set spacing was 17.2 inches between rolls. The DDVIF provided 11 inertia weight settings 250-pound increments from 1,750 pounds to 3,000 pounds, and 500-pound increments from 3,000 pounds to 5,550 pounds. The dynamometer in Test Cell 1 was equipped for automatic load control and 125-pound increment inertia weights.

A digital voltmeter (DVM) indicating in miles per hour was used to monitor the dynamometer front or rear roll speed. A digital meter, calibrated and scaled to read out directly in indicated horsepower within ±0.1 horsepower, was used to monitor the power absorption unit. Separate revolution counters were used to count and store each segment of the FTP.

The driver's aid was a computer-controlled, Hewlett-Packard recorder onto which the FTP driving cycle was traced by a Hewlett-Packard computer. This hard copy of the desired trace showed all significant events during the cycle, such as cranking, idle, transmission in gear, engine shut-off, and bag switching times. The computer also printed out the crank-time and total test time for the FTP. The driver's aid was also equipped to record dynamometer load and front roll speed during coastdown calibrations and load setting before and after tests. The driver's aid cabinet also included indicator lights which informed the driver and operator of equipment status.

A Hewlett-Packard Model 2114A was used as the mass emission test system controller. The computer system was a real time interrupt system and controlled the functions of both the driver's aid and the CVS. The system operator, using a terminal, entered the test to be conducted and descriptive information. The test driver, using a push-button pendant started the test from the vehicle. After initiation of the test; i.e., engine cranking, all sampling functions were controlled by the computer system. Bag analysis, however, was performed manually.

Additional supportive instruments and equipment which were used for this program included:

- Merriam Model 50MC2-4F Laminar Flow Element including manometers, timers and temperature meters for CVS calibration.
- Sargent-Welch Cat. No. S-4565, Mercury column barometers for ambient pressure measurement in the test cells.
- Rustrak recorders for continuous recording of soak area temperature, wet and dry bulb temperature at the vehicle cooling inlet fan in the test area and CVS pump inlet temperature.
- Sargent-Welch portable motorized psychrometer for recording temperatures during driveability tests.
- Sun Model TUT 1015 engine parameter diagnostic scope.
- Two Sargent-Welch Cat. No. S-42610, motor-ventilated hygrometers for monitoring wet/dry bulb temperatures, modified for continuous reading.
- Water manometers for measurement of CVS inlet pressure and differential pressure of the CVS pump.
- Mettler Model 1200 precision balances for propane recovery tests.
- Hartzell Model N24-DUW cooling fans (instrumented with the motor-ventilated hydrometers).

- Maxon vehicle lift rated at 7,000 pounds.

- A fenced security area at the rear of the facility to provide parking for up to 14 vehicles.

- Raw analysis instrument system for undiluted exhaust sampling containing NDIR HC/CO analyzers and a chemiluminescent $NO_x$ analyzer.

The Mini CVS system was developed by SC to provide a means of determining the mass emissions of HC, CO, $CO_2$, and $NO_x$ before the catalyst. The data obtained from the Mini CVS when compared with the tail pipe emission data provided a means of computing catalytic converter efficiencies. The Mini CVS was a proportional sampling device coupled to a scaled down constant volume sampler. The Mini CVS was designed to duplicate the sampling method used in the CVS. A proportional sample of the engine-out gases was diluted with filtered make-up air such that the total gas flow was kept at a constant flow rate. From this constant volume flow of diluted engine-out gases, a sample was drawn off at a fixed flow rate and stored in a sample bag for analysis later. The total flow in the Mini CVS was maintained at approximately 1.0 cubic feet per minute which was less than one part in 300 of the Maxi CVS flow rate. A proportioning orifice in the engine-out gas stream maintained the engine-out sample flow at a constant proportion ( 0.3 percent) of the total gas flow in the header pipe. This provided approximately the same air dilution ratios for the CVS and Mini CVS which allowed the use of the same analytical instrument system to measure the concentrations of the engine-out and tail pipe bag samples. Since the actual proportioning and air dilution ratios were not constant, a mathematical correction of the engine-out concentrations was made using the principle of carbon mass conservation upstream and downstream of the converter.

### 2.2.5 Selection of Candidate Disablements

The disablements for testing and for the evaluation of field service were specified by ARB. The disablements included components which provided sensory input or controller actuation output signals from the on-board computer, the electronic control module (ECM). Components selected and the method of disablement are shown for each test vehicle in Tables 2-6 through 2-15. In some cases disablements resulted in no-start or no-run conditions; i.e. would not idle or would not run off-idle. These disablements are noted in Tables 2-6 through 2-15, but there is no test data. At least 10 disablements were attempted on each vehicle, but not every vehicle had 10 completed tests.

## 2.3 — FIELD SERVICE EVALUATION

### 2.3.1. Inducement of Selected Disablements

Based on a review of the test data, one disablement was selected by ARB to evaluate field service of each test vehicle. The disablement was induced and the vehicles were then taken to three dealerships. The disablements were selected to give some overt symptom an ordinary driver would be expected to notice. Typical symptoms included driveability problems, warning lights, smoke, or State Motor Vehicle Inspection Program (MVIP) failure reports. Vehicle drivers contacting dealerships described the symptom of failure but did not suggest any probable cause. Symptoms were represented as having suddenly appeared within the last few days.

Table 2-16 summarizes the components, symptoms and method of disablement selected for each vehicle. Disablements were induced so that the mechanics could not easily identify the disablement by visual inspection, but that diagnostic procedures specified by the vehicle manufacturer would lead to identification of the disablement.

### 2.3.2 Selection of Repair Facilities

Repair facilities were selected from the telephone book "yellow pages". All repair facilities were new car dealerships selling the specific make of vehicle. Three dealerships were selected for each vehicle. No dealership was visited more than once. In a few cases, dealerships of vehicles mechanically identical to the test vehicle, but bearing different divisional names; i.e. Ford-Mercury, Dodge-Plymouth, were used. Some dealerships were not licensed Motor Vehicle Pollution Control (MVPC) stations. Except for vehicles failing the MVIP test, this was not a problem as far as getting the vehicle accepted by the dealership for service. Two dealerships declined to service vehicles which failed the MVIP test because they were not MVPC stations.

Table 2-6

DISABLEMENTS FOR VEHICLE #103 (CUTLASS 3.8L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect lead at sensor |
| 2. | Coolant temperature sensor | Disconnect lead at sensor |
| 3. | Throttle position sensor | Disconnect center lead at sensor |
| 4. | Barometric pressure sensor | Disconnect center lead at sensor |
| 5. | Manifold pressure sensor | Disconnect center lead at sensor |
| 6. | Vehicle speed sensor | Disconnect #16 contact at ECM |
| 7. | Park/neutral switch | Disconnect "H" wire at ECM |
| 8. | Throttle switch | Disconnect "B" contact at idle speed controller |
| 9. | Mixture control solenoid | Disconnect at carburetor |
| 10. | Electronic spark timing | Disconnect at distributor |

Table 2-7

DISABLEMENTS FOR VEHICLE #130 (FORD GRANADA 2.3L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2. | Low temperature switch | Disconnect #5 wire at ECM |
| 3. | Idle tracking switch | Disconnect #6 wire at ECM |
| 4. | Vacuum switch | Disconnect #7 wire at ECM |
| 5. | Fuel control solenoid | Disconnect #23 wire at ECM |
| 6. | RPM connection | Disconnect #8 wire at ECM |
| 7. | Power connection (ECM) | Disconnect #20 wire at ECM |
| 8. | Engine block ground wire | Disconnect at block |
| 9. | Power connection (ECM) | Disconnect #20 wire at ignition switch |
| 10. | Diverter air solenoid | Disconnect at solenoid |

Table 2-8

DISABLEMENTS FOR VEHICLE #131 (FORD LTD 5.8L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2. | Coolant temperature sensor | Disconnect light green-yellow wire at sensor |
| 3. | Throttle position sensor | Disconnect dark green-light green wire at sensor |
| 4. | Barometric pressure sensor | Disconnect dark blue-light green wire at sensor |
| 5. | Manifold pressure sensor | Disconnect light green-black wire at sensor |
| 6. | Feedback carburetor actuator | Disconnect at actuator |
| 7.* | Crankshaft position sensor | Disconnect grey wire at sensor |
| 8. | EGR valve position sensor | Disconnect brown-light green wire at sensor |
| 9. | Reference voltage | Disconnect #3 wire at ECM |
| 10.* | Electronic spark timing | Disconnect #17 wire at ECM |
| 11. | Ground connection | Disconnect #19 wire at ECM |
| 12.* | Power connection | Disconnect #24 wire at ECM |
| 13. | $O_2$ sensor ground | Disconnect #7 wire at ECM |

*These disablements would not start.

Table 2-9

DISABLEMENTS FOR VEHICLE #133 (PLYMOUTH RELIANT 2.2L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2. | Coolant switch | Disconnect at switch |
| 3. | Carburetor ground switch | Insulate contactor and reset idle speed to specification |
| 4. | Carburetor feedback solenoid | Disconnect at carburetor |
| 5. | Vacuum actuated electrical switch | Disconnect at switch |
| 6. | Six-way connector | Disconnect at computer |
| 7. | Oil pressure switch | Disconnect at switch |
| 8.* | Computer ground wire | Disconnect #10 wire at ECM (cut wire) |
| 9.* | Distributor ground wire | Disconnect #9 wire at ECM (cut wire) |
| 10. | Idle stop solenoid | Disconnect red wire at solenoid connector |
| 11. | Electric choke heater | Disconnect at choke |
| 12. | Vacuum transducer | Disconnect vacuum hose and plug |

*Disablement 8 started but would not continue running. Disablement 9 would not start.

Table 2-10

DISABLEMENTS FOR VEHICLE #136 (LINCOLN MARK VI 5.0L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2.* | Coolant temperature sensor | Disconnect green/yellow wire at sensor |
| 3.** | Throttle position sensor | Disconnect dark green-green wire at sensor |
| 4. | Barometric sensor | Disconnect dark blue-light green wire at sensor |
| 5. | Manifold pressure sensor | Disconnect light green-black wire at sensor |
| 6. | Air charge temperature sensor | Disconnect green/purple wire at sensor |
| 7.** | Crankshaft position sensor | Disconnect grey wire at harness connector |
| 8.* | EGR valve position sensor | Disconnect brown/green wire at sensor |
| 9.** | Ground connection | Disconnect #3 wire at ECM |
| 10.** | Spark timing | Disconnect orange/yellow wire at ignition module |
| 11.** | Reference voltage | Disconnect #19 wire at ECM |
| 12. | EGR vent solenoid | Disconnect dark green wire at solenoid |
| 13. | EGR control solenoid | Disconnect yellow wire at solenoid |
| 14. | Thermactor air diverter solenoid | Disconnect at solenoid |
| 15. | Coolant temperature sensor | Short at sensor |
| 16. | Air charge temperature sensor | Short at sensor |

*These component disablements would start but were not driveable

**These component disablements would not start

Table 2-11

DISABLEMENTS FOR VEHICLE #137 (CHEVROLET CITATION 2.5L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2. | Coolant temperature sensor | Disconnect at sensor |
| 3. | Idle speed control (ISC) throttle switch | Disconnect #8 wire at ISC |
| 4. | Vacuum sensor | Disconnect #21 wire at sensor connector |
| 5. | Vacuum sensor filter | Disconnect "E" wire at vacuum filter terminal |
| 6. | Park/neutral switch | Disconnect "H" wire at ECM |
| 7. | Fuel metering solenoid | Disconnect at solenoid connector |
| 8. | Idle speed control | Disconnect "M" wire and "F" wire at ECM |
| 9. | Electronic spark timing | Disconnect at distributor connector |
| 10. | Sensor return (ground) | Disconnect #22 wire at ECM |

Table 2-12

DISABLEMENTS FOR VEHICLE #139 (TOYOTA CELICA SUPRA 2.8L)

| DEFECT | COMPONENT | DISABLEMENT |
| --- | --- | --- |
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2.* | Coolant temperature sensor | Disconnect at sensor |
| 3.** | Air flow and temperature connector | Disconnect at air flow sensor |
| 4. | Throttle position switch | Disconnect at switch |
| 5. | Air temperature sensor | Disconnect #11e wire at computer |
| 6.* | Air flow sensor | Disconnect #3f wire at computer |
| 7.* | Ignition switch to computer | Disconnect #5f wire at computer |
| 8.* | Battery lead to computer | Disconnect #6f wire at computer |
| 9.* | Computer ground | Disconnect #7e wire and #8e wire at computer |
| 10.*** | High altitude sensor | Disconnect at sensor |
| 11.** | Throttle position switch (idle) | Short leads #1 and #2 together |
| 12.* | Distributor signal | Disconnect #9f wire at computer |
| 13. | $O_2$ sensor/air temperature sensor | Unplug $O_2$ sensor and #11e wire at computer |
| 14. | Start injector time switch | Disconnect at switch |
| 15.* | Air flow sensor | Disconnect #2f wire at computer |
| 16.** | Air valve | Disconnect at valve |

*These component disablements would not start

**These component disablements would start but would not continue to run

***The test vehicle was not equipped with this component

Table 2-13

DISABLEMENTS FOR VEHICLE #140 (CADILLAC SEDAN DE VILLE 4.1L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2. | Coolant temperature sensor | Disconnect at sensor |
| 3. | Throttle position sensor | Disconnect "B" wire at sensor |
| 4. | Barometric pressure sensor | Disconnect at sensor |
| 5. | Manifold pressure sensor | Disconnect at sensor |
| 6. | Vehicle speed sensor | Disconnect #2 wire in connector P-3 at ECM (orange connector) |
| 7. | Throttle switch | Disconnect "B" wire at idle speed controller |
| 8. | Manifold air temperature sensor | Disconnect at sensor |
| 9. | Transmission position/TCC | Disconnect at connector on transmission |
| 10. | Sensor ground | Disconnect #5 wire in connector P-3 at ECM |

Table 2-14

DISABLEMENTS FOR VEHICLE #143 (BMW 528e 2.7L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect at sensor |
| 2. | Coolant temperature sensor | Disconnect at sensor |
| 3.* | Air flow + temperature connector | Disconnect at air flow meter |
| 4. | Throttle position switch | Disconnect at switch |
| 5. | Air temperature sensor | Disconnect at sensor at air flow meter |
| 6.* | Air flow sensor | Disconnect at sensor |
| 7.* | RPM pick-up | Disconnect at sensor |
| 8.* | Reference point pick-up | Disconnect at sensor |
| 9. | Thermo switch (Coolant) | Disconnect at switch at coolant inlet hose |
| 10. | Idle speed control (ISC) valve | Disconnect #5 wire at ISC unit at ECM |
| 11. | $O_2$ and coolant temperature sensors | Unplug both sensors |
| 12.* | Coolant temperature sensor | Short leads together |
| 13. | $O_2$ and air temperature sensors | Unplug both sensors |

*These component disablements would not start

Table 2-15

DISABLEMENTS FOR VEHICLE #144 (DATSUN 280ZX 2.8L)

| DEFECT | COMPONENT | DISABLEMENT |
|---|---|---|
| 1. | $O_2$ sensor | Disconnect connector |
| 2.* | Cylinder head temperature sensor | Disconnect connector |
| 3.* | Crank angle sensor | Disconnect connector |
| 4. | Vehicle speed sensor | Disconnect #29 wire at ECM harness (cut wire) |
| 5.* | Air flow + temperature connector | Disconnect at air flow meter |
| 6.** | Air flow meter signal | Disconnect #31 wire at ECM (cut wire) |
| 7. | Air temperature sensor | Disconnect #30 wire at ECM (cut wire) |
| 8. | Throttle valve switch | Disconnect connector |
| 9.* | Distributor connection | Disconnect #5 wire at ECM (cut wire) |
| 10. | Detonation sensor | Disconnect sensor |
| 11.* | Park/neutral switch | Disconnect at switch |
| 12. | Vacuum control modulator | Disconnect EGR and idle speed connectors at modulator |
| 13.** | Cylinder head temperature sensor | Short leads together |
| 14.** | Throttle valve switch | Short leads together |
| 15.* | Crank angle sensor | Disconnect #8 or #17 wires at ECM (cut wires) |
| 16.** | Air temperature sensor | Short #30 and #31 wires together at ECM |

*These component disablements would not start

**These component disablements would start but would not continue to run, or were nondriveable

Table 2-16. METHOD OF INDUCING DISABLEMENT FOR FIELD SURVEY

| CAR | CODE | COMPONENT | SYMPTOM | DISABLEMENT METHOD |
|---|---|---|---|---|
| 103 | (OLD) | (3)* Throttle position sensor | "Check Engine" light | Broke #2 contact pin at ECM terminal plug |
| 130 | (GRA) | (8) Engine block ground | Poor fuel economy | Disconnected ground cable at engine |
| 131 | (LTD) | (2) Coolant temperature sensor | Knock | Applied 30 Volts AC to sensor resulting in open circuit |
| 133 | (PLY) | (6) Six-way connector | Poor fuel economy | Unplugged at ECM |
| 136 | (LIN) | (4) Barometric sensor | Failed MVIP | Applied 30 Volts AC to sensor resulting in open circuit |
| 137 | (CIT) | (4) Vacuum sensor | "Check Engine" light | Applied 30 Volts AC to sensor resulting in open circuit |
| 139 | (TOY) | (13) $O_2$ and air temperature sensors | Poor fuel economy | Unplugged $O_2$ sensor lead and disconnected terminal pin of #11e wire at air temperature sensor terminal |
| 140 | (CAD) | (6) Vehicle speed sensor | "Check Engine" light | Applied 30 Volts AC to fuse in vehicle speed sensor resulting in open circuit |
| 143 | (BMW) | (10) Idle speed control valve | Unstable idle speed | Unsoldered wire from terminal pin of #5 wire at control valve connector |
| 144 | (DAT) | (1) $O_2$ sensor | Failed MVIP | Unplugged $O_2$ sensor lead |

*Numbers in parenthesis are defect numbers for each car

## .4 ASSESSMENT OF DIAGNOSIS AND REPAIR

### 2.4.1 Types of Diagnostic Systems

Three fundamental diagnostic system approaches were utilized by the manufacturers of vehicles in this project: 1) on-board diagnostic fault codes and warning lights (GM cars only), 2) remote diagnostic testers which could be connected to the electronic control system to provide fault codes (most cars), and 3) diagnostic procedures using normal garage-type test equipment (Chrysler car). Most manufacturers of remote diagnostic systems also provided quick functional diagnostic procedures based on garage-type equipment.

### 2.4.2. Symptoms of Component Failures

Symptoms of component failures were categorized for each disablement. The symptoms generally fell into the following categories: 1) no detectable effect, 2) FTP emissions/fuel economy effect not detectable by vehicle operator, 3) MVIP emission test failure, 4) overt performance deterioration detectable by vehicle operator and 5) warning light. The assessment of diagnosis and repair intentionally excluded categories 1 and 2 as conditions which would not generate a repair facility visit by the typical vehicle owner. The category 3 symptom, MVIP test failure, was used only if there were no category 4 or 5 symptoms. Specific symptoms for each disablement are presented in Section 3.

### 2.4.3 Detection of Failures

Detection of failures was evaluated in two parts. The first evaluation considered all disablements induced on each vehicle and rated the detectability of the defect by the vehicle driver. This evaluation was performed by assigning a point score to each disablement using the following formula:

$$\text{Driver Index} = \frac{D + I + W + N}{15} \times 100\%$$

where:

Index = relative detectability of component defect

D = 0 for no change or reduction in driveability demerits

1 for marginal increase in driveability demerits

2 for moderate increase in driveability demerits

4 for substantial increase in driveability demerits

I = 0 for passing inspection test results

1 for failing inspection test results

W = 0 for warning light off or not installed

10 for warning light on

N = 0 for driveability condition resulting in complete test

15 for non driveable condition

This formula resulted in a point score ranging from "0" for a disablement which was undetectable to a "15" for a disablement which caused a warning light, severe driveability problems and an inspection test failure. A non-driveable condition also resulted in a score of "15". The actual score expressed as a percent of 15 was reported for each disablement on each car.

The second part of the evaluation involved the ability of dealerships to detect the implanted disablement. In this evaluation the three dealer visits for each car were rated according to the following formula:

$$\text{Service Index (S)} = \frac{\sum \text{Dealer Score}}{15} \times 100\%$$

Where the Dealer Score was:

0 = no apparent attempt to identify defect

1 = appeared to perform some diagnostic effort but did not find defect

2 = performed sufficient diagnostic effort to identify basic problem, i.e. failed circuit although specific disablement was not detected.

5 = identified specific disablement as shown by actual repair or by ordering of correct replacement part.

For each of the ten cars, the dealership evaluation could have a score ranging from "0" to "15". The actual score expressed as a percent of 15 was reported for each car.

### 2.4.4 Correction of Failures

The effectiveness of repair was not measured quantitatively since no tests were performed after repair and most vehicles were not repaired even though a correct diagnosis might have been performed. However, an approximate measure of effective repair could be made by determining the relative number of Type 2 and 5 diagnoses that were performed for each diagnostic system.

Section 3

# RESULTS

This section describes the results of the test program. Separate subsections are devoted to the following:

- o Effect of disabling electronic emission controls
- o Effectiveness of field service
- o On-board versus remote diagnostic systems

## 3.1 EFFECT OF DISABLING ELECTRONIC EMISSION CONTROLS

This section discusses the following topics:

- o Presentation of test data
- o Emissions
- o Fuel economy
- o Driveability

### 3.1.1 Presentation of Test Data

The emission and fuel economy test data were reduced to grams per mile and miles per gallon in accordance with standard formulas incorporated in the FTP. Engine-out emissions and converter efficiencies were computed based on carbon balance principles. This was accomplished by multiplying the diluted engine-out emission component concentration by a carbon ratio which was the total carbon mole percent in the tailpipe exhaust sample divided by the total carbon mole percent in the engine-out exhaust sample. The formula to determine the carbon value was:

$$\text{Carbon ratio} = \frac{\text{Tailpipe }(CO_{2\,ppm} + CO_{ppm} + HC_{ppm})}{\text{Engine-out }(CO_{2\,ppm} + CO_{ppm} + HC_{ppm})}$$

The carbon ratio represented the relative difference in dilution of the engine-out sample and the tailpipe sample. The ratio permitted adjustment of the measured engine-out emission component concentrations to the level that would have been measured if the dilution ratio of the engine-out sample had been the same as for the tailpipe sample. This adjustment then permitted engine-out mass emission calculations using the CVS total flow volume.

Converter efficiencies were computed from the tailpipe and engine-out mass emissions as follows:

$$\text{Percent converter efficiency} = \frac{(\text{Engine-out}) - (\text{Tailpipe})}{\text{Engine-out}} \times 100\%$$

Driveability data was reduced to weighted demerits for each data sheet (three warm driveability tests and one cold driveability test) for each disablement. The demerits for the three warm driveability tests were averaged to provide a single measure of warm driveability. The weighting factors were defined in the ARB procedure and were as follows for each malfunction:

| | Demerits | | | | Weighting Factor |
|---|---|---|---|---|---|
| Malfunction Rated | Trace | Moderate | Heavy | Yes | |
| Idle Roughness | 1 | 2 | 3 | - | 1 |
| Hesitation | 1 | 3 | 6 | - | 4 |
| Stretchiness | 1 | 3 | 6 | - | 4 |
| Stumble | 1 | 3 | 6 | - | 4 |
| Surge | 1 | 2 | 3 | - | 3 |
| Stall at Start | - | - | - | 6 | 2 |
| Stall, Driving | - | - | - | 6 | 6 |
| Backfire | 1 | 2 | 3 | - | 3 |
| Detonation | 1 | 3 | 6 | - | 2 |
| Dieseling | - | - | - | 6 | 1 |
| Starting Time - Time per each Start (Seconds - 2.0) (If value negative, use 0 demerits) | | | | | 1 |

Where:

Trace - intermittent or barely detectable by rater, probably not detectable by ordinary drivers

Moderate - easily detectable by rater, probably detectable by ordinary driver

Heavy - easily detectable by both rater and ordinary driver and probably objectionable to driver

Hesitation - temporary lack of initial response in accelerate rate when throttle is depressed

Stretchiness - lack of anticipated response to throttle movement during light to moderate acceleration from a steady state condition at road load

Stumble - short, sharp reduction in acceleration rate

Surge - short, sharp fluctuations in speed from a steady state condition at any speed and/or load

Detonation - ping or knock which is audible

Dieseling - engine continues to run after ignition is turned off

For comparison with other ARB programs, driveability was also reported in terms of an ARB scale which is 100 minus the total demerits (cold, plus average of hot driveability). The ARB scale in other programs related numerical score to overall driveability quality. The ARB scale is described below. Further discussion is contained in Section 3.1.4.

| ARB Scale | General Driveability Evaluations |
|---|---|
| 100 | No trace of any undesireable element can be found and in addition, the car has exceptionally good responsive feel under all conditions. |
| 90 | No trace of any undesireable element can be found but lacking the responsiveness and feel of a 100 rating |
| 80 | Traces of undesireable elements can be found by the trained observer. |
| 70 | One or more undesireable characteristics can be found by the trained observer (Examples are light surge or off idle flatness). |
| 60 | The undesireable characteristics are definitely noticeable but not objectionable to the critical driver. (Examples are moderate surge, sags and/or stumble). |
| 50 | The undesireable characteristics are obvious and somewhat irritating to the common driver and may lead to complaints by the critical driver. (Examples are medium surge, sags and/or stumble). |
| Unacceptable | |
| 40 | Heavy surges, sags and/or stumbles where the average customer would definitely seek corrective action. |
| 30 | Condition which undermines driver's confidence in the car's ability to perform reliably at all times. Severe surge, sags and/or stumbles. |

20 Failure of the engine to continue running while being driven around. Examples are deceleration die-outs.

10 A condition exists which could cause upredictable driveability during normal operations. An engine will stall irrespective of vehicle movement.

Test data were tabulated (Tables 3-1 through 3-10) for each vehicle showing the initial baseline test, the completed disablement tests (up to 10), the final baseline test, the average of the baseline tests and the $\pm$90% confidence interval limits for the following data:

FTP emissions in grams per mile (HC, CO, $NO_x$)
HFET emissions in grams per mile (HC, CO, $NO_x$)
FTP converter efficiency in percent (HC, CO, $NO_x$)
Fuel economy in miles per gallon (FTP, HFET)
ARB loaded mode test emissions in ppm or % (HC, CO, $NO_x$
for high cruise, low cruise and idle)
ARB driveability test in demerits (cold, hot, total and ARB
scale, i.e., 100-Total)

The defect codes in the tables correspond to the defect numbers in Tables 2-6 through 2-15. The initial baseline data are coded "0.0". The final baseline data are coded "0.1". Table 3-11 shows a master matrix of car number, defect code, and component name.

The percent increase or decrease of the disablement data compared to the average of the baseline tests was tabulated. A code (1, 2, or 3) was used to show if the disablement test data were outside the $\pm$90%, $\pm$95% or $\pm$99% confidence limit respectively. In those cases of the baseline test standard deviation equalling 0, the confidence interval was computed based on an arbitrary estimate of scatter given by the mean value plus and minus 10% of mean. In a few cases, the mean of the baseline tests equalled zero. In these cases (only ARB Loaded Mode Test data), the confidence interval was computed based on a standard deviation of 0.01414. These tables are shown in the Appendix.

Table 3-1. SUMMARY TEST DATA FOR CAR #103 - 1981 OLDSMOBILE CUTLASS 3.8L

| DEFECT | CVS EMISSIONS (GM/MI) FTP | | | HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG. ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.39 | 5.68 | 0.94 | 0.03 | 0.64 | 0.28 | 84. | 63. | 66. | 20.64 | 29.66 |
| 1.0 | 0.39 | 2.34 | 2.35 | 0.02 | 0.00 | 2.29 | 87. | 64. | 8. | 21.03 | 30.83 |
| 2.0 | 1.02 | 25.70 | 2.48 | 0.95 | 43.26 | 0.50 | 56. | 56. | 31. | 17.76 | 25.51 |
| 3.0 | 0.43 | 5.97 | 0.85 | 0.25 | 4.39 | 0.15 | 81. | 66. | 73. | 18.98 | 30.00 |
| 4.0 | 0.65 | 14.28 | 0.22 | 0.33 | 7.67 | 0.02 | 72. | 46. | 71. | 16.67 | 22.68 |
| 5.0 | 0.46 | 6.52 | 0.64 | 0.19 | 3.63 | 0.16 | 81. | 63. | 76. | 20.69 | 29.94 |
| 6.0 | 0.52 | 7.44 | 0.59 | 0.32 | 5.13 | 0.18 | 79. | 59. | 74. | 20.56 | 28.29 |
| 7.0 | 0.49 | 6.98 | 0.56 | 0.24 | 4.06 | 0.14 | 80. | 59. | 76. | 21.04 | 30.99 |
| 8.0 | 0.41 | 5.48 | 0.82 | 0.20 | 3.11 | 0.16 | 82. | 67. | 75. | 19.17 | 29.84 |
| 9.0 | 3.44 | 112.20 | 0.62 | 1.69 | 74.72 | 0.46 | 0. | 0. | 34. | 17.42 | 24.89 |
| 10.0 | 3.14 | 125.56 | 0.29 | 1.49 | 97.00 | 0.11 | 5. | 0. | 38. | 14.10 | 19.31 |
| 0.1 | 0.45 | 6.79 | 0.51 | 0.05 | 0.62 | 0.20 | 87. | 64. | 73. | 20.99 | 30.80 |
| AVERB | 0.42 | 6.24 | 0.73 | 0.04 | 0.63 | 0.24 | 86. | 64. | 70. | 20.82 | 30.23 |
| -90%CL | 0.23 | 2.73 | -0.63 | -0.02 | 0.57 | -0.01 | 76. | 60. | 47. | 19.71 | 26.63 |
| +90%CL | 0.61 | 9.74 | 2.08 | 0.10 | 0.69 | 0.49 | 95. | 67. | 92. | 21.92 | 33.83 |
| AVERD | 1.10 | 31.25 | 0.94 | 0.57 | 24.30 | 0.42 | 62. | 48. | 56. | 18.74 | 27.23 |

DISABLEMENTS

1. Disconnect $O_2$ Sensor
2. Disconnect coolant temperature sensor
3. Disconnect center lead of throttle position sensor
4. Disconnect center lead of barometric pressure sensor
5. Disconnect center lead of manifold pressure sensor
6. Disconnect #16 contact at ECM (vehicle speed sensor)
7. Disconnect "H" wire at ECM (Park/neutral switch)
8. Disconnect "B" contact at idle speed controller (throttle switch)
9. Disconnect mixture control solenoid at carburetor
10. Disconnect electronic spark timing at distributor

AVERB - Means average of baseline tests on each car
AVERD - Means average of all disablement tests on each car

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILI TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TOTA |
| 0.0 | 30. | 0.01 | 825. | 40. | 0.03 | 1175. | 20. | 0.01 | 78. | 20. | 12. | 32. |
| 1.0 | 25. | 0.01 | 900. | 30. | 0.01 | 1150. | 10. | 0.00 | 50. | 62. | 64. | 126. |
| 2.0 | 85. | 3.20 | 900. | 110. | 3.50 | 750. | 200. | 0.80 | 100. | 5. | 8. | 13. |
| 3.0 | 35. | 0.32 | 26. | 35. | 0.32 | 55. | 7. | 0.02 | 10. | 11. | 13. | 24. |
| 4.0 | 20. | 0.35 | 15. | 30. | 0.20 | 8. | 12. | 0.02 | 5. | 139. | 57. | 196. |
| 5.0 | 24. | 0.20 | 60. | 30. | 0.35 | 110. | 75. | 0.10 | 15. | 44. | 91. | 135. |
| 6.0 | 45. | 0.30 | 88. | 40. | 0.30 | 125. | 25. | 0.03 | 5. | 39. | 19. | 58. |
| 7.0 | 42. | 0.22 | 27. | 40. | 0.30 | 85. | 200. | 0.16 | 5. | 62. | 29. | 91. |
| 8.0 | 34. | 0.10 | 10. | 30. | 0.16 | 25. | 10. | 0.01 | 25. | 61. | 31. | 92. |
| 9.0 | 175. | 3.20 | 250. | 195. | 2.30 | 325. | 580. | 2.30 | 20. | 25. | 7. | 32. |
| 10.0 | 70. | 4.00 | 35. | 85. | 2.00 | 40. | 150. | 1.50 | 3. | 186. | 28. | 214. |
| 0.1 | 20. | 0.00 | 275. | 25. | 0.01 | 450. | 17. | 0.01 | 35. | 32. | 12. | 44. |
| AVERB | 25. | 0.00 | 550. | 33. | 0.02 | 812. | 19. | 0.01 | 57. | 26. | 12. | 38. |
| -90%CL | -7. | -0.03 | -1186. | -15. | -0.04 | -1476. | 9. | 0.00 | -79. | -12. | 4. | ( |
| +90%CL | 57. | 0.04 | 2286. | 80. | 0.08 | 3101. | 28. | 0.02 | 192. | 64. | 20. | 7 |
| AVERD | 56. | 1.19 | 231. | 62. | 0.94 | 267. | 127. | 0.49 | 24. | 63. | 35. | 98 |

Table 3-1. SUMMARY TEST DATA FOR CAR #103 - 1981 OLDSMOBILE CUTLASS 3.8L (CONTIN[illegible])

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TOT |
| 0.0 | 30. | 0.01 | 825. | 40. | 0.03 | 1175. | 20. | 0.01 | 78. | 20. | 12. | 32 |
| 1.0 | 25. | 0.01 | 900. | 30. | 0.01 | 1150. | 10. | 0.00 | 50. | 62. | 64. | 126 |
| 2.0 | 85. | 3.20 | 900. | 110. | 3.50 | 750. | 200. | 0.80 | 100. | 5. | 8. | 13 |
| 3.0 | 35. | 0.32 | 26. | 35. | 0.32 | 55. | 7. | 0.02 | 10. | 11. | 13. | 24 |
| 4.0 | 20. | 0.35 | 15. | 30. | 0.20 | 8. | 12. | 0.02 | 5. | 139. | 57. | 196 |
| 5.0 | 24. | 0.20 | 60. | 30. | 0.35 | 110. | 75. | 0.10 | 15. | 44. | 91. | 135 |
| 6.0 | 45. | 0.30 | 88. | 40. | 0.30 | 125. | 25. | 0.03 | 5. | 39. | 19. | 58 |
| 7.0 | 42. | 0.22 | 27. | 40. | 0.30 | 85. | 200. | 0.16 | 5. | 62. | 29. | 91 |
| 8.0 | 34. | 0.10 | 10. | 30. | 0.16 | 25. | 10. | 0.01 | 25. | 61. | 31. | 92 |
| 9.0 | 175. | 3.20 | 250. | 195. | 2.30 | 325. | 580. | 2.30 | 20. | 25. | 7. | 32 |
| 10.0 | 70. | 4.00 | 35. | 85. | 2.00 | 40. | 150. | 1.50 | 3. | 186. | 28. | 214 |
| 0.1 | 20. | 0.00 | 275. | 25. | 0.01 | 450. | 17. | 0.01 | 35. | 32. | 12. | 44 |
| AVERB | 25. | 0.00 | 550. | 33. | 0.02 | 812. | 19. | 0.01 | 57. | 26. | 12. | 38 |
| -90%CL | -7. | -0.03 | -1186. | -15. | -0.04 | -1476. | 9. | 0.00 | -79. | -12. | 4. | |
| +90%CL | 57. | 0.04 | 2286. | 80. | 0.08 | 3101. | 28. | 0.02 | 192. | 64. | 20. | 7 |
| AVERD | 56. | 1.19 | 231. | 62. | 0.94 | 267. | 127. | 0.49 | 24. | 63. | 35. | 98 |

Table 3-2. SUMMARY TEST DATA FOR CAR #130 - 1981 FORD GRANADA 2.3L

| DEFECT | CVS EMISSIONS (GM/MI) FTP | | | HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.27 | 3.05 | 0.65 | 0.04 | 0.01 | 0.34 | 91. | 92. | 94. | 20.00 | 27.86 |
| 1.0 | 0.42 | 4.67 | 0.67 | 0.12 | 0.46 | 0.52 | 87. | 93. | 32. | 19.39 | 26.23 |
| 2.0 | 0.30 | 3.89 | 1.42 | 0.08 | 0.01 | 2.02 | 89. | 92. | 7. | 19.98 | 28.23 |
| 3.0 | 1.68 | 32.64 | 0.77 | 1.10 | 15.67 | 0.10 | 40. | 32. | 59. | 20.09 | 28.32 |
| 4.0 | 0.29 | 3.02 | 0.73 | 0.01 | 0.01 | 0.43 | 89. | 90. | 60. | 20.31 | 27.85 |
| 5.0 | 0.30 | 5.06 | 0.65 | 0.12 | 0.34 | 0.56 | 90. | 94. | 34. | 18.93 | 26.59 |
| 6.0 | 0.37 | 3.95 | 0.90 | 0.12 | 0.07 | 0.57 | 86. | 91. | 42. | 20.13 | 27.81 |
| 7.0 | 2.92 | 109.81 | 0.67 | 1.61 | 35.29 | 0.19 | 6. | -5. | 56. | 17.20 | 26.96 |
| 8.0 | 3.31 | 268.46 | 0.64 | 1.66 | 108.98 | 0.25 | 1. | -2. | 51. | 11.57 | 19.85 |
| 9.0 | 3.13 | 79.81 | 0.76 | 1.64 | 34.92 | 0.26 | 6. | -9. | 56. | 17.71 | 24.97 |
| 10.0 | 0.34 | 3.35 | 1.56 | 0.08 | 0.02 | 1.80 | 87. | 95. | 2. | 17.67 | 25.54 |
| 0.1 | 0.27 | 2.42 | 0.86 | 0.04 | 0.02 | 0.47 | 89. | 91. | 55. | 20.51 | 28.44 |
| AVERB | 0.27 | 2.74 | 0.75 | 0.04 | 0.01 | 0.41 | 90. | 92. | 75. | 20.26 | 28.15 |
| -90%CL | 0.10 | 0.75 | 0.09 | 0.01 | -0.02 | -0.01 | 84. | 88. | -49. | 18.64 | 26.32 |
| +90%CL | 0.44 | 4.72 | 1.42 | 0.07 | 0.05 | 0.82 | 96. | 95. | 198. | 21.87 | 29.98 |
| AVERD | 1.31 | 51.47 | 0.88 | 0.65 | 19.58 | 0.67 | 58. | 57. | 40. | 18.30 | 26.24 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
2. Disconnect #5 wire at ECM (low temperature switch)
3. Disconnect #6 wire at ECM (idle tracking switch)
4. Disconnect #7 wire at ECM (vacuum switch)
5. Disconnect #23 wire at ECM (fuel control solenoid)
6. Disconnect #8 wire at ECM (RPM connection)
7. Disconnect #20 wire at ECM (power connection)
8. Disconnect ground wire at engine block
9. Disconnect #20 wire at ignition switch
10. Disconnect diverter air solenoid

AVERB - Means average baseline tests on each car
AVERD - Means average of all disablement tests on each car

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

Table 3-2. SUMMARY TEST DATA FOR CAR #130 - 1981 Ford Granada 2.3L (Continued)

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TOT |
| 0.0 | 27. | 0.00 | 80. | 18. | 0.00 | 80. | 22. | 0.00 | 40. | 40. | 17. | 57 |
| 1.0 | 37. | 0.01 | 420. | 32. | 0.09 | 175. | 25. | 0.01 | 50. | 30. | 12. | 42 |
| 2.0 | 30. | 0.00 | 875. | 30. | 0.01 | 660. | 25. | 0.01 | 60. | 37. | 15. | 52 |
| 3.0 | 25. | 0.01 | 875. | 155. | 0.90 | 45. | 230. | 3.20 | 13. | 13. | 9. | 22 |
| 4.0 | 175. | 0.01 | 118. | 150. | 0.01 | 115. | 230. | 2.30 | 5. | 42. | 5. | 47 |
| 5.0 | 35. | 0.01 | 375. | 32. | 0.07 | 180. | 23. | 0.04 | 48. | 23. | 4. | 27 |
| 6.0 | 65. | 0.00 | 170. | 70. | 0.01 | 95. | 68. | 0.01 | 25. | 25. | 5. | 30 |
| 7.0 | 173. | 2.25 | 200. | 210. | 3.10 | 65. | 265. | 3.40 | 5. | 24. | 5. | 29 |
| 8.0 | 160. | 0.60 | 165. | 205. | 0.80 | 65. | 270. | 1.40 | 15. | 42. | 7. | 49 |
| 9.0 | 165. | 1.80 | 225. | 200. | 2.90 | 20. | 250. | 2.50 | 10. | 28. | 7. | 35 |
| 10.0 | 15. | 0.01 | 700. | 17. | 0.04 | 420. | 15. | 0.01 | 58. | 33. | 7. | 40 |
| 0.1 | 15. | 0.01 | 142. | 23. | 0.01 | 107. | 23. | 0.00 | 43. | 38. | 7. | 45 |
| AVERB | 21. | 0.00 | 111. | 21. | 0.00 | 94. | 23. | 0.00 | 42. | 39. | 12. | 51 |
| -90%CL | -17. | -0.03 | -85. | 5. | -0.03 | 8. | 19. | -0.06 | 32. | 33. | -20. | 1 |
| +90%CL | 59. | 0.04 | 307. | 36. | 0.04 | 179. | 26. | 0.06 | 51. | 45. | 44. | 8 |
| AVERD | 88. | 0.47 | 412. | 110. | 0.79 | 184. | 140. | 1.29 | 29. | 30. | 8. | 37 |

Table 3-3. SUMMARY TEST DATA FOR CAR #131 - 1981 FORD LTD. 5.8L

| DEFECT | CVS EMISSIONS (GM/MI) FTP | | | HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.23 | 1.57 | 0.61 | 0.05 | 0.02 | 0.38 | 92. | 94. | 55. | 15.79 | 25.93 |
| 1.0 | 0.46 | 3.82 | 0.68 | 0.10 | 0.35 | 0.47 | 88. | 94. | 42. | 13.91 | 24.77 |
| 2.0 | 3.58 | 85.47 | 0.75 | 1.68 | 45.83 | 0.55 | 5. | 3. | 83. | 13.81 | 23.18 |
| 3.0 | 0.31 | 1.97 | 0.62 | 0.06 | 0.01 | 0.43 | 91. | 93. | 48. | 15.56 | 26.23 |
| 4.0 | 0.33 | 1.58 | 0.69 | 0.05 | 0.03 | 0.51 | 90. | 94. | 49. | 16.11 | 26.59 |
| 5.0 | 0.32 | 2.42 | 0.50 | 0.08 | 0.85 | 0.25 | 90. | 96. | 46. | 13.34 | 22.17 |
| 6.0 | 0.40 | 1.96 | 0.77 | 0.10 | 0.14 | 0.54 | 88. | 96. | 47. | 15.40 | 26.02 |
| 8.0 | 0.23 | 1.31 | 2.45 | 0.04 | 0.01 | 1.33 | 93. | 96. | 68. | 15.62 | 25.07 |
| 9.0 | 0.61 | 3.18 | 1.81 | 0.03 | 0.32 | 0.36 | 84. | 98. | 57. | 15.40 | 26.40 |
| 11.0 | 3.41 | 77.70 | 1.08 | 1.50 | 41.08 | 0.97 | 2. | -1. | 78. | 14.01 | 23.62 |
| 13.0 | 0.33 | 3.18 | 0.69 | 0.10 | 0.50 | 0.45 | 90. | 95. | 42. | 15.43 | 25.91 |
| 0.1 | 0.31 | 1.64 | 0.69 | 0.34 | 0.01 | 0.45 | 90. | 94. | 51. | 16.28 | 26.89 |
| AVERB | 0.27 | 1.61 | 0.65 | 0.20 | 0.01 | 0.41 | 91. | 94. | 53. | 16.03 | 26.41 |
| -90%CL | 0.02 | 1.38 | 0.40 | -0.72 | -0.02 | 0.19 | 85. | 35. | 40. | 14.49 | 23.38 |
| +90%CL | 0.52 | 1.83 | 0.90 | 1.11 | 0.05 | 0.64 | 97. | 153. | 66. | 17.58 | 29.44 |
| AVERD | 1.00 | 18.26 | 1.00 | 0.37 | 8.91 | 0.59 | 72. | 76. | 56. | 14.86 | 25.00 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
2. Disconnect light green-yellow wire at coolant temperature sensor
3. Disconnect dark green-light green wire at throttle position sensor
4. Disconnect dark blue-light green wire at barometric pressure sensor
5. Disconnect light green-black wire at manifold pressure sensor
6. Disconnect feedback carburetor actuator
7. Disconnect grey wire at crankshaft position sensor
8. Disconnect brown-light green wire at EGR valve position sensor
9. Disconnect #3 wire at ECM (reference voltage)
10. Disconnect #17 wire at ECM (electric spark timing)
11. Disconnect #19 wire at ECM (ground connection)
12. Disconnect #24 wire at ECM (power connection)
13. Disconnect #7 wire at ECM ($O_2$ sensor ground)

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

Table 3-3. SUMMARY TEST DATA FOR CAR #131 1981 FORD LTD 5.8L (CONTINUED)

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 15. | 0.00 | 100. | 25. | 0.02 | 145. | 20. | 0.01 | 10. | 14. | 8. | 2 |
| 1.0 | 25. | 0.00 | 220. | 35. | 0.05 | 300. | 25. | 0.03 | 25. | 28. | 7. | 3 |
| 2.0 | 260. | 1.75 | 225. | 240. | 1.70 | 170. | 320. | 4.10 | 5. | 66. | 59. | 12 |
| 3.0 | 20. | 0.10 | 75. | 27. | 0.02 | 183. | 23. | 0.01 | 10. | 16. | 6. | 2 |
| 4.0 | 15. | 0.10 | 115. | 22. | 0.03 | 323. | 13. | 0.00 | 18. | 47. | 4. | 5 |
| 5.0 | 20. | 0.02 | 82. | 17. | 0.03 | 150. | 32. | 0.05 | 32. | 20. | 1. | 2 |
| 6.0 | 23. | 0.00 | 225. | 30. | 0.05 | 315. | 25. | 0.02 | 30. | 8. | 6. | 1 |
| 8.0 | 10. | 0.00 | 250. | 25. | 0.01 | 325. | 14. | 0.00 | 20. | 154. | 69. | 22 |
| 9.0 | 15. | 0.00 | 500. | 13. | 0.00 | 950. | 20. | 0.01 | 30. | 154. | 94. | 24 |
| 11.0 | 127. | 2.25 | 680. | 125. | 2.10 | 473. | 800. | 4.00 | 1. | 340. | 110. | 45 |
| 13.0 | 25. | 0.20 | 160. | 22. | 0.20 | 276. | 450. | 5.50 | 8. | 25. | 54. | 7 |
| 0.1 | 15. | 0.00 | 115. | 22. | 0.01 | 190. | 17. | 0.01 | 18. | 36. | 2. | 3 |
| AVERB | 15. | 0.00 | 108. | 24. | 0.01 | 168. | 19. | 0.01 | 14. | 25. | 5. | 3 |
| -90%CL | 6. | -0.06 | 60. | 14. | -0.02 | 25. | 9. | 0.00 | -11. | -44. | -14. | - |
| +90%CL | 24. | 0.06 | 155. | 33. | 0.05 | 310. | 28. | 0.02 | 39. | 94. | 24. | |
| AVERD | 54. | 0.44 | 253. | 56. | 0.42 | 347. | 172. | 1.37 | 18. | 86. | 41. | 12 |

AVERB - Means average of baseline tests on each car

AVERD - Means average of all disablement tests on each car

Table 3-4. SUMMARY TEST DATA FOR CAR #133 - 1981 PLYMOUTH RELIANT 2.2L

| DEFECT | CVS EMISSIONS (GM/MI) FTP | | | HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.34 | 4.67 | 0.61 | 0.04 | 0.37 | 0.42 | 88. | 92. | 41. | 22.24 | 34.71 |
| 1.0 | 0.26 | 9.40 | 0.38 | 0.14 | 13.34 | 0.30 | 93. | 91. | 15. | 20.97 | 29.89 |
| 2.0 | 0.33 | 4.01 | 0.52 | 0.04 | 0.18 | 0.41 | 89. | 93. | 46. | 22.59 | 35.97 |
| 3.0 | 0.23 | 1.86 | 0.46 | 0.03 | 0.00 | 0.41 | 91. | 92. | 63. | 24.55 | 36.16 |
| 4.0 | 0.91 | 28.94 | 0.28 | 0.67 | 53.33 | 0.14 | 81. | 77. | 27. | 19.40 | 24.93 |
| 5.0 | 0.44 | 7.24 | 0.47 | 0.04 | 0.08 | 0.36 | 86. | 89. | 48. | 22.68 | 35.93 |
| 6.0 | 1.16 | 13.35 | 0.27 | 0.36 | 34.86 | 0.15 | 75. | 88. | 32. | 20.78 | 27.03 |
| 7.0 | 2.39 | 73.23 | 0.19 | 0.21 | 17.53 | 0.18 | 65. | 61. | 17. | 16.02 | 28.01 |
| 10.0 | 0.28 | 3.70 | 0.53 | 0.04 | 0.06 | 0.37 | 92. | 94. | 47. | 22.63 | 35.79 |
| 11.0 | 0.64 | 11.16 | 0.56 | 0.01 | 0.00 | 0.40 | 82. | 66. | 53. | 20.99 | 35.51 |
| 12.0 | 0.32 | 5.70 | 0.53 | 0.08 | 0.44 | 0.16 | 89. | 90. | 36. | 21.71 | 30.85 |
| 0.1 | 0.34 | 3.75 | 0.55 | 0.03 | 0.08 | 0.42 | 89. | 94. | 46. | 22.66 | 35.77 |
| AVERB | 0.34 | 4.21 | 0.58 | 0.04 | 0.23 | 0.42 | 89. | 93. | 44. | 22.45 | 35.24 |
| -90%CL | 0.13 | 1.31 | 0.39 | 0.00 | -0.69 | 0.15 | 85. | 87. | 28. | 21.12 | 31.89 |
| +90%CL | 0.55 | 7.11 | 0.77 | 0.07 | 1.14 | 0.69 | 92. | 99. | 59. | 23.78 | 38.59 |
| AVERD | 0.70 | 15.86 | 0.42 | 0.16 | 11.98 | 0.29 | 84. | 84. | 38. | 21.23 | 32.01 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
2. Disconnect coolant switch
3. Insulate contactor on carburetor ground switch and reset idle speed to specification
4. Disconnect carburetor feedback solenoid
5. Disconnect vacuum actuated eletrical switch
6. Disconnect six-way connector at computer
7. Disconnect oil pressure switch
10. Disconnect red wire at solenoid connector on idle stop solenoid
11. Disconnect electric choke heater
12. Disconnect and plug vacuum hose on vacuum transducer

STANDARDS (GRAMS/MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

AVERB - Means average of baseline tests on each car
AVERD - Means average of all disablement tests on each car

Table 3-4. SUMMARY TEST DATA FOR CAR #133 - 1981 PLYMOUTH RELIANT 2.2L (CONTINUED)

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TOT |
| 0.0 | 15. | 0.01 | 100. | 25. | 0.02 | 150. | 23. | 0.01 | 35. | 32. | 27. | 59 |
| 1.0 | 17. | 0.01 | 308. | 20. | 0.01 | 407. | 17. | 0.01 | 55. | 38. | 23. | 61 |
| 2.0 | 10. | 0.01 | 75. | 18. | 0.01 | 145. | 18. | 0.01 | 35. | 22. | 27. | 49 |
| 3.0 | 23. | 0.01 | 105. | 18. | 0.01 | 125. | 20. | 0.01 | 0. | 104. | 52. | 156 |
| 4.0 | 18. | 0.02 | 110. | 38. | 1.10 | 67. | 26. | 0.03 | 30. | 26. | 16. | 42 |
| 5.0 | 20. | 0.01 | 85. | 25. | 0.01 | 125. | 25. | 0.01 | 27. | 50. | 22. | 72 |
| 6.0 | 10. | 0.10 | 75. | 23. | 0.36 | 60. | 17. | 0.07 | 33. | 33. | 27. | 60 |
| 7.0 | 22. | 1.10 | 70. | 38. | 0.45 | 58. | 30. | 0.07 | 30. | 46. | 41. | 87 |
| 10.0 | 24. | 0.01 | 100. | 23. | 0.00 | 118. | 33. | 0.02 | 30. | 52. | 45. | 97 |
| 11.0 | 25. | 0.02 | 85. | 23. | 0.02 | 125. | 40. | 0.02 | 15. | 43. | 33. | 76 |
| 12.0 | 30. | 0.22 | 100. | 15. | 0.00 | 100. | 25. | 0.00 | 25. | 36. | 41. | 77 |
| 0.1 | 23. | 0.01 | 105. | 28. | 0.00 | 125. | 27. | 0.01 | 30. | 36. | 37. | 73 |
| AVERB | 19. | 0.01 | 103. | 27. | 0.01 | 138. | 25. | 0.01 | 33. | 34. | 32. | 66 |
| -90%CL | -6. | 0.00 | 87. | 17. | -0.05 | 59. | 12. | 0.00 | 17. | 21. | 0. | 2[illegible] |
| +90%CL | 44. | 0.02 | 118. | 36. | 0.07 | 216. | 38. | 0.02 | 48. | 47. | 64. | 11[illegible] |
| AVERD | 20. | 0.15 | 111. | 24. | 0.20 | 133. | 25. | 0.03 | 28. | 45. | 33. | 78 |

Table 3-5. SUMMARY TEST DATA FOR CAR #136 - 1981 LINCOLN MARK VI 5.0L

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.31 | 2.96 | 0.82 | 0.07 | 0.04 | 0.84 | 88. | 86. | 53. | 16.02 | 25.71 |
| 1.0 | 0.39 | 5.94 | 0.97 | 0.09 | 0.20 | 1.24 | 87. | 88. | 35. | 15.63 | 25.51 |
| 4.0 | 2.21 | 57.58 | 0.43 | 2.08 | 102.81 | 0.17 | 57. | 59. | 70. | 12.35 | 19.12 |
| 5.0 | 19.55 | 472.41 | 0.02 | 8.86 | 290.07 | 0.02 | 17. | 4. | 89. | 8.26 | 13.71 |
| 6.0 | 29.29 | 447.13 | 0.13 | 99.99 | 999.99 | 99.99 | 0. | 20. | 59. | 6.35 | 0.00 |
| 12.0 | 0.42 | 0.74 | 1.14 | 0.14 | 0.17 | 0.77 | 89. | 96. | 67. | 16.42 | 25.29 |
| 13.0 | 0.43 | 2.00 | 1.05 | 0.12 | 0.11 | 1.23 | 88. | 90. | 73. | 16.34 | 25.23 |
| 14.0 | 0.57 | 4.72 | 0.75 | 0.13 | 0.16 | 0.54 | 85. | 77. | 61. | 16.47 | 25.41 |
| 15.0 | 0.52 | 5.11 | 1.29 | 0.09 | 2.27 | 1.14 | 82. | 80. | 60. | 15.39 | 24.98 |
| 16.0 | 0.38 | 1.99 | 0.71 | 0.09 | 0.05 | 0.50 | 86. | 89. | 53. | 16.19 | 24.77 |
| 0.1 | 0.32 | 1.23 | 0.87 | 0.10 | 0.09 | 0.53 | 88. | 93. | 56. | 16.86 | 25.84 |
| AVERB | 0.31 | 2.10 | 0.85 | 0.09 | 0.07 | 0.69 | 88. | 90. | 55. | 16.44 | 25.77 |
| -90%CL | 0.28 | -3.37 | 0.69 | -0.01 | -0.09 | -0.29 | 32. | 67. | 45. | 13.79 | 25.36 |
| +90%CL | 0.35 | 7.56 | 1.00 | 0.18 | 0.22 | 1.66 | 144. | 112. | 64. | 19.09 | 26.19 |
| AVERD | 5.97 | 110.85 | 0.72 | 12.40 | 155.09 | 11.73 | 66. | 67. | 63. | 13.71 | 20.45 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
4. Disconnect dark blue-light green wire at throttle position sensor
5. Disconnect light green-black wire at manifold pressure sensor
6. Disconnect green/purple wire at air charge temperature sensor
12. Disconnect dark green wire at EGR vent solenoid
13. Disconnect yellow wire at EGR control solenoid
14. Disconnect thermactor air diverter solenoid
15. Short coolant temperature sensor
16. Short air charge temperature sensor

AVERB - Means average of baseline tests on each car
AVERD - Means average of all disablement tests on each car

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

Table 3-5. SUMMARY TEST DATA FOR CAR #136 - 1981 LINCOLN MARK VI 5.0L (CONTINUED)

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TOT |
| 0.0 | 17. | 0.01 | 155. | 27. | 0.01 | 180. | 20. | 0.01 | 70. | 13. | 4. | 17 |
| 1.0 | 20. | 0.02 | 425. | 20. | 0/02 | 275. | 25. | 0.01 | 30. | 6. | 8. | 14 |
| 4.0 | 180. | 5.50 | 150. | 210. | 6.00 | 180. | 35. | 1.00 | 15. | 4. | 2. | 6 |
| 5.0 | 320. | 9.99 | 5. | 250. | 9.99 | 0. | 700. | 9.99 | 20. | 13. | 10. | 23 |
| 6.0 | 9999. | 9.99 | 0. | 9999. | 9.99 | 0. | 9999. | 9.99 | 0. | 252. | 449. | 701 |
| 12.0 | 22. | 0.01 | 220. | 30. | 0.01 | 250. | 15. | 0.01 | 60. | 3. | 1. | 4 |
| 13.0 | 25. | 0.01 | 275. | 25. | 0.01 | 250. | 12. | 0.02 | 75. | 8. | 2. | 10 |
| 14.0 | 20. | 0.00 | 625. | 25. | 0.01 | 225. | 20. | 0.01 | 50. | 3. | 3. | 6 |
| 15.0 | 20. | 0.00 | 150. | 15. | 0.02 | 225. | 10. | 0.01 | 100. | 9. | 8. | 17 |
| 16.0 | 25. | 0.10 | 100. | 25. | 0.01 | 225. | 10. | 0.01 | 75. | 5. | 5. | 10 |
| 0.1 | 20. | 0.01 | 100. | 20. | 0.02 | 175. | 10. | 0.01 | 55. | 1. | 1. | [illegible] |
| AVERB | 19. | 0.01 | 128. | 24. | 0.01 | 178. | 15. | 0.01 | 62. | 7. | 2. | 10 |
| -90%CL | 9. | 0.00 | -46. | 1. | -0.02 | 162. | -17. | 0.00 | 15. | -31. | -7. | - |
| +90%CL | 28. | 0.02 | 301. | 46. | 0.05 | 193. | 47. | 0.02 | 110. | 45. | 12. | [illegible] |
| AVERD | 1181. | 2.85 | 217. | 1178. | 2.90 | 181. | 1203. | 2.34 | 47. | 34. | 54. | 8 |

Note: 9999 or 9.99 indicates off-scale reading

Table 3-6. SUMMARY TEST DATA FOR CAR #137 - 1981 CHEVROLET CITATION 2.5L

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.14 | 1.05 | 0.78 | 0.05 | 0.18 | 0.33 | 89. | 95. | 58. | 22.75 | 34.13 |
| 1.0 | 0.10 | 1.03 | 2.14 | 0.10 | 1.03 | 2.15 | 90. | 91. | 10. | 23.65 | 35.94 |
| 2.0 | 0.95 | 49.72 | 0.64 | 0.84 | 51.94 | 0.04 | 42. | 30. | 48. | 18.31 | 29.11 |
| 3.0 | 0.12 | 0.44 | 1.20 | 0.05 | 0.10 | 0.38 | 92. | 98. | 71. | 16.84 | 33.13 |
| 4.0 | 1.85 | 89.10 | 0.28 | 0.99 | 8.34 | 0.08 | 16. | 6. | 51. | 19.43 | 38.71 |
| 5.0 | 0.14 | 0.92 | 0.82 | 0.04 | 0.10 | 0.29 | 89. | 95. | 54. | 23.54 | 35.41 |
| 6.0 | 0.10 | 0.56 | 0.76 | 0.05 | 0.11 | 0.30 | 92. | 97. | 56. | 23.58 | 35.10 |
| 7.0 | 2.17 | 102.65 | 0.39 | 1.13 | 64.88 | 0.11 | 8. | 3. | 43. | 20.12 | 30.35 |
| 8.0 | 0.13 | 0.77 | 0.80 | 0.04 | 0.13 | 0.32 | 90. | 96. | 53. | 23.71 | 35.21 |
| 9.0 | 1.93 | 168.89 | 0.12 | 0.61 | 95.51 | 0.02 | 25. | 5. | 79. | 11.81 | 31.04 |
| 10.0 | 0.14 | 0.79 | 0.53 | 0.05 | 0.02 | 0.18 | 95. | 98. | 80. | 22.10 | 30.23 |
| 0.1 | 0.13 | 0.70 | 0.75 | 0.05 | 0.04 | 0.29 | 91. | 96. | 56. | 24.16 | 35.62 |
| AVERB | 0.14 | 0.87 | 0.76 | 0.05 | 0.11 | 0.31 | 90. | 96. | 57. | 23.45 | 34.88 |
| -90%CL | 0.10 | -0.23 | 0.67 | 0.02 | -0.33 | 0.18 | 84. | 92. | 51. | 19.00 | 30.17 |
| +90%CL | 0.17 | 1.98 | 0.86 | 0.08 | 0.55 | 0.44 | 96. | 99. | 63. | 27.91 | 39.58 |
| AVERD | 0.76 | 41.49 | 0.77 | 0.39 | 22.22 | 0.39 | 64. | 62. | 55. | 20.31 | 33.42 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
2. Disconnect coolant temperature sensor
3. Disconnect #8 wire at idle speed control (ISC) throttle switch
4. Disconnect #21 wire at vacuum sensor
5. Disconnect "E" wire at vacuum filter terminal
6. Disconnect "H" wire at ECM (park/neutral switch)
7. Disconnect solenoid connector of fuel metering solenoid
8. Disconnect "M" wire and "F" wire at ECM (idle speed control)
9. Disconnect electronic spark timing at distributor connector
10. Disconnect #22 wire at ECM (sensor return)

AVERB - Means average of baseline tests on each car
AVERD - Means average of all disablement tests on each car

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

Table 3-6. SUMMARY TEST DATA FOR CAR #137 - 1981 CHEVROLET CITATION 2.5L (CONTINUED)

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | T( |
| 0.0 | 20. | 0.01 | 45. | 25. | 0.02 | 52. | 25. | 0.01 | 25. | 53. | 3. | 5 |
| 1.0 | 30. | 0.00 | 750. | 30. | 0.08 | 50. | 25. | 0.00 | 65. | 45. | 19. | 6 |
| 2.0 | 15. | 0.00 | 420. | 63. | 3.05 | 8. | 48. | 0.80 | 3. | 20. | 6. | 2 |
| 3.0 | 30. | 0.01 | 53. | 20. | 0.01 | 32. | 25. | 1.20 | 0. | 56. | 2. | 5 |
| 4.0 | 70. | 4.20 | 5. | 80. | 4.60 | 3. | 170. | 5.00 | 10. | 81. | 5. | 8 |
| 5.0 | 20. | 0.01 | 55. | 20. | 0.01 | 50. | 23. | 0.01 | 10. | 26. | 4. | 3 |
| 6.0 | 60. | 0.02 | 50. | 32. | 0.01 | 43. | 20. | 0.01 | 0. | 52. | 13. | 6 |
| 7.0 | 115. | 4.40 | 50. | 130. | 4.80 | 30. | 220. | 6.50 | 20. | 34. | 11. | 4 |
| 8.0 | 40. | 0.90 | 100. | 10. | 0.01 | 100. | 60. | 0.02 | 5. | 41. | 7. | 4 |
| 9.0 | 20. | 3.50 | 0. | 25. | 4.41 | 0. | 70. | 8.30 | 0. | 71. | 50. | 12 |
| 10.0 | 5. | 0.00 | 25. | 4. | 0.00 | 20. | 5. | 0.00 | 5. | 47. | 4. | 5 |
| 0.1 | 18. | 0.01 | 55. | 15. | 0.01 | 50. | 18. | 0.01 | 5. | 55. | 10. | 6 |
| AVERB | 19. | 0.01 | 50. | 20. | 0.01 | 51. | 22. | 0.01 | 15. | 54. | 7. | 6 |
| -90%CL | 13. | 0.00 | 18. | -12. | -0.02 | 45. | -1. | 0.00 | -48. | 48. | -16. | |
| +90%CL | 25. | 0.02 | 82. | 52. | 0.05 | 57. | 44. | 0.02 | 78. | 60. | 29. | |
| AVERD | 41. | 1.30 | 151. | 41. | 1.70 | 34. | 67. | 2.18 | 12. | 47. | 12. | 5 |

Table 3-7. SUMMARY TEST DATA FOR CAR #139 - 1982 TOYOTA CELICA SUPRA 2.8L

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.29 | 2.98 | 0.46 | 0.01 | 0.31 | 0.06 | 90. | 76. | 89. | 21.21 | 35.19 |
| 1.0 | 0.49 | 6.74 | 0.58 | 0.31 | 5.05 | 0.17 | 84. | 58. | 85. | 21.26 | 34.82 |
| 4.0 | 0.30 | 2.10 | 0.28 | 0.02 | 0.36 | 0.03 | 90. | 82. | 93. | 21.35 | 34.84 |
| 5.0 | 0.31 | 3.38 | 0.47 | 0.01 | 0.21 | 0.09 | 88. | 72. | 88. | 21.65 | 35.26 |
| 13.0 | 1.92 | 82.28 | 0.17 | 1.75 | 49.61 | 0.13 | 59. | 7. | 89. | 18.39 | 30.20 |
| 14.0 | 0.22 | 2.23 | 0.45 | 0.10 | 0.24 | 0.08 | 92. | 81. | 88. | 21.67 | 39.70 |
| 0.1 | 0.29 | 2.11 | 0.39 | 0.02 | 0.23 | 0.05 | 78. | 82. | 90. | 21.46 | 34.46 |
| AVERB | 0.29 | 2.55 | 0.43 | 0.01 | 0.27 | 0.05 | 84. | 79. | 90. | 21.33 | 34.83 |
| -90%CL | 0.11 | -0.20 | 0.20 | -0.02 | 0.02 | 0.02 | 46. | 60. | 86. | 20.55 | 32.52 |
| +90%CL | 0.47 | 5.29 | 0.65 | 0.05 | 0.52 | 0.09 | 122. | 98. | 93. | 22.12 | 37.13 |
| AVERD | 0.65 | 19.35 | 0.39 | 0.44 | 11.09 | 0.10 | 83. | 60. | 89. | 20.86 | 34.96 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
4. Disconnect throttle position switch
5. Disconnect #11e wire at computer (air temperature sensor)
13. Unplug $O_2$ sensor and #11e wire at computer ($O_2$ sensor and air temperature sensor)
14. Disconnect start injector time switch

AVERB - Means average of baseline tests for each car
AVERD - Means average of all disablement tests for each car

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

Table 3-7. SUMMARY TEST DATA FOR CAR #139 - 1982 TOYOTA CELICA SUPRA 2.8L (CONTINUED)

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 14. | 0.02 | 50. | 23. | 0.05 | 35. | 10. | 0.01 | 5. | 6. | 8. | 1. |
| 1.0 | 100. | 0.08 | 145. | 62. | 0.08 | 20. | 25. | 0.01 | 8. | 0. | 0. | [illegible] |
| 4.0 | 20. | 0.02 | 250. | 22. | 0.03 | 15. | 18. | 0.01 | 20. | 0. | 0. | [illegible] |
| 5.0 | 25. | 0.01 | 50. | 20. | 0.02 | 5. | 25. | 0.01 | 20. | 8. | 0. | [illegible] |
| 13.0 | 230. | 4.20 | 175. | 230. | 4.50 | 50. | 210. | 3.60 | 5. | 0. | 0. | [illegible] |
| 14.0 | 10. | 0.01 | 50. | 15. | 0.05 | 5. | 15. | 0.01 | 20. | 20. | 4. | 2. |
| 0.1 | 7. | 0.01 | 0. | 100. | 0.05 | 20. | 7. | 0.00 | 10. | 2. | 3. | [illegible] |
| AVERB | 11. | 0.01 | 25. | 62. | 0.05 | 28. | 9. | 0.00 | 7. | 4. | 6. | 1[illegible] |
| -90%CL | -12. | -0.02 | -133. | -182. | 0.02 | -20. | -1. | -0.03 | -8. | -9. | -10. | -[illegible] |
| +90%CL | 33. | 0.05 | 183. | 305. | 0.08 | 75. | 18. | 0.04 | 23. | 17. | 21. | [illegible] |
| AVERD | 77. | 0.86 | 134. | 70. | 0.94 | 19. | 59. | 0.73 | 15. | 6. | 1. | [illegible] |

Table 3-8. SUMMARY TEST DATA FOR CAR #140 - 1982 CADILLAC SEDAN DE VILLE 4.1L

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.27 | 3.09 | 0.48 | 0.06 | 2.24 | 0.34 | 91. | 83. | 69. | 16.57 | 25.19 |
| 1.0 | 0.27 | 3.04 | 0.84 | 0.15 | 4.93 | 0.61 | 91. | 85. | 56. | 16.60 | 24.92 |
| 2.0 | 0.64 | 3.75 | 8.21 | 0.10 | 2.22 | 0.32 | 77. | 64. | 15. | 17.30 | 25.40 |
| 3.0 | 0.30 | 2.77 | 0.78 | 0.04 | 0.14 | 0.34 | 90. | 67. | 65. | 17.60 | 27.10 |
| 4.0 | 0.47 | 6.99 | 0.52 | 0.43 | 6.79 | 0.15 | 83. | 61. | 77. | 16.65 | 25.11 |
| 5.0 | 15.93 | 229.99 | 0.50 | 9.50 | 195.00 | 0.13 | -15. | 27. | 53. | 11.28 | 16.05 |
| 6.0 | 2.12 | 26.87 | 0.35 | 1.71 | 25.11 | 0.24 | 43. | 27. | 81. | 17.37 | 26.23 |
| 7.0 | 1.65 | 23.79 | 0.29 | 1.47 | 23.43 | 0.24 | 50. | 30. | 83. | 16.09 | 25.28 |
| 8.0 | 0.73 | 10.89 | 0.55 | 1.10 | 19.49 | 0.28 | 78. | 49. | 77. | 16.89 | 25.09 |
| 9.0 | 0.69 | 6.39 | 0.76 | 0.90 | 18.23 | 0.34 | 79. | 66. | 69. | 17.26 | 23.75 |
| 10.0 | 23.44 | 406.21 | 0.37 | 9.45 | 240.94 | 0.13 | -99. | 6. | 4. | 8.65 | 15.28 |
| 0.1 | 0.28 | 3.69 | 0.72 | 0.05 | 1.14 | 0.14 | 90. | 80. | 60. | 16.23 | 25.68 |
| AVERB | 0.28 | 3.39 | 0.60 | 0.05 | 1.69 | 0.24 | 91. | 82. | 65. | 16.40 | 25.44 |
| -90%CL | 0.24 | 1.50 | -0.16 | 0.02 | -1.78 | -0.39 | 87. | 72. | 36. | 15.33 | 23.89 |
| +90%CL | 0.31 | 5.28 | 1.36 | 0.09 | 5.16 | 0.87 | 94. | 91. | 93. | 17.47 | 26.98 |
| AVERD | 4.62 | 72.07 | 1.32 | 2.49 | 53.63 | 0.28 | 48. | 48. | 58. | 15.57 | 23.42 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
2. Disconnect coolant temperature sensor
3. Disconnect "B" wire at throttle position sensor
4. Disconnect barometric pressure sensor
5. Disconnect manifold pressure sensor
6. Disconnect #2 wire in connector P-3 at ECM (vehicle speed sensor)
7. Disconnect "B" wire at idle speed controller (throttle switch)
8. Disconnect manifold air temperature sensor
9. Disconnect connector on transmission position/TCC
10. Disconnect #5 wire in connector P-3 at ECM (sensor ground)

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

AVERB - Means average of baseline tests for each car
AVERD - Means average of all disablement tests for each car

DEFECT [illegible] TEST

| DEFECT | HIGH HC | HIGH CO | HIGH NOX | LOW HC | LOW CO | LOW NOX | IDLE HC | IDLE CO | IDLE NOX | DRIVEABILITY TEST COLD | HOT | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 25. | 0.00 | 100. | 32. | 0.00 | 200. | 23. | 0.00 | 60. | 16. | 6. | 22 |
| 1.0 | 32. | 0.01 | 220. | 32. | 0.18 | 208. | 40. | 0.04 | 0. | 28. | 0. | 28 |
| 2.0 | 23. | 0.08 | 75. | 10. | 0.00 | 80. | 8. | 0.00 | 25. | 14. | 4. | 18 |
| 3.0 | 25. | 0.01 | 90. | 15. | 0.01 | 100. | 25. | 0.01 | 20. | 39. | 2. | 41 |
| 4.0 | 50. | 0.06 | 100. | 60. | 0.10 | 140. | 40. | 0.18 | 40. | 36. | 3. | 39 |
| 5.0 | 380. | 9.99 | 55. | 380. | 8.80 | 55. | 1300. | 9.99 | 70. | 24. | 13. | 37 |
| 6.0 | 190. | 1.10 | 70. | 330. | 7.90 | 45. | 280. | 0.15 | 5. | 33. | 7. | 40 |
| 7.0 | 60. | 0.15 | 105. | 325. | 8.00 | 35. | 37. | 0.14 | 0. | 33. | 12. | 45 |
| 8.0 | 20. | 0.00 | 60. | 200. | 2.10 | 210. | 250. | 0.90 | 5. | 13. | 3. | 16 |
| 9.0 | 14. | 0.02 | 150. | 190. | 1.70 | 250. | 42. | 0.05 | 4. | 10. | 4. | 14 |
| 10.0 | 15. | 0.01 | 2500. | 230. | 2.30 | 525. | 250. | 1.20 | 5. | 203. | 98. | 301 |
| 0.1 | 25. | 0.02 | 40. | 15. | 0.01 | 30. | 20. | 0.01 | 45. | 24. | 7. | 31 |
| AVERB | 25. | 0.01 | 70. | 24. | 0.00 | 115. | 22. | 0.00 | 53. | 20. | 7. | 27 |
| -90%CL | 9. | -0.05 | -119. | -30. | -0.03 | -422. | 12. | -0.03 | 5. | -5. | 3. | - |
| +90%CL | 41. | 0.07 | 259. | 77. | 0.04 | 652. | 31. | 0.04 | 100. | 45. | 10. | 5 |
| AVERD | 81. | 1.14 | 343. | 177. | 3.11 | 165. | 227. | 1.27 | 17. | 43. | 15. | 5[illegible] |

Table 3-9. SUMMARY OF TEST DATA FOR CAR #143 - 1982 BMW 528e 2.7L

| DEFECT | CVS EMISSIONS (GM/MI) FTP | | | CVS EMISSIONS (GM/MI) HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL ECONOMY (MPG) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.31 | 2.00 | 0.23 | 0.03 | 0.80 | 0.05 | 86. | 68. | 95. | 21.91 | 29.95 |
| 1.0 | 0.66 | 5.37 | 1.59 | 0.10 | 2.29 | 0.81 | 71. | 27. | 67. | 22.09 | 29.76 |
| 2.0 | 20.82 | 336.97 | 0.43 | 9.19 | 258.02 | 0.07 | -16. | 2. | 21. | 11.54 | 16.12 |
| 4.0 | 0.46 | 2.13 | 0.17 | 0.16 | 1.59 | 0.02 | 84. | 62. | 97. | 21.57 | 28.62 |
| 5.0 | 0.37 | 2.45 | 0.16 | 0.09 | 0.62 | 0.01 | 87. | 62. | 97. | 22.16 | 29.46 |
| 9.0 | 0.29 | 1.98 | 0.22 | 0.07 | 1.09 | 0.04 | 89. | 69. | 96. | 21.97 | 29.60 |
| 10.0 | 0.24 | 1.26 | 0.66 | 0.06 | 0.68 | 0.12 | 92. | 82. | 89. | 16.35 | 29.47 |
| 11.0 | 23.48 | 470.05 | 0.16 | 9.46 | 259.08 | 0.06 | -42. | 2. | 28. | 8.54 | 15.53 |
| 13.0 | 4.03 | 51.66 | 0.25 | 1.95 | 35.71 | 0.05 | 18. | -13. | 92. | 20.05 | 26.73 |
| 0.1 | 0.47 | 2.80 | 0.30 | 0.05 | 0.78 | 0.02 | 85. | 66. | 94. | 21.75 | 29.23 |
| AVERB | 0.39 | 2.40 | 0.27 | 0.04 | 0.79 | 0.04 | 86. | 67. | 95. | 21.83 | 29.59 |
| -90%CL | -0.12 | -0.13 | 0.04 | -0.02 | 0.73 | -0.06 | 82. | 61. | 91. | 21.32 | 27.32 |
| +90%CL | 0.90 | 4.93 | 0.49 | 0.10 | 0.85 | 0.13 | 89. | 73. | 98. | 22.34 | 31.86 |
| AVERD | 6.29 | 108.98 | 0.46 | 2.64 | 69.89 | 0.15 | 48. | 37. | 73. | 18.03 | 25.66 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
2. Disconnect coolant temperature sensor
4. Disconnect throttle position switch
5. Disconnect air temperature sensor at airflow meter
9. Disconnect thermo switch at coolant inlet hose
10. Disconnect #5 wire at ISC unit at ECM
11. Unplug $O_2$ and coolant temperature sensors
13. Unplug $O_2$ and air temperature sensors

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

AVERB - Means average of baseline tests on each car
AVERD - Means average of all disablement tests on each car

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABIL. Y TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 15. | 0.03 | 100. | 20. | 0.02 | 487. | 20. | 0.05 | 0. | 28. | 9. | 3 |
| 1.0 | 15. | 0.00 | 830. | 40. | 0.15 | 18. | 220. | 2.00 | 5. | 14. | 4. | 1 |
| 2.0 | 700. | 9.99 | 70. | 775. | 9.99 | 60. | 2000. | 9.99 | 120. | 108. | 55. | 16 |
| 4.0 | 10. | 0.01 | 10. | 25. | 0.02 | 60. | 25. | 0.10 | 0. | 15. | 8. | 2 |
| 5.0 | 25. | 0.10 | 15. | 25. | 0.02 | 15. | 20. | 0.06 | 0. | 37. | 6. | 4 |
| 9.0 | 5. | 0.01 | 0. | 15. | 0.01 | 100. | 10. | 0.00 | 35. | 38. | 5. | 4 |
| 10.0 | 20. | 0.05 | 220. | 10. | 0.02 | 220. | 205. | 0.01 | 15. | 21. | 11. | 3 |
| 11.0 | 640. | 9.99 | 25. | 640. | 9.99 | 22. | 125. | 9.99 | 170. | 21. | 31. | 5 |
| 13.0 | 215. | 3.10 | 15. | 250. | 3.50 | 75. | 400. | 6.00 | 0. | 65. | 3. | 6 |
| 0.1 | 15. | 0.03 | 50. | 18. | 0.01 | 108. | 12. | 0.01 | 5. | 13. | 3. | 1 |
| AVERB | 15. | 0.03 | 75. | 19. | 0.01 | 298. | 16. | 0.03 | 2. | 21. | 6. | 2 |
| -90%CL | 6. | 0.01 | -83. | 13. | -0.02 | -899. | -9. | -0.10 | -13. | -27. | -13. | - |
| +90%CL | 24. | 0.05 | 233. | 25. | 0.05 | 1494. | 41. | 0.16 | 18. | 68. | 25. | |
| AVERD | 204. | 2.91 | 148. | 223. | 2.96 | 71. | 376. | 3.52 | 43. | 40. | 15. | 5 |

Table 3-10. SUMMARY OF TEST DATA FOR CAR #144 - 1981 DATSUN 280ZX 2.8L

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0.24 | 1.15 | 0.39 | 0.04 | 0.53 | 0.07 | 89. | 90. | 77. | 19.64 | 24.38 |
| 1.0 | 0.34 | 2.10 | 1.21 | 0.06 | 0.59 | 1.32 | 79. | 81. | 39. | 19.69 | 25.37 |
| 4.0 | 0.44 | 3.72 | 0.31 | 0.10 | 1.86 | 0.09 | 82. | 79. | 85. | 18.71 | 24.77 |
| 7.0 | 0.36 | 3.10 | 0.25 | 0.06 | 0.81 | 0.05 | 85. | 82. | 84. | 19.13 | 24.63 |
| 8.0 | 0.42 | 2.42 | 0.31 | 0.07 | 0.86 | 0.05 | 83. | 85. | 81. | 19.46 | 24.95 |
| 10.0 | 0.09 | 1.94 | 0.36 | 0.06 | 0.63 | 0.08 | 97. | 87. | 80. | 19.46 | 24.95 |
| 12.0 | 1.87 | 5.24 | 0.23 | 0.11 | 0.82 | 0.09 | 78. | 74. | 85. | 18.60 | 24.80 |
| 0.1 | 0.36 | 2.79 | 0.34 | 0.06 | 0.80 | 0.07 | 85. | 82. | 80. | 19.35 | 24.78 |
| AVERB | 0.30 | 1.97 | 0.37 | 0.05 | 0.67 | 0.07 | 87. | 86. | 79. | 19.50 | 24.58 |
| -90%CL | -0.08 | -3.21 | 0.21 | -0.01 | -0.19 | 0.03 | 74. | 61. | 69. | 18.58 | 23.32 |
| +90%CL | 0.68 | 7.15 | 0.52 | 0.11 | 1.52 | 0.11 | 100. | 111. | 88. | 20.41 | 25.84 |
| AVERD | 0.59 | 3.09 | 0.45 | 0.08 | 0.93 | 0.28 | 84. | 81. | 76. | 19.18 | 24.91 |

DISABLEMENTS

1. Disconnect $O_2$ sensor
4. Disconnect #29 wire at ECM harness on(vehicle speed sensor)
7. Disconnect #30 wire at ECM on(air temperature sensor)
8. Disconnect connector of throttle valve switch
10. Disconnect detonation sensor
12. Disconnect EGR and idle speed connectors at vacuum control modulator

STANDARDS (GRAMS PER MILE)

HC - 0.41
CO - 7.0
$NO_x$ - 0.7

AVERB - Means average of baseline testson each car

AVERD - Means average of all disablement tests on each car

Table 3-10. SUMMARY OF TEST DATA FOR CAR #144 - DATSUN 280ZX 2.8L (CONTINUED)

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TC |
| 0.0 | 22. | 0.10 | 33. | 23. | 0.14 | 52. | 140. | 0.10 | 9. | 28. | 9. | 3 |
| 1.0 | 15. | 0.01 | 700. | 50. | 0.70 | 15. | 130. | 1.60 | 0. | 4. | 7. | 1 |
| 4.0 | 10. | 0.03 | 20. | 24. | 0.12 | 20. | 10. | 0.10 | 5. | 43. | 14. | 5 |
| 7.0 | 14. | 0.03 | 30. | 22. | 0.10 | 25. | 15. | 0.01 | 5. | 25. | 8. | 3 |
| 8.0 | 15. | 0.01 | 20. | 22. | 0.05 | 20. | 15. | 0.01 | 5. | 77. | 13. | 9 |
| 10.0 | 10. | 0.02 | 10. | 20. | 0.04 | 20. | 20. | 0.02 | 20. | 22. | 16. | 3 |
| 12.0 | 10. | 0.02 | 25. | 20. | 0.03 | 25. | 620. | 0.55 | 10. | 145. | 83. | 22 |
| 0.1 | 10. | 0.01 | 93. | 22. | 0.08 | 20. | 22. | 0.02 | 45. | 13. | 5. | 1 |
| AVERB | 16. | 0.05 | 63. | 23. | 0.11 | 36. | 81. | 0.06 | 27. | 21. | 7. | 2 |
| -90%CL | -22. | -0.23 | -126. | 19. | -0.08 | -65. | -292. | -0.19 | -87. | -27. | -6. | - |
| +90%CL | 54. | 0.34 | 252. | 26. | 0.30 | 137. | 454. | 0.31 | 141. | 68. | 20. | |
| AVERD | 12. | 0.02 | 134. | 26. | 0.17 | 21. | 135. | 0.38 | 7. | 53. | 24. | [illegible] |

Table 3-11. COMPONENTS DISABLED AND DEFECT CODE/MATRIX

| COMPONENT NAME | DISABLEMENT CODE BY CAR NUMBER 103 (OLD) | 130 (GRA) | 131 (LTD) | 133 (PLY) | 136 (LIN) | 137 (CIT) | 139 (TOY) | 140 (CAD) | 143 (BMW) | 144 (DAT) | % OF CARS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $O_2$ Sensor | 1 | 1 | 1 | 1 | 1 | 1 | 1/13 | 1 | 1/11/13 | 1 | 100% |
| Coolant Temperature Sensor | 2 | 2 | 2 | 2 | 2/15 | 2 | 2 | 2 | 2/9/11/12 | - | 90% |
| Throttle Switch | 8 | 3 | - | 3 | - | 3 | 4/11 | 7 | 4 | 8/14 | 80% |
| Electronic Spark Timing | 10 | - | 10 | 9 | 10 | 9 | 12 | - | - | 9 | 70% |
| Manifold Pressure Sensor | 5 | - | 5 | 12 | 5 | 4 | - | 5 | - | - | 60% |
| Mixture Control Solenoid | 9 | 5 | 6 | 4 | - | 7 | - | - | - | - | 50% |
| Intake Air Temperature Sensor | - | - | - | - | 6/16 | - | 3/5/13 | 8 | 5/13 | 5/7/16 | 50% |
| Throttle Position Sensor | 3 | - | 3 | - | 3 | - | - | 3 | - | - | 40% |
| Barometric Pressure Sensor | 4 | - | 4 | - | 4 | - | - | 4 | - | - | 40% |
| Park/Neutral Switch | 7 | - | - | - | - | 6 | - | 9 | - | 11 | 40% |
| ECM Ground Wire | - | - | 11 | 8 | 9 | - | 9 | - | - | - | 40% |
| Sensor Ground Wire | - | 8 | 13 | - | - | 10 | - | 10 | - | - | 40% |
| Sensor Reference Voltage | - | - | 9 | - | 11 | - | - | - | 8 | - | 30% |
| ECM Power Connection | - | 7/9 | 12 | - | - | - | 8 | - | - | - | 30% |
| Vehicle Speed Sensor | 6 | - | - | - | - | - | - | 6 | - | 4 | 30% |
| Crankshaft Position Sensor | - | - | 7 | - | 7 | - | - | - | - | 3/15 | 30% |
| Air Flow Sensor | - | - | - | - | - | - | 3/6/15 | - | 3/6 | 5/6 | 30% |
| Engine RPM Sensor | - | 6 | - | - | - | - | - | - | 7 | - | 20% |
| AIP Diverter Valve | - | 10 | - | - | 14 | - | - | - | - | - | 20% |
| EGR Valve Position Sensor | - | - | 8 | - | 8 | - | - | - | - | - | 20% |
| Vacuum Switch | - | 4 | - | 5 | - | - | - | - | - | - | 20% |
| Oil Pressure Switch | - | - | - | 7 | - | - | - | - | - | - | 10% |
| Six-Way Connector | - | - | - | 6 | - | - | - | - | - | - | 10% |
| Idle Stop Solenoid | - | - | - | 10 | - | - | - | - | - | - | 10% |
| Electric Choke Heater | - | - | - | 11 | - | - | - | - | - | - | 10% |
| EGR Vent Solenoid | - | - | - | - | 12 | - | - | - | - | - | 10% |
| Idle Speed Control | - | - | - | - | - | 8 | - | - | - | - | 10% |
| EGR Control Solenoid | - | - | - | - | 13 | - | - | - | - | - | 10% |
| Vacuum Sensor Filter | - | - | - | - | - | 5 | - | - | - | - | 10% |
| Air Valve | - | - | - | - | - | - | 16 | - | - | - | 10% |
| ECM Ignition Switch | - | - | - | - | - | - | 7 | - | - | - | 10% |
| Start Injector Switch | - | - | - | - | - | - | 14 | - | - | - | 10% |
| Idle Speed Control Valve | - | - | - | - | - | - | - | - | 10 | - | 10% |
| Detonation Sensor | - | - | - | - | - | - | - | - | - | 10 | 10% |
| Vacuum Control Modulator | - | - | - | - | - | - | - | - | - | 12 | 10% |
| Cylinder Head Temperature Sensor | - | - | - | - | - | - | - | - | - | 2 | 10% |

Since the test fleet was not statistically representative of the vehicle population, different components were disabled on different cars, and the effect of disabling the same or similar components on different cars frequently led to significantly different results, vehicle group averages of test data were practically meaningless and were not calculated. Rather, the discussion is based on how individual disablements affected each vehicle and how similar components affected different vehicles. Grouping of data within cars or components was based on the effect being within the 90% confidence limit of the baseline data (0), greater than the upper limit (+) or less than the lower limit (-). Non-testable operating conditions were not shown except for driveability effects where non-testable conditions were treated as a significant increase in demerits.

### 3.1.2 Emissions Impact

The effect of disabling electronic emission controls varied widely depending on the component, method of disablement and function of the component in a particular vehicle. Each component on each car was tabulated (Table 3-12) showing whether the effect was within or outside of the 90% confidence interval limits of the two baseline tests. The actual percent differences are shown in the appendix. These data are then discussed for each car and, for those components tested on at least two vehicles, for each component.

#### 3.1.2.1 Discussion of Results by Car

Table 3-13 presents results of emissions impact by car. For the 10 cars in the test program, an average of five disablements resulted in statistically significant increases of one or more pollutants. Two vehicles (Lincoln and Cadillac) were relatively unusually sensitve to disablements with 7 and 8 component disablements, respectively, showing significant increases in one or more pollutants. Two vehicles (Toyota and Datsun) showed relatively low sensitivity with two components each showing significant increases in one or more pollutants. Average emission levels of those components in all cars causing significant increases was 4.5 gram/mile HC (1,400%), 134 grams/mile CO (46,690%) and 2.4 grams per mile $NO_x$ (300%). The average of the baseline tests for these cars was 0.30 grams/mile HC, 2.81 grams/mile CO and 0.60 grams/mile $NO_x$.

Table 3-12. COMPONENT DISABLEMENTS CAUSING SIGNIFICANT EMISSIONS IMPACT

| CAR | COMPONENT | FTP | | | HFET | | | CONVERTER EFFICIENCY | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HC | CO | $NO_x$ | HC | CO | $NO_x$ | HC | CO | $NO_x$ |
| 103 (OLD) | (1) $O_2$ Sensor | 0 | - | + | 0 | - | + | 0 | 0 | - |
| | (2) Coolant Temperature Sensor | + | + | + | + | + | + | - | - | - |
| | (3) Throttle Position Sensor | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 |
| | (4) Barometric Pressure Sensor | + | + | 0 | + | + | 0 | - | - | + |
| | (5) Manifold Pressure Sensor | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 |
| | (6) Vehicle Speed Sensor | 0 | 0 | 0 | + | + | 0 | 0 | - | 0 |
| | (7) Park/Neutral Switch | 0 | 0 | 0 | + | + | 0 | 0 | - | 0 |
| | (8) Throttle Switch | 0 | 0 | 0 | + | + | 0 | 0 | + | 0 |
| | (9) Mixture Control Solenoid | + | + | 0 | + | + | 0 | - | - | - |
| | (10) Electronic Spark Timing | + | + | 0 | + | + | 0 | - | - | - |
| 130 (GRA) | (1) $O_2$ Sensor | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 |
| | (2) Low Temperature Switch | 0 | 0 | + | + | 0 | + | 0 | 0 | 0 |
| | (3) Idle Tracking Switch | + | + | 0 | + | + | 0 | - | - | 0 |
| | (4) Vacuum Switch | 0 | 0 | 0 | - | 0 | 0 | 0 | 0 | 0 |
| | (5) Fuel Control Solenoid | 0 | + | 0 | + | + | 0 | 0 | 0 | 0 |
| | (6) RPM Connection | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 |
| | (7) ECM Power Connection | + | + | 0 | + | + | 0 | - | - | 0 |
| | (8) Engine Block Ground Wire | + | + | 0 | + | + | 0 | - | - | 0 |
| | (9) Power Connection | + | + | 0 | + | + | 0 | - | - | 0 |
| | (10) Diverter Air Solenoid | 0 | 0 | + | + | 0 | + | 0 | + | 0 |
| 131 (LTD) | (1) $O_2$ Sensor | 0 | + | 0 | 0 | + | 0 | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | + | + | 0 | + | + | 0 | - | - | + |
| | (3) Throttle Position Sensor | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (4) Barometric Pressure Sensor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (5) Manifold Pressure Sensor | 0 | + | 0 | 0 | + | 0 | 0 | 0 | 0 |
| | (6) Feedback Carburetor Actuator | 0 | + | 0 | 0 | + | 0 | 0 | 0 | 0 |
| | (8) EGR Valve Position Sensor | 0 | - | + | 0 | 0 | + | 0 | 0 | + |
| | (9) Reference Voltage | + | + | + | 0 | + | 0 | - | 0 | 0 |
| | (11) Ground Connection | + | + | + | + | + | + | - | - | + |
| | (13) $O_2$ Sensor Ground Wire | 0 | + | 0 | 0 | + | 0 | 0 | 0 | 0 |

Table 3-12. COMPONENT DISABLEMENTS CAUSING SIGNIFICANT EMISSIONS IMPACT (Continued)

| CAR | COMPONENT | FTP | | | HFET | | | CONVERTER EFFICIENCY | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HC | CO | $NO_x$ | HC | CO | $NO_x$ | HC | CO | $NO_x$ |
| 133 (PLY) | (1) $O_2$ Sensor | 0 | + | - | + | + | 0 | 0 | 0 | + |
| | (2) Coolant Switch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (3) Carburetor Ground Switch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + |
| | (4) Carburetor Feedback Solenoid | + | + | - | + | + | - | - | - | - |
| | (5) Vacuum Actuated Electrical Switch | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (6) Six-way Connector | + | + | - | + | + | - | - | 0 | 0 |
| | (7) Oil Pressure Switch | + | + | - | + | + | 0 | - | - | - |
| | (10) Idle Stop Solenoid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (11) Electric Choke Heater | + | + | 0 | 0 | 0 | 0 | - | - | 0 |
| | (12) Vacuum Transducer | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| 136 (LIN) | (1) $O_2$ Sensor | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| | (4) Barometric Pressure Sensor | + | + | - | + | + | 0 | 0 | 0 | + |
| | (5) Manifold Pressure Sensor | + | + | - | + | + | 0 | - | - | + |
| | (6) Air Charge Temperature Sensor | + | + | - | 0 | 0 | 0 | - | - | 0 |
| | (12) EGR Vent Solenoid | + | 0 | + | 0 | 0 | 0 | 0 | 0 | + |
| | (13) EGR Control Solenoid | + | 0 | + | 0 | 0 | 0 | 0 | 0 | + |
| | (14) Thermactor Air Diverter Valve | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (15) Coolant Temperature Sensor (Shorted) | + | 0 | + | 0 | + | 0 | 0 | 0 | 0 |
| | (16) Air Charge Temperature Sensor (Shorted) | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 137 (CIT) | (1) $O_2$ Sensor | - | 0 | + | + | + | + | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | + | + | - | + | + | - | - | - | - |
| | (3) Throttle Switch | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | + |
| | (4) Vacuum Sensor | + | + | - | + | + | - | - | - | 0 |
| | (5) Vacuum Sensor Filter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (6) Park/Neutral Switch | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (7) Fuel Metering Solenoid | + | + | - | + | + | - | - | - | - |
| | (8) Idle Speed Control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (9) Electronic Spark Timing | + | + | - | + | + | - | - | - | + |
| | (10) Sensor Ground Wire | 0 | 0 | - | 0 | 0 | - | 0 | 0 | + |

Table 3-12. COMPONENT DISABLEMENTS CAUSING SIGNIFICANT EMISSIONS IMPACT (Continued)

| CAR | COMPONENT | FTP | | | HFET | | | CONVERTER EFFICIENCY | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HC | CO | $NO_x$ | HC | CO | $NO_x$ | HC | CO | $NO_x$ |
| 139 (TOY) | (1) $O_2$ Sensor | + | + | 0 | + | + | + | 0 | - | - |
| | (4) Throttle Switch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + |
| | (5) Air Temperature Sensor | 0 | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 |
| | (13) Air Temperature + $O_2$ Sensors | + | + | - | + | + | + | 0 | - | 0 |
| | (14) Start Injector Time Switch | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| 140 (CAD) | (1) $O_2$ Sensor | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | + | 0 | + | + | 0 | 0 | - | - | - |
| | (3) Throttle Position Sensor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | 0 |
| | (4) Barometric Pressure Sensor | + | + | 0 | + | + | 0 | - | - | 0 |
| | (5) Manifold Pressure Sensor | + | + | 0 | + | + | 0 | - | - | 0 |
| | (6) Vehicle Speed Sensor | + | + | 0 | + | + | 0 | - | - | 0 |
| | (7) Throttle Switch | + | + | 0 | + | + | 0 | - | - | 0 |
| | (8) Manifold Air Temperature Sensor | + | + | 0 | + | + | 0 | - | - | 0 |
| | (9) Transmission Position Switch | + | + | 0 | + | + | 0 | - | - | 0 |
| | (10) Sensor Ground Wire | + | + | 0 | + | + | 0 | - | - | - |
| 143 (BMW) | (1) $O_2$ Sensor | 0 | + | + | 0 | + | + | - | - | - |
| | (2) Coolant Temperature Sensor | + | + | 0 | + | + | 0 | - | - | - |
| | (4) Throttle Position Switch | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 |
| | (5) Air Temperature Sensor | 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | 0 |
| | (9) Thermo Switch (Coolant) | 0 | 0 | 0 | 0 | + | 0 | + | 0 | 0 |
| | (10) Idle Speed Control Valve | 0 | 0 | + | 0 | - | 0 | + | + | - |
| | (11) Coolant Temperature + $O_2$ Sensors | + | + | 0 | + | + | 0 | - | - | - |
| | (13) Air Temperature + $O_2$ Sensors | + | + | 0 | + | + | 0 | - | - | 0 |
| 144 (DAT) | (1) $O_2$ Sensor | 0 | 0 | + | 0 | 0 | + | 0 | 0 | - |
| | (4) Vehicle Speed Sensor | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 |
| | (7) Air Temperature Sensor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (8) Throttle Valve Switch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (10) Detonation Sensor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (12) Vacuum Control Modulator | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3-13 ANALYSIS OF EMISSION IMPACT BY CAR

| CAR | CODE | # OF COMPONENT DISABLEMENTS | # OF DISABLEMENTS TESTABLE | # OF DISABLEMENTS CAUSING SIGNIFICANT INCREASE | AVERAGE OF FTP EMISSIONS WITH SIGNIFICANT INCREASE | | |
|---|---|---|---|---|---|---|---|
| | | | | | HC (gm/mi) | CO (gm/mi) | $NO_x$ (gm/mi) |
| 103 | OLD | 10 | 10 | 5 | 2.04 | 69.44 | 2.42 |
| 130 | GRA | 10 | 10 | 6 | 2.76 | 98.14 | 1.49 |
| 131 | LTD | 13 | 10 | 4 | 3.50 | 81.59 | 1.78 |
| 133 | PLY | 12 | 10 | 6 | 1.28 | 23.89 | NS |
| 136 | LIN | 16 | 9 | 7 | 9.00 | 325.71 | 1.16 |
| 137 | COT | 10 | 10 | 6 | 1.73 | 102.59 | 1.67 |
| 139 | TOY | 15 | 5 | 2 | 1.21 | 82.28 | NS |
| 140 | CAD | 10 | 10 | 8 | 5.71 | 139.55 | 8.21 |
| 143 | BMW | 13 | 8 | 4 | 16.11 | 268.23 | 1.59 |
| 144 | DAT | 16 | 6 | 2 | 1.87 | NS | 1.21 |
| Average | | | | 5 | 4.52 | 134.38 | 2.44 |
| Standard Deviation | | | | 2 | 4.74 | 102.43 | 2.36 |
| ± 90 Confidence Limit | | | | ±1.2 | ±2.75 | ±63.51 | ±1.58 |

NOTES: Emission increase was deemed significant if the disablement test emissions were greater than the upper 90% confidence limit of the baseline tests.

NS means that none of the disablement tests resulted in emissions significantly higher than baseline.

Car 103 - Oldsmobile Cutlass 3.8L with Carburetor

This vehicle was relatively insensitive to disablements during the FTP, but highly sensitive during the HFET. During the FTP, five components caused large (> 50%) and statistically significant increases in emissions of one or more pollutants. These increases resulted in emission levels at least twice the applicable standard and also caused the vehicle to fail MVIP standards for three of the five components. Average FTP emissions of disablements causing significant increase was 2.0 grams per mile HC, 69 grams per mile CO and 2.4 grams per miles $NO_x$.

During the HFET, all ten components caused a large (> 100%) and statistically significant increase in one or more pollutants. All but two components (the $O_2$ and coolant temperature sensors) caused higher HC and CO but lower $NO_x$. The coolant temperature sensor caused statistically significant increases in all three pollutants. The $O_2$ sensor caused a significant increase in $NO_x$ but a decrease in CO emissions and did not significantly effect HC emissions. The emissions changes generally indicated a shift in stoichiometry towards rich operation.

Car 130 - Ford Granada 2.3L with Carburetor

This vehicle was relatively insensitive to disablements during the FTP, but highly sensitive during the HFET. During the FTP, six components caused large (> 75%) and statistically significant increases in emissions of one or more pollutants. With one exception, these increases resulted in emissions several times the applicable standard and caused an MVIP failure in four of the six cases. One component (the vacuum switch) caused MVIP failures without significantly increasing either FTP or HFET emissions. Average emission levels of those components in all cars causing significant increases was 2.8 grams per mile HC, 98 grams per mile CO and 1.5 grams per mile $NO_x$. During the HFET, nine of the ten components caused a large (> 100%) and statistically significant increase in emissions of one or more pollutants. One component, (the vacuum switch) caused a decrease in HC emissions. All components except the vacuum switch generally indicated a shift in stoichiometry towards rich operation.

Car 131 - Ford LTD 5.8L with Carburetor

This vehicle was relatively sensitive to component disablements during both the FTP and HFET. Thirteen component disablements were induced, three of which resulted in an undriveable condition. Of the remaining ten disablements which were testable, seven during the FTP and eight during the HFET resulted in a large ( >75%) and statistically significant increase in one or more pollutants. Because of unusually good repeatability of FTP CO baseline data, two other disablements also had emissions significantly higher than baseline, even though the increase was relatively small (20%). Two component disablements caused HC/CO emissions to substantially exceed both FTP standards and MVIP standards. Three component disablements caused $NO_x$ emissions to substantially exceed FTP standards, however, none failed MVIP standards. Average FTP emissions of disablements causing significant emission increases were 3.5 grams per mile HC, 82 grams per mile CO, and 1.8 grams per mile $NO_x$.

Car 133 - Plymouth Reliant 2.2L with Carburetor

This vehicle was relatively sensitive to component disablements. Twelve disablements were induced. Two of the twelve disablements resulted in nontestable operation. Of the remaining ten disablements, six caused a significant and large ( >75%) increase in HC and/or CO emissions during the FTP compared to five during the HFET. None of the disablements resulted in an increase in $NO_x$ emissions and several decreases were statistically significant. Only one component failed the MVIP test (the mixture control solenoid). The results indicate a shift in stoichiometry towards rich operation. Average FTP emissions for components causing significant increases in emission was 1.3 grams per mile HC and 24 grams per mile CO.

Car 136 - Lincoln Continental Mark VI 5.0L with Central Fuel Injection

This vehicle was relatively sensitive to component disablements during the FTP, but relatively insensitive during the HFET. A total of sixteen disablements were attempted on this vehicle of which seven resulted in an undriveable condition. Two components (coolant and temperature sensors) were disabled in different failure modes (shorted as well as open). All nine of the disablements tested caused a statistically significant increase in HC emissions during the FTP.

However, only five had substantial ( >75%) increases, the other four increased moderately (20%-30%). Three components caused substantial ( >200%) and statistically significant increases in CO emissions and decreases ( >50%) in $NO_x$ emissions. Additionally, three components caused moderate (20-50%) but significant increases in $NO_x$. Average FTP emissions for disablements causing significant increases were 9.0 grams per mile HC, 326 grams per mile CO and 1.2 grams per mile $NO_x$.

Three components barometric pressure, manifold pressure, and air charge temperature sensors resulted in HC and/or CO FTP emissions substantially exceeding the applicable FTP standards. These failures were detected by the MVIP test. The car failed the $NO_x$ standard on baseline test (average of 0.85 grams/mile). Three components (EGR vent and control solenoids and shorted coolant temperature sensor) had statistically significant $NO_x$ emission increases ( >1.0 grams/mile), however, none of these failures were detected by the MVIP test.

During the HFET, two components (barometric and manifold pressure sensors) caused substantial ( >100%) and significant increases in HC and CO emissions. Another component (shorted coolant temperature sensor) caused a substantial and significant increase in CO emissions only. One component (the air change temperature sensor) was not tested during the HFET because of exhaust overheating due to excessively rich operation. None of the component disablements resulted in a statistically significant change in $NO_x$ emissions, even though there were some large ( >50%) increases and decreases in emissions.

Car 137 - Chevrolet Citation 2.5L with Carburetor

This vehicle was moderately responsive to component disablements during both the FTP and HFET. Six components caused a statistically significant increase in one or more pollutants during the FTP. Four components (coolant temperature and vacuum sensors, fuel metering solenoid and electronic spark timing) caused substantial ( >600%) and statistically significant increases in HC and CO emissions and smaller but statistically significant decreases in $NO_x$ emissions during both the FTP and HFET. Two components ($O_2$ sensor and throttle switch) caused a significant increase in $NO_x$ emissions during the FTP. Average FTP emissions of components causing significant increases were 1.7 grams per mile HC, 103 grams per mile CO and 1.7 grams per mile $NO_x$.

These disablements resulted in emissions several times higher than applicable FTP standards. The MVIP test detected component failures causing HC/CO emission increases but did not detect failures causing high $NO_x$ emissions.

Car 139 - Toyota Celica Supra 2.8L with Electronic Fuel Injection

This vehicle's emissions were relatively insensitive to component disablements, since most of the disablements prevented the vehicle from starting. A total of 16 components were disabled of which only 5 resulted in testable operation. Several components were disabled with shorted as well as open circuits and in combination with other components. Of the five testable component disablements, only two caused statistically significant increases in HC/CO emissions and none of the disablements resulted in significant increases in $NO_x$ emissions during the FTP. Average FTP emissions of components causing significant increases were 1.2 grams per mile HC, 82 grams per mile CO.

During the HFET, the same two components resulted in substantial emission increases, although two other components also provided much smaller but significant emission increases. Both components resulted in failure of HC and CO FTP emission standards, although only one was detected by the MVIP test.

Car 140 - Cadillac Sedan de Ville 4.16L with Central Fuel Injection

This car was relatively sensitive to components disablements. During the FTP, eight out of ten disablements resulted in substantial ( 50%) and statistically significant increases in HC and/or CO emissions. One component caused a large and significant increase in $NO_x$ during the FTP. The increases resulted in eight components failing the FTP standards. Of these eight, six failed the MVIP standard. During the HFET nine out of ten disablements resulted in HC/CO emission increases. Average FTP emissions of components causing significant increases were 5.71 grams per mile HC, 140 grams per mile CO, and 8.2 grams per mile $NO_x$.

Car 143 - BMW 528e 2.7L with Electronic Fuel Injection

This vehicle was relatively insensitive in terms of component disablements resulting in high emissions. However, those components causing emission increases resulted in very high emission levels. Thirteen component disablements were performed, of which 5 resulted in nondriveable operation. Of the remaining eight, 5 resulted in a substantial ( > 100%) and statistically significant emissions increase during the FTP. These increases led to substantial failures of the FTP standards in three cases. The three components with substantial emissions effect were detected by the MVIP test. The two components with smaller increases were not detected by the MVIP test. Average FTP emissions of disablements resulting in significant increases were 16.1 grams per mile HC, 286 grams per mile CO and 1.6 grams per mile $NO_x$. During the HFET six of the eight testable disablements resulted in statistically significant emission increases, although only three were substantial ( > 100%).

Car 144 - Datsun 280ZX 2.8L with Electronic Fuel Injection

This vehicle was relatively insensitive to component disablements. A total of 16 disablements were attempted. Only six resulted in testable operation. Of the six, one component (the vacuum control modulator) resulted in a substantial ( > 200%) and statistically significant increase in HC emissions during the FTP. One component (the $O_2$ sensor) resulted in significant increase in $NO_x$ emissions. None of the components affected CO emissions significantly. Both components resulted in failure of FTP emission standard as well as MVIP standards. Average FTP emissions were 1.87 grams per mile HC and 1.21 grams per mile $NO_x$. During the HFET, the $O_2$ sensor resulted in statistically significant increases in $NO_x$ emissions and the vehicle speed sensor resulted in statistically significant increases in CO emissions. None of the components resulted in significant HC emission increases.

### 3.1.2.2 Discussion of Results by Component

Table 3-14 presents results of emissions impact by component. All components are tabulated along with the cars on which the component was disabled, the number of cars tested with the component disabled, the number of cars which had a significant emissions increase with the disabled component and the average of emissions which were significantly higher than baseline. The average emission level of a disabled component was 3.7 grams/mile HC, 96 grams/mile CO, and 1.74 grams/mile $NO_x$. Thirty-six components, or component types, were tested. Fifteen components were tested only on one vehicle. Thirteen components were tested on or more cars and only six components were tested on 6 or more cars.

Table 3-14. EMISSIONS IMPACT BY DISABLED COMPONENT

| COMPONENT NAME | # OF CARS DISABLED | # OF CARS TESTABLE | # OF CARS WITH SIGNIFICANT INCREASE | AVERAGE OF EMISSIONS WITH SIGNIFICANT INCREASE HC (gm/mi) | CO (gm/mi) | $NO_x$ (gm/mi) |
|---|---|---|---|---|---|---|
| $O_2$ Sensor | 10 | 10 | 6 | 0.49 | 9.40 | 1.82 |
| Coolant Temperature Sensor | 9 | 8 | 7 | 4.58 | 124.47 | 3.35 |
| Throttle Switch | 8 | 8 | 3 | 1.67 | 28.22 | 1.20 |
| Electronic Spark Timing | 7 | 2 | 2 | 2.54 | 147.23 | NS |
| Manifold Pressure Sensor | 6 | 6 | 3 | 12.44 | 263.83 | NS |
| Mixture Control Solenoid | 5 | 5 | 3 | 2.14 | 81.26 | NS |
| Intake Air Temperature Sensor | 5 | 5 | 2 | 15.00 | 229.01 | NS |
| Throttle Position Sensor | 4 | 3 | 0 | - | - | - |
| Barometric Pressure Sensor | 4 | 4 | 3 | 1.11 | 35.93 | NS |
| Park/Neutral Switch | 4 | 3 | 1 | 0.69 | NS | NS |
| ECM Ground Wire | 4 | 1 | 1 | 3.41 | 77.70 | 1.08 |
| Sensor Ground Wire | 4 | 4 | 2 | 13.38 | 337.34 | NS |
| Sensor Reference Voltage | 3 | 1 | 1 | 0.61 | NS | 1.81 |
| ECM Power Connection | 3 | 1 | 1 | 3.03 | 74.81 | NS |
| Vehicle Speed Sensor | 3 | 1 | 1 | 2.12 | 26.87 | NS |
| Crankshaft Position Sensor | 3 | 0 | - | - | - | - |
| Air Flow Sensor | 3 | 0 | - | - | - | - |
| Engine RPM Sensor | 2 | 1 | 0 | NS | NS | NS |
| AIP Diverter Valve | 2 | 2 | 2 | 0.57 | NS | 1.56 |
| EGR Valve Position Sensor | 2 | 1 | 1 | - | - | - |
| Vacuum Switch | 2 | 2 | 1 | - | 7.24 | - |
| Oil Pressure Switch | 1 | 1 | 1 | 2.39 | 73.23 | NS |
| Six-Way Connector | 1 | 1 | 1 | 1.16 | 13.35 | NS |
| Idle Stop Solenoid | 1 | 1 | 0 | NS | NS | NS |
| Electric Choke Heater | 1 | 1 | 1 | 0.64 | 11.16 | NS |
| EGR Vent Solenoid | 1 | 1 | 1 | NS | NS | 1.14 |
| Idle Speed Control | 1 | 1 | 0 | NS | NS | NS |
| EGR Control Solenoid | 1 | 1 | 1 | NS | NS | 1.05 |
| Vacuum Sensor Filter | 1 | 1 | 0 | NS | NS | NS |
| Air Valve | 1 | 1 | 0 | NS | NS | NS |
| ECM Ignition Switch | 1 | 0 | - | - | - | - |
| Start Injection Switch | 1 | 1 | 0 | NS | NS | NS |
| Idle Speed Control Valve | 1 | 1 | 0 | NS | NS | NS |
| Detonation Sensor | 1 | 1 | 0 | NS | NS | NS |
| Vacuum Control Modulator | 1 | 1 | 1 | 1.87 | NS | NS |
| Cylinder Head Temperature Sensor | 1 | 0 | - | - | - | - |
| Average | | | | 3.68 | 96.32 | 1.74 |
| Standard Deviation | | | | 4.57 | 100.48 | 0.82 |
| 90% Confidence Level | | | | ±1.86 | ±44.04 | ±0.55 |

\- means component was not tested

NS means that none of the disablement tests resulted in emissions significantly higher than baseline

## Components Showing No Significant Effect On Emissions

The following component disablements showed no significant effect on emissions; or were not startable or driveable on any of the vehicles. These components were tested on four or fewer cars and the results may not be indicative of all vehicles equipped with them.

Throttle position sensor
Crankshaft position sensor
Air flow sensor
Engine RPM sensor
Idle stop solenoid
Idle speed control
Vacuum sensor filter
Air valve
ECM ignition switch
Start injection switch
Idle speed control valve
Detonation sensor
Cylinder head temperature sensor

## $O_2$ Sensor

The $O_2$ sensor was tested on all 10 cars and caused a significant emissions increase in 6 cars. The principle effect was increased $NO_x$ (approximately twice the baseline emissions). Emissions of hydrocarbons and carbon monoxide were increased significantly for only one car each (139 and 133 respectively) and emissions levels on both cars were only slightly greater than baseline. The average FTP emissions level was 0.49 grams per mile HC, 9.40 grams per mile CO and 1.82 grams per mile $NO_x$.

## Coolant Temperature Sensor

The coolant temperature sensor was selected as a disablement on 9 cars, tested on 8 cars, and caused significant emissions increases in 7 cars. All three pollutants were increased substantially on average, although individual cars showed widely differing effect. Average FTP emission level was 4.58 grams per mile HC, 124 grams per mile CO and 3.35 grams per mile $NO_x$. Shorting the sensor gave different results than disconnecting it.

Throttle Switch

The throttle switch was selected and tested as a disablement on 8 cars and caused significant emissions increase in three cars. Two cars (130 and 140) had increased HC and CO emissions. One car (137) had increased $NO_x$ emissions. Average FTP emission level was 1.67 grams per mile HC, 28 grams per mile CO and 1.20 grams per mile $NO_x$.

Electronic Spark Timing

The electronic spark timing was selected as a disablement on 7 cars, but was testable on only 2 cars (103 and 137). Both cars showed dramatically increased HC and CO (2.5 and 147 grams per mile) emissions. $NO_x$ emissions were not significantly difference than baseline.

Manifold Pressure Sensor

The manifold pressure sensor was selected and tested on six cars and showed significant increase for three cars. All three cars (136, 137 and 140) showed dramatically increased HC and CO emissions (12.4 and 264 grams per mile respectively). Emissions of $NO_x$ were not significantly different than baseline.

Mixture Control Solenoid

The mixture control solenoid was selected and tested on five cars. Three cars (103, 133 and 137) showed dramatically higher HC and CO emissions (2.1 and 81 grams per mile respectively) and unchanged $NO_x$ emissions.

Intake Air Temperature Sensor

The intake air temperature sensor was selected and tested on five cars. One car (136) showed dramatically higher HC and CO emissions with the component open but no effect with the component shorted. One car (140) showed marginally higher HC and CO emissions with the component open. The other cars were not significantly affected. The average FTP emissions were 15.0 grams per mile HC and 229 grams per mile CO.

Barometric Pressure Sensor

The barometric pressure sensor was selected and tested on four cars. One car (136) showed dramatically higher HC and CO emissions. Two vehicles (103 and 140) showed marginally higher HC and CO emissions. Emissions of $NO_x$ were not affected on any car. The average FTP emissions were 1.1 grams per mile HC and 36 grams per mile CO.

Park/Neutral Switch

The park/neutral switch was selected and disabled on four vehicles. One vehicle (144) would not start. Of the other three vehicles which were testable only one (140) showed HC emissions (0.69 grams per mile) significantly higher than baseline. None of the vehicles showed significant effect on CO or $NO_x$ emissions.

Sensor Ground Wire

The sensor ground wire caused dramatic increases in HC and CO emissions in two cars (130 and 140) with no significant change in $NO_x$ emissions. The average FTP emissions were 13 grams per mile HC and 337 grams per mile CO.

AIP Diverter Valve

The AIP diverter valve was tested on two vehicles. One vehicle (136) showed increased HC emissions (0.57 grams per mile). The other (130) showed increased $NO_x$ emissions (1.56 grams per mile).

Components Showing Significant Effect On Emissions But Disabled or Tested On Only One Car

The following components were disabled on only one car, or if disabled on more than one, were driveable on only one. These components resulted in statistically significant increases in one or more pollutants.

| | |
|---|---|
| ECM ground wire | (HC, CO $NO_x$) |
| Sensor reference voltage | (HC, $NO_x$) |
| ECM power connection | (HC, CO) |

| | |
|---|---|
| Vehicle speed sensor | (HC, CO) |
| EGR valve position sensor | ($NO_x$) |
| Vacuum switch | (CO) |
| Oil pressure switch | (HC, CO) |
| Six-way connector | (HC, CO) |
| Electric choke heater | (HC, CO) |
| EGR vent solenoid | ($NO_x$) |
| EGR control solenoid | ($NO_x$) |
| Vacuum control modulator | (HC) |

### 3.1.3 Fuel Economy

The effect of disabling electronic emission controls was generally negative or statistically unchanged from baseline fuel economy although there were three instances of improved fuel economy. Table 3-15 shows whether the effect was within or outside the 90% confidence interval limits of the two baseline tests. The data in Table 3-15 is discussed by car and by component below.

#### 3.1.3.1 Discussion of Results by Car

Table 3-16 summarizes the results of fuel economy impact by car. The impact is characterized by the number of disablements causing a significant change, either positive or negative in fuel economy and the average of the significant differences. On average, three components for each car caused a signficant change (decrease) in fuel economy for both the FTP and HFET. The average decrease was 22% for the FTP and 15% for the HFET. The average baseline fuel economy for the ten cars was 19.85 mpg for the FTP and 29.51 mpg for the HFET.

Car 103 - Oldsmobile Cutlass 3.8L with Carburetor

This vehicle's fuel economy was relatively sensitive to component disablements. Ten components were disabled and tested. On the FTP, 6 components decreased fuel economy an average of 17%. On the HFET 4 of the 6 components decreased fuel economy an average of 24%. The same four components (coolant temperature sensor, barometric pressure sensor, mixture control solenoid, and electronic spark timing) also caused significant increases of HC and CO emissions due to mixture enrichment.

Table 3-15

COMPONENT DISABLEMENTS CAUSING SIGNIFICANT FUEL ECONOMY IMPACT

| CAR | COMPONENT | FTP | HFET |
|---|---|---|---|
| 103 | (1) $O_2$ Sensor | 0 | 0 |
| | (2) Coolant Temperature Sensor | - | - |
| | (3) Throttle Position Sensor | - | 0 |
| | (4) Barometric Pressure Sensor | - | - |
| | (5) Manifold Pressure Sensor | 0 | 0 |
| | (6) Vehicle Speed Sensor | 0 | 0 |
| | (7) Park/Neutral Switch | 0 | 0 |
| | (8) Throttle Switch | - | 0 |
| | (9) Mixture Control Solenoid | - | - |
| | (10) Electronic Spark Timing | - | - |
| 130 | (1) $O_2$ Sensor | 0 | - |
| | (2) Low Temperature Switch | 0 | 0 |
| | (3) Idle Tracking Switch | 0 | 0 |
| | (4) Vacuum Switch | 0 | 0 |
| | (5) Fuel Control Solenoid | 0 | 0 |
| | (6) RPM Connection | 0 | 0 |
| | (7) ECM Power Connection | - | 0 |
| | (8) Engine Block Ground Wire | - | - |
| | (9) Power Connection | - | - |
| | (10) Diverter Air Solenoid | - | - |
| 131 | (1) $O_2$ Sensor | - | 0 |
| | (2) Coolant Temperature Sensor | - | - |
| | (3) Throttle Position Sensor | 0 | 0 |
| | (4) Barometric Pressure Sensor | 0 | 0 |
| | (5) Manifold Pressure Sensor | - | - |
| | (6) Feedback Carburetor Actuator | 0 | 0 |
| | (8) EGR Valve Position Sensor | 0 | 0 |
| | (9) Reference Voltage | 0 | 0 |
| | (11) Ground Connection | - | 0 |
| | (13) $O_2$ Sensor Ground Wire | 0 | 0 |
| 133 | (1) $O_2$ Sensor | - | - |
| | (2) Coolant Switch | 0 | 0 |
| | (3) Carburetor Ground Switch | + | 0 |
| | (4) Carburetor Feedback Solenoid | - | - |
| | (5) Vacuum Actuated Electrical Switch | 0 | 0 |
| | (6) Six-way Connector | - | - |
| | (7) Oil Pressure Switch | - | - |
| | (10) Idle Stop Solenoid | 0 | 0 |
| | (11) Electric Choke Heater | - | 0 |
| | (12) Vacuum Transducer | 0 | - |

Table 3-15. (Continued)

COMPONENT DISABLEMENTS CAUSING SIGNIFICANT FUEL ECONOMY IMPACT

| CAR | COMPONENT | FTP | HFET |
|---|---|---|---|
| 136 | (1) $O_2$ Sensor | 0 | 0 |
| | (4) Barometric Pressure Sensor | - | - |
| | (5) Manifold Pressure Sensor | - | - |
| | (6) Air Charge Temperature Sensor | - | - |
| | (12) EGR Vent Solenoid | 0 | - |
| | (13) EGR Control Solenoid | 0 | - |
| | (14) Thermactor Air Diverter Valve | 0 | 0 |
| | (15) Coolant Temperature Sensor (Shorted) | 0 | - |
| | (16) Air Charge Temperature Sensor (Shorted) | 0 | - |
| 137 | (1) $O_2$ Sensor | 0 | 0 |
| | (2) Coolant Temperature Sensor | - | - |
| | (3) Throttle Switch | - | 0 |
| | (4) Vacuum Sensor | 0 | 0 |
| | (5) Vacuum Sensor Filter | 0 | 0 |
| | (6) Park/Neutral Switch | 0 | 0 |
| | (7) Fuel Metering Solenoid | 0 | 0 |
| | (8) Idle Speed Control | 0 | 0 |
| | (9) Electronic Spark Timing | - | 0 |
| | (10) Sensor Ground Wire | 0 | 0 |
| 139 | (1) $O_2$ Sensor | 0 | 0 |
| | (4) Throttle Switch | 0 | 0 |
| | (5) Air Temperature Sensor | 0 | 0 |
| | (13) Air Temperature + $O_2$ Sensors | - | - |
| | (14) Start Injector Time Switch | 0 | + |
| 140 | (1) $O_2$ Sensor | 0 | 0 |
| | (2) Coolant Temperature Sensor | 0 | 0 |
| | (3) Throttle Position Sensor | + | + |
| | (4) Barometric Pressure Sensor | 0 | 0 |
| | (5) Manifold Pressure Sensor | - | - |
| | (6) Vehicle Speed Sensor | 0 | 0 |
| | (7) Throttle Switch | 0 | 0 |
| | (8) Manifold Air Temperature Sensor | 0 | 0 |
| | (9) Transmission Position Switch | 0 | - |
| | (10) Sensor Ground Wire | - | - |
| 143 | (1) $O_2$ Sensor | 0 | 0 |
| | (2) Coolant Temperature Sensor | - | - |
| | (4) Throttle Position Switch | 0 | 0 |
| | (5) Air Temperature Sensor | 0 | 0 |
| | (9) Thermo Switch (Coolant) | 0 | 0 |
| | (10) Idle Speed Control Valve | - | 0 |
| | (11) Coolant Temperature + $O_2$ Sensors | - | - |
| | (13) Air Temperature + $O_2$ Sensors | - | - |
| 144 | (1) $O_2$ Sensors | 0 | 0 |
| | (4) Vehicle Speed Sensor | 0 | 0 |
| | (7) Air Temperature Sensor | 0 | 0 |
| | (8) Throttle Valve Switch | 0 | 0 |
| | (10) Detonation Sensor | 0 | 0 |
| | (12) Vacuum Control Modulator | 0 | 0 |

Table 3-16. ANALYSIS OF FUEL ECONOMY IMPACT BY CAR

| CAR | CODE | # OF COMPONENT DISABLEMENTS | # OF DISABLEMENTS TESTABLE | # OF DISABLEMENTS CAUSING SIGNIFICANT CHANGE (+ or -) FTP | HFET | AVERAGE OF FUEL ECONOMY CHANGES SIGNIFICANTLY DIFFERENT THAN BASELINE (%MPG) | (%MPG) |
|---|---|---|---|---|---|---|---|
| 103 | OLD | 10 | 10 | 6 | 4 | -17% | -24% |
| 130 | GRA | 10 | 10 | 4 | 4 | -21% | -14% |
| 131 | LTD | 13 | 10 | 4 | 2 | -14% | -14% |
| 133 | PLY | 12 | 10 | 6 | 5 | - 9% | -20% |
| 136 | LIN | 16 | 9 | 3 | 7 | -45% | -26% |
| 137 | CIT | 10 | 10 | 3 | 1 | -33% | -17% |
| 139 | TOY | 15 | 5 | 1 | 2 | -14% | +1% |
| 140 | CAD | 10 | 10 | 3 | 4 | -24% | -19% |
| 143 | BMW | 13 | 8 | 4 | 3 | -21% | -35% |
| 144 | DAT | 16 | 6 | 0 | 0 | NS | NS |
| Average | | | | 3.40 | 3.20 | -22.0% | -18.7% |
| Standard Deviation | | | | 1.90 | 1.85 | 11.1% | 9.90% |
| ±90% Confidence Limit | | | | ±1.10 | ±1.07 | ±6.88% | ±6.14% |

NS means changes were not significant compared to baseline tests

Car 130 - Ford Granada 2.3L with Carburetor

Ten components were disabled and tested. Four components decreased fuel economy during the FTP (21%) and HFET (14%). Three of the four were the same components (engine block ground wire, power connection and diverter air solenoid). The fourth component for the FTP was the ECM power connection and for the HFET was the $O_2$ sensor. Except for the $O_2$ sensor, these componenets also increased emissions of HC and CO or $NO_x$ during the FTP.

Car 131 - Ford LTD 5.8L with Carburetor

Thirteen components were disabled and ten were tested. Four components decreased fuel economy during the FTP an average of 14% ($O_2$ sensor coolant temperature sensor, manifold pressure sensor and ground connection). Two of these (coolant temperature sensor and manifold pressure sensor) also reduced HFET fuel economy an average of 14%. These four components also increased one or more of the pollutant emissions during the FTP.

Car 133 - Plymouth Reliant 2.2L with Carburetor

Twelve components were disabled and ten were tested. Five components decreased FTP fuel economy an average of 13% and HFET an average of 20%. One component (carburetor ground switch) caused a significant increase in FTP fuel economy of 9%. Four of the components decreasing fuel economy on the FTP and HFET were the same ($O_2$ sensor, carburetor feedback solenoid, six-way connector and oil pressure switch). For the FTP, the electric choke heater decreased and the carburetor ground switch increased fuel economy. For the HFET, the vacuum transducer decreased fuel economy. Except for the carburetor ground switch and vacuum transducer both of which had no significant effect on emissions, the components decreasing fuel economy also increased emissions of HC or CO.

Car 136 - Lincoln Mark VI 5.0L with Fuel Injection

Sixteen components were disabled and nine were tested. Three components (barometric pressure sensor, manifold pressure sensor and air charge temperature sensor-open) caused very significant decreases fuel economy on both the FTP

(45%) and HFET (57%). These components also caused very significant increases in HC and CO emissions. On the HFET, 4 other components (EGR vent and control solenoids, coolant and air charge temperature sensors) caused smaller but significant decreases in HFET fuel economy, but did not significantly affect FTP fuel economy. The average HFET fuel economy loss caused by the seven components was 26%. All components increased one ~~of~~ or more of the pollutants.

Car 137 - Chevrolet Citation 2.5L with Carburetor

Ten components were disabled and tested. Three components (coolant temperature sensor, throttle switch and electric spark timing) reduced fuel economy an average of 33% on the FTP and increased HC and CO or $NO_x$ emissions. For the HFET, only the coolant temperature sensor decreased fuel economy (17%).

Car 139 - Toyota Celica Supra 2.8L with Carburetor

Fifteen components were disabled and five were tested. Only one component disablement (air temperature and $O_2$ sensor) significantly reduced fuel economy on either the FTP (14%) or HFET (13%). These components disabled individually did not impact fuel economy. The start injector time switch caused a 14% increase in fuel economy on the HFET. Disabling the $O_2$ and air temperature sensors together and the $O_2$ sensor individually also increased HC and CO emissions during the FTP and HFET.

Car 140 - Cadillac Sedan deVille 4.1L with Digital Fuel Injection

Ten components were disabled and tested. One component (throttle position sensor) resulted in improved (7%) fuel economy on both the FTP and HFET. This disablement did not significantly affect emission levels. Two components (manifold pressure sensor and the sensor ground wire) decreased (39%) FTP and HFET fuel economy and significantly increased emissions of HC and CO. One component (transmission position switch) decreased HFET fuel economy. The average of the significant effects on this car were a 24% decrease in FTP fuel economy and a 19% decrease in HFET fuel economy.

Car 143 - BMW 528e 2.7L with Electronic Fuel Injection

Thirteen components were disabled and eight were tested. This car had 3 component disablements (coolant temperature sensor, coolant temperature and $O_2$ sensors, and air temperature and $O_2$ sensors) which caused decreased fuel economy on the FTP (20%) and the HFET (35%). These three components increased emissions of HC and CO or $NO_x$. A fourth component (idle speed control valve) decreased FTP fuel economy and increased FTP $NO_x$ emissions. The average fuel economy decrease from the four components during the FTP was 24%.

Car 144 - Datsun 280ZX 2.8L with Electronic Fuel Injection

Sixteen components were disabled and six were tested. This vehicle's fuel economy was insensitive to component disablements. None of the component disablement tests resulted in a significant decrease (or increase) in fuel economy.

### 3.1.3.2 Discussion of Results by Component

Table 3-17 summarizes the fuel economy impact by component type. The table presents the number of cars on which the disablement was induced, the number of cars which were testable, the number of cars with a statistically significant increase or decrease in fuel economy and the percent change in fuel economy averaged over those cars with a statistically significant effect. No component disablement resulted in statistically significant fuel economy changes on more than two cars for the FTP or three cars for the HFET, even though more cars may have been tested. The average of the statistically significant decreases in fuel economy was 22% for the FTP and 17% for the HFET.

Components With Statistically Significant Fuel Economy Effect On Only One Car

The following thirteen components were disabled on only one car, or if disabled on more than one, were driveable on only one. These components resulted in statistically significant reductions in fuel economy. The reductions ranged from a low of 7% to a high of 61% on the FTP and from 14% increase to a 52% reduction on the HFET.

Table 3-17 FUEL ECONOMY IMPACT BY DISABLED COMPONENT

| COMPONENT NAME | # OF CARS DISABLED | # OF CARS TESTABLE | AVERAGE OF FUEL ECONOMY WITH SIGNIFICANT CHANGES: FTP # CHANGED | FTP %MPG | HFET # CHANGED | HFET %MPG |
|---|---|---|---|---|---|---|
| $O_2$ Sensor | 10 | 10 | 2 | -10 | 2 | -11 |
| Coolant Temperature Sensor | 9 | 8 | 2 | -15 | 3 | -10 |
| Throttle Switch | 8 | 8 | 2 | 1 | 0 | NS |
| Electronic Spark Timing | 7 | 2 | 2 | -41 | 1 | -36 |
| Manifold Pressure Sensor | 6 | 6 | 2 | -34 | 3 | -25 |
| Mixture Control Solenoid | 5 | 5 | 2 | -15 | 2 | -24 |
| Intake Air Temperature Sensor | 5 | 5 | 1 | -61 | 1 | -52 |
| Throttle Position Sensor | 4 | 3 | 0 | NS | 0 | NS |
| Barometric Pressure Sensor | 4 | 4 | 2 | -22 | 2 | -26 |
| Park/Neutral Switch | 4 | 3 | 0 | NS | 1 | - 7 |
| ECM Ground Wire | 4 | 1 | 1 | -13 | 1 | NS |
| Sensor Ground Wire | 4 | 4 | 1 | -45 | 1 | -35 |
| Sensor Reference Voltage | 3 | 1 | 0 | NS | 0 | NS |
| ECM Power Connector | 3 | 1 | 1 | -14 | 1 | - 8 |
| Vehicle Speed Sensor | 3 | 1 | 0 | NS | 0 | NS |
| Crankshaft Position Sensor | 3 | 0 | - | - | - | - |
| Air Flow Sensor | 3 | 0 | - | - | - | - |
| Engine RPM Sensor | 2 | 1 | 0 | NS | 0 | NS |
| AIP Diverter Valve | 2 | 2 | 1 | -13 | 1 | - 9 |
| EGR Valve Position Sensor | 2 | 1 | 0 | NS | 0 | NS |
| Vacuum Switch | 2 | 2 | 0 | NS | 0 | NS |
| Oil Pressure Switch | 1 | 1 | 1 | -29 | 1 | -21 |
| Six-Way Connector | 1 | 1 | 1 | - 7 | 1 | -23 |
| Idle Stop Solenoid | 1 | 1 | 0 | NS | 0 | NS |
| Electric Choke Heater | 1 | 1 | 1 | - 7 | 0 | NS |
| EGR Vent Solenoid | 1 | 1 | 0 | NS | 1 | - 2 |
| Idle Speed Control | 1 | 1 | 0 | NS | 0 | NS |
| EGR Control Solenoid | 1 | 1 | 0 | NS | 1 | - 2 |
| Vacuum Sensor Filter | 1 | 1 | 0 | NS | 0 | NS |
| Air Valve | 1 | 0 | - | - | - | - |
| ECM Ignition Switch | 1 | 0 | - | - | - | - |
| Start Injection Switch | 1 | 1 | 0 | NS | 1 | 14 |
| Idle Speed Control Valve | 1 | 1 | 1 | -25 | 0 | NS |
| Detonation Sensor | 1 | 1 | 0 | NS | 0 | NS |
| Vacuum Control Modulator | 1 | 1 | 0 | NS | 0 | NS |
| Cylinder Head Temperature Sensor | 1 | 0 | - | - | - | - |
| Average | | | | -21.9 | | -17.3 |
| Standard Deviation | | | | -15.90 | | -16.12 |
| ±90% Confidence Interval | | | | ± 6.97 | | ± 7.06 |

\- Means component was not tested

NS Means that none of the disablement tests resulted in fuel economy significantly different than baseline

| | |
|---|---|
| Intake air temperature sensor | (FTP/HFET) |
| Park/neutral switch | (HFET) |
| ECM ground wire | (FTP/HFET) |
| Sensor ground wire | (FTP/HFET) |
| ECM power connector | (FTP/HFET) |
| AIP diverter valve | (FTP/HFET) |
| Oil pressure switch | (FTP/HFET) |
| Six-way connector | (FTP/HFET) |
| Electric choke heater | (FTP) |
| EGR vent solenoid | (HFET) |
| Start injection switch | (HFET) |
| Idle speed control valve | (FTP) |

<u>Components Without Statistically Significant Fuel Economy Effect In Any Car</u>

The following eleven components were tested in up to four cars and showed no impact on fuel economy for either the FTP or HFET, or were not startable or testable on any of the cars.

Throttle position sensor
Sensor reference voltage
Vehicle speed sensor
Crankshaft position sensor
Air flow sensor
Engine rpm sensor
EGR valve position sensor
Vacuum switch
Idle stop solenoid
Idle speed control
Vacuum sensor filter
Air valve
ECM ignition switch
Detonation sensor
Vacuum control modulator
Cylinder head temperature sensor

## $O_2$ Sensor

The component was disabled and tested on ten cars. Two cars (131 and 133) showed significant impact on FTP fuel economy and the magnitude was relatively small (10%) decrease on the HFET, two cars (#130 and #133) showed an 11% decrease in fuel economy.

## Coolant Temperature Sensor

This component was disabled on nine cars and tested on eight cars. Two cars (103 and 131) showed significant impact (-15%) in FTP fuel economy. Three cars (103, 131 and 136) showed significant impact (-10%) on HFET fuel economy.

## Throttle Switch

This component was disabled and tested on eight cars. Two cars (103 and 133) showed significant impact on FTP fuel economy, however one increased 9% and one decreased 8%. None of the cars showed significant impact on HFET fuel economy.

## Electronic Spark Timing

This disablement was induced in seven cars but was driveable in only two cars. Both cars (103 and 137) showed a significant fuel economy reduction for the FTP (averaging 41%), but only one (103) showed a significant reduction (36%) for the HFET.

## Manifold Pressure Sensor

The manifold pressure sensor was disabled and tested in six cars. Two cars (131 and 136) showed an average of 34% reduction in FTP fuel economy. Three cars (131, 133 and 136) showed an average of 25% reduction in HFET fuel economy.

## Mixture Control Solenoid

The mixture control solenoid was disabled and tested in five cars. Two vehicles (103 and 133) showed significant fuel economy reductions averaging 15% on the FTP and 24% on the HFET.

Barometric Pressure Sensor

The barometric pressure sensor was disabled and tested in four cars. Two vehicles (103 and 136) showed significant fuel economy reductions averaging 22% on the FTP and 26% on the HFET.

### 3.1.4 Driveability

The statistical significance of the driveability data are summarized in Table 3-18 for all component disablements including those which were not driveable. The majority of component disablements on most cars which were driveable did not result in statistically significant changes in total driveability demerits, even though cold or hot driveability may have been individually impacted. These data are discussed below by car and component.

#### 3.1.4.1 Discussion of Driveability Impact by Car

Table 3-19 presents average results by car. The table shows the number of component disablements induced, the number driveable and the number causing significantly better or worse driveability. The average of the demerits for disablements with significant affect are also shown. Only one car (#137) showed any improvement in driveability when components were disabled. For these ten cars, the average demerits for baseline tests was 25 cold, 10 hot and 35 total demerits. On average, five components resulted in worse driveability on each car with total demerits of 258, cold demerits of 142 and hot demerits of 116.

Car 103 - Oldsmobile Cutlass 3.8L with Carburetor

Ten components were disabled and tested on this car. This car was driveable in all disablements. Four disablements ($O_2$ Sensor, barometric pressure transducer, manifold pressure transducer, and electronic spark timing) resulted in significantly worse driveability than baseline. Driveability was degraded during both the cold driveaway (108 demerits) and warmed-up (60 demerits) portions of the test.

TABLE 3-18

COMPONENT DISABLEMENTS CAUSING SIGNIFICANT DRIVEABILITY IMPACT

| CAR | COMPONENT | ARB DRIVEABILITY TEST COLD | HOT | TOTAL | 100-TOTAL |
|---|---|---|---|---|---|
| 103 (OLD) | (1) $O_2$ Sensor | + | + | + | - |
| | (2) Coolant Temperature Sensor | - | 0 | 0 | 0 |
| | (3) Throttle Position Sensor | - | 0 | 0 | 0 |
| | (4) Barometric Pressure Sensor | + | + | + | - |
| | (5) Manifold Pressure Sensor | 0 | + | + | - |
| | (6) Vehicle Speed Sensor | 0 | 0 | 0 | 0 |
| | (7) Park/Neutral Switch | + | 0 | 0 | 0 |
| | (8) Throttle Switch | + | 0 | 0 | 0 |
| | (9) Mixture Control Solenoid | 0 | 0 | 0 | 0 |
| | (10) Electronic Spark Timing | + | 0 | + | - |
| 130 (GRA) | (1) $O_2$ Sensor | - | 0 | 0 | 0 |
| | (2) Low Temperature Switch | 0 | 0 | 0 | 0 |
| | (3) Idle Tracking Switch | - | 0 | 0 | 0 |
| | (4) Vacuum Switch | 0 | 0 | 0 | 0 |
| | (5) Fuel Control Solenoid | - | 0 | 0 | 0 |
| | (6) RPM Connection | - | 0 | 0 | 0 |
| | (7) ECM Power Connection | - | 0 | 0 | 0 |
| | (8) Engine Block Ground Wire | 0 | 0 | 0 | 0 |
| | (9) Power Connection | - | 0 | 0 | 0 |
| | (10) Diverter Air Solenoid | 0 | 0 | 0 | 0 |
| 131 (LTD) | (1) $O_2$ Sensor | 0 | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | 0 | + | + | - |
| | (3) Throttle Position Sensor | 0 | 0 | 0 | 0 |
| | (4) Barometric Pressure Sensor | 0 | 0 | 0 | 0 |
| | (5) Manifold Pressure Sensor | 0 | 0 | 0 | 0 |
| | (6) Feedback Carburetor Actuator | 0 | 0 | 0 | 0 |
| | (7) Crankshaft Position Sensor | + | + | + | - |
| | (8) EGR Valve Position Sensor | + | + | + | - |
| | (9) Reference Voltage | + | + | + | - |
| | (10) Electronic Spark Timing | + | + | + | - |
| | (11) Ground Connection | + | + | + | - |
| | (12) ECM Power Connection | + | + | + | - |
| | (13) $O_2$ Sensor Ground Wire | 0 | + | 0 | 0 |
| 133 (PLY) | (1) $O_2$ Sensor | 0 | 0 | 0 | 0 |
| | (2) Coolant Switch | 0 | 0 | 0 | 0 |
| | (3) Carburetor Ground Switch | + | 0 | + | - |
| | (4) Carburetor Feedback Solenoid | 0 | 0 | 0 | 0 |
| | (5) Vacuum Actuated Electrical Switch | + | 0 | 0 | 0 |
| | (6) Six-Way Connector | 0 | 0 | 0 | 0 |
| | (7) Oil Pressure Switch | 0 | 0 | 0 | 0 |
| | (8) Computer Ground Wire | + | + | + | - |
| | (9) Distributor Ground Wire | + | + | + | - |
| | (10) Idle Stop Solenoid | + | 0 | 0 | 0 |
| | (11) Electric Choke Heater | 0 | 0 | 0 | 0 |
| | (12) Vacuum Transducer | 0 | 0 | 0 | 0 |

Table 3-18 (Continued)

COMPONENT DISABLEMENTS CAUSING SIGNIFICANT DRIVEABILITY IMPACT

| CAR | COMPONENT | ARB DRIVEABILITY TEST | | | |
|---|---|---|---|---|---|
| | | COLD | HOT | TOTAL | 100-TOTAL |
| 136 (LIN) | (1) $O_2$ Sensor | 0 | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | + | + | + | - |
| | (3) Throttle Position Sensor | + | + | + | - |
| | (4) Barometric Pressure Sensor | 0 | 0 | 0 | 0 |
| | (5) Manifold Pressure Sensor | 0 | 0 | 0 | 0 |
| | (6) Air Charge Temperature Sensor | + | + | + | - |
| | (7) Crankshaft Position Sensor | + | + | + | - |
| | (8) EGR Valve Position Sensor | + | + | + | - |
| | (9) Ground Connection | + | + | + | - |
| | (10) Spark Timing | + | + | + | - |
| | (11) Reference Voltage | + | + | + | - |
| | (12) EGR Vent Solenoid | 0 | 0 | 0 | 0 |
| | (13) EGR Control Solenoid | 0 | 0 | 0 | 0 |
| | (14) Thermactor Air Diverter Valve | 0 | 0 | 0 | 0 |
| | (15) Coolant Temperature Sensor (Shorted) | 0 | 0 | 0 | 0 |
| | (16) Air Charge Temperature Sensor (Shorted) | 0 | 0 | 0 | 0 |
| 137 (CIT) | (1) $O_2$ Sensor | - | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | - | 0 | - | + |
| | (3) Throttle Switch | 0 | 0 | 0 | 0 |
| | (4) Vacuum Sensor | + | 0 | 0 | 0 |
| | (5) Vacuum Sensor Filter | - | 0 | - | + |
| | (6) Park/Neutral Switch | 0 | 0 | 0 | 0 |
| | (7) Fuel Metering Solenoid | - | 0 | 0 | 0 |
| | (8) Idle Speed Control | - | 0 | 0 | 0 |
| | (9) Electronic Spark Timing | + | + | + | - |
| | (10) Sensor Ground Wire | - | 0 | 0 | 0 |
| 139 (TOY) | (1) $O_2$ Sensor | 0 | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | + | + | + | - |
| | (3) Air Flow and Temperature Connector | + | + | + | - |
| | (4) Throttle Switch | 0 | 0 | 0 | 0 |
| | (5) Air Temperature Sensor | 0 | 0 | 0 | 0 |
| | (6) Air Flow Sensor | + | + | + | - |
| | (7) Ignition Switch to Computer | + | + | + | - |
| | (8) Battery Lead to Computer | + | + | + | - |
| | (9) Computer Ground | + | + | + | - |
| | (11) Throttle Position Switch | + | + | + | - |
| | (12) Distributor Signal | + | + | + | - |
| | (13) Air Temperature + $O_2$ Sensor | 0 | 0 | 0 | 0 |
| | (14) Start Injector Time Switch | + | 0 | 0 | 0 |
| | (15) Air Flow Sensor | + | + | + | - |
| | (16) Air Valve | + | + | + | - |

Table 3-18 (Continued)

COMPONENT DISABLEMENTS CAUSING SIGNIFICANT DRIVEABILITY IMPACT

| CAR | COMPONENT | ARB DRIVEABILITY TEST | | | |
|---|---|---|---|---|---|
| | | COLD | HOT | TOTAL | 100-TOTAL |
| 140 (CAD) | (1) $O_2$ Sensor | 0 | - | 0 | 0 |
| | (2) Coolant Temperature Sensor | 0 | 0 | 0 | 0 |
| | (3) Throttle Position Sensor | 0 | - | 0 | 0 |
| | (4) Barometric Pressure Sensor | 0 | - | 0 | 0 |
| | (5) Manifold Pressure Sensor | 0 | + | 0 | 0 |
| | (6) Vehicle Speed Sensor | 0 | 0 | 0 | 0 |
| | (7) Throttle Switch | 0 | + | 0 | 0 |
| | (8) Manifold Air Temperature Sensor | 0 | - | 0 | 0 |
| | (9) Transmission Position Switch | 0 | 0 | 0 | 0 |
| | (10) Sensor Ground Wire | + | + | + | - |
| 143 (BMW) | (1) $O_2$ Sensor | 0 | 0 | 0 | 0 |
| | (2) Coolant Temperature Sensor | + | + | 0 | - |
| | (3) Air Flow & Temperature Connector | + | + | + | - |
| | (4) Throttle Position Switch | 0 | 0 | 0 | 0 |
| | (5) Air Temperature Sensor | 0 | 0 | 0 | 0 |
| | (6) Air Flow Sensor | + | + | + | - |
| | (7) RPM Pick-up | + | + | + | - |
| | (8) Reference Point Pick-up | + | + | + | - |
| | (9) Thermo Switch (Coolant) | 0 | 0 | 0 | 0 |
| | (10) Idle Speed Control Valve | 0 | 0 | 0 | 0 |
| | (11) Coolant Temperature + $O_2$ Sensors | 0 | 0 | 0 | 0 |
| | (12) Coolant Temperature Sensor | + | + | + | - |
| | (13) Air Temperature + $O_2$ Sensors | 0 | 0 | 0 | 0 |
| 144 (DAT) | (1) $O_2$ Sensor | 0 | 0 | 0 | 0 |
| | (2) Cylinder Head Temperature Sensor | + | + | + | - |
| | (3) Crank Angle Sensor | + | + | + | - |
| | (4) Vehicle Speed Sensor | 0 | 0 | 0 | 0 |
| | (5) Air Flow & Temperature Connector | + | + | + | - |
| | (6) Air Flow Meter | + | + | + | - |
| | (7) Air Temperature Sensor | 0 | 0 | 0 | 0 |
| | (8) Throttle Valve Switch | + | 0 | + | - |
| | (9) Distributor Connector | + | + | + | - |
| | (10) Detonation Sensor | 0 | 0 | 0 | 0 |
| | (11) Park/Neutral Switch | + | + | + | - |
| | (12) Vacuum Control Modulator | + | + | + | - |
| | (13) Cylinder Head Temperature Sensor | + | + | + | - |
| | (14) Throttle Valve Switch | + | + | + | - |
| | (15) Crank Angle Sensor | + | + | + | - |
| | (16) Air Temperature Sensor | + | + | + | - |

(+) means significant increase in demerits
(-) means significant decrease in demerits
(0) means no significant difference in demerits

Table 3-19. DRIVEABILITY IMPACT BY CAR

| CAR | CODE | # OF COMPONENT DISABLEMENTS | # OF DISABLEMENTS TESTABLE | # OF DISABLEMENTS CAUSING SIGNIFICANT CHANGE IN DRIVEABILITY | | INCREASE IN DEMERITS RELATIVE TO BASELINE FOR DISABLEMENTS WITH SIGNIFICANT EFFECT | | |
|---|---|---|---|---|---|---|---|---|
| | | | | WORSE* | BETTER | COLD | HOT | TOTAL |
| 103 | OLD | 10 | 10 | 4 | 0 | 72 | 44 | 116 |
| 130 | GRA | 10 | 10 | 0 | 0 | NS | NS | NS |
| 131 | LTD | 13 | 10 | 7 | 0 | 154 | 78 | 232 |
| 133 | PLY | 12 | 10 | 3 | 0 | 70 | 20 | 90 |
| 136 | LIN | 16 | 9 | 8 | 0 | 245 | 447 | 692 |
| 137 | CIT | 10 | 10 | 1 | 2 | 15 | 13 | -2 |
| 139 | TOY | 15 | 5 | 10 | 0 | NS | NS | NS |
| 140 | CAD | 10 | 10 | 1 | 0 | 183 | 91 | 274 |
| 143 | BMW | 13 | 8 | 5 | 0 | 87 | 49 | 136 |
| 144 | DAT | 16 | 6 | 2 | 0 | 90 | 41 | 131 |
| Average | | | | 4.20 | 0.20 | 110.8 | 87.9 | 208.6 |
| Standard Deviation | | | | 3.39 | 0.63 | 80.3 | 143.5 | 212.7 |
| ±90% Confidence Limit | | | | 2.36 | 0.37 | 53.8 | 96.1 | 142.5 |

NS means changes were not significant compared to baseline tests

* Includes non-testable disablements

Car 130 - Ford Granada 2.3L with Carburetor

Ten components were disabled and tested on this car. This car was driveable in all disablements, however, it had relatively poor, i.e., sluggish driveability in all conditions, including baseline. None of the disablements caused significant increases or decreases in total driveability demerits, although six resulted in improved cold driveaway performance.

Car 131 - Ford LTD 5.81 with Carburetor

Thirteen components were disabled on this car. This car was not driveable in three disablements (crankshaft position sensor, electronic spark timing, and ECM power connection). Of the ten disablements that were tested, four resulted in significantly worse driveability (coolant temperature sensor, EGR valve position sensor, reference voltage, ground connection). Driveability was significantly degraded during both cold driveaway (179 demerits) and warmed-up (83 demerits) portions of the test.

Car 133 - Plymouth Reliant 2.2L with Carburetor

Twelve components were disabled on this car. This car was not testable in two disablements (computer ground wire and distributor ground wire). The computer ground wire disablement prevented the vehicle from entering closed loop control. Although the vehicle would operate in this mode, it was decided not to test this condition and to proceed to another disablement. The distributor ground wire disablement was not testable. Of the remaining 10 disablements that were tested, only one (carburetor ground switch) caused a significant increase in demerits. Cold driveaway demerits were 104. Warmed-up demerits were 52 (not statistically different from baseline).

Car 136 - Lincoln Mark VI 5.0L with Central Fuel Injection

Sixteen disablements were attempted on this vehicle. Only nine resulted in testable operation. One component (air charge temperature sensor) resulted in statistically worse driveability. Driveability was so bad that the HFET test on the dynamometer was aborted due to excessive particulate (smoke) emissions which clogged the sampling system. The disablements which were not driveable were the following: coolant temperature sensor, throttle position sensor, crankcase position sensor, EGR valve position sensor, ground connection, spark timing and reference voltage.

Car 137 - Chevrolet Citation 2.5L with Carburetor

This was the only vehicle to show significantly better driveability as measured by total demerits. All ten planned disablements were testable. One (electronic spark timing) resulted in worse driveability. Two (coolant temperature sensor, and vacuum sensor filter) resulted in better driveability, primarily during cold operation.

Car 139 - Toyota Celica Supra 2.6L with Electronic Fuel Injection

Fifteen disablements were induced on this vehicle. Ten disablements were not testable. None of the testable disablements caused a significant impact on driveability. The components that were not driveable included: coolant temperature sensor, air flow and temperature sensor connector, air flow sensor, ignition switch to the computer, battery connection to the computer, computer ground wire, throttle position sensor, distributor signal and air valve.

Car 140 - Cadillac Sedan deVille 4.1L with Central Fuel Injection

All ten planned components were disabled on this car. Only one disablement caused significantly worse driveability (sensor ground wire) as measured by total demerits. Several components caused changes, either improvements or degradations in warmed-up driveability, but not in cold driveability.

Car 143 - BMW 528e 2.7L with Electronic Fuel Injection

Five disablements resulted in non-testable operation (air flow and temperature connector, air flow sensor, RPM pickup, thermo switch-coolant). Except for the nondriveable test conditions, none of the induced disablements impacted driveability. The fuel injection systems in this car and #139 are basically the same (Bosch) although component disablements induced and tested were not necessarily the same.

Car 144 - Datsun 280ZX 2.8L with Electronic Fuel Injection

Sixteen disablements were induced although only six resulted in testable operation. Of the disablements which were testable only 2 (throttle valve switch and the vacuum control modulator) resulted in worse driveability than baseline. The disablements not tested included the following: cylinder head temperature sensor, crankangle sensor, air flow and temperature sensor, air flow meter, distributor connector and park/neutral switch. Several of the components were tested in two different disablements (shorted and open).

### 3.1.4.2 Analysis of Driveability Impact by Component

Driveability impact was measured in two ways. For those components which were testable, i.e. could be started and would continue to run, the average demerits for statistically significant effects was calculated along with the number of vehicles with a statistically significant effect. The vehicles which were not testable, i.e., could not be started or kept running, also were impacted by the disablement even though a quantitative measurement could not be made. The impact of nontestable cars was included qualitatively by adding the number of them to the vehicles which were tested and had shown statistically significant driveability impact.

Table 3-20 summarizes the driveability impact by component. The table shows the number of cars on which the disablement was induced, the number of cars testable, the number with significant change in driveability (including non-testable and testable cars), and the average number of driveability demerits for disablements with significant effect. The average number of demerits for components with statistically significant impact was 129, 81 and 207 for cold driveaway, warm driveability and total driveability, respectively. These demerit levels compare to average baseline demerits of 25 for cold driveaway, 10 for warm driveability and 35 total demerits for the ten cars in the test program. Only two components (both from car #137) gave significantly better driveability when disabled.

Components With No Significant Impact On Driveability

The following components did not have a significant impact on driveability on ny car tested:

Table 3-20. DRIVEABILITY IMPACT BY COMPONENT

| COMPONENT NAME | # OF CARS DISABLED | # OF CARS TESTABLE | # OF CARS CHANGED NOT TESTABLE | # OF CARS CHANGED TESTED | # OF CARS CHANGED TOTAL | INCREASE IN DEMERITS FOR DISABLEMENTS WITH SIGNIFICANT EFFECT TOTAL | COLD | HOT |
|---|---|---|---|---|---|---|---|---|
| $O_2$ Sensor | 10 | 10 | 0 | 1 | 1 | 91 | 37 | 54 |
| Coolant Temperature Sensor | 9 | 8 | 1 | 3 | 4 | 51 | 22 | 29 |
| Throttle Switch | 8 | 8 | 0 | 1 | 1 | 131 | 79 | 42 |
| Electronic Spark Timing | 7 | 2 | 5 | 2 | 7 | 118 | 89 | 29 |
| Manifold Pressure | 6 | 6 | 0 | 1 | 1 | 97 | 18 | 79 |
| Mixture Control Solenoid | 5 | 5 | 0 | 0 | 0 | NS | NS | NS |
| Intake Air Temperature Sensor | 5 | 5 | 0 | 1 | 1 | 346 | 121 | 225 |
| Throttle Position Sensor | 4 | 3 | 1 | 0 | 1 | NS | NS | NS |
| Barometric Pressure Sensor | 4 | 4 | 0 | 1 | 1 | 158 | 113 | 45 |
| Park/Neutral Switch | 4 | 3 | 1 | 0 | 1 | NS | NS | NS |
| ECM Ground Wire | 4 | 1 | 3 | 1 | 4 | 420 | 315 | 105 |
| Sensor Ground Wire | 4 | 4 | 0 | 1 | 1 | 274 | 183 | 91 |
| Sensor Reference Voltage | 3 | 1 | 2 | 1 | 3 | 218 | 129 | 89 |
| ECM Power Connection | 3 | 1 | 2 | 0 | 2 | NS | NS | NS |
| Vehicle Speed Sensor | 3 | 1 | 2 | 0 | 2 | NS | NS | NS |
| Crankshaft Position Sensor | 3 | 0 | 3 | 0 | 3 | - | - | - |
| Air Flow Sensor | 3 | 0 | 3 | 0 | 3 | - | - | - |
| Engine RPM Sensor | 2 | 1 | 1 | 0 | 1 | NS | NS | NS |
| AIP Diverter Valve | 2 | 2 | 0 | 0 | 0 | NS | NS | NS |
| EGR Valve Position Sensor | 2 | 1 | 1 | 1 | 2 | 193 | 129 | 64 |
| Vacuum Switch | 2 | 2 | 0 | 0 | 0 | NS | NS | NS |
| Oil Pressure Switch | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Six-Way Connector | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Idle Stop Solenoid | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Electric Choke Heater | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| EGR Vent Solenoid | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Idle Speed Control | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| EGR Control Solenoid | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Vacuum Sensor Filter | 1 | 1 | 0 | 1 | 1 | -31 | -28 | -3 |
| Air Valve | 1 | 0 | 1 | 0 | 1 | - | - | - |
| ECM Ignition Switch | 1 | 0 | 1 | 0 | 1 | - | - | - |
| Start Injection Switch | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Idle Speed Control Valve | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Detonation Sensor | 1 | 1 | 0 | 0 | 0 | NS | NS | NS |
| Vacuum Control Modulator | 1 | 1 | 0 | 1 | 1 | 200 | 124 | 76 |
| Cylinder Head Temperature Sensor | 1 | 0 | 1 | 0 | 1 | - | - | - |
| Average | | | | | | 174.3 | 102.4 | 72.8 |
| Standard Deviation | | | | | | 121.9 | 86.4 | 54.1 |
| ±90% Confidence Limit | | | | | | ±60.2 | ±42.7 | ±28.1 |

\- Means component was not tested

NS Means that none of the disablement tests resulted in driveability significantly different than baseline

Mixture control solenoid
AIP diverter valve
Vacuum switch
Oil pressure switch
Six-way connector
Idle stop solenoid
Electric choke heater
EGR vent solenoid
Idle speed control
EGR control solenoid
Start injection switch
Idle speed control valve
Detonation sensor

$O_2$ Sensor

The $O_2$ sensor was disabled and tested on all ten cars. Only one car (#103) showed a significant change (worse) in driveability. The driveability degradation was due to poor part throttle acceleration.

Coolant Temperature Sensor

The coolant temperature sensor was disabled in nine cars and was testable in eight out of nine. Two of the vehicles (#131 and 143) increased in demerits. Car #131 had sever detonation and car #143 had extremely poor cold driveability. One of the vehicles (#137) decreased in demerits. One car (#139) would not start with the component disabled.

Throttle Switch

This component was disabled and tested in eight cars. Only one car (#133) showed a significant increase in demerits which was due to extremely poor cold driveability.

Electronic Spark Timing

This disablement was included on seven cars. Only two of the cars (#103 and #137) were testable and both had significant driveability deterioration. Therefore, this disablement impacted driveability for all vehicles either by failure to start or extreme loss of power and acceleration.

Manifold Pressure Sensor

This disablement was induced and tested on six cars. Only one of the cars (#103) showed significant driveability impact due to detonation during hot tests and poor acceleration at all times.

Intake Air Temperature Sensor

This component was disabled and tested on five cars. One car (#136) showed very severe driveability impact when the component was disconnected. The same car showed no significant effect when the component was shorted.

Throttle Position Sensor

This component was disabled in four cars and tested in three cars. None of the cars tested showed significant impact. The car which was not testable (#136) would start but would not run except at idle.

Barometric Pressure Sensor

This component was disabled and tested in four cars. One car (#103) showed significant impact from the disablement during part throttle accelerations, particularly when cold.

Park/Neutral Switch

This component was disabled on four cars and tested in three cars. The car (#144) which was not testable could not be started. The other three cars did not show significant impact on driveability.

ECM Ground Wire

This component was disabled in four cars. One car (#131) was barely driveable, yielding a total of 450 demerits and the other three cars (#133, 136, 139) could not be started.

Sensor Ground Wire

This disablement was induced and tested in four cars. One car (#140) showed a significant impact on driveability. The other cars were not significantly affected.

Sensor Reference Voltage

This disablement was induced in three cars. One car (#131) was driveable but yielded high total demerits (248). The other two cars could not be started.

ECM Power Connection

This disablement was induced in three cars. One car was testable but showed no significant impact. The two other cars (#131 and 139) could not be started.

Vehicle Speed Sensor

This component was disabled in three cars. Two cars (#140 and 144) would not run. A third car (#103) would run and the disablement had no significant impact.

Crankshaft Position Sensor

This component was disabled in the three cars (#131, 136 and 144). None of the cars could be started.

Air Flow Sensor

This component was disabled in three cars (#139, 143 and 144). None of the vehicles were driveable.

Engine RPM Sensor

This component was disabled in two cars and tested in one car. The vehicle which was not tested (#143) could not be started. The vehicle which was tested (#130) had no significant impact on driveability.

EGR Valve Position Sensor

This component was disabled in two cars (#131 and 136). One vehicle (#136) was not driveable. The other (#131) had very high demerits (223).

Components Disabled in One Car

Fifteen component disablements were induced in only one car. Most of these had no significant impact on driveability. However, three components (air valve, ECM ignition switch, and cylinder head temperature sensor) resulted in non testable conditions. One component (vacuum control modulator) had very high demerits due to repeated stalling and lack of power. One component (vacuum sensor filter) had a significant, but relatively small impact on driveability.

## 3.2 EFFECTIVENESS OF FIELD SERVICE

This section describes the diagnostic approaches used by dealerships and their success at detecting the implanted defects.

### 3.2.1 Diagnostic Approaches

The dealership diagnosis could be classified in three levels. The level utilized was dependent on the symptom described by the vehicle operator and the nature of supporting evidence, i.e., "check engine" lights illuminated, obvious symptom or failed vehicle inspection reports. The three level approaches were:

- utilization of diagnostic aids as evidenced by correct identification of components or circuit
- symptom was normal for car or due to external problem, i.e., fuel
- standard maintenance practice - no attempt at diagnosis specifically oriented toward electronic control system components

The first approach was required in vehicles with on-board warning lights (103, 137, 140) which stayed illuminated until the problem was corrected and which gave general guidance to the mechanic with codes indicating the faulted circuit or component. Mechanics could not easily disregard the visible warning, although in one case, the mechanic reported that he could not verify the "check engine" light or fault code.

The remote diagnostic systems also provided this information, but required the mechanic to connect a special test instrument in order to conduct the diagnosis. Some mechanics used the systems effectively; others did not. The failure symptom tended to determine whether mechanics would go to the trouble of using the diagnostic equipment. If the car also had an overt symptom, i.e. pinging or smoke, the mechanic was more likely to proceed with diagnosis than if the car had a subjective complaint, i.e. poor fuel economy.

Standard maintenance practices were often used on cars with remote diagnostic systems. The standard maintenance practices consisted of "scope and adjust" or "tune-up" which was unrelated to the induced fault. The following are examples of ineffective maintenance which would have been avoided if the manufacturer's diagnostic procedures had been followed by dealer mechanics.

disconnected $O_2$ sensor wire: tune-up performed
disconnected engine ground strap: diagnosed defective ECS component
defective barometric pressure sensor: replaced spark plug

The third response was predominately encountered when fuel economy or driveability symptoms were used as the driver complaint. In these cases, the mechanics appeared to discount the importance of the problem. Several characteristic situations are shown below.

disconnected engine ground strap: suggested poor quality fuel
defective coolant temperature sensor: suggested poor quality fuel
disconnected $O_2$ sensor wire: performed tune-up
disconnected 5-way connector: recommended tune-up

### 3.2.2 Fault Detection

In Task 2, the effectiveness of fault detection by the dealerships was evaluated in terms of the diagnostic or repair action performed by the dealership mechanic This evaluation was based on a review of the invoice and a physical examination of the vehicle after its return to SC. Table 3-21 summarizes the results of the field survey. A discussion of each car follows below.

#### Car 103 - Oldsmobile Cutlass 3.8L with Carburetor

This vehicle was the first car and was taken to the dealers clearly identified as an SC test car on which a problem had developed. The symptom identified was the check engine light and a reported loss of a few miles per gallon in fuel economy. The SC representative informed the dealer that SC's mechanic was unable to find or correct the problem.

Table 3-21

RESULTS OF FIELD SURVEY

Vehicle #103 - Disablement #3 - Broken Connector in Throttle Position Sensor Circuit (Check Engine Light "on")

| | |
|---|---|
| Dealer A: | Declined to service vehicle |
| Dealer B: | Correctly diagnosed failure as broken connector |
| Dealer C: | Incorrectly diagnosed failure as faulty throttle position sensor (correct circuit) |
| Dealer D: | Incorrectly diagnosed several different faults; replaced several components and eventually gave up |

Vehicle #130 - Disablement #8 - Disconnected Engine Ground

| | |
|---|---|
| Dealer H: | Diagnosed wrong part - did not repair |
| Dealer I: | Correctly diagnosed and repaired defect |
| Dealer J: | Did not find or repair defect - suggested poor quality fuel |

Vehicle #131 - Disablement #2 - Open Circuit in Coolant Temperature Sensor

| | |
|---|---|
| Dealer E: | Did not find or repair defect - suggested poor quality fuel |
| Dealer F: | Correctly diagnosed and repaired fault |
| Dealer G: | Correctly diagnosed and repaired fault |

Vehicle #133 - Disablement #6 - Disconnected 5-Way Connector

| | |
|---|---|
| Dealer K: | Did not find or repair defect - recommended tune-up |
| Dealer L: | Correctly diagnosed and repaired defect |
| Dealer M: | Did not find or repair defect - recommended tune-up |

Vehicle #136 - Disablement #4 - Open Circuit in Barometric Pressure Sensor

| | |
|---|---|
| Dealer W: | Correctly diagnosed and replaced faulty component |
| Dealer X: | Incorrectly diagnosed and replaced EGR valve and position sensor |
| Dealer Y: | Incorrectly diagnosed fault as misfire; replaced spark plugs |

Vehicle #137 - Disablement #4 - Open Circuit in Vacuum Sensor (Check Engine Light "on")

| | |
|---|---|
| Dealer N: | Correctly diagnosed faulty component and ordered replacement |
| Dealer O: | Correctly diagnosed faulty component and replaced it |
| Dealer P: | Correctly diagnosed faulty component and ordered replacement |

Table 3-21 (Continued)

RESULTS OF FIELD SURVEY

| | |
|---|---|
| **Vehicle #139 - Disablement #13 - Disconnected $O_2$ Sensor and Air Temperature Sensor** | |
| Dealer T: | Did not find disablement; performed scheduled 7,500 mile service |
| Dealer U: | Incorrectly diagnosed defect as faulty $O_2$ sensor and ordered part (correct circuit) |
| Dealer V: | Did not find disablement; reported engine set rich; and performed "scope and adjust" |
| **Vehicle #140 - Disablement #6 - Open Circuit in Vehicle Speed Sensor (Check Engine Light "on")** | |
| Dealer Q: | Did not find disablement; could not verify symptom |
| Dealer R: | Correctly diagnosed and repaired fault |
| Dealer S: | Could not find disablement; returned vehicle after 3 days |
| **Vehicle #143 - Disablement #10 - Disconnected Idle Speed Control Valve** | |
| Dealer Z: | Incorrectly diagnosed faulty component as idle control valve (correct symptom) |
| Dealer AA: | Incorrectly diagnosed faulty component as ECM |
| Dealer BB: | Correctly diagnosed and repaired disablement |
| **Vehicle #144 - Disablement #1 - Disconnected $O_2$ Sensor** | |
| Dealer CC: | Did not find disablement; performed low emission tune-up |
| Dealer DD: | Incorrectly diagnosed fault as defective $O_2$ sensor and ordered part (correct circuit) |
| Dealer EE: | Did not find disablement; performed low emission tune-up |

The disablement had been inadvertently induced by SC test personnel during driveability testing and in fact, the SC mechanic had not isolated the fault at the time the car was taken to the first dealer. At that time, SC believed the defect to be a failed ECM. However, the fault was actually a broken pin on the ECM connector terminal which resulted in an open circuit in the throttle position sensor. This fault resulted in an intermittently illuminated check engine light, normal driveability, no significant emissions impact and approximately 2 miles per gallon loss in fuel economy during the FTP.

The recommended diagnostic procedure is to readout the fault message stored in the ECM. The fault message was 21 and 35 which are the throttle position sensor and the speed controller circuits. The diagnostic fault tree contained in the service manual directs the mechanic through several steps to determine whether the sensors are faulty or whether some other defect may be present. The checks involve continuity and resistance checks of the throttle position sensor and idle speed controller.

Four dealers were visited with the car. The first dealer flatly refused to service the car because it was a test car, even if SC agreed to pay for the diagnosis and repair. The second dealer correctly identified the broken connector and correctly determined that the throttle position sensor was not defective.

The third dealer correctly identified the faulted circuit but did not follow through with the complete diagnostic procedure as recommended by the manufacturer. The third dealer ordered a replacement throttle position sensor. The vehicle was not returned to this dealer when the part arrived, so it is not known what final diagnosis would have been made when the sensor was replaced and the fault remained. The fourth dealer also apparently initiated the diagnosis correctly but also was unable to locate the connector. This dealer proceeded to field diagnose the car by replacing several components including the throttle position sensor, $O_2$ sensor, and ECM from other vehicles without eliminating the problem. The dealer checked the wiring continuity and found it to be satisfactory and finally gave up after several weeks.

Car 130 - Ford Granada 2.3L with Carburetor

This car was taken into dealerships with a disconnected ground strap which allowed most of the engine mounted sensors and actuators to operate at a different ground potential than the ECM. The symptoms included very high FTP HC and CO emissions and very poor fuel economy. The SC representative complained of a sudden loss of fuel economy.

The diagnostic procedure for fuel economy complaints includes checking for misfire, carburetor idle mixture, electronic ignition, and carburetor including ECS components affecting carburetor operation. A remote diagnostic tester is used to check elements of the ECS, however, the tester will not operate properly with the ground strap disconnected. The manufacturer's diagnostic procedure includes checking for ground and wiring connections if the diagnostic tester does not operate properly.

The first dealer apparently attempted to use the tester even though the ground strap was disconnected. He indicated that there was a failure in the vehicle's ECS and a part had to be ordered and installed before a complete diagnosis could be performed. He did not find the disconnected ground strap. The second dealer correctly identified the disconnected ground strap and reconnected it. The third dealer apparently did not attempt to diagnose the problem with the tester since he merely suggested poor quality fuel.

Car 131 - Ford LTD 5.8L with Carburetor

The coolant temperature sensor was selected as the component for field service evaluation. The coolant temperature sensor was mounted in a location that made simple disconnection of the sensor wire too obvious. It was therefore decided to fail the component in the open condition by passing excessive current through it. The symptoms included high HC and CO emissions, heavy detonation, and a loss of approximately two miles per gallon. The SC representative reported severe detonation beginning a few days before.

The manufacturer's diagnostic procedure includes using an off-board diagnostic tester. Unfortunately, on this particular car, it is necessary to remove the cruise control unit in order to connect the tester which makes using the tester very inconvenient. Components suggested as causing pinging or detonation are electronic ignition, EGR system, and fuel system including carburetor and fuel quality. The coolant temperature sensor has its own failure code which is displayed on the tester.

The first dealer apparently did not attempt to use the tester because he suggested poor quality fuel. The second and third dealers correctly diagnosed the failed component and replaced it. Without using the tester it is unlikely that they would have identified the sensor.

Car 133 - Plymouth Reliant 2.2L with Carburetor

This vehicle was taken to dealers with a disconnected 5-way connector which brings signals from several sensors into the ECM. This disablement resulted in moderate HC and CO emissions and lower fuel economy. There was no driveability impact from the disablement. The driver complaint was poor fuel economy occuring a few days before.

There is no off-board ECS diagnostic tester for this car. Components identified as related to fuel economy were electronic ignition, carburetor and fuel control computer. Diagnostic procedures consist of checking continuity, voltage and resistance levels at various points at the ECM or sensors and actuators. During these checks, the open circuit caused by the disconnected connector would have been found.

The first and third dealers did not find the disablement. Both recommended a tune-up since the vehicle was approaching the scheduled tune-up mileage interval. Both dealers reported "scope" or "test" of engine as the basis for their diagnosis. The second dealer found and corrected the disablement. He reported "repair of $O_2$ system (wire disconnected), scope and set to specs".

Car 136 - Lincoln Continental 5.0L with Central Fuel Injection

The barometric pressure sensor was selected as the failed component on this car. The disablement caused high HC and CO emissions, a loss of four to five miles per gallon in fuel economy and no effect on driveability. The vehicle also failed MVIP standards at cruise. The driver complaint on this vehicle was a failed MVIP test report showing HC and CO failures at cruise. As in the coolant temperature sensor for car 131, this disablement was induced by failing the component with excessive electric current. This component has a specific error code using the off-board tester.

The first dealer correctly identified and replaced the faulty component. The second dealer incorrectly diagnosed and replaced the EGR valve and EGR valve position sensor. Since the tester did not indicate EGR system malfunction, the mechanic's action indicates either misuse or non-use of the tester. The third dealer incorrectly replaced the spark plugs in response to the MVIP low emission tune-up message. The MVIP printout also showed the following messages:

- failure of catalytic converter or related emission control system components
- cruise air/fuel mixture rich
- misfire at cruise

The third dealer apparently did not use the tester but performed the minimum indicated by the MVIP report. Since the vehicle did not fail at idle to begin with, his emission check (at idle) showed the car passing after tune-up and he probably felt that the problem was corrected.

Car 137 - Chevrolet Citation 2.5L with Carburetor

The disablement on this car was an open circuit in the manifold vacuum sensor. This component disablement resulted in increased HC and CO emissions, a loss of 3 miles per gallon in fuel economy during the FTP and degraded cold driveability. The check engine light came on intermittently. The component was disabled as described above for the coolant temperature sensor in Car 131. This disablement had a specific fault code which was stored in the ECM memory. The driver complaint was the check engine light coming on.

All three dealers correctly diagnosed the faulty component. Two dealers ordered the replacement sensor, one dealer replaced it from stock. The results indicate that all three dealers correctly followed manufacturer diagnostic procedures.

Car 139 - Toyota Celica Supra 2.7L with Electronic Fuel Injection

The disablement selected for this vehicle was a combination of disconnected $O_2$ and intake air temperature sensors. This disablement resulted in increased HC and CO emissions and a loss of three to four gallons of fuel economy. There was no loss of driveability and no overt symptoms. The vehicle, however, did fail MVIP standards at idle and cruise. The driver complaint was sudden loss of fuel economy.

This disablement was the only one which affected emissions and fuel economy. The manufacturer's manual suggested fuel injection system and electronic ignition system problems. This car was equipped with a diagnostic tester connection. Specific functional checks with tolerances for voltage and resistance were also provided for some components, including the $O_2$ sensor and air temperature sensor. The manuals available to SC did not have instructions or diagnostic procedures for the diagnostic tester.

The first dealer did not find either disablement. The scheduled 7500 mile service which consists primarily of lubrication, was performed. There was no evidence of any effort to diagnose the actual fault. The second dealer correctly identified the $O_2$ sensor circuit, but incorrectly diagnosed the $O_2$ sensor as defective. The air temperature sensor disablement was not identified. The $O_2$ sensor was ordered but the car was not returned when it arrived so the final diagnostic action is not known. The third dealer reported the engine set rich and "scope and adjust engine" performed. The only adjustment on the engine is idle speed, which was adjusted up 100 rpm. There was no evidence of any effort to diagnose the actual fault.

Car 140 - Cadillac Sedan de Ville 4.1L with Central Fuel Injection

Car 140 was taken to dealerships with an open circuit in the vehicle speed sensor. This disablement resulted in high HC and CO emissions and a slight drop in fuel economy. The check engine light was on continuously but there was no driveability impact from the disablement. The driver complaint was the check engine light. The disablement was induced by identifying a fuse which affected only the speed sensor and blowing it with electric current. The disablement had a specific fault code which was read out on the vehicle dashboard display.

The first dealer returned the car after reporting that he could not verify the check engine light or fault code. When returned to SC, the check engine light was on and the fault code was set. Apparently in order to set the code, it was necessary to operate the vehicle for several seconds at part throttle in other than first gear. The dealer mechanic apparently did not to that, although he reported road testing the car. The second dealership's service writer performed a first level diagnosis by reading the fault code and identifying the speed sensor circuit as the problem. This was the only case in the program of the service writer confirming the symptom upon receipt of the car. The fault was found and corrected. The third dealership did not find the disablement, but apparently did attempt to diagnose it. The vehicle speed sensor was replaced without correcting the problem. After three days the car was picked up with the defect still implanted.

Car 143 - BMW 528e 2.7L with Electronic Fuel Injection

The disablement selected for this car was the idle control valve which resulted in a cyclical oscillation of the idle speed between 600 and approximately 1800 rpm during idle and part throttle cruise under 30 mph. Other symptoms included a 5-6 mpg loss of FTP fuel economy and a slight increase in $NO_x$ emissions. The disablement was induced by unsoldering the wire from the #5 pins of the control valve connector. The connector appeared normal but the one wire was open. The driver complaint was erratic idle speed.

This vehicle is equipped with a remote diagnostic tester connection, however the tester does not test the idle control valve. None of the manufacturer's service procedures included functional or parameter specifications for the valve.

The first dealer performed a correct diagnosis of the symptom, but determined that the idle control valve itself was defective. Since the valve was not available and the car was not subsequently returned, the final diagnosis is not known. The second dealer incorrectly diagnosed the ECM as the faulty component. The third dealer correctly diagnosed and repaired the disablement.

<u>Car 144 - Datsun 280ZX 2.8L with Electronic Fuel Injection</u>

This vehicle was taken to dealers with the $O_2$ sensor disconnected. This disablement resulted in high FTP $NO_x$ emissions, marginal failures of idle CO and HC MVIP standards, no appreciable impact on fuel economy and improved driveability. The driver complaint for this vehicle was the failed MVIP test report. showing an idle HC failure and failure codes indicating misfire at idle and low emission tune-up.

The vehicle is equipped with a diagnostic tester connection for use with a remote tester. The tester checks the $O_2$ sensor circuit. The manufacturer recommends performing this check when an emissions problem occurs. The first dealership performed a "low emission tune" which consists of an idle speed adjustment on this car and reported idle HC and CO emissions within MVIP standards. The disablement was not detected and there is no evidence of any diagnosis of the EECS. The vehicle was sent back to the MVIP test facility and failed idle HC again, although the absolute level was lower than the initial inspection. The second dealership correctly identified the $O_2$ sensor circuit, reported that an $O_2$ sensor had been ordered and instructed SC's representative to return the car when notified. Since the car was not returned, the final outcome of the diagnosis is not known. The third dealership also performed "low emission tune" and reported exactly the same HC and CO idle emission data as the first dealership. There was no evidence of diagnosis of the EECS.

The results of the field service evaluation were reduced to a numerical score based on the formula and criteria described in Section 2. The overall results of the field survey in terms of detectability of the implanted disablements is shown in Table 3-22 for each car. The table shows both the driver detection rate and the dealer detection rate for the disablements used in the field service evaluation. Except for cars 103 and 139, dealer detection of the disablement was better than the driver's. Five vehicles (130, 133, 139, 143 and 144) had disablements which were essentially undetectable by the vehicle driver. These cars were not equipped with on-board warning lights. Three cars (103, 137 and 140), all of them equipped with on-board warning lights, ranged from 67% to 87% in driver detectability. The corresponding dealer score ranged from 47% to 100%. Only vehicle (137) achieved a 100% rating on dealer detection. For all ten cars, the average driver detection rating was 33% and the dealer detection was 46%.

## 3.3 ON-BOARD VERSUS REMOTE DIAGNOSTIC SYSTEMS

This section compares the performance and benefits of on-board and remote diagnostic systems in terms of fault detection, both by the owner/operator of the vehicle and by the mechanic servicing the vehicle; and effectiveness of fault diagnosis and repair. This analysis is based on the results of the testing and field service evaluation presented above. The pertinent data are summarized in Table 3-23 for each car.

### 3.3.1 Detection of Failure

The detection of failure was determined quantitatively for each car as described in Section 2 for all of the disablements attempted. No-start and no-run conditions were rated along with conditions which were testable. Based on all induced defects, a point score was obtained for each car. This score was then expressed as a percent of the maximum score which could have been obtained. The result was Driver 1 Index in Table 3-23. This index measured the overall detectability of defects by the vehicle driver in terms of warning lights, driveability, non-operation, high emissions and fuel economy. Non-operation and warning lights contributed significantly to the index. Therefore, cars

Table 3-22. EFFECTIVENESS OF FAULT DETECTION

| CAR | DIAGNOSTIC SYSTEM | DISABLED COMPONENT | IMPACT | DRIVER DETECTION | DRIVER COMPLAINT | DEA DETEC |
|---|---|---|---|---|---|---|
| 103 (OLD) | On-board | (3) Throttle Position Sensor | Marginal Increase in HC/CO; Decrease in Fuel Economy | 67% | "Check Engine" Light | 5 |
| 130 (GRA) | Remote | (8) Engine Ground | High HC/CO | 7% | Poor Fuel Economy | 4 |
| 131 (LTD) | Remote | (2) Coolant Temperature Sensor | High HC/CO, Detonation | 33% | Knocks | 6 |
| 133 (PLY) | Manual | (6) Six-way Connector | High HC/CO, Poor Fuel Economy | 0 | Poor Fuel Economy | 3 |
| 136 (LIN) | Remote | (4) Barometric Pressure Sensor | High HC/CO, Poor Fuel Economy, Smoke | 31% | Failed VIP | 4 |
| 137 (CIT) | On-board | (4) Vacuum Sensor | High HC/CO | 87% | "Check Engine" Light | 10 |
| 139 (TOY) | Remote | (13) $O_2$/Air Temperature Sensor | High HC/CO | 7% | Poor Fuel Economy | 1 |
| 140 (CAD) | On-board | (6) Vehicle Speed Sensor | High HC/CO | 80% | "Check Engine" Light | 4 |
| 143 (BMW) | Remote | (10) Idle Speed Control Valve | High HC/$NO_x$, Poor Fuel Economy | 7% | Erratic Idle Speed | 5 |
| 144 (DAT) | Remote | (1) $O_2$ Sensor | High $NO_x$/HC | 7% | Failed VIP | 1 |

Numbers in parentheses are the defect number for the component.

Table 3-23. COMPARISON OF DIAGNOSTIC SYSTEMS

| CAR | CODE | DIAGNOSTIC SYSTEM | INDICES EXPRESSED AS % DRIVER 1 | DRIVER 2 | SERVICE | REPAIR |
|---|---|---|---|---|---|---|
| 103 | OLD | On-board | 64 | 67 | 53 | 47 |
| 130 | GRA | Remote | 3 | 7 | 40 | 33 |
| 131 | LTD | Remote | 35 | 33 | 67 | 67 |
| 133 | PLY | Manual | 25 | 0 | 33 | 33 |
| 136 | LIN | Remote | 47 | 31 | 40 | 33 |
| 137 | CIT | On-board | 41 | 87 | 100 | 100 |
| 139 | TOY | Remote | 62 | 7 | 13 | 13 |
| 140 | CAD | On-board | 78 | 80 | 47 | 33 |
| 143 | BMW | Remote | 46 | 7 | 53 | 47 |
| 144 | DAT | Remote | 71 | 7 | 13 | 13 |
| All Car Average | | | 47 | 33 | 46 | 41 |
| On-board Average | | | 61 | 78 | 67 | 60 |
| Remote Diagnostic Average | | | 44 | 15 | 38 | 33 |
| Manual | | | 25 | 0 | 33 | 33 |

Driver 1 Index is the average detectability of all component disablements for each car.

Driver 2 Index is the detectability of the component disablement used for dealership visits.

Service Index is the average diagnostic effectiveness of three dealership visits with one component disablement for each car.

Repair Index is average repair effectiveness of three dealership visits with one component disablement for each car.

with on-board systems resulted in higher than average driver detectability ratings (61%). Cars with remote diagnostic systems were rated lower (44%) and would have been rated considerably lower if two cars (139 and 144) had not had a large number of non-driveable disablements. Excluding those two cars, the four car average rating was 33%. The lowest detectability rating (3%) was on car 130 which was equipped with a remote diagnostic system. The next lowest rating (25%) was on car 133 which did not have a diagnostic test system. Even with an on-board diagnostic system, some defects did not trigger the warning light on two of the cars (103 and 137).

The Driver 2 Index in Table 3-23 shows the detectability of the single disablement used for the dealer survey. For five of the cars (103, 130, 131, 136 and 140) the Driver 2 Index agreed with the Driver 1 Index, indicating that the detectability of the single disablement was typical of all disablements. For five cars (133, 137, 139, 143 and 144) the Driver 2 Index was different than the Driver 1 Index. The rating was 0% on car 133 and the highest was 87% on car 137. The average index rating of cars with on-board systems was 78% compared to 15% for cars with remote diagnostic systems and 0% for manual diagnostics.

Both driver indices showed that on-board diagnostic systems provided substantially better driver detection of problems than remote diagnostic or manual systems.

### 3.3.2 Diagnosis of Failure

The dealer Service Index in Table 3-23 represents the success of the mechanic in identifying the disablement. A 100% rating for a car meant that all three dealers succeeded in diagnosing the problem. The index varied from a low of 13% on cars 139 and 144, both equipped with remote diagnostic systems to a high of 100% on car 137 which was equipped with an on-board system. On average, the cars with on-board diagnostic systems had a higher Service Index (67%) than cars with remote diagnostic systems (38%) or manual systems (33%). This indicated that the on-board systems provided substantially better diagnostic information to the mechanic than did remote diagnostic systems and were more likely to result in a correct diagnosis.

On most cars, the Service Index was higher than the Driver 2 Index which implied that there was a better chance of the dealer mechanic detecting the problem than the vehicle owner. However, on two cars (103 and 140) with on-board diagnostic systems, the Driver 2 Index was higher than the Service Index which implied that although the presence of a problem was more easily detected, diagnosis of the problem was not assured.

### 3.3.3 Repair of Failure

Effectiveness of fault repair was not quantitatively determined since not all vehicles were repaired. An estimate of repair effectiveness, however, was based on the dealer score from the analysis of fault diagnosis. Dealer scores of 2 or 5 indicated either identification of the correct circuit or the specific component disablement, respectively. For each car, dealer scores of 2 or 5 were added to obtain a score for repair actions which resulted in or would have resulted in correction of the disablement if implemented. These scores were then expressed as a percent of the maximum possible score (15) to obtain the Repair Index shown in Table 3-23.

The highest rating (100%) was obtained on car 137 which was equipped with an on-board diagnostic system. The lowest rating (13%) was obtained on cars 139 and 144, with remote diagnostic systems. The average Repair Index for cars with on-board diagnostic systems was 60% compared to 33% for cars with remote diagnostic systems. This indicated that on-board diagnostic systems were more likely to result in a correct repair than remote diagnostic systems. There were, however, individual cases where cars with remote diagnostic systems provided higher Repair Indices than cars with on-board systems.

## GLOSSARY OF ABREVIATIONS

| | |
|---|---|
| $CO_2$ | carbon dioxide |
| CO | carbon monoxide |
| CVS | constant volume sampler |
| EECS | electronic emission control system |
| ECM | electronic control module (microprocessor) |
| ECU | electronic control unit (microprocessor) |
| EGR | exhaust gas recirculation |
| FTP | federal test procedure |
| GM/MI | grams per mile |
| HC | hydrocarbons |
| HFET | highway fuel economy test |
| MPG | miles per gallon |
| $NO_x$ | oxides of nitrogen |

# APPENDIX

DEFINITIONS OF SYMBOLS USED IN APPENDIX

The numbers shown in the following tables are the precent increases or decrease (-) of the parameters relative to the mean of the baseline tests. Defect codes are defined in Table 3-11 in the body of the report. Initial and final baseline tests are coded "0.0" and "0.1" respectively. The numbers shown in parenthesis indicate the confidence level that the change is statistically significant: (0) = less than 90%, (1) = greater than 90%, (2) = greater than 95%, (3) = greater than 99%. "% AVERD" is the average effect of all disablements on each car. "*****" means that the change is 10,000% or more and occured for hot start (HFET or ARB loaded test) HC or CO data in those cases where low baseline emission levels were combined with high disablement test emission levels.

EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 103

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | -7(0) | -9(0) | 30(0) | -25(0) | 2(0) | 17(0) | -2(0) | -1(0) | -5(0) | -1(0) | -2(0) |
| 1.0 | -7(0) | -62(1) | 224(1) | -50(0) | -100(3) | 854(3) | 2(0) | 1(0) | -88(2) | 1(0) | 2(0) |
| 2.0 | 143(2) | 312(3) | 242(1) | 2275(3) | 6767(3) | 108(1) | -35(2) | -12(2) | -55(1) | -15(2) | -16(1) |
| 3.0 | 2(0) | -4(0) | 17(0) | 525(2) | 597(3) | -37(0) | -5(0) | 4(0) | 5(0) | -9(1) | -1(0) |
| 4.0 | 55(1) | 129(2) | -70(0) | 725(2) | 1117(3) | -92(0) | -16(1) | -28(3) | 2(0) | -20(2) | -25(2) |
| 5.0 | 10(0) | 5(0) | -12(0) | 375(2) | 476(3) | -33(0) | -5(0) | -1(0) | 9(0) | -1(0) | -1(0) |
| 6.0 | 24(0) | 19(0) | -19(0) | 700(2) | 714(3) | -25(0) | -8(0) | -7(1) | 6(0) | -1(0) | -6(0) |
| 7.0 | 17(0) | 12(0) | -23(0) | 500(2) | 544(3) | -42(0) | -6(0) | -7(1) | 9(0) | 1(0) | 3(0) |
| 8.0 | -2(0) | -12(0) | 13(0) | 400(2) | 394(3) | -33(0) | -4(0) | 6(1) | 8(0) | -8(1) | -1(0) |
| 9.0 | 719(3) | 1700(3) | -14(0) | 4125(3) | *****3) | 92(0) | -100(3) | -100(3) | -51(1) | -16(2) | -18(1) |
| 10.0 | 648(3) | 1914(3) | -60(0) | 3625(3) | *****3) | -54(0) | -94(3) | -100(3) | -45(1) | -32(3) | -36(2) |
| 0.1 | 7(0) | 9(0) | -30(0) | 25(0) | -2(0) | -17(0) | 2(0) | 1(0) | 5(0) | 1(0) | 2(0) |
| % AVERD | 161. | 401. | 30. | 1320. | 3757. | 74. | -27. | -24. | -20. | -10. | -10. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR # 103

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 20(0) | 100(0) | 50(0) | 23(0) | 50(0) | 45(0) | 8(0) | 0(0) | 38(0) | -23(0) | 0(0) | -16 |
| 1.0 | 0(0) | 100(0) | 64(0) | -8(0) | -50(0) | 42(0) | -46(0) | -100(1) | -12(0) | 138(0) | 433(3) | 232 |
| 2.0 | 240(1) | *****3) | 64(0) | 238(1) | *****3) | -8(0) | 981(3) | 7900(3) | 77(0) | -81(0) | -33(0) | -66 |
| 3.0 | 40(0) | 6300(3) | -95(0) | 8(0) | 1500(2) | -93(0) | -62(1) | 100(1) | -82(0) | -58(0) | 8(0) | -37 |
| 4.0 | -20(0) | 6900(3) | -97(0) | -8(0) | 900(2) | -99(0) | -35(0) | 100(1) | -91(0) | 435(2) | 375(3) | 416 |
| 5.0 | -4(0) | 3900(3) | -89(0) | -8(0) | 1650(3) | -86(0) | 305(3) | 900(3) | -73(0) | 69(0) | 658(3) | 255 |
| 6.0 | 80(0) | 5900(3) | -84(0) | 23(0) | 1400(2) | -85(0) | 35(0) | 200(2) | -91(0) | 50(0) | 58(0) | 53 |
| 7.0 | 68(0) | 4300(3) | -95(0) | 23(0) | 1400(2) | -90(0) | 981(3) | 1500(3) | -91(0) | 138(0) | 142(2) | 139 |
| 8.0 | 36(0) | 1900(2) | -98(0) | -8(0) | 700(2) | -97(0) | -46(0) | 0(0) | -56(0) | 135(0) | 158(2) | 142 |
| 9.0 | 600(2) | *****3) | -55(0) | 500(2) | *****3) | -60(0) | 3035(3) | *****3) | -65(0) | -4(0) | -42(0) | -16 |
| 10.0 | 180(1) | *****3) | -94(0) | 162(1) | 9900(3) | -95(0) | 711(3) | *****3) | -95(0) | 615(2) | 133(2) | 463 |
| 0.1 | -20(0) | -100(0) | -50(0) | -23(0) | -50(0) | -45(0) | -8(0) | 0(0) | -38(0) | 23(0) | 0(0) | 16 |
| % AVERD | 122. | ***** | -58. | 92. | 4620. | -67. | 586. | 4840. | -58. | 144. | 189. | 158 |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 130

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0(0) | 12(0) | -14(0) | 0(0) | -33(0) | -16(0) | 1(0) | 1(0) | 26(0) | -1(0) | -1(0) |
| 1.0 | 56(0) | 71(0) | -11(0) | 200(2) | 2967(3) | 28(0) | -3(0) | 2(0) | -57(0) | -4(0) | -7(1) |
| 2.0 | 11(0) | 42(0) | 88(1) | 100(1) | -33(0) | 399(2) | -1(0) | 1(0) | -91(0) | -1(0) | 0(0) |
| 3.0 | 522(3) | 1093(3) | 2(0) | 2650(3) | *****3) | -75(0) | -56(3) | -65(3) | -21(0) | -1(0) | 1(0) |
| 4.0 | 7(0) | 10(0) | -3(0) | -75(1) | -33(0) | 6(0) | -1(0) | -2(0) | -19(0) | 0(0) | -1(0) |
| 5.0 | 11(0) | 85(1) | -14(0) | 200(2) | 2167(3) | 38(0) | 0(0) | 3(0) | -54(0) | -7(0) | -6(0) |
| 6.0 | 37(0) | 44(0) | 19(0) | 200(2) | 367(1) | 41(0) | -4(0) | -1(0) | -44(0) | -1(0) | -1(0) |
| 7.0 | 981(3) | 3915(3) | -11(0) | 3925(3) | *****3) | -53(0) | -93(3) | -105(3) | -25(0) | -15(1) | -4(0) |
| 8.0 | 1126(3) | 9716(3) | -15(0) | 4050(3) | *****3) | -38(0) | -99(3) | -102(3) | -32(0) | -43(3) | -29(2) |
| 9.0 | 1059(3) | 2818(3) | 1(0) | 4000(3) | *****3) | -36(0) | -93(3) | -110(3) | -25(0) | -13(1) | -11(1) |
| 10.0 | 26(0) | 22(0) | 107(1) | 100(1) | 33(0) | 344(2) | -3(0) | 4(1) | -97(0) | -13(1) | -9(1) |
| 0.1 | 0(0) | -12(0) | 14(0) | 0(0) | 33(0) | 16(0) | -1(0) | -1(0) | -26(0) | 1(0) | 1(0) |
| % AVERD | 384. | 1782. | 16. | 1535. | ***** | 65. | -35. | -38. | -46. | -10. | -7. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR #130

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 29(0) | -100(0) | -28(0) | -12(0) | -100(0) | -14(0) | -2(0) | 0(0) | -4(0) | 3(0) | 42(0) | 12 |
| 1.0 | 76(0) | 100(0) | 278(1) | 56(0) | 1700(2) | 87(0) | 11(0) | 10(0) | 20(0) | -23(1) | 0(0) | -18 |
| 2.0 | 43(0) | -100(0) | 688(2) | 46(0) | 100(0) | 606(3) | 11(0) | 10(0) | 45(1) | -5(0) | 25(0) | 2 |
| 3.0 | 19(0) | 100(0) | 688(2) | 656(3) | *****3) | -52(0) | 922(3) | 3200(3) | -69(2) | -67(2) | -25(0) | -57 |
| 4.0 | 733(2) | 100(0) | 6(0) | 632(3) | 100(0) | 23(0) | 922(3) | 2300(3) | -88(2) | 8(0) | -58(0) | -8 |
| 5.0 | 67(0) | 100(0) | 238(1) | 56(0) | 1300(2) | 93(1) | 2(0) | 40(0) | 16(0) | -41(2) | -67(0) | -47 |
| 6.0 | 210(1) | -100(0) | 53(0) | 241(2) | 100(0) | 2(0) | 202(3) | 10(0) | -40(1) | -36(2) | -58(0) | -41 |
| 7.0 | 724(2) | *****3) | 80(0) | 924(3) | *****3) | -30(0) | 1078(3) | 3400(3) | -88(2) | -38(2) | -58(0) | -43 |
| 8.0 | 662(2) | *****3) | 49(0) | 900(3) | *****3) | -30(0) | 1100(3) | 1400(3) | -64(2) | 8(0) | -42(0) | -4 |
| 9.0 | 686(2) | *****3) | 103(0) | 876(3) | *****3) | -79(0) | 1011(3) | 2500(3) | -76(2) | -28(1) | -42(0) | -31 |
| 10.0 | -29(0) | 100(0) | 531(2) | -17(0) | 700(1) | 349(2) | -33(2) | 10(0) | 40(1) | -15(0) | -42(0) | -22 |
| 0.1 | -29(0) | 100(0) | 28(0) | 12(0) | 100(0) | 14(0) | 2(0) | 0(0) | 4(0) | -3(0) | -42(0) | -12 |
| % AVERD | 319. | 9300. | 271. | 437. | ***** | 97. | 523. | 0. | -30. | -24. | -37. | -27. |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 131

| DEFECT | CVS EMISSIONS (GM/MI) FTP | | | CVS EMISSIONS (GM/MI) HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | -15(0) | -2(0) | -6(0) | -74(0) | 33(0) | -8(0) | 1(0) | 0(0) | 4(0) | -2(0) | -2(0) |
| 1.0 | 70(0) | 138(3) | 5(0) | -49(0) | 2233(3) | 13(0) | -3(0) | 0(0) | -21(0) | -13(1) | -6(0) |
| 2.0 | 1226(3) | 5225(3) | 15(0) | 762(1) | *****3) | 33(0) | -95(3) | -97(1) | 57(2) | -14(1) | -12(1) |
| 3.0 | 15(0) | 23(1) | -5(0) | -69(0) | -33(0) | 4(0) | 0(0) | -1(0) | -9(0) | -3(0) | -1(0) |
| 4.0 | 22(0) | -2(0) | 6(0) | -74(0) | 100(0) | 23(0) | -1(0) | 0(0) | -8(0) | 0(0) | 1(0) |
| 5.0 | 19(0) | 51(2) | -23(0) | -59(0) | 5567(3) | -40(0) | -1(0) | 2(0) | -13(0) | -17(1) | -16(1) |
| 6.0 | 48(0) | 22(1) | 18(0) | -49(0) | 833(2) | 30(0) | -3(0) | 2(0) | -11(0) | -4(0) | -1(0) |
| 8.0 | -15(0) | -18(1) | 277(3) | -79(0) | -33(0) | 220(2) | 2(0) | 2(0) | 28(1) | -3(0) | -5(0) |
| 9.0 | 126(1) | 98(3) | 178(2) | -85(0) | 2033(3) | -13(0) | -8(1) | 4(0) | 8(0) | -4(0) | -0(0) |
| 11.0 | 1163(3) | 4741(3) | 66(1) | 669(1) | *****3) | 134(2) | -98(3) | -101(1) | 47(1) | -13(1) | -11(0) |
| 13.0 | 22(0) | 98(3) | 6(0) | -49(0) | 3233(3) | 8(0) | -1(0) | 1(0) | -21(0) | -4(0) | -2(0) |
| 0.1 | 15(0) | 2(0) | 6(0) | 74(0) | -33(0) | 8(0) | -1(0) | 0(0) | -4(0) | 2(0) | 2(0) |
| % AVERD | 270. | 1038. | 54. | 92. | ***** | 41. | -21. | -19. | 6. | -7. | -5. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR # 131

ARB LOADED TEST

| DEFECT | HIGH | | | LOW | | | IDLE | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | T( |
| 0.0 | 0(0) | 0(0) | -7(0) | 6(0) | 33(0) | -13(0) | 8(0) | 0(0) | -29(0) | -44(0) | 60(0) | -2 |
| 1.0 | 67(1) | 0(0) | 105(2) | 49(1) | 233(1) | 79(0) | 35(0) | 200(2) | 79(0) | 12(0) | 40(0) | 1 |
| 2.0 | 1633(3) | 1750(3) | 109(2) | 921(3) | *****3) | 1(0) | 1630(3) | *****3) | -64(0) | 164(0) | 1080(2) | 31 |
| 3.0 | 33(0) | 100(1) | -30(0) | 15(0) | 33(0) | 9(0) | 24(0) | 0(0) | -29(0) | -36(0) | 20(0) | -2 |
| 4.0 | 0(0) | 100(1) | 7(0) | -6(0) | 100(0) | 93(1) | -30(0) | -100(1) | 29(0) | 88(0) | -20(0) | 7( |
| 5.0 | 33(0) | 20(0) | -24(0) | -28(0) | 100(0) | -10(0) | 73(1) | 400(3) | 129(0) | -20(0) | -80(0) | -3( |
| 6.0 | 53(0) | 0(0) | 109(2) | 28(0) | 233(1) | 88(1) | 35(0) | 100(1) | 114(0) | -68(0) | 20(0) | -5 |
| 8.0 | -33(0) | 0(0) | 133(2) | 6(0) | -33(0) | 94(1) | -24(0) | -100(1) | 43(0) | 516(1) | 1280(2) | 64 |
| 9.0 | 0(0) | 0(0) | 365(3) | -45(1) | -100(0) | 467(3) | 8(0) | 0(0) | 114(0) | 516(1) | 1780(2) | 72 |
| 11.0 | 747(3) | 2250(3) | 533(3) | 432(3) | *****3) | 182(2) | 4224(3) | *****3) | -93(0) | 1260(2) | 2100(3) | 140( |
| 13.0 | 67(1) | 200(2) | 49(1) | -6(0) | 1233(3) | 65(0) | 2332(3) | *****3) | -43(0) | 0(0) | 980(2) | 16 |
| 0.1 | 0(0) | 0(0) | 7(0) | -6(0) | -33(0) | 13(0) | -8(0) | 0(0) | 29(0) | 44(0) | -60(0) | 2 |
| % AVERD | 260. | 0. | 136. | 137. | 2693. | 107. | 831. | ***** | 28. | 243. | 720. | 32 |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 133

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 0(0) | 11(0) | 5(0) | 14(0) | 64(0) | 0(0) | -1(0) | -1(0) | -6(0) | -1(0) | -2(0) |
| 1.0 | -24(0) | 123(1) | -34(1) | 300(2) | 5829(3) | -29(0) | 5(1) | -2(0) | -66(1) | -7(1) | -15(1) |
| 2.0 | -3(0) | -5(0) | -10(0) | 14(0) | -20(0) | -2(0) | 1(0) | 0(0) | 6(0) | 1(0) | 2(0) |
| 3.0 | -32(0) | -56(0) | -21(0) | -14(0) | -100(0) | -2(0) | 3(0) | -1(0) | 45(1) | 9(1) | 3(0) |
| 4.0 | 168(2) | 587(3) | -52(1) | 1814(3) | *****3) | -67(1) | -8(2) | -17(2) | -38(1) | -14(2) | -29(2) |
| 5.0 | 29(0) | 72(1) | -19(0) | 14(0) | -64(0) | -14(0) | -3(0) | -4(0) | 10(0) | 1(0) | 2(0) |
| 6.0 | 241(2) | 217(2) | -53(1) | 929(3) | *****3) | -64(1) | -15(2) | -5(0) | -26(0) | -7(1) | -23(2) |
| 7.0 | 603(3) | 1639(3) | -67(2) | 500(3) | 7691(3) | -57(0) | -27(3) | -34(3) | -61(1) | -29(2) | -21(2) |
| 10.0 | -18(0) | -12(0) | -9(0) | 14(0) | -73(0) | -12(0) | 4(1) | 1(0) | 8(0) | 1(0) | 2(0) |
| 11.0 | 88(1) | 165(2) | -3(0) | -71(0) | -100(0) | -5(0) | -7(2) | -29(2) | 22(0) | -7(1) | 1(0) |
| 12.0 | -6(0) | 35(0) | -9(0) | 129(1) | 96(0) | -62(0) | 1(0) | -3(0) | -17(0) | -3(0) | -12(1) |
| 0.1 | 0(0) | -11(0) | -5(0) | -14(0) | -64(0) | 0(0) | 1(0) | 1(0) | 6(0) | 1(0) | 2(0) |
| % AVERD | 105. | 277. | -28. | 363. | 5225. | -31. | -5. | -10. | -12. | -5. | -9. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR # 133

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | T |
| 0.0 | -21(0) | 0(0) | -2(0) | -6(0) | 100(0) | 9(0) | -8(0) | 0(0) | 8(0) | -6(0) | -16(0) | -1 |
| 1.0 | -11(0) | 0(0) | 200(3) | -25(0) | 0(0) | 196(2) | -32(0) | 0(0) | 69(1) | 12(0) | -28(0) | - |
| 2.0 | -47(0) | 0(0) | -27(1) | -32(0) | 0(0) | 5(0) | -28(0) | 0(0) | 8(0) | -35(0) | -16(0) | -2 |
| 3.0 | 21(0) | 0(0) | 2(0) | -32(0) | 0(0) | -9(0) | -20(0) | 0(0) | -100(2) | 206(3) | 62(0) | 13 |
| 4.0 | -5(0) | 100(1) | 7(0) | 43(1) | *****3) | -51(0) | 4(0) | 200(2) | -8(0) | -24(0) | -50(0) | -3 |
| 5.0 | 5(0) | 0(0) | -17(1) | -6(0) | 0(0) | -9(0) | 0(0) | 0(0) | -17(0) | 47(1) | -31(0) | |
| 6.0 | -47(0) | 900(3) | -27(1) | -13(0) | 3500(3) | -56(0) | -32(0) | 600(3) | 2(0) | -3(0) | -16(0) | - |
| 7.0 | 16(0) | *****3) | -32(2) | 43(1) | 4400(3) | -58(1) | 20(0) | 600(3) | -8(0) | 35(0) | 28(0) | 3 |
| 10.0 | 26(0) | 0(0) | -2(0) | -13(0) | -100(0) | -14(0) | 32(0) | 100(1) | -8(0) | 53(1) | 41(0) | 4 |
| 11.0 | 32(0) | 100(1) | -17(1) | -13(0) | 100(0) | -9(0) | 60(1) | 100(1) | -54(1) | 26(0) | 3(0) | 1 |
| 12.0 | 58(0) | 2100(3) | -2(0) | -43(1) | -100(0) | -27(0) | 0(0) | -100(1) | -23(0) | 6(0) | 28(0) | 1 |
| 0.1 | 21(0) | 0(0) | 2(0) | 6(0) | -100(0) | -9(0) | 8(0) | 0(0) | -8(0) | 6(0) | 16(0) | 1 |
| % AVERD | 5. | 1410. | 9. | -9. | 1870. | -3. | 0. | 150. | -14. | 32. | 2. | 1 |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 136

| DEFEC. | CVS EMISSIONS (GM/MI) FTP | | | CVS EMISSIONS (GM/MI) HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | -2(0) | 41(0) | -3(0) | -18(0) | -38(0) | 23(0) | 0(0) | -4(0) | -3(0) | -3(0) | -0(0) |
| 1.0 | 24(2) | 184(0) | 15(0) | 6(0) | 208(0) | 81(0) | -1(0) | -2(0) | -36(2) | -5(0) | -1(0) |
| 4.0 | 602(3) | 2648(3) | -49(2) | 2347(3) | *****3) | -75(0) | -35(0) | -34(1) | 28(1) | -25(1) | -26(3) |
| 5.0 | 6106(3) | *****3) | -98(3) | *****3) | *****3) | -97(0) | -81(1) | -96(2) | 63(2) | -50(2) | -47(3) |
| 6.0 | 9198(3) | *****3) | -85(2) | *****3) | *****3) | *****3) | -100(1) | -78(2) | 8(0) | -61(2) | -100(3) |
| 12.0 | 33(2) | -65(0) | 35(1) | 65(0) | 162(0) | 12(0) | 1(0) | 7(0) | 23(1) | -0(0) | -2(1) |
| 13.0 | 37(2) | -5(0) | 24(1) | 41(0) | 69(0) | 80(0) | 0(0) | 1(0) | 34(1) | -1(0) | -2(1) |
| 14.0 | 81(3) | 125(0) | -11(0) | 53(0) | 146(0) | -21(0) | -3(0) | -14(0) | 12(0) | 0(0) | -1(0) |
| 15.0 | 65(3) | 144(0) | 53(2) | 6(0) | 3392(3) | 66(0) | -7(0) | -11(0) | 10(0) | -6(0) | -3(1) |
| 16.0 | 21(2) | -5(0) | -16(0) | 6(0) | -23(0) | -27(0) | -2(0) | -1(0) | -3(0) | -2(0) | -4(2) |
| 0.1 | 2(0) | -41(0) | 3(0) | 18(0) | 38(0) | -23(0) | 0(0) | 4(0) | 3(0) | 3(0) | 0(0) |
| % AVERD | 1796. | 5191. | -15. | ***** | ***** | 1613. | -25. | -25. | 16. | -17. | -21. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR #136

| DEFECT | ARB LOADED TEST HIGH HC | HIGH CO | HIGH NOX | LOW HC | LOW CO | LOW NOX | IDLE HC | IDLE CO | IDLE NOX | DRIVEABILITY TEST COLD | HOT | TC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | -8(0) | 0(0) | 22(0) | 15(0) | -33(0) | 1(0) | 33(0) | 0(0) | 12(0) | 86(0) | 60(0) | 79 |
| 1.0 | 8(0) | 100(1) | 233(1) | -15(0) | 33(0) | 55(3) | 67(0) | 0(0) | -52(0) | -14(0) | 220(0) | 47 |
| 4.0 | 873(3) | *****3) | 18(0) | 794(3) | *****3) | 1(0) | 133(0) | 9900(3) | -76(1) | -43(0) | -20(0) | -37 |
| 5.0 | 1630(3) | *****3) | -96(0) | 964(3) | *****3) | -100(3) | 4567(3) | *****3) | -68(0) | 86(0) | 300(0) | 142 |
| 6.0 | *****3) | *****3) | -100(0) | *****3) | *****3) | -100(3) | *****3) | *****3) | -100(1) | 3500(3) | *****3) | 7279 |
| 12.0 | 19(0) | 0(0) | 73(0) | 28(0) | -33(0) | 41(2) | 0(0) | 0(0) | -4(0) | -57(0) | -60(0) | -58 |
| 13.0 | 35(0) | 0(0) | 116(0) | 6(0) | -33(0) | 41(2) | -20(0) | 100(1) | 20(0) | 14(0) | -20(0) | 5 |
| 14.0 | 8(0) | -100(1) | 390(2) | 6(0) | -33(0) | 27(2) | 33(0) | 0(0) | -20(0) | -57(0) | 20(0) | -37 |
| 15.0 | 8(0) | -100(1) | 18(0) | -36(0) | 33(0) | 27(2) | -33(0) | 0(0) | 60(0) | 29(0) | 220(0) | 79 |
| 16.0 | 35(0) | 900(3) | -22(0) | 6(0) | -33(0) | 27(2) | -33(0) | 0(0) | 20(0) | -29(0) | 100(0) | 5 |
| 0.1 | 8(0) | 0(0) | -22(0) | -15(0) | 33(0) | -1(0) | -33(0) | 0(0) | -12(0) | -86(0) | -60(0) | -79 |
| % AVERD | 6285. | ***** | 70. | 4911. | ***** | 2. | 7919. | ***** | -24. | 381. | 2069. | 825 |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 137

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | 4(0) | 20(0) | 2(0) | 0(0) | 64(0) | 6(0) | -1(0) | -1(0) | 2(0) | -3(0) | -2(0) |
| 1.0 | -26(1) | 18(0) | 180(3) | 100(1) | 836(2) | 594(3) | 0(0) | -5(1) | -82(3) | 1(0) | 3(0) |
| 2.0 | 604(3) | 5582(3) | -16(1) | 1580(3) | *****3) | -87(2) | -53(3) | -69(3) | -16(1) | -22(1) | -17(1) |
| 3.0 | -11(0) | -50(0) | 57(2) | 0(0) | -9(0) | 23(0) | 2(0) | 3(0) | 25(2) | -28(1) | -5(0) |
| 4.0 | 1270(3) | *****3) | -63(3) | 1880(3) | 7482(3) | -74(1) | -82(3) | -94(3) | -11(0) | -17(0) | 11(0) |
| 5.0 | 4(0) | 5(0) | 7(0) | -20(0) | -9(0) | -6(0) | -1(0) | -1(0) | -5(0) | 0(0) | 2(0) |
| 6.0 | -26(1) | -36(0) | -1(0) | 0(0) | -0(0) | -3(0) | 2(0) | 2(0) | -2(0) | 1(0) | 1(0) |
| 7.0 | 1507(3) | *****3) | -49(2) | 2160(3) | *****3) | -65(1) | -91(3) | -97(3) | -25(2) | -14(0) | -13(0) |
| 8.0 | -4(0) | -12(0) | 5(0) | -20(0) | 18(0) | 3(0) | 0(0) | 1(0) | -7(0) | 1(0) | 1(0) |
| 9.0 | 1330(3) | *****3) | -84(3) | 1120(3) | *****3) | -94(2) | -72(3) | -95(3) | 39(2) | -50(2) | -11(0) |
| 10.0 | 4(0) | -10(0) | -31(2) | 0(0) | -82(0) | -42(1) | 6(0) | 3(0) | 40(2) | -6(0) | -13(0) |
| 0.1 | -4(0) | -20(0) | -2(0) | 0(0) | -64(0) | -6(0) | 1(0) | 1(0) | -2(0) | 3(0) | 2(0) |
| % AVERD | 465. | 4641% | 0. | 680. | ***** | 25. | -29. | -35. | -4. | -13. | -4. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR #137

| DEFEC. | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | T |
| 0.0 | 5(0) | 0(0) | -10(0) | 25(0) | 33(0) | 2(0) | 16(0) | 0(0) | 67(0) | -2(0) | -54(0) | - |
| 1.0 | 58(1) | -100(1) | 1400(3) | 50(0) | 433(2) | -2(0) | 16(0) | -100(1) | 333(0) | -17(1) | 192(0) | [illegible] |
| 2.0 | -21(0) | -100(1) | 740(3) | 215(1) | *****3) | -84(3) | 123(1) | 7900(3) | -80(0) | -63(3) | -8(0) | -5 |
| 3.0 | 58(1) | 0(0) | 6(0) | 0(0) | -33(0) | -37(2) | 16(0) | *****3) | -100(0) | 4(0) | -69(0) | - |
| 4.0 | 268(3) | *****3) | -90(1) | 300(1) | *****3) | -94(3) | 691(3) | *****3) | -33(0) | 50(2) | -23(0) | 4 |
| 5.0 | 5(0) | 0(0) | 10(0) | 0(0) | -33(0) | -2(0) | 7(0) | 0(0) | -33(0) | -52(2) | -38(0) | -5 |
| 6.0 | 216(3) | 100(1) | 0(0) | 60(0) | -33(0) | -16(1) | -7(0) | 0(0) | -100(0) | -4(0) | 100(0) | [illegible] |
| 7.0 | 505(3) | *****3) | 0(0) | 550(2) | *****3) | -41(2) | 923(3) | *****3) | 33(0) | -37(2) | 69(0) | -2 |
| 8.0 | 111(2) | 8900(3) | 100(1) | -50(0) | -33(0) | 96(3) | 179(1) | 100(1) | -67(0) | -24(2) | 8(0) | -2 |
| 9.0 | 5(0) | *****3) | -100(1) | 25(0) | *****3) | -100(3) | 226(2) | *****3) | -100(0) | 31(2) | 669(1) | 10 |
| 10.0 | -74(2) | -100(1) | -50(0) | -80(0) | -100(0) | -61(2) | -77(0) | -100(1) | -67(0) | -13(1) | -38(0) | -1 |
| 0.1 | -5(0) | 0(0) | 10(0) | -25(0) | -33(0) | -2(0) | -16(0) | 0(0) | -67(0) | 2(0) | 54(0) | [illegible] |
| % AVERD | 113. | ***** | 202. | 107. | ***** | -34. | 210. | ***** | -21. | -12. | 86. | - |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR #139

| DEFECT | CVS EMISSIONS (GM/MI) FTP HC | FTP CO | FTP NOX | HFET HC | HFET CO | HFET NOX | FTP (%) CONVERTER EFFICIENCY HC | CO | NOX | FUEL (MPG) ECONOMY FTP | HFET |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0(0) | 17(0) | 8(0) | -33(0) | 15(0) | 9(0) | 7(0) | -4(0) | -1(0) | -1(0) | 1(0) |
| 1.0 | 69(1) | 165(1) | 36(0) | 1967(3) | 1770(3) | 209(2) | 0(0) | -27(1) | -5(1) | -0(0) | -0(0) |
| 4.0 | 3(0) | -17(0) | -34(0) | 33(0) | 33(0) | -45(0) | 7(0) | 4(0) | 4(1) | 0(0) | 0(0) |
| 5.0 | 7(0) | 33(0) | 11(0) | -33(0) | -22(0) | 64(1) | 5(0) | -9(0) | -2(0) | 1(0) | 1(0) |
| 13.0 | 562(3) | 3133(3) | -60(1) | *****3) | *****3) | 136(2) | -30(0) | -91(2) | -1(0) | -14(2) | -13(1) |
| 14.0 | -24(0) | -12(0) | 6(0) | 567(2) | -11(0) | 45(0) | 10(0) | 3(0) | -2(0) | 2(0) | 14(2) |
| 0.1 | 0(0) | -17(0) | -8(0) | 33(0) | -15(0) | -9(0) | -7(0) | 4(0) | 1(0) | 1(0) | -1(0). |
| % AVERD | 123. | 660. | -8. | 2820. | 4009. | 82. | -2. | -24. | -1. | -2. | 0. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR # 139

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 33(0) | 33(0) | 100(0) | -63(0) | 0(0) | 27(0) | 18(0) | 100(0) | -33(0) | 50(0) | 45(0) | 47 |
| 1.0 | 852(2) | 433(2) | 480(0) | 1(0) | 60(0) | -27(0) | 194(1) | 100(0) | 7(0) | -100(0) | -100(0) | -100 |
| 4.0 | 90(0) | 33(0) | 900(1) | -64(0) | -40(0) | -45(0) | 112(1) | 100(0) | 167(0) | -100(0) | -100(0) | -100 |
| 5.0 | 138(0) | -33(0) | 100(0) | -67(0) | -60(0) | -82(0) | 194(1) | 100(0) | 167(0) | 100(0) | -100(0) | -16 |
| 13.0 | 2090(3) | *****3) | 600(0) | 274(0) | 8900(3) | 82(0) | 2371(3) | *****3) | -33(0) | -100(0) | -100(0) | -100 |
| 14.0 | -5(0) | -33(0) | 100(0) | -76(0) | 0(0) | -82(0) | 76(0) | 100(0) | 167(0) | 400(1) | -27(0) | 153 |
| 0.1 | -33(0) | -33(0) | -100(0) | 63(0) | 0(0) | -27(0) | -18(0) | -100(0) | 33(0) | -50(0) | -45(0) | -47 |
| % AVERD | 633. | 5660. | 436. | 13. | 1772. | -31. | 589. | ***** | 95. | 40. | -85. | -33 |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 140

| DEFECT | CVS EMISSIONS (GM/MI) FTP | | | CVS EMISSIONS (GM/MI) HFET | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | -2(0) | -9(0) | -20(0) | 9(0) | 33(0) | 42(0) | 1(0) | 2(0) | 7(0) | 1(0) | -1(0) |
| 1.0 | -2(0) | -10(0) | 40(0) | 173(2) | 192(0) | 154(0) | 1(0) | 4(0) | -13(0) | 1(0) | -2(0) |
| 2.0 | 133(3) | 11(0) | 1268(3) | 82(1) | 31(0) | 33(0) | -15(2) | -21(1) | -77(1) | 5(0) | -0(0) |
| 3.0 | 9(0) | -18(0) | 30(0) | -27(0) | -92(0) | 42(0) | -1(0) | -18(1) | 1(0) | 7(1) | 7(1) |
| 4.0 | 71(3) | 106(1) | -13(0) | 682(3) | 302(1) | -37(0) | -8(2) | -25(2) | 19(0) | 2(0) | -1(0) |
| 5.0 | 5693(3) | 6684(3) | -17(0) | *****3) | *****3) | -46(0) | -117(3) | -67(3) | -18(0) | -31(2) | -37(3) |
| 6.0 | 671(3) | 693(3) | -42(0) | 3009(3) | 1386(3) | -0(0) | -52(3) | -67(3) | 26(0) | 6(0) | 3(0) |
| 7.0 | 500(3) | 602(3) | -52(0) | 2573(3) | 1286(3) | -0(0) | -45(3) | -63(3) | 29(0) | -2(0) | -1(0) |
| 8.0 | 165(3) | 221(2) | -8(0) | 1900(3) | 1053(3) | 17(0) | -14(2) | -40(2) | 19(0) | 3(0) | -1(0) |
| 9.0 | 151(3) | 88(1) | 27(0) | 1536(3) | 979(2) | 42(0) | -13(2) | -19(1) | 7(0) | 5(0) | -7(1) |
| 10.0 | 8424(3) | *****3) | -38(0) | *****3) | *****3) | -46(0) | -209(3) | -93(3) | -94(2) | -47(3) | -40(3) |
| 0.1 | 2(0) | 9(0) | 20(0) | -9(0) | -33(0) | -42(0) | -1(0) | -2(0) | -7(0) | -1(0) | 1(0) |
| % AVERD | 1581. | 2026. | 120. | 4418. | 3073. | 16. | -47. | -41. | -10. | -5. | -8. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR #140

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 0(0) | -100(0) | 43(0) | 36(0) | -100(0) | 74(0) | 7(0) | -100(0) | 14(0) | -20(0) | -8(0) | -17 |
| 1.0 | 28(0) | 0(0) | 214(0) | 36(0) | 3500(3) | 81(0) | 86(1) | 700(1) | -100(1) | 40(0) | -100(2) | 6 |
| 2.0 | -8(0) | 700(1) | 7(0) | -57(0) | -100(0) | -30(0) | -63(1) | -100(0) | -52(0) | -30(0) | -38(0) | -32 |
| 3.0 | 0(0) | 0(0) | 29(0) | -36(0) | 100(0) | -13(0) | 16(0) | 100(0) | -62(0) | 95(0) | -69(1) | 55 |
| 4.0 | 100(1) | 500(0) | 43(0) | 155(0) | 1900(2) | 22(0) | 86(1) | 3500(3) | -24(0) | 80(0) | -54(1) | 47 |
| 5.0 | 1420(3) | *****3) | -21(0) | 1517(3) | *****3) | -52(0) | 5947(3) | *****3) | 33(0) | 20(0) | 100(2) | 40 |
| 6.0 | 660(3) | *****3) | 0(0) | 1304(3) | *****3) | -61(0) | 1202(3) | 2900(2) | -90(1) | 65(0) | 8(0) | 51 |
| 7.0 | 140(2) | 1400(2) | 50(0) | 1283(3) | *****3) | -70(0) | 72(1) | 2700(2) | -100(1) | 65(0) | 85(1) | 70 |
| 8.0 | -20(0) | -100(0) | -14(0) | 751(2) | *****3) | 83(0) | 1063(3) | *****3) | -90(1) | -35(0) | -54(1) | -40 |
| 9.0 | -44(0) | 100(0) | 114(0) | 709(2) | *****3) | 117(0) | 95(2) | 900(1) | -92(1) | -50(0) | -38(0) | -47 |
| 10.0 | -40(0) | 0(0) | 3471(3) | 879(2) | *****3) | 357(0) | 1063(3) | *****3) | -90(1) | 915(3) | 1408(3) | 1036 |
| 0.1 | 0(0) | 100(0) | -43(0) | -36(0) | 100(0) | -74(0) | -7(0) | 100(0) | -14(0) | 20(0) | 8(0) | 17 |
| % AVERD | 224. | ***** | 389. | 654. | ***** | 43. | 957. | ***** | -67. | 117. | 125. | 118 |

EMISSIONS AND FUEL ECONOMY DATA FOR CAR #143

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | -21(0) | -17(0) | -13(0) | -25(0) | 1(0) | 43(0) | 1(0) | 1(0) | 1(0) | 0(0) | 1(0) |
| 1.0 | 69(0) | 124(1) | 500(3) | 150(0) | 190(3) | 2214(3) | -17(2) | -60(3) | -29(3) | 1(0) | 1(0) |
| 2.0 | 5238(3) | *****3) | 62(0) | *****3) | *****3) | 100(0) | -119(3) | -97(3) | -78(3) | -47(3) | -46(3) |
| 4.0 | 18(0) | -11(0) | -36(0) | 300(1) | 101(3) | -43(0) | -2(0) | -7(0) | 3(0) | -1(0) | -3(0) |
| 5.0 | -5(0) | 2(0) | -40(0) | 125(0) | -22(2) | -71(0) | 2(0) | -7(0) | 3(0) | 2(0) | -0(0) |
| 9.0 | -26(0) | -17(0) | -17(0) | 75(0) | 38(2) | 14(0) | 4(1) | 3(0) | 2(0) | 1(0) | 0(0) |
| 10.0 | -38(0) | -47(0) | 149(1) | 50(0) | -14(1) | 243(0) | 8(2) | 22(2) | -6(1) | -25(3) | -0(0) |
| 11.0 | 5921(3) | *****3) | -40(0) | *****3) | *****3) | 71(0) | -149(3) | -97(3) | -70(3) | -61(3) | -48(3) |
| 13.0 | 933(3) | 2052(3) | -6(0) | 4775(3) | 4420(3) | 43(0) | -79(3) | -119(3) | -3(0) | -8(2) | -10(1) |
| 0.1 | 21(0) | 17(0) | 13(0) | 25(0) | -1(0) | -43(0) | -1(0) | -1(0) | -1(0) | -0(0) | -1(0) |
| % AVERD | 1514. | 4441. | 72. | 6488. | 8746. | 321. | -44. | -45. | -22. | -17. | -13. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR # 143

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 0(0) | 0(0) | 33(0) | 5(0) | 33(0) | 64(0) | 25(0) | 67(0) | -100(0) | 37(0) | 50(0) | 40 |
| 1.0 | 0(0) | -100(1) | 1007(2) | 111(2) | 900(2) | -94(0) | 1275(3) | 6567(3) | 100(0) | -32(0) | -33(0) | -32 |
| 2.0 | 4567(3) | *****3) | -7(0) | 3979(3) | *****3) | -80(0) | *****3) | *****3) | 4700(3) | 427(1) | 817(2) | 515 |
| 4.0 | -33(0) | -67(1) | -87(0) | 32(0) | 33(0) | -80(0) | 56(0) | 233(0) | -100(0) | -27(0) | 33(0) | -13 |
| 5.0 | 67(1) | 233(2) | -80(0) | 32(0) | 33(0) | -95(0) | 25(0) | 100(0) | -100(0) | 80(0) | 0(0) | 62 |
| 9.0 | -67(1) | -67(1) | -100(0) | -21(0) | -33(0) | -66(0) | -37(0) | -100(0) | 1300(2) | 85(0) | -17(0) | 62 |
| 10.0 | 33(0) | 67(1) | 193(0) | -47(1) | 33(0) | -26(0) | 1181(3) | -67(0) | 500(0) | 2(0) | 83(0) | 21 |
| 11.0 | 4167(3) | *****3) | -67(0) | 3268(3) | *****3) | -93(0) | 681(2) | *****3) | 6700(3) | 2(0) | 417(1) | 96 |
| 13.0 | 1333(3) | *****3) | -80(0) | 1216(3) | *****3) | -75(0) | 2400(3) | *****3) | -100(0) | 217(0) | -50(0) | 157 |
| 0.1 | 0(0) | 0(0) | -33(0) | -5(0) | -33(0) | -64(0) | -25(0) | -67(0) | 100(0) | -37(0) | -50(0) | -40 |
| % AVERD | 1258. | 9588. | 98. | 1071. | ***** | -76. | 2248. | ***** | 1625. | 95. | 156. | 108 |

# EMISSIONS AND FUEL ECONOMY DATA FOR CAR # 144

| DEFECT | CVS EMISSIONS (GM/MI) | | | | | | FTP (%) CONVERTER EFFICIENCY | | | FUEL (MPG) ECONOMY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTP | | | HFET | | | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | FTP | HFET |
| 0.0 | -20(0) | -42(0) | 7(0) | -20(0) | -20(0) | 0(0) | 2(0) | 5(0) | -2(0) | 1(0) | -1(0) |
| 1.0 | 13(0) | 7(0) | 232(3) | 20(0) | -11(0) | 1786(3) | -9(0) | -6(0) | -50(2) | 1(0) | 3(0) |
| 4.0 | 47(0) | 89(0) | -15(0) | 100(0) | 180(1) | 29(0) | -6(0) | -8(0) | 8(0) | -4(0) | 1(0) |
| 7.0 | 20(0) | 57(0) | -32(0) | 20(0) | 22(0) | -29(0) | -2(0) | -5(0) | 7(0) | -2(0) | 0(0) |
| 8.0 | 40(0) | 23(0) | -15(0) | 40(0) | 29(0) | -29(0) | -5(0) | -1(0) | 3(0) | -0(0) | 2(0) |
| 10.0 | -70(0) | -2(0) | -1(0) | 20(0) | -5(0) | 14(0) | 11(0) | 1(0) | 2(0) | -0(0) | 2(0) |
| 12.0 | 523(2) | 166(0) | -37(0) | 120(0) | 23(0) | 29(0) | -10(0) | -14(0) | 8(0) | -5(0) | 1(0) |
| 0.1 | 20(0) | 42(0) | -7(0) | 20(0) | 20(0) | 0(0) | -2(0) | -5(0) | 2(0) | -1(0) | 1(0) |
| % AVERD | 96. | 57. | 22. | 53. | 40. | 300. | -3. | -5. | -4. | -2. | 1. |

LOADED TEST AND DRIVEABILITY DATA FOR CAR # 144

| DEFECT | ARB LOADED TEST | | | | | | | | | DRIVEABILITY TEST | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HIGH | | | LOW | | | IDLE | | | | | |
| | HC | CO | NOX | HC | CO | NOX | HC | CO | NOX | COLD | HOT | TO |
| 0.0 | 37(0) | 82(0) | -48(0) | 2(0) | 27(0) | 44(0) | 73(0) | 67(0) | -67(0) | 37(0) | 29(0) | 35( |
| 1.0 | -6(0) | -82(0) | 1011(2) | 122(3) | 536(2) | -58(0) | 60(0) | 2567(3) | -100(0) | -80(0) | 0(0) | -60( |
| 4.0 | -37(0) | -45(0) | -68(0) | 7(0) | 9(0) | -44(0) | -88(0) | 67(0) | -81(0) | 110(0) | 100(0) | 107( |
| 7.0 | -12(0) | -45(0) | -52(0) | -2(0) | -9(0) | -31(0) | -81(0) | -83(0) | -81(0) | 22(0) | 14(0) | 20( |
| 8.0 | -6(0) | -82(0) | -68(0) | -2(0) | -55(0) | -44(0) | -81(0) | -83(0) | -81(0) | 276(1) | 86(0) | 227( |
| 10.0 | -37(0) | -64(0) | -84(0) | -11(0) | -64(0) | -44(0) | -75(0) | -67(0) | -26(0) | 7(0) | 129(0) | 38( |
| 12.0 | -37(0) | -64(0) | -60(0) | -11(0) | -73(0) | -31(0) | 665(1) | 817(1) | -63(0) | 607(2) | 1086(3) | 729( |
| 0.1 | -37(0) | -82(0) | 48(0) | -2(0) | -27(0) | -44(0) | -73(0) | -67(0) | 67(0) | -37(0) | -29(0) | -35( |
| % AVERD | -23. | -64. | 113. | 17. | 58. | -42. | 67. | 536. | -72. | 157. | 236. | 177. |