1993

# Provo Pollution Prevention Program

Donald H. Stedman

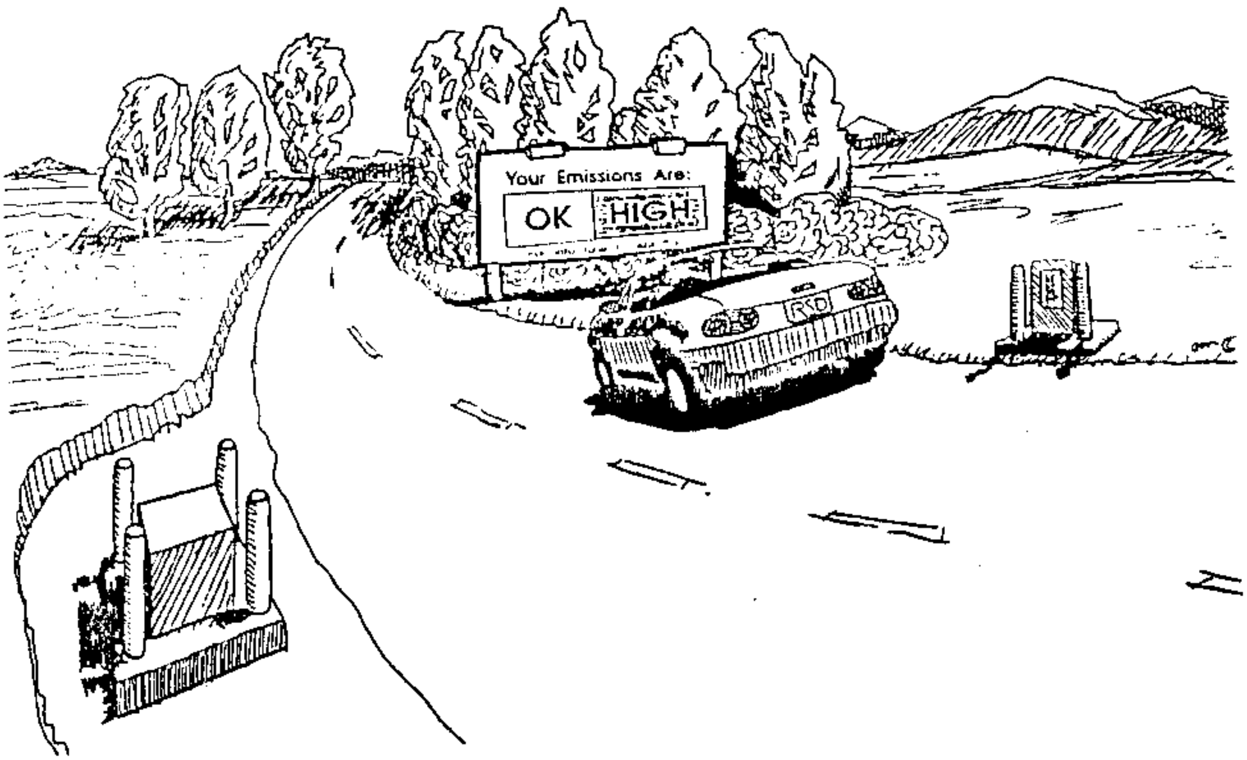
Gary A. Bishop

James E. Peterson

Theresa Hosick

# PROVO POLLUTION PREVENTION PROGRAM

A Pilot Study of the Cost-Effectiveness of an On-Road Vehicle Emissions Reduction Program.




January 15, 1993

# PROVO POLLUTION PREVENTION PROGRAM

A study designed to show that cost-effective on-road emissions reductions can be achieved with a targeted repair program.


Prepared by
University of Denver
Chemistry Department
University Park
Denver, CO 80208-0179

Investigators:

Donald H. Stedman, Gary A. Bishop,
James E. Peterson, and Theresa Hosick


In Cooperation with Mr. Orrin Nelson
and the staff of the Utah Valley Community College ADT Program


Supporting Agencies Include
City of Provo
Shell Development
Utah Department of Environmental Quality
Utah Energy Office
Utah Petroleum Association Members
Amoco
Chevron
Crysen
Flying J
Pennzoil
University of Denver
U. S. Environmental Protection Agency
Utah Valley Community College
The Waters Foundation
The World Wildlife Fund

January 15, 1993

ACKNOWLEDGEMENTS

This project would not have been possible without the support, encouragement and participation of many individuals from the Utah Valley Community College (Dr. Kerry Romeburg, Mr. Orrin Nelson, Ms. Jacquie Nelson and Mr. Chase Mitchell), the City of Provo (Mayor Joseph Jenkins and Mr. David Graves) the Utah Department of Environmental Quality (Ms. Barbara Cole, Mr. Robert Angelilli and Mr. Ron Vincent) and all of the sponsoring agencies. The opinions expressed are those of the investigators and do not represent the opinion of any of the sponsoring agencies.

# TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

# EXECUTIVE SUMMARY

The cost-effectiveness of repair of on-road identified gross polluting vehicles was investigated over the 1991-92 winter period in Provo Utah. This pilot program used on-road remote sensing at two locations to identify repeat gross polluting vehicles. The owners of gross polluters observed at one of the locations were solicited for a free repair program carried out under the direction of the Utah Valley Community College, Auto-Diesel Division. The same two locations were revisited after the repair program had terminated and the vehicle emissions remeasured. More than 17,000 measurements of over 10,000 individual vehicles were obtained. As observed elsewhere, half the total carbon monoxide was emitted by only about ten percent of the vehicles. 114 notification letters were sent and 47 vehicles were recruited. Of the 47 vehicles 28 were remeasured when the site was revisited at the end of the program. They had improved their measured on-road emissions by more than 50%. The vehicles which were identified as gross polluters at the second location, but were not notified of their status were used as a control group. Their emissions were also reduced, as expected, but only by 14%.

This is the first program in which on-road emissions reductions have been demonstrated relative to an unrepaired control fleet. We believe that this pilot program of identification and repair was responsible for more than 20 tons of carbon monoxide removed from the Provo/Orem airshed. This emission reduction is larger than would be obtained by eliminating entirely the lowest emitting 2500 vehicles from the fleet of over 7,000. A conservative estimate of the cost of a larger scale program based upon the same concepts leads to CO emissions reduction at a cost effectiveness of $200 per ton. Such a program would more than pay for itself in terms of improved fuel economy. The program would also generate the on-road fleet emissions data necessary to evaluate its effectiveness without the need to rely upon computer modelling.

# I. INTRODUCTION

Urban air quality does not meet the federal standards in many cities. Violations of the ozone standard arise from photochemical transformation of oxides of nitrogen ($NO_x$) and hydrocarbons (HC). Carbon monoxide (CO) standards are primarily violated as a result of direct emission of the gas. Although there are differences between compounds, and between different urban areas, mobile sources are a major factor in all urban emissions inventories for carbon monoxide, hydrocarbons, and oxides of nitrogen.

Air pollution control measures taken to mitigate mobile source emissions in non-attainment areas include inspection and maintenance (I/M) programs, oxygenated fuels mandates and transportation control measures. Nonetheless many areas of non-attainment remained after the 1987 deadline, and some are projected to remain in non-attainment for several more years despite the measures currently undertaken. The remote sensing techniques discussed in this report may have the potential to contribute to further control measures in non-compliance areas.

The 1990 U. S. Clean Air Act amendments require non-attainment areas to include "on-road emissions monitoring" in their post-1990 I/M programs. This language, the "Barton Clean Air Smog Trap Amendment" was included based on literature and demonstrations of remote sensing to the U. S. Congress by the University of Denver.

With initial support from the Colorado Office of Energy Conservation in 1987, the University of Denver developed an infra-red (IR) remote monitoring system for automobile carbon monoxide (CO) exhaust emissions. Significant fuel economy improvements result if rich-burning (high CO and HC emissions) or misfiring (high HC emissions) vehicles are tuned to a more stoichiometric and more efficient air/fuel (A/F) ratio. Therefore, the University of Denver CO/HC remote sensor is named Fuel Efficiency Automobile Test (FEAT). The basic instrument measures the carbon monoxide to carbon dioxide ratio ($CO/CO_2$) and the hydrocarbon to carbon dioxide ratio ($HC/CO_2$) in the exhaust of any vehicle passing through an infra-red light beam which is transmitted across a single lane of roadway. Figure 1 shows a schematic diagram of the instrument. The IR source sends a horizontal beam of radiation across a single traffic lane, approximately 10 inches above the road surface. This beam is picked up by the detector on the opposite side and split into four wavelength channels; CO, $CO_2$, HC, and reference. Data from all four channels are fed to a computer for analysis. The calibration gases (mixtures of CO, propane and $CO_2$ in nitrogen) are used as a daily quality assurance check on the system.

The FEAT remote sensor is accompanied by a video system when license plate information is required. The video camera is coupled directly into the data analysis computer so that the image of each passing vehicle is frozen onto the video screen. The computer writes the date, time and the calculated exhaust CO, HC, and $CO_2$ percentage concentrations at the bottom of the image. These images are stored on videotape or digital storage media.

FEAT is effective across traffic lanes of up to 40 feet in width. FEAT can be operated across double lanes of traffic with additional video hardware, however the normal operating mode is on

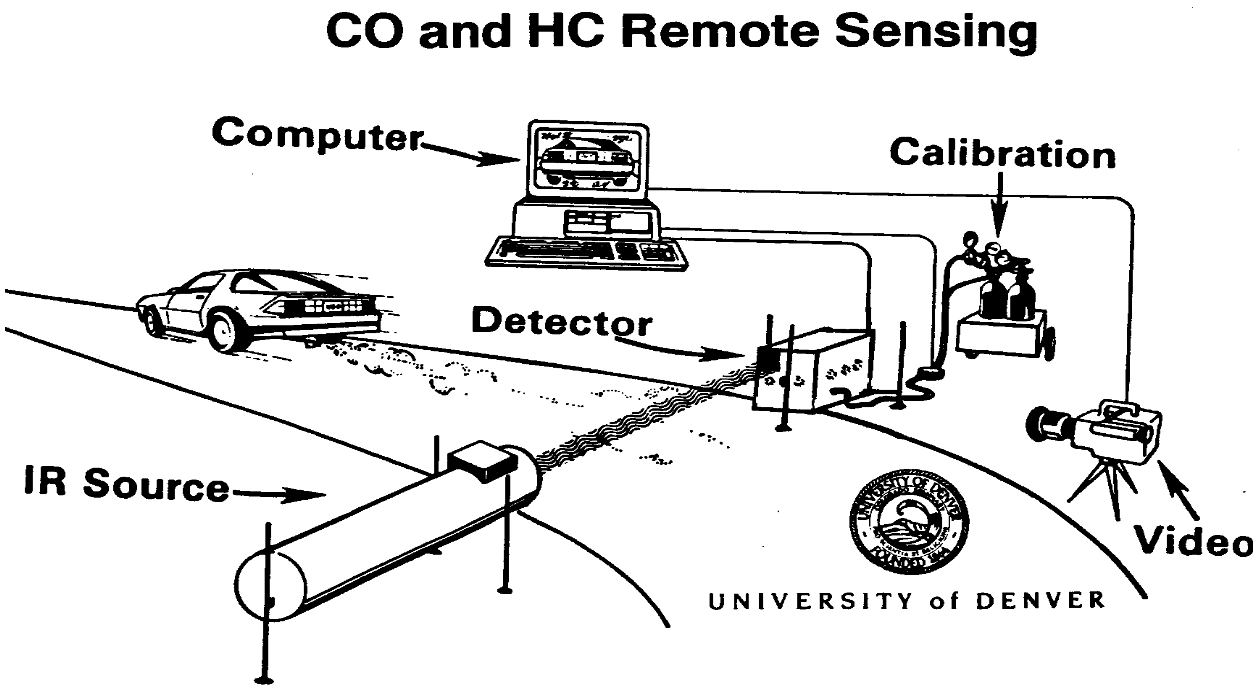



**Figure 1.** A schematic diagram of the University of Denver on-road emissions monitor. It is capable of monitoring emissions at vehicle speeds between 2.5 and 150 mph in under one second per vehicle.

single lane traffic. FEAT operates most effectively on dry pavement. Rain, snow, and very wet pavement cause scattering of the IR beam. These interferences cause the frequency of invalid readings to increase, ultimately to the point that all data are rejected as being contaminated by too much "noise". At suitable locations we have monitored exhaust from over one thousand vehicles per hour. FEAT has been used to measure the emissions of more than 500,000 vehicles in Denver, Chicago, the Los Angeles Basin, Toronto, the United Kingdom, and Mexico.

The instrument determines the $CO/CO_2$ and $HC/CO_2$ ratios. This ratio is itself a useful parameter to describe the combustion system. Most vehicles show ratios close to zero. When $CO/CO_2$ ratios greater than zero are observed the engine must be operating with a fuel rich air/fuel ratio. In the case of a large $HC/CO_2$ ratio, a fuel lean air/fuel ratio which is causing a misfire is also a possibility, particularly under deceleration conditions. In addition, for either case the emission control system is not fully operational.

With a fundamental knowledge of combustion chemistry, many parameters of the vehicle and its emissions system can be determined, including the instantaneous air/fuel ratio, grams of CO or HC emitted per gallon of gasoline and the percentage of CO or HC which would be measured by a tailpipe probe.

## A. Chemistry of CO and HC Emissions from Automobiles

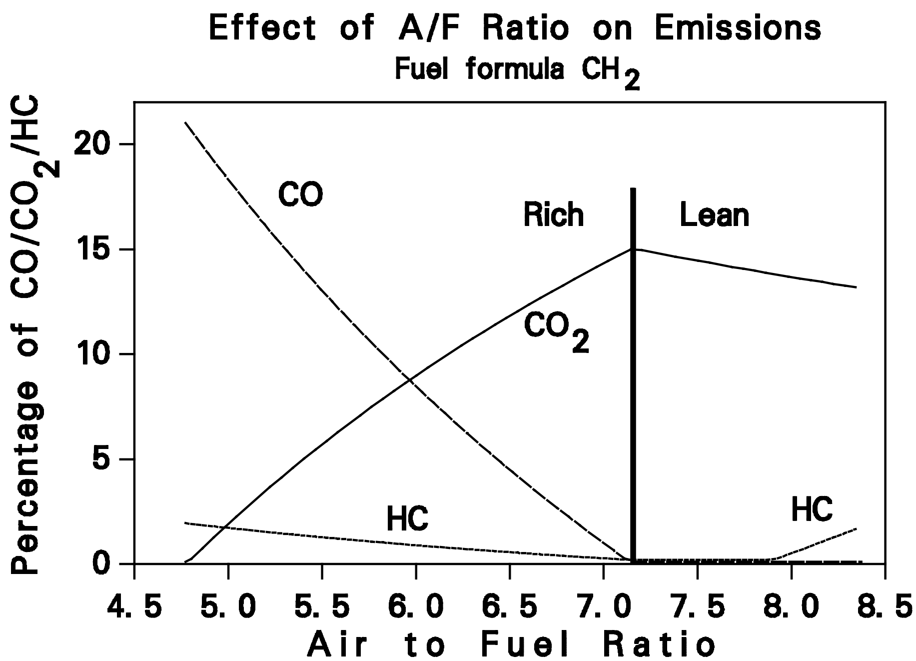



**Figure 2.** An approximate diagram showing the relative concentrations of CO and HC produced by a spark ignited engine as a function of air/fuel ratio by moles. Air to fuel ratio by weight is approximately double.

This section is a short summary of the parameters which influence the HC and CO emissions from automobiles. The reader should consult one of the text books on the subject, for instance Heywood (1988) for more details. HC and CO emissions in the exhaust manifold are a function of the air to fuel ratio at which the engine is operating. These "engine out" emissions are further altered by any tailpipe emission controls which may be present. Figure 2 shows an approximate diagram of engine out emissions as a function of air to fuel ratio where 7.09 (14.7% air to fuel by weight) is the stoichiometric ratio at which there is exactly enough air to fully burn the fuel to carbon dioxide and water. Carbon monoxide emissions, as explained in another report (Stedman and Bishop, 1990, pp. 3-6), are caused solely by the lack of adequate air for complete combustion. The CO is formed uniformly throughout the volume of the combustion chamber if the air/fuel mix is uniform.

For HC the situation is more complex. In the main part of the combustion chamber away from the walls essentially all the HC is burnt, however the flame front initiated by the spark plug can not continue to propagate within about one millimeter of the relatively cold cylinder walls. This phenomenon causes a "quench layer" next to the walls which is a thin layer of unburnt air/fuel mix. The opening exhaust valve and the rising piston scrape this layer off the walls and send it out the exhaust manifold. As the mixture becomes richer, the quench layer contains more HC, thus more HC is emitted when the vehicle is operating with rich mixtures. There is a second peak in HC emissions indicated on the right hand (fuel lean) side of the diagram. This phenomenon is known as "lean burn misfire" or "lean miss", it is the cause of the hesitation experienced at idle before a cold vehicle has fully warmed up. When this misfiring occurs a whole cylinder full of unburnt air/fuel mix is emitted into the exhaust manifold. Misfiring also occurs if a spark plug lead is missing, or the ignition system to one cylinder is otherwise fatally compromised. Severe gas mileage loss occurs when significant misfiring is taking place.

The fact that there are two regions of high HC and only one of high CO already shows that one would not expect a high correlation between HC and CO exhaust emissions. High HC would be expected for very low CO vehicles as well as for high CO vehicles. One would not expect to see many very low HC readings in the presence of high CO. This conclusion confounded however, by the presence of catalytic convertors in the exhaust system. If a vehicle which is running with a rich mixture has a functioning air injection system and catalyst then both the HC and CO will be removed. If the catalyst is functioning but there is no air injection then some or all of the HC will be converted to CO but the CO will remain since there is inadequate oxygen for its oxidation. For this reason it is possible for a catalyst equipped vehicle which is in fact in the lean burn misfire region to emit CO into the air even though it was not emitting CO into its own exhaust manifold.

## B. Remote Sensing Equations

FEAT can measure the CO and HC emissions in all vehicles, including gasoline and diesel-powered vehicles, as long as the exhaust plume exits the vehicle within a few feet of the ground. Due to the current height of the sensing beam, FEAT will not register emissions from exhausts which exit from the top of vehicles such as heavy duty diesel vehicles. Carbon monoxide and hydrocarbon emissions from diesel vehicles are in any case relatively small.

The mechanism by which FEAT measures a ratio is explained in Bishop et al. (1989). The $CO/CO_2$ and $HC/CO_2$ ratios can be determined by remote sensing, independent of wind, temperature, and turbulence in 0.9 seconds per passing car. Other peer-reviewed publications describing remote sensing are listed in the references. FEAT has been shown to give correct readings for CO by means of double-blind studies of vehicles both on the road and on dynamometers (Lawson et al. 1990; Stedman and Bishop, 1991). The HC channel has been subjected to similar rigorous testing in California in May of 1991 and has also been validated (Ashbaugh et al. 1992).

The mass emissions in grams CO per gallon of gasoline burned can be derived from the reported %CO and %HC (as propane) with an estimated fuel density of 0.726 gm/ml thus.

$$\frac{gCO}{gal} = \frac{5506 * \%CO}{(\%CO + 3 * \%HC + \%CO_2)}$$

The gHC/gal can be estimated from

$$\frac{gHC}{gal} = \frac{8644 * \%HC}{(\%CO + 3 * \%HC + \%CO_2)}$$

According to Glover and Clemmens (1991) the on-road results of remote sensing test have similar predictive power to idle/2500 rpm testing when compared to the EPA I/M 240 test. Their report also shows that remote sensing is ten to one hundred times faster and more convenient. Glover and Clemmens used Corporate Average Fuel Economy (CAFE) gas mileage estimates to compare fleet on-road emissions with I/M 240 gCO/mile emissions for the same fleets. Data from a study of on-road gross polluters in California added one more data point. The correlation is shown in Figure 3. The conclusion we draw from these data is that, even for small fleets of vehicles, I/M 240 emissions are in agreement with actual measured on-road grams/gallon emission data when that data is converted to grams/mile using CAFE gas-mileage estimates.

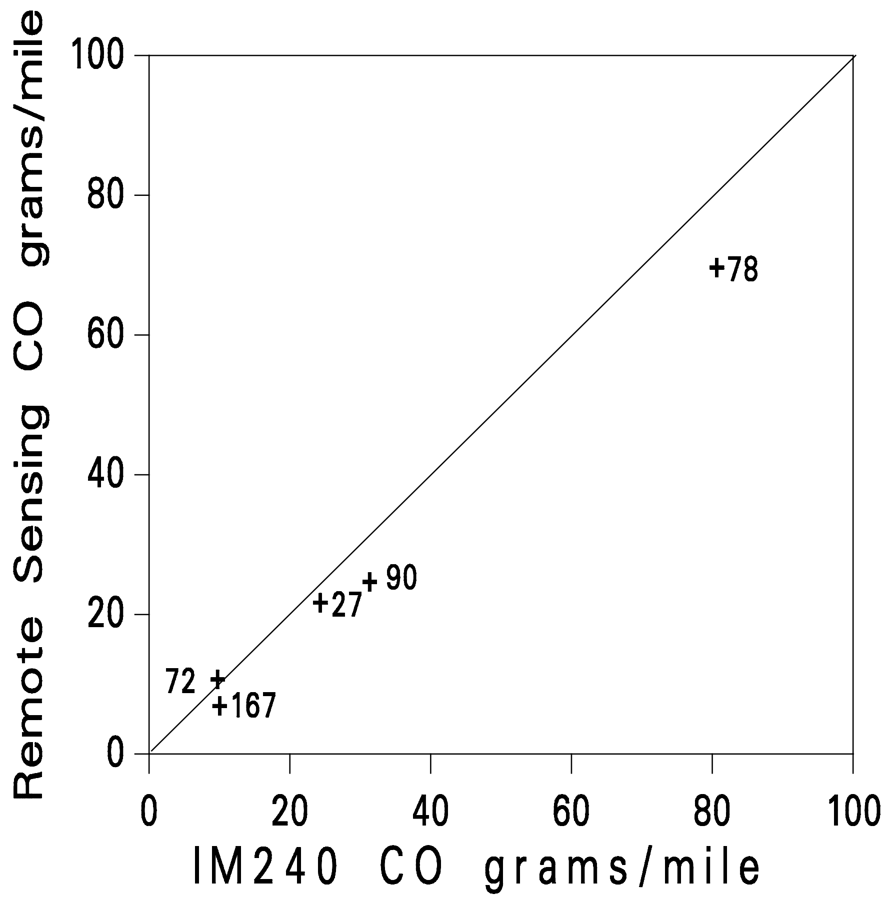



**Figure 3.** On-road fleet %CO emissions converted to grams/mile emissions compared to I/M 240 CO grams/mile emissions. Numbers next to the +'s are the fleet size.

## II. THE PROVO PROJECT

Mayor Joseph Jenkins of Provo, Utah invited the University of Denver to design a program for Provo which would address the problem of excess carbon monoxide emissions from automobiles. Early discussions indicated a great deal of interest in a program which identified and attempted to repair vehicles with excessive on-road carbon monoxide emissions. This would require the remote sensing of several thousand vehicles with frequent high CO emitters being contacted and offered free repairs for volunteering their vehicle. The Utah Valley Community College's Auto - Diesel Division (UVCC) joined the program to provide the direct oversight that would be needed for recruiting the vehicles and organizing the repair work.

The operational plan involved the remote sensing of a fleet of vehicles, preferably commuting, along with an analogous fleet of vehicles which would be used as a control. Vehicles for recruitment would be identified on more than one occasion as gross polluting CO emitters (%CO > 4%, this was later lowered to 3% CO to account for rejections). The vehicle license plates were forwarded to David Graves of the City of Provo who acquired, through the State of Utah's vehicle registration information, the names, addresses and phone numbers necessary to contact the owners and offer them free repairs on their vehicles. Initial contact was made by mail with a follow-up by phone for those who did not respond.

Vehicle owners who volunteered their vehicle were eligible for free emission related repairs and, if necessary, a free rental car while repairs were being made. Appointments were made through UVCC for the vehicle exchange or drop off. Participants were required to sign a waiver releasing UVCC from liability of loss or damage to the vehicle. Diagnosis and repairs were made by local dealers and service shops and included idle and 2500 rpm emissions measurements before and after repairs. UVCC was responsible for approving all repairs and making sure that they were performed by the repair shop. An initial goal of successfully recruiting and repairing 50 vehicles was set.

After all of the repairs had been performed the two fleets would be subjected to unscheduled remote sensing to obtain measurements to help quantify the effectiveness of the repairs.

### A. Remote Sensing Measurements

The most important site selection criteria was that the location be used by morning commuters to maximize the repeat measurements necessary to qualify a vehicle for recruitment. Additional desires included a location with a companion monitoring site to make possible measurements of a control vehicle fleet (no repairs performed). The site should also have restricted access to eliminate the possibility of measuring vehicles which had not fully warmed to operating temperature. A local freeway interchange (Interstate 15 and University Blvd.) was selected which would allow measurements of two distinct commuting fleets. The fleet slated for repair would be measured from north bound I-15 to University Blvd. while a control fleet of vehicles could be measured at the companion ramp from south bound I-15 to University Blvd. This interchange is isolated at the south end of Provo with adjacent interchanges more than a mile away in either direction. The isolation ensures that warm operating modes were sampled.

The north bound ramp was a high speed off-ramp with a slight uphill grade. Vehicles at this ramp were observed during deceleration from highway speeds and under light cruise modes. The south bound ramp was slightly uphill and U-shaped with the remote sensing measurements being made after the first major curve. This allowed a light cruise to be observed for all vehicles at speeds in the range of 35 to 45 mph. Measurements were made by the University of Denver during November, 1991, January and March/April of 1992. In addition measurements were made on the north bound ramp during December for recruitment purposes only by the staff of UVCC. Table I details the locations, dates and vehicle counts that were obtained. Measurement times vary for each of the dates due to equipment problems, weather and the amount of available sunlight.

**Table I.** Measurement locations and dates.

| Remote Sensing Measurement Dates | | |
|---|---|---|
| Location | Dates | Valid CO Measurements and License Plate Information |
| N.B. I-15 | Nov. 13 - 15, 1991<br>Dec. 5, 12, 1991<br>Jan. 28 - 31, 1992<br>Mar. 30 - April 3, 1992 | 2,382<br>751<br>3,078<br>5,854 |
| S.B. I-15 | Nov. 12 - 15, 1991<br>Jan. 31, 1992<br>Mar. 31 - April 3, 1992 | 2,516<br>175<br>2,685 |

The low sun angle and the orientation of the Provo site combined with Utah license plates having a white background contributed to the lower total number of successful license plate transcriptions for the November and January data. Iris setting constraints on our video camera severely limited our ability to accurately meter the white plates under direct sunlight when attached to non-white vehicles. After several unsuccessful attempts to overcome the limitations a successful adjustment was made by adding a small white card to the bottom of each of the camera's field of view. This forced the camera's electronics to balance on the color of the plate and not the color of the vehicle.

Video tape transcription was carried out under the direction of Barbara J. Cole at the Utah Department of Environmental Quality, Division of Air Quality. State motor vehicle records were obtained by the University of Denver from the Utah Department of Environmental Quality and successfully paired with the remote sensing measurements to complete the Provo database. The database is available upon request from the University of Denver.

## B. Recruitment and Repair Program

The intent was to identify and solicit repeat carbon monoxide gross polluters driving north on I-15 onto University Blvd. in Provo Utah, diagnose and repair (within flexible cost limits) any observable emission-related problems, and retest the repaired vehicles at the same location. Vehicles subject to the free repair program were only selected from the north bound I-15 ramp. Since this ramp was the first opportunity to enter Provo from the south it was expected that many commuting vehicles would use this ramp on a consistent basis. Vehicles were picked which exceeded the 3.0 %CO cutpoint at least twice. This would place these vehicles in the top 10% of emitters for this ramp and location. From the November and January measurements one hundred and thirty one title registration matches were successfully completed.

Two additional criteria were added before vehicles were solicited, namely that the vehicle should be registered in Utah county (the county Provo/Orem are located in), and that the model year be newer than 1965. Within these restrictions one hundred and fourteen letters were sent. Each letter (Appendix A contains a sample copy) contained relevant information about the program; why Provo was picked, that included were free diagnosis/repairs, a rental car if needed, drop-off or pickup service and that no tax dollars were involved. Accompanying the letter were some answers to common questions about the remote sensor measurements and how they relate to the current idle inspection system and a brochure provided by the University of Denver.

Each letter was followed up with a phone call to encourage the vehicle owner to participate and to learn the reason for not participating. There were fifty-two responses from which forty seven vehicles were submitted for diagnosis and repairs. Recruitment was very successful, thanks to UVCC and to very helpful TV, radio and newspaper coverage. Many vehicle test programs expect to be able to recruit less than one car in ten.

The positive media coverage at the end of the January measurement period greatly improved the response rate to the letters. The response rate after the media coverage was so good that many people who did not even live in the Provo area called asking if their car could be repaired. This underscores the reasons for which we limited the earlier media coverage so as not to encourage people to drive by the remote sensing site with cars that were not their primary commuting vehicles. As such, no one except those involved in the program were aware of the measurement locations and dates ahead of time. Repairs started in early December 1991 and continued to completion in March 1992.

Upon receipt of the vehicle the owners were required to sign a waiver (copy included in Appendix A) releasing UVCC and others involved in the program of any liability from loss or damage to the vehicle. Each vehicle was given a visual survey and was assigned to either UVCC technical staff or referred to one of nine private garages. Each vehicle underwent diagnosis and repairs which included a Utah County I/M test before and after the repairs. For this program repairs were performed irrespective of whether the vehicles emission control system had been tampered with. All of the vehicles were described to the private garages as vehicles which had failed the emissions test. Each garage was required to receive formal approval from UVCC staff covering the diagnosis and cost of repairs before repairs could begin. Vehicles which were determined to be in need of major work (i.e. engine overhaul) were evaluated on a vehicle by vehicle basis as to the best course of action. Offers were made to purchase two vehicles, a 1974 Ford LTD and a 1976 Ford Mustang. Both were in need of major engine work and the most cost effective solution would be to purchase at the Blue book price or higher and to permanently retire the vehicles. In both cases the offers were refused and the best possible repairs were carried out.

A complete description of the diagnosis and repairs was received by UVCC and if repairs were performed by private garages, UVCC technicians reviewed the work to assure that it had been performed. This resulted in only one vehicle needing major follow-up work. A 1985 Plymouth Voyager which needed a carburetor rebuild. The rebuild was found to have been done incorrectly or not at all, this required the work to be performed at a separate shop at additional cost. This vehicle had the highest repair cost because the dealership refused to warrant the work.

The vehicles were subsequently returned to their owners and an additional follow-up telephone call was attempted. This final call collected any new information concerning gas milage, as well as the vehicle owner’s satisfaction with the repairs and the program. Overall appreciation for the program and the repairs was high. However, just because something is free does not mean it will be appreciated as was experienced on a few occasions. In addition, several owners complained of problems experienced after repairs involving exhaust or suspension parts which were not covered under the emission repairs. Several of these problems were fixed by UVCC employees at their own expense.

## III. RESULTS

Overall statistics for the two remote monitoring locations are summarized in Table II. Traffic flow was lower at the south bound ramp than the north bound ramp due to other city access points for the south bound traffic. The south bound fleet was also approximately one year newer on average than the north bound fleet. The lower age is reflected in a lower mean %CO and in a higher %CO cut point for the fleet emission 50 percent level. Load differences at the two sites can be seen in the flatter %CO distribution (higher median) at the north bound ramp and a elevated %HC mean. High speed off-ramps of the type monitored in Provo have been previously documented to have average HC emissions about double a comparable on-ramp (Stedman et al, 1991). Standard error of the means are given. They have been obtained by dividing the database into consecutive 500 record blocks and applying normal statistics to means of these data.

**Table II.** Summary of Provo remote sensing statistics

| | North Bound I-15 ramp | | South Bound I-15 ramp* |
|---|---|---|---|
| | %CO | %HC | %CO |
| Mean | 1.17 ± 0.07 | 0.22 ± 0.02 | 1.00 ± 0.09 |
| Median | 0.45 | 0.127 | 0.19 |
| Percent of total emissions from dirtiest 20% of fleet | 71 | 61 | 83 |
| Percent of fleet responsible for 50% of emissions | 9.00 | 13.5 | 9.26 |
| Fleet emission 50 percent cut point | 3.52 | 0.414 | 4.33 |
| Number of records | 12,066 | 10,244 | 5,376 |
| Number of unique vehicles | 7,160 | 6,257 | 2,875 |
| Average fleet age(years) | 8.1 | 8.2 | 7.2 |
| *Equipment malfunction in sensor made HC data unusable. | | | |

With the above stated differences the two fleets are otherwise very similar with the majority of vehicles being low CO emitting vehicles. Figures 4 and 5 give two different representations of this fact. Figure 4 shows that because the overwhelming majority (72%) of vehicles are less than 1 percent CO they account for only 16% of the emissions. In contrast the deciles in Figure 5 show that the last 10% of the fleet is responsible for 53% of the total emissions. The data shown here are comparable to those found at many other locations in the USA.

At every location where on-road remote sensing has been used in the USA it has been shown that half the CO emissions arise from about 10% of the vehicles. These vehicles, the gross polluters, have been shown in other programs to be in need of repair. Lawson and Gunderson (1992) have shown that for repeat gross polluting vehicles pulled over in California more than 40% show evidence of tampering, more than 60% have tampered or defective emission control equipment and more than 90% fail an I/M test. These results seem to be independent of location and independent of the presence of absence of centralized or decentralized emission testing programs.

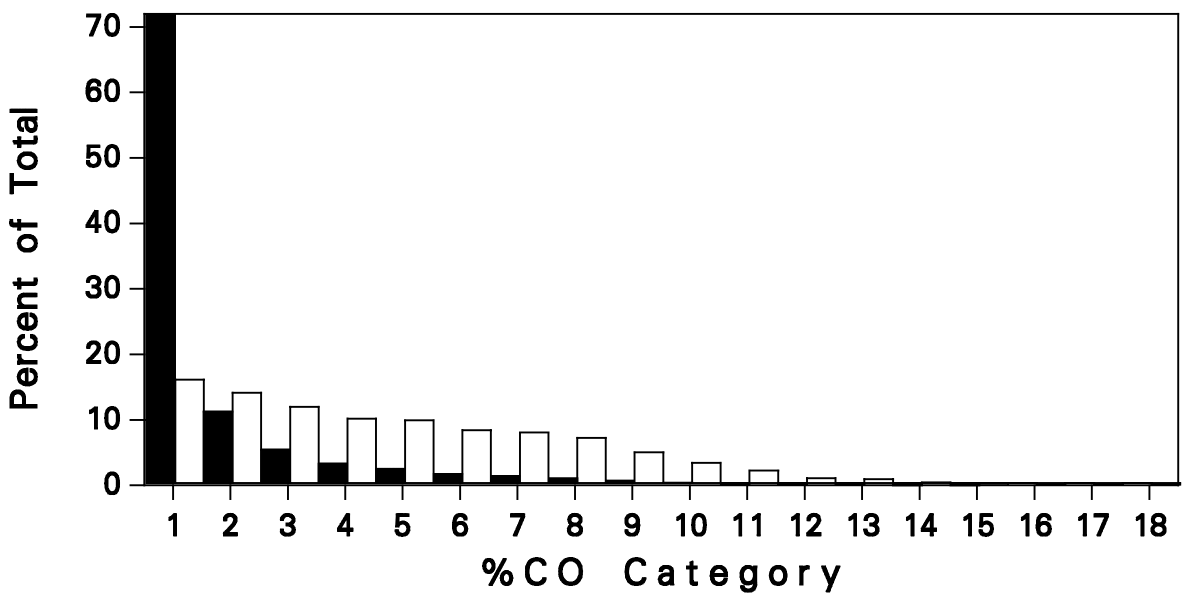



**Figure 4.** Normalized histogram showing as black bars the percentage of the fleet of vehicles with emissions less than the stated %CO category. Clear bars show the percentage of emissions.

Figure 6 shows carbon monoxide data as a function of fleet age from across the US and Canada. The two X's are the points for the north bound and south bound data collected in Provo. As discussed before, fleet age is the dominating factor in the differences found between locations. Figure 7 shows this effect, a steady rise in the average CO emissions for each preceding model year, for the Provo data. This increase is not caused by a dramatic increase in the median vehicle emissions, but by a rise in the percentage of gross polluting vehicles. Evidence from this and other studies suggests that this is a result of increasing mal-maintenance.

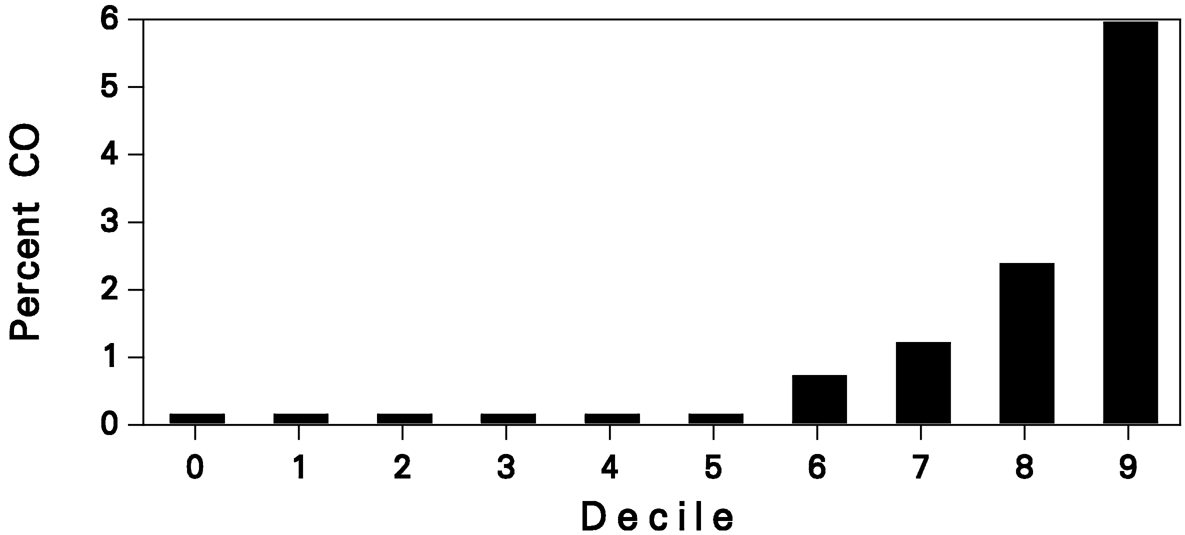



**Figure 5.** Average %CO emissions contribution by deciles for the combined north bound and south bound fleets. The cleanest six deciles are given the average of all six since the differences are negligible. Each decile contains 1744 measurements.

In a situation where more than half the pollution comes from only 10% of the vehicles, one might predict very cost-effective pollution reduction by identification and repair of those gross polluting vehicles. This pilot program shows that a small subset of the gross polluters can be identified and repaired, and that significant emissions reductions result. Because of the need to demonstrate reductions, two control fleets were used. The first control fleet consisted of vehicles identified on the north bound ramp as repeat gross polluters, which were solicited but not repaired. The second control fleet consisted of the vehicles on the southbound ramp which would have been solicited had they been on the other ramp.

### A. Repair Data

Appendix B contains a complete listing of the 47 vehicles which were brought in for diagnosis and repairs. Each record contains owner and vehicle information, diagnosis and repair information, costs of repairs which do not include taxes or rental car costs and measured emissions data before and after repairs if available. The average model year of the repaired fleet was 1978.5 with an average odometer reading of 125,000 miles. The oldest model year was 1966, the newest 1986. The majority of vehicles are from communities south of Provo located on or near interstate 15 within Utah county.

Vehicles which volunteered for repairs were significantly older than the entire fleet by approximately 5.5 years (avg. model yr. 1978.5 versus 1984). Three out of the 47 vehicles were only inspected with no repairs being performed. This situation arose because the vehicles met the current Utah county Inspection/Maintenance idle emission standards at the time of inspection.

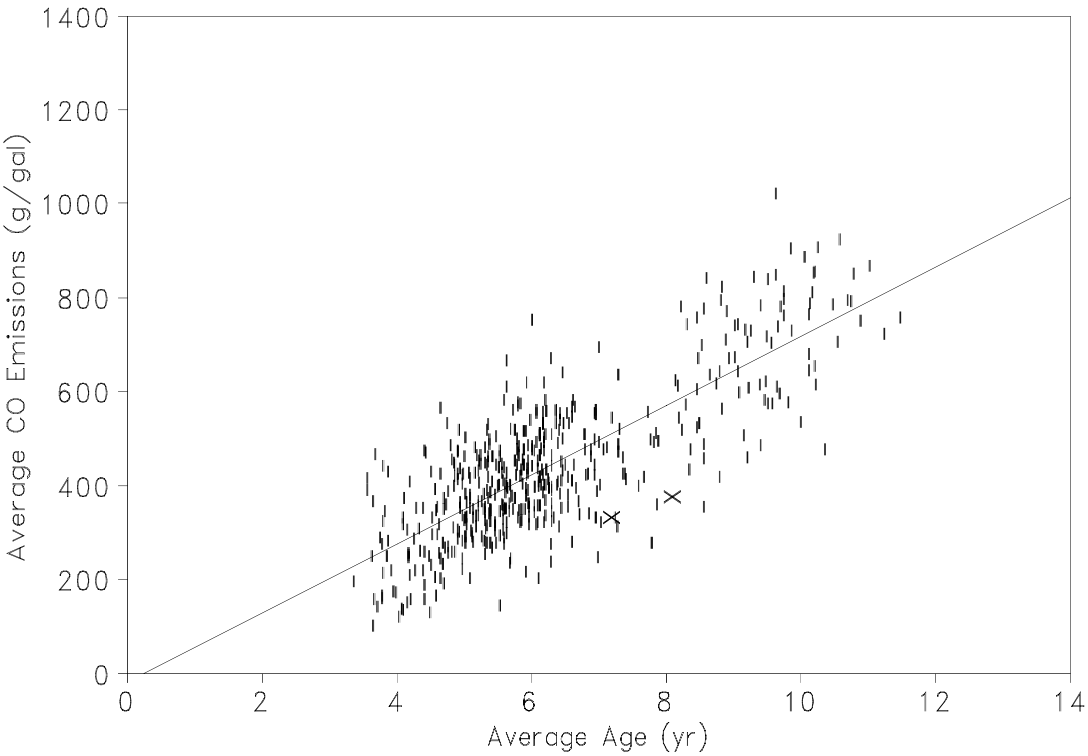



**Figure 6.** Average CO emissions in grams/gallon for all US and Canada locations below 7000 ft. elevation as a function of fleet age. The Provo data are included as X's. The line is the best fit for the data.

These vehicles could have been subjected to further diagnosis but were not. Vehicles solicited later in the program with low idle emissions were referred to a local tune shop which had a chassis dynamometer for a loaded-mode diagnosis.

As can be seen from the data in Appendix B, all of the vehicles (except the three mentioned above) had large reductions in idle and 2500 rpm emissions. On average the CO idle emissions decreased from 3.84% to 0.86%, more than a factor of four reduction. The 2500 rpm idle showed similar reductions. Table III summarizes the on-road emissions reductions which, while significant, were not as large as the idle reductions. Of the 28 vehicles which were successfully remeasured, 23 showed on-road CO emissions reductions while three remained unchanged and two significantly increased. The error estimates provided are standard errors of the mean and should be viewed as the best available estimate. This is because 8 of the 28 remeasured vehicles were measured only once. The mean CO emissions for the entire northbound fleet is 375 grams/gallon. The median is 160 grams/gallon. The recruited vehicles measured before repair had gCO/gallon emissions which averaged 4 times higher the fleet mean and 9 times higher than

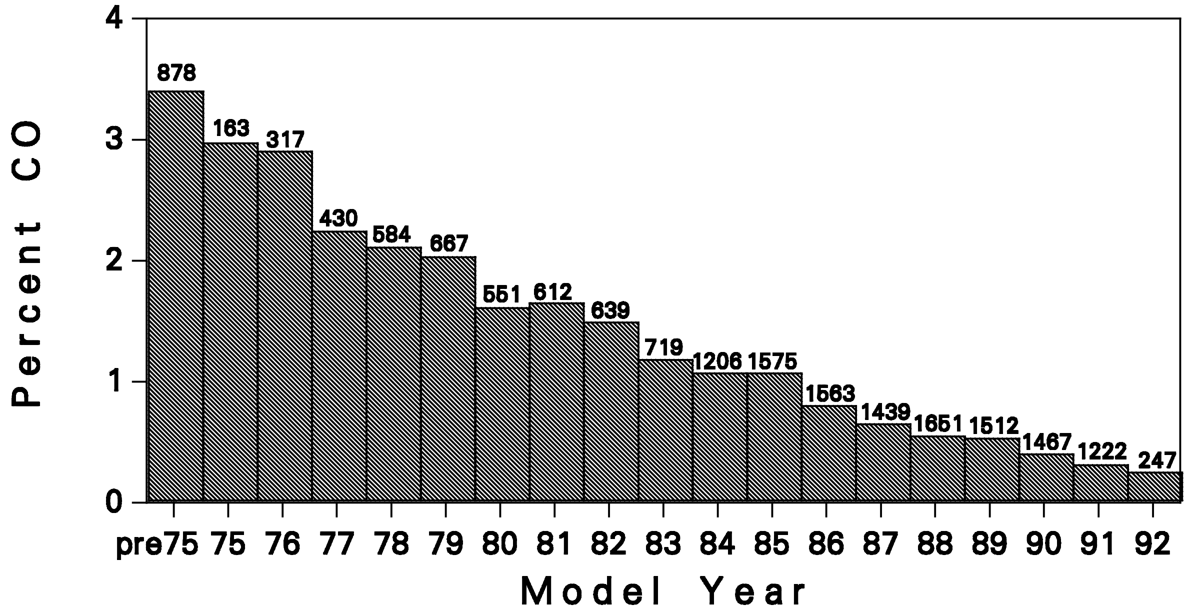



**Figure 7.** Average percent CO emissions as a function of model year for the entire vehicle Provo measured fleet. The number above each bar is the number of vehicles measured in each model year.

**Table III.** Data for repaired and remeasured vehicles. Measured gCO/gallon error estimates are standard errors of the mean.

| Sample Size / Number Remeasured | Measurement period | Measured gCO/gallon | Miles per gallon* | Estimated gCO/mile |
|---|---|---|---|---|
| 47 / 28 | Before repairs | 1507 ± 109 | 13.7 | 110 |
| | After repairs | 776 ± 118 | 15.5 | 50 |

*Data from vehicle owners who reported gas mileage for the before and after periods.

most vehicles (the median). Seven of the 47 repaired vehicles were tampered.

Repairs ranged from replacing a cam shaft, lifters and timing chain to freeing stuck chokes. There were three major area's where most of the work was concentrated. Adjustments and minor repairs included tune-ups, vacuum line rerouting or repair, air filter replacement and repairing chokes. Fuel system repairs consisted mainly of carburetor overhauls, but did include an altitude compensator kit and removal of a steel ball from a fuel tank return line which was responsible for excess back pressure on the throttle body fuel injector. The last major category was emission control equipment repair or replacement. This covered catalyst replacement, air pump repairs and engine computer and sensor replacement. A number of the vehicles had multiple repairs from more than one of these major categories.

**Table IV.** Repair data summary according to vehicle emissions technology grouping for the 28 vehicles which were successfully remeasured after repairs.

| Emissions Technology Grouping | Number of Vehicles | Average gCO/gallon Before Repairs | Average gCO/gallon After Repairs | Average gCO/gallon Reduction | Average gCO/gallon of Fleet |
|---|---|---|---|---|---|
| post 82 | 6 | 1567 | 671 | 896 | 229 |
| 81 - 82 | 1 | 1538 | 609 | 929 | 505 |
| 75 - 80 | 16 | 1404 | 714 | 690 | 684 |
| pre 75 | 5 | 1760 | 1132 | 628 | 1060 |

Table IV details the repair result according to model year. The model year groups have been chosen to reflect the different emissions control technology. Vehicles manufactured after 1982 employ closed loop computer controlled fuel systems and three way catalyst. Automobiles built between 1981 and 1982 model years contained a mixture of old (pre 1981) and new (post 1982) technologies. The years of 1975 to 1980 saw mostly vehicles with air pumps and oxidation catalysts if catalysts were used at all. As can be seen all of the groups achieved about the same reduction regardless of the emissions technology. The post 1982 technology group suffered the worst repair record when compared to the average fleet emissions for its age group. This was due to the failure to repair the 1986 Ford Aerostar van, which was significantly higher in on-road emissions after the repairs than before. Whitney and Glover (1992) show similar reductions for the on-road emissions of a fleet of vehicles tested by means of remote sensing and repaired in Arizona.

The total expenditures for the repairs are itemized in Table V. The costs for the repairs included any costs incurred by UVCC staff for pickup and drop off of vehicles with owners and repair shops. While all vehicle owners were offered rental cars not all owners found them necessary. Rentals were arranged through a Budget Rental Car agency in Provo at a $28.45/day rate for a mid or full size vehicle, which included unlimited mileage and the optional daily insurance. The typical rental was for two days.

**Table V.** Cost Summary for Repairs.

| Expense | Number of Vehicles | Cost | Average Cost per Repaired Vehicle |
| --- | --- | --- | --- |
| Repairs and Administration | 47 | $9,154 | $195 |
| Rental Cars | 31 | $2,031 | $43 |
| Total Costs | 47 | $11,185 | $238 |

# IV. DISCUSSION

Since on-road emissions reduction is the stated goal of most automobile pollution abatement programs, on-road identification and successful repair of vehicles is likely to be a very cost effective CO emissions reduction strategy. We initially had hoped that repair industry would be able to lower the solicited vehicles emissions to the fleet mean. They failed to do so as detailed in Table IV. This underscores the oft-repeated but also oft-ignored fact that no testing program achieves any reduction without a successful repair industry. We have long advocated that less money be spent on testing and more be available for diagnosis and repair, which are the keys to a successful outcome.

Two problems which we are aware of in this study are 1) incorrect diagnoses which lead to repairs not related to the problem and 2) not having the right equipment. Often times number one was a result of number two. For example as in the case of the Aerostar, the shop complained that the problem did not show up when measuring the vehicles idle emissions. This lead to an expensive repair bill that did not fix the problem. The repair shops were presented with a "Failed Emissions" repair order and in their minds this meant "failed the Utah idle/2500 rpm emissions test." The repair sheets in Appendix B show dramatic (an average of over a factor of four) reductions at idle/2500 rpm which unfortunately are not always reflected under load. The repair shops generally do not have the tools to carry out on-road emissions monitoring tests. Access is needed to on-board monitors, a chassis dynamometer, or to a public remote sensor with a big board display of emissions. One of these devices would enable the repair technician to evaluate the success of the repair.

The on-road emissions monitor targeted a fleet of vehicles in need of repair. We needed to show that the 49% emission reduction observed in gCO/gallon (55% estimated per mile) for the repaired fleet would not have occurred naturally because of normal service/repair. The two control fleets provided some evidence in this respect (see Table VI). Control group one contained the 67 vehicle owners who were solicited but chose not to participate and 17 additional vehicles which were registered out of county (131 total registration matches). Control group two was made up of vehicles which were identified on the south bound ramp. The vehicles would have qualified for repair if they had been measured on the north bound ramp. The vehicles in control group one had a measured CO emissions reduction of 1416 to 1024 grams/gallon or 28%. The vehicles in control group two had a measured CO emissions reduction of 1755 to 1504 grams/gallon or 14%.

It was not unexpected that each of the control groups would show reductions over the time period. Because of the selection criteria, i.e. that all of the vehicles in the group be gross polluters, it would be expected that some owners of broken vehicles will seek repairs on their own and thus decrease the group emissions. An analysis of the available data shows four statistically distinct fleets. One numerically dominant fleet of low emitting vehicles, or those vehicles identified only once on-road as a gross polluter and three distinct identified gross polluting fleets. The gross polluting fleet categories are a) solicited and repairs were attempted, b) identified and solicited but failed to participate and c) met all the emissions criteria for

**Table VI.** Control data for repaired fleet statistics.

| Control Fleet | Sample Size / Number Remeasured | Measurement Period* | Measured gCO/gallon | Percent Reduction |
|---|---|---|---|---|
| N.B. vehicles, most of fleet notified but no repairs | 84/33 | Before Repairs | 1416 ± 116 | 28% |
| | | After Repairs | 1024 ± 100 | |
| S.B. vehicles, no notification and no repairs | 51/31 | Before Repairs | 1755 ± 78 | 14% |
| | | After Repairs | 1504 ± 164 | |

*Before repair period from 11/91 - 2/92, After repair period contains only the last measurement period 3/92 - 4/92.

solicitation but were not notified of their status. The difference between fleets a) and c) we attribute to the overall effect of our program of identification, solicitation and repair. The difference between fleet b) and c) can be attributed to the letter which the owners received explaining that their vehicle was in need of repair which had the potential to pay for itself in improved gas mileage. Some owners feel that service facilities have a natural tendency to propose unnecessary maintenance. Therefore, the independent use of remote sensing to point out to a vehicle owner that service on his vehicle is likely to be of benefit is itself a strong incentive to carry out the maintenance.

Based on using the unsolicited and unrepaired vehicles as a control fleet, the emission reduction attributable to our program is 515 grams/gallon of CO. We arrive at this number by reducing the before repair gCO/gal value of 1507 found in Table III by the 14% improvement experienced by control group two. The difference between this value and the after repair measurements is the calculated reduction. If this reduction can be correctly ascribed to all 47 repaired vehicles then the repairs provided more emission reduction than would be achieved by completely eliminating the 2,500 lowest emitting vehicles from the total fleet of 7,160 individual vehicles. This remarkable statistic arises because of the skewed nature of emission distributions (a few gross polluters) which is the main force working against voluntary emission reduction programs such as no-drive days and employer trip reduction programs. These types of programs are more likely to remove the median vehicle (50th percentile) which is a very low emitting vehicle and not contributing to air quality problems.

Applying the same calculation to the estimated grams/mile emissions after adjustment, we estimate that the repairs produced a 45 gCO/mile emissions reduction. In view of the fact that these vehicles were measured repeatedly on-road, and based upon information provided by some of the owners, we estimate that they drive an average of 12,000 miles per year. Therefore we calculate close to half a metric ton of CO emissions reduction per repaired vehicle per year. A look at the repair sheets in appendix B indicates that most of the repairs will last a lot longer than one year (replaced cam shaft for instance). Conservatively we estimate that the repairs will last an average of two years for an emissions reductions cost of approximately $200 per ton of CO.

It was hoped that the emissions reduction obtained from the repaired vehicles would be reflected in the fleet measured mean %CO values. The total reductions from the repaired vehicles account for less than two percent of the total emissions at the northbound ramp. The error associated with measurements at the northbound ramp are in excess of 5%. This precludes the possibility of directly observing the impact of the repaired vehicles on the fleet emissions.

Assuming that the repairs and associated gas mileage improvement last for two years, that the vehicles are driven 12,000 miles per year and the cost of gasoline is $1.10 per gallon, one can calculate the average fuel cost savings to the vehicle owner of the free repair program thus:

$$12{,}000 * \left(\frac{1}{13.7} - \frac{1}{15.5}\right) * 1.10 * 2 = \$224$$

If remote sensing test and gross polluter identification are carried out routinely it is estimated that the cost per test is about $0.50, or $5.00 per identified gross polluter.
If it were required to check vehicles an average of four times per year at $0.50 per test and one assumes (as observed) that 10% of the fleet need repair, and that the repair costs and benefits will be as shown in this pilot program, then for each repaired vehicle:

| | |
|---|---|
| Cost of identification  $0.50 * 4 * 10 | = $20 |
| Cost of repair | = $195 |
| Total identified cost | = $215 |
| Benefit gas mileage improvement | = ($224) |

If $25 were spent per repaired vehicle for program administration on each gross polluter, the emissions reduction (0.5 tons CO/year) would have a net cost of $16 for CO reduction only.

Although Provo does not have an ozone violation problem, and HC emissions were not used as a criterion, there were two gross HC emitters repaired. The 1979 Chevy Nova with the flat cam shaft and missing air pump showed HC emissions reductions from 578 grams/gallon to 87 grams/gallon ($550). The 1974 LTD emissions went from 317 grams/gallon to 21 grams/gallon with a valve grind ($481). These two vehicles reduced their HC emissions by 787 grams/gallon (approximately 0.6 tons/year). If the total repair cost is ascribed to only the HC reductions, and the repairs are assumed to last two years, these two vehicles reduced HC emissions for $850 per ton.

We note that two vehicles which we tried to purchase for more than their value, opted for repair. Vehicles which are routinely driven have more value to their owners than vehicles which are not. This fact and its converse are the fatal flaw in conventional scrappage programs which encourage scrapping of the vehicle valued least (driven least) by its owner. A successful scrappage program will have to acquire the type of vehicle which we attempted to acquire in this program. Successful acquisition and replacement of these vehicles with a properly maintained vehicle would further improve the cost per ton value calculated above.

Listed in Appendix B are 7 out of 47 vehicles with diagnosed emissions system tampering. Repair of these tampered vehicles cost $1,072. Emissions system tampering, although illegal is by no means non-existent and the current laws are rarely enforced. Enforcement is difficult without a change in the law since the tamperer, not the owner, is liable under most states current statutes. If laws to repair tampered vehicles were properly drafted and enforced then a program based on these results would have 20% lower repair costs for the same benefits. If the owners of tampered vehicles were fined as well as being required to repair their vehicle, the resulting income could be used to finance the repair program. In California the Los Angeles District Attorney's office is contemplating a program in which remote sensing of gross polluters is used as probable cause for an immediate pullover by an officer of the law, accompanied by an inspection for tampering. According to the results of a pilot program in 1991 (Lawson and Gunderson, 1992), 92% of vehicles identified in California as gross polluters failed the applicable emissions standards, 43% were clearly tampered and an additional 23% had defective emission control systems. The District Attorney's office envisages that a properly enforced anti-tampering program could be revenue neutral based on fines levied for egregious tampering or failure to comply with a prior warning.

# V. REFERENCES


L.L Ashbaugh, D.R. Lawson, G.A. Bishop, P.L. Guenther, D.H. Stedman, R.D. Stephens, P.J. Groblicki, B.J. Johnson and S.C. Huang, "On-Road Remote Sensing of Carbon Monoxide and Hydrocarbon Emissions During Several Vehicle Operating Conditions", Presented at AWMA International Specialty Conference, Phoenix, Az., (1992).

G.A. Bishop, J.R. Starkey, A. Ihlenfeldt, W.J. Williams, and D.H. Stedman. "IR Long-Path Photometry, A Remote Sensing Tool For Automobile Emissions", Anal. Chem., 61, 671A-677A, (1989).

E. Glover and W. Clemmens, "Identifying Excess Emitters with a Remote Sensing Device: A Preliminary Analysis", Society of Automotive Engineers #911672, (1991).

J.B. Heywood, "Internal Combustion Engine Fundamentals." McGraw Hill, (1988).

D.R. Lawson, P.J. Groblicki, D.H. Stedman, G.A. Bishop and P.L. Guenther, "Emissions from In-use Motor Vehicles in Los Angeles: A Pilot Study of Remote Sensing and the Inspection and Maintenance Program", J. Air Waste Manage. Assoc., 40, 8, (1990).

D.R. Lawson and J.A. Gunderson, Presentation to California I/M Review Committee, January 29, (1992).

D.H. Stedman and G.A. Bishop, "An Analysis of On-Road Remote Sensing As A Tool For Automobile Emissions Control," Illinois Department of Energy and Natural Resources, Report # ILENR/RE-AQ-90/05, (1990).

D.H. Stedman and G.A. Bishop, "Remote Sensing for Mobile Source CO Emission Reduction", Final Report EPA 600/4-90/032, (1991).

D.H. Stedman, G.A. Bishop, J.E. Peterson, P.L. Guenther, I.F. McVey and S.P. Beaton, "On-Road Carbon Monoxide and Hydrocarbon Remote Sensing in the Chicago Area", Illinois Department of Energy and Natural Resources, Report # ILENR/RE-AQ-91/14, (1991).

U.S. Environmental Protection Agency I/M 240 justification, Federal Register 57 52947 et seq, November 5, (1992).

K.A. Whitney and E.L. Glover, "Evaluation of a Remote Sensing Device at a Centralized I/M Lane", Society of Automotive Engineers #922315, (1992).

# VI. APPENDICES

# APPENDIX A: Program Literature

Letter to Potential Recruits

November 20, 1991

Dear Mr./Ms. ___________:

**This letter extends an invitation to you to participate in an exciting new approach to automobile pollution, <u>and fuel economy improvement</u>**. As you are probably aware, the Provo area does not currently meet the Federal Clean Air standards for carbon monoxide. This colorless, odorless gas is predominantly emitted by inefficient automobiles which will get better gas mileage upon repair. **<u>Recent research by the University of Denver and others has shown that only 10% of vehicles on the road today are responsible for 50% of the carbon monoxide emissions</u>**. These are not all "old" vehicles, many late model vehicles may be in need of adjustment or need repairs for failed components.

A trial program is now under way in the Provo area which includes participants from the City of Provo, Utah Valley Community College, The University of Denver, the Environmental Protection Agency and many local automotive service and repair centers. The program is two pronged, 1) **<u>To identify high carbon monoxide emitting vehicles and</u> 2) <u>To recruit some of those vehicles and offer at NO COST TO THE OWNER any needed emissions related repairs and/ or maintenance</u>**. Not only should the environment benefit but we expect many of the repaired vehicles to offer better fuel economy.

**<u>A concern you may have, would be if tax dollars are being spent on this project</u>**. **<u>The answer is no</u>**. All funding has been donated. You are encouraged to take a few moments and read the accompanying literature which gives more details about the equipment and how it can be used to help improve the air quality in the Provo area.

**<u>Your vehicle, (include description and license)</u>**, has been identified as a high emitting carbon monoxide vehicle and one that would most likely benefit from repair/maintenance. The length of time your vehicle is in the repair shop will depend upon the repairs and/or maintenance needed. **<u>In addition to the free repairs, you will be offered a rental car during the time your vehicle is undergoing diagnosis and repair</u>**. We will also provide a drop off and pickup service. Utah Valley Community College is coordinating and overseeing all of the diagnosis and repairs.

If you would be interested in participating in this program and receiving the free vehicle maintenance **<u>please contact me at UVCC 222-8000 ext. 8243. Your prompt reply is requested.</u>**

Sincerely,

Orrin A. Nelson

UVCC Coordinator

QUESTIONS AND ANSWERS ABOUT
THE FEAT AIR POLLUTION REDUCTION PROGRAM

1. I passed my state inspection test, but FEAT says my car is a high polluter. How is this possible?

   **Your car may have gone out of tune or experienced some kind of failure since you state test. Also, some vehicles behave quite differently when idling (as during the state test) and when being driven. During normal driving (as this FEAT test), you use the most gasoline, so reducing carbon monoxide emissions and improving fuel economy in this mode is the most effective.**

2. FEAT says my car is operating properly but I just failed my state inspection test. How is this possible?

   **See the answer to No. 1 above. Also, the state test includes some conditions which measure other pollutants and which inspect things that do not necessarily magnify your car's on road emissions.**

3. Will I be cited by the county or state for tampering with my vehicle if I agree to participate in this program?

   **No. This is a research study only. With the initiation of this program, we are trying to reduce the overall CO emissions in the Provo area. You are being offered the free repairs to illustrate that keeping your car in good repair has overall effect on reducing CO emissions, and possibly increasing your vehicle gas mileage.**

4. Is there a cost limit to the repairs that will be performed on my vehicle?

   **Yes. Vehicles needing major repair, such as a motor overhaul, will not be repaired.**

5. How is it possible for FEAT to analyze my car's emissions in only one second while I am driving by?

   **FEAT measures the carbon monoxide and carbon dioxide gasses in your car's exhaust 50 times in half a second. Both carbon monoxide and carbon dioxide strongly absorb infra-red radiation, which FEAT uses to measure their relative concentrations. A half a second later, the FEAT computer calculates your actual carbon monoxide emissions.**

6. Is this test adding to air pollution by making me drive my car through the test beam?

**No. The beam was set up on your normal driving route so as to cause no inconvenience. Carbon monoxide emissions from high polluting cars can be corrected. It is helpful to reduce driving as much as possible, but is more important to drive a well maintained car when you do drive. Ten percent of the cars on the road contribute half the carbon monoxide pollution. Identifying and fixing those high polluting cars is the most effective way to reduce pollution.**

WAIVER

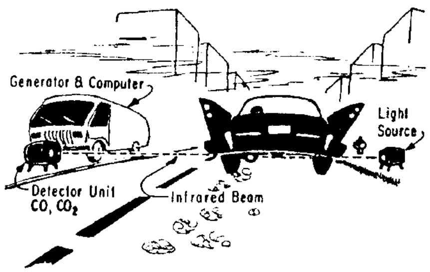
I, _________________________________________________ have consented to participate in this Corrective Maintenance program to have my vehicle, _______________________ License #______________, a gross polluter repaired.  I release Utah Valley Community College, their agents and employees, and volunteers, from and against any and all loss damages, injury, liability, suits and proceedings arising out of the performance of this task by the contractor, its agents, volunteers, or employees.  I release the State of Utah, and the State officers, agents, and employees from and against any and all loss, damages, injury, liability, suits and proceedings arising out of the performance of this Task by the Contractor, its agents, volunteers, or employees.  I also release the University of Denver, their agents and employees, and volunteers, from and against any and all loss damages, injury, liability, suits and proceedings arising out of the performance of this task by the contractor, its agents, volunteers or employees.

I further agree and understand that due to the cost restrictions of this program, the above described vehicle will not be repaired if at the discretion of the contractor, it is determined that major repairs are necessary.

SIGNED______________________________________DATE_______________________

WITNESS_______________________________________

WITNESS_______________________________________




An Innovative development which includes two commercially available air monitoring systems can determine, by remote sensing, the fuel efficiency of individual automobiles as they pass through an infrared light beam. According to test results, at least 10 percent of vehicles monitored will be found to be emitting large concentrations of carbon monoxide, thus running with a lower gas mileage and contributing the majority of a serious pollutant to the air quality of the Front Range.

Developed by:

Dr. Donald H. Stedman
Chemistry Department
University of Denver
Denver, CO 80208
(303) 871-3530

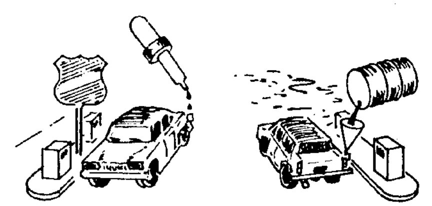
# THE DENVER FEAT

## SAVES FUEL AND CLEANS THE AIR

UNIVERSITY OF DENVER

# THE DENVER FEAT: SAVES FUEL AND CLEANS THE AIR

In December 1986, the University of Denver received a grant from the Colorado Office of Energy Conservation to develop the Fuel Efficiency Automobiles Test (FEAT) system. FEAT will identify automobiles that are not performing economically and as a result are wasting fuel and polluting the air with carbon monoxide (CO).



## CARBON MONOXIDE AND YOUR AUTOMOBILE

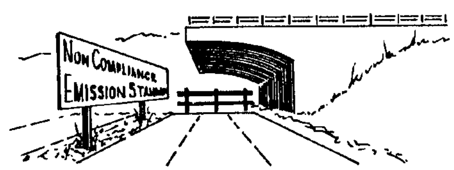
CO is formed when there is not enough oxygen to burn the fuel mixture completely, a condition termed fuel rich. This results in decreased energy efficiency of your automobile and lower gas mileage. As the air/fuel ratio becomes richer, your gas mileage goes lower and more CO is released to the atmosphere. A rich mixture is the only cause for CO emissions.

The automobile contributes heavily to the total pollutants caused by man. More than 90 percent of the total CO emissions come from the automobile. FEAT provides a rapid inspection under realistic road conditions to identify automobiles that greatly exceed CO emission limits.

## CARBON MONOXIDE AND THE LAW

Effective October 15, 1985, the Environmental Protection Agency (EPA) issued National Ambient Air Quality Standards for Carbon Monoxide. Denver, Colorado, currently exceeds those standards during the high pollution winter months. The largest contributor to the high levels of carbon monoxide is automobile exhaust. FEAT can help meet EPA compliance standards and improve the efficiency of your automobile engine.

To assist in meeting the EPA CO standards, Colorado established the Automobile Inspection and Readjustment (AIR) Program. AIR is administered by the Colorado Department of Health, Air Pollution Control Division, and the Colorado Department of Revenue, Motor Vehicle Division. The AIR Program covers an eight-county area along the Front Range. All 1968 and newer automobiles must have an annual test to meet acceptable CO emission levels.




## THE FEAT SYSTEM

The FEAT system uses CO and carbon dioxide ($CO_2$) monitors to determine the gasoline efficiency of your car as you drive through an infrared light beam.

The source for the beam is located on one side of the road and the detectors are on the opposite side. There are two detectors, one for CO, one for $CO_2$ and a computer. The detectors record the amount of CO and $CO_2$ in the automobile exhaust. This information is fed into the computer to obtain a ratio. A high percent of CO indicates that the engine is running fuel rich.

It has been determined that 10 percent of the automobiles on the road create 40 percent of the CO problem. Using the flexibility of the FEAT system to identify these high polluters will benefit you and your environment. A properly tuned engine provides potential for both fuel savings and improved air quality.

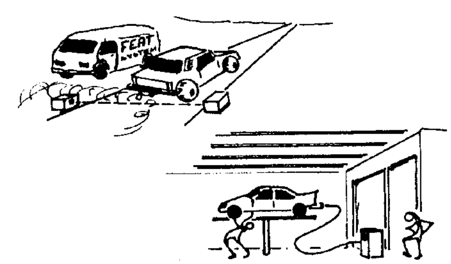
## CARBON MONOXIDE AND YOUR HEALTH

Control of human exposure to sources of CO is important because, when inhaled, CO enters the bloodstream and disrupts the delivery of oxygen to the body's tissues. A continuous and adequate flow of oxygen is essential to maintain normal health.

Studies on exposure to CO indicate adverse health effects on the heart and the central nervous system of the human body. High levels of CO in your system can result in headaches, dizziness, drowsiness, nausea, vomiting, collapse, coma, or death, depending on the extent to which the flow of oxygen to the body is restricted.

Groups at greatest risk from low-level ambient exposure to CO include:

- Persons with angina or other types of cardiovascular disease.
- Persons with chronic respiratory problems.
- The elderly.
- Fetuses and young infants.



## THE FEAT ADVANTAGE

The system has potential use by every state in the union to save energy and to solve CO inspection problems. FEAT can monitor automobiles as they drive by and flag only those that are violating the pollution standards.

The FEAT system is a convenient, innovative technique for identifying automobiles that are operating inefficiently and are polluting the air. The FEAT system benefits everyone. This rapid testing for mass numbers of automobiles represents a savings of time and money for drivers as well as cleaning up the air for the public health.

# APPENDIX B: Repaired Vehicle Data

Idle emissions data are reported in percent of CO and ppm hexane for the hydrocarbon measurements. Some of the HC readings of 2000 ppm or 9999 ppm indicate off-scale readings on the test meter. Missing data result from gaps in hand-recorded field data and video tape transcription.

```
Name         Lawrence Rees
Address      P.O. Box 421  Salem, Ut.,
County       Ut         Telephone 423-2443
License      002AWJ     Make      Dodge        Model  Dart      Year      1975
Value             400  Odometer        130000 Date   03/09/92
Repairs      Carb kit, spark plugs, diagnostic



Cost           100.80
Reason       normal wear and tear
Comments     F/U 3/23 choke problems, bringing for adjust. Did not track gas
             mileage.


Co_idle       5.50       Co_idle_ar   0.67      Mpgbefore       *
Hc_idle       600.0      Hc_idle_ar   100.0
Co_2500       5.00       Co_2500_ar   1.20
Hc_2500       450.0      Hc_2500_ar   200.0

On-Road data in grams/gallon (Number of measurements)
Co_before    620.63(5)  Co_after      49.99(2) Mpgafter        *
Hc_before     76.49(4)  Hc_after      51.95(2)
```

```
Name         Forrest Allen
Address      1600 W  7348 So Spanish Fork, UT. 84660
County       UT         Telephone 798-9227  W375-3393
License      016BSW     Make      Volks        Model  bus       Year      1974
Value            1000  Odometer        160000 Date   02/18/92
Repairs      Set timing,adjust carb, made little difference.  Valve grind
             replace #3 cylinder,tune-up, replaced some emission controls
             but not pipes, too much expense.

Cost           448.00
Reason       tampering & normal wear and tear
Comments     Engine shot,10# compression in #3 cylinder.  Valve grind
             done. Tampered. Emissions pipes missing from engine.
             follow-up 3/18/92. Runs better,gas mileage bad.

Co_idle       0.94       Co_idle_ar   1.30      Mpgbefore      15
Hc_idle        63.0      Hc_idle_ar   205.0
Co_2500       9.76       Co_2500_ar   2.60
Hc_2500       769.0      Hc_2500_ar   484.0

On-Road data in grams/gallon (Number of measurements)
Co_before   2800.29(2)  Co_after    1960.11(2) Mpgafter        *
Hc_before    245.00(2)  Hc_after     401.07(2)
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Shauna/David Morgan | | | | | | |
| Address | 440 N 700 E Mapleton, Ut., 84664 | | | | | | |
| County | Ut | Telephone | W374-7800 H489-0340 | | | | |
| License | 054BNL | Make | Dodge | Model | Caravan | Year | 1984 |
| Value | 4000 | Odometer | 115000 | Date | 03/02/92 | | |
| Repairs | Cleaned and adjusted carburetor. | | | | | | |

| | |
|---|---|
| Cost | 48.44 |
| Reason | normal wear and tear |
| Comments | F/U 3/18, 3/31 running good, did not track gas mileage |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 2.37 | Co_idle_ar | 0.55 | Mpgbefore | * |
| Hc_idle | 156.0 | Hc_idle_ar | 171.0 | | |
| Co_2500 | 0.30 | Co_2500_ar | 0.50 | | |
| Hc_2500 | 126.0 | Hc_2500_ar | 113.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1326.13(4) | Co_after | 138.78(1) | Mpgafter | * |
| Hc_before | 85.80(4) | Hc_after | 120.50(1) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Steve Turpin | | | | | | |
| Address | 420E 300S Spanish Fork, UT. 84660 | | | | | | |
| County | Ut | Telephone | 798-3027 | | | | |
| License | 1259BN | Make | ford | Model | pickup | Year | 1978 |
| Value | 5000 | Odometer | 57000 | Date | 12/16/91 | | |
| Repairs | Carb overhaul | | | | | | |

| | |
|---|---|
| Cost | 131.22 |
| Reason | Normal wear and tear |
| Comments | F/U 3/18 no answer 3/31 runs better |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.27 | Co_idle_ar | 3.90 | Mpgbefore | 14 |
| Hc_idle | 2000.0 | Hc_idle_ar | 116.0 | | |
| Co_2500 | 5.81 | Co_2500_ar | 0.43 | | |
| Hc_2500 | 97.0 | Hc_2500_ar | 0.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 2517.00(2) | Co_after | 151.04(1) | Mpgafter | * |
| Hc_before | 51.48(2) | Hc_after | 21.48(1) | | |

```
Name         Robert Griffiths
Address      90 E 200 S  Spanish Fork, Ut, 84660
County       Ut        Telephone H798-2723 W373-1063
License      190DWV    Make      Ford         Model  LTD       Year      1979
Value             400  Odometer        165919 Date   02/28/92
Repairs      Overhaul Carb and made necessary adjustments.  Repaired broken and
             missing vacuum lines and valves.


Cost           241.72
Reason       Tampering and normal wear and tear
Comments     possible tampering before. Vacuum lines broken and/or missing. F/U
             3/11 runs fine.


Co_idle       8.87       Co_idle_ar   1.27      Mpgbefore       *
Hc_idle       750.0      Hc_idle_ar   244.0
Co_2500       2.54       Co_2500_ar   0.53
Hc_2500       114.0      Hc_2500_ar    74.0

On-Road data in grams/gallon (Number of measurements)
Co_before    1398.99(3)  Co_after     706.57(4) Mpgafter        *
Hc_before      70.44(3)  Hc_after     155.75(4)



Name         Peggy Knots
Address      Box 492 Spanish Fork, Ut, 84660
County       Ut        Telephone 798-9243 after 2 pm
License      194CRA    Make      Chev         Model  Caprice   Year      1977
Value             500  Odometer        179000 Date   03/04/92
Repairs      Adjust carb/air fuel mix. Clean PCV valve, tighten vacuum lines
             rear of carb


Cost            20.00
Reason       normal wear and tear
Comments     F/U attempted x 3 but unable to contact.



Co_idle       0.31       Co_idle_ar   0.24      Mpgbefore       8
Hc_idle       195.0      Hc_idle_ar   226.0
Co_2500       3.50       Co_2500_ar   0.92
Hc_2500       195.0      Hc_2500_ar    98.0

On-Road data in grams/gallon (Number of measurements)
Co_before    1764.47(4)  Co_after    1134.75(5) Mpgafter        *
Hc_before      47.07(2)  Hc_after      51.52(5)
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Wendy Bradford | | | | | | |
| Address | 1135 E 1025 S Spanish Fork,Ut., 84660 | | | | | | |
| County | Ut | Telephone 798-3121 | | | | | |
| License | 196EKM | Make | Plym | Model | Fur | Year | 1975 |
| Value | 500 | Odometer | 175000 | Date | 02/12/92 | | |
| Repairs | Coil wire replaced and adjustments made | | | | | | |

| | |
|---|---|
| Cost | 31.34 |
| Reason | Normal wear and tear |
| Comments | F/U 3/23 running good, didn’t track mileage. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 4.44 | Co_idle_ar | 1.56 | Mpgbefore | 6 |
| Hc_idle | 265.0 | Hc_idle_ar | 241.0 | | |
| Co_2500 | 0.57 | Co_2500_ar | 0.93 | | |
| Hc_2500 | 1040.0 | Hc_2500_ar | 93.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1901.87(2) | Co_after | **** | Mpgafter | * |
| Hc_before | 58.17(2) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Calvin Thomas | | | | | | |
| Address | 254 E Center Spanish Fork, Ut,84660 | | | | | | |
| County | Ut | Telephone 798-7135 W798-7351 | | | | | |
| License | 202CVK | Make | Pont | Model | GrandAm | Year | 1986 |
| Value | 3500 | Odometer | 70000 | Date | 02/26/92 | | |
| Repairs | Dynamometer tune-up, plugs and points | | | | | | |

| | |
|---|---|
| Cost | 58.10 |
| Reason | Normal wear and tear |
| Comments | Emissions o.k. except under heavy acceleration, checked on dynamometer. F/U 3/31 no answer. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 1.20 | Co_idle_ar | 0.51 | Mpgbefore | * |
| Hc_idle | 440.0 | Hc_idle_ar | 285.0 | | |
| Co_2500 | 1.80 | Co_2500_ar | 0.84 | | |
| Hc_2500 | 370.0 | Hc_2500_ar | 106.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 845.71(3) | Co_after | **** | Mpgafter | * |
| Hc_before | 33.65(2) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Tammy Stickney | | | | | | |
| Address | 57 N Center Santaquin, Ut, 84655 | | | | | | |
| County | Ut | Telephone H754-5920 W377-5660 | | | | | |
| License | 239ETF | Make | Chev | Model | Blazer | Year | 1979 |
| Value | 3000 | Odometer | 96868 | Date | 03/02/92 | | |

Repairs: repaired stuck choke. Replaced manifold donuts, catalytic converter.

Cost: 251.35
Reason: Clearly tampered with
Comments: Tampered vehicle, using regular gas. F/U 3/18/92 runs great, very satisfied. Significant improvement in gas mileage.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 9.31 | Co_idle_ar | 0.81 | Mpgbefore | 8 |
| Hc_idle | 9999.0 | Hc_idle_ar | 122.0 | | |
| Co_2500 | 4.55 | Co_2500_ar | 1.61 | | |
| Hc_2500 | 254.0 | Hc_2500_ar | 117.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 708.21(4) | Co_after | **** | Mpgafter | 11 |
| Hc_before | 56.77(3) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | James Moon | | | | | | |
| Address | RFD 1 Box 432 Spanish Fork,Ut, 84660 | | | | | | |
| County | UT | Telephone 798-7116 W 375-3766 | | | | | |
| License | 309AKT | Make | Toyota | Model | Str | Year | 1982 |
| Value | 300 | Odometer | 175000 | Date | 02/06/92 | | |

Repairs: Gas cap , emissions checked. Vehicle within state limits.

Cost: 19.86
Reason: normal wear and tear
Comments: Emissions within state limits when checked at station. Probable cause hi Co car operating under load. F/U 2/13, appreciative of work. Running good, no change in gas mileage

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.01 | Co_idle_ar | 0.01 | Mpgbefore | 30 |
| Hc_idle | 34.0 | Hc_idle_ar | 34.0 | | |
| Co_2500 | 0.03 | Co_2500_ar | 0.03 | | |
| Hc_2500 | 71.0 | Hc_2500_ar | 71.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1029.42(1) | Co_after | **** | Mpgafter | 30 |
| Hc_before | 654.89(1) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Christie Peterson | | | | | | |
| Address | 308 N 400 E Payson,Ut., 84651 | | | | | | |
| County | Ut | Telephone 465-2142 | | | | | |
| License | 321DJN | Make | Dodge | Model | Caravan | Year | 1984 |
| Value | 2500 | Odometer | 82000 | Date | 02/07/92 | | |
| Repairs | Installed high altitude compensator kit, carb adjusted | | | | | | |

| | |
|---|---|
| Cost | 84.82 |
| Reason | accidental neglect |
| Comments | Vehicle purchased out of state, Utah is a higher elevation. F/U 3/23 Sold. but ran fine, gas no change in mileage noticed. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.40 | Co_idle_ar | 0.01 | Mpgbefore | * |
| Hc_idle | 32.0 | Hc_idle_ar | 11.0 | | |
| Co_2500 | 3.00 | Co_2500_ar | 0.84 | | |
| Hc_2500 | 138.0 | Hc_2500_ar | 14.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1165.17(2) | Co_after | **** | Mpgafter | * |
| Hc_before | **** | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Jill Tuckett | | | | | | |
| Address | 150 N 1000 E Payson, Ut, 84651 | | | | | | |
| County | Ut | Telephone 465-3739 | | | | | |
| License | 358CEJ | Make | Ford | Model | Aerostar | Year | 1986 |
| Value | 4000 | Odometer | 125000 | Date | 02/26/92 | | |
| Repairs | Control module, pickup coil, O2 sensor, EGR valve. | | | | | | |

| | |
|---|---|
| Cost | 386.27 |
| Reason | Normal wear and tear |
| Comments | Underload problem. Intermit response. Readings would not reflect. F/U 3/23, 3/31 unable to contact. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 1.50 | Co_idle_ar | 0.00 | Mpgbefore | * |
| Hc_idle | 250.0 | Hc_idle_ar | 94.0 | | |
| Co_2500 | 3.50 | Co_2500_ar | 0.00 | | |
| Hc_2500 | 400.0 | Hc_2500_ar | 43.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1222.18(6) | Co_after | 1827.05(5) | Mpgafter | * |
| Hc_before | 100.26(5) | Hc_after | 200.06(5) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Kyrt/Grace Nay | | | | | | |
| Address | 7651 N 740 E Mapleton, Ut | | | | | | |
| County | Ut | Telephone 489-8762 W429-7722 | | | | | |
| License | 368BLE | Make | Ford | Model | Ltd | Year | 1975 |
| Value | 400 | Odometer | 148000 | Date | 03/04/92 | | |
| Repairs | Choke not coming off. Adjustments made. | | | | | | |

| | |
|---|---|
| Cost | 13.00 |
| Reason | normal wear and tear |
| Comments | F/U 3/18/92. Very pleased. MPG improved by 20% |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.56 | Co_idle_ar | 0.56 | Mpgbefore | 12 |
| Hc_idle | 185.0 | Hc_idle_ar | 185.0 | | |
| Co_2500 | 0.46 | Co_2500_ar | 0.46 | | |
| Hc_2500 | 49.0 | Hc_2500_ar | 49.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1900.51(4) | Co_after | 385.53(3) | Mpgafter | 14 |
| Hc_before | 63.67(3) | Hc_after | 119.06(3) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | David Taylor | | | | | | |
| Address | 385 E 600 S Springville, Ut, 84663 | | | | | | |
| County | Ut | Telephone 489-4963 | | | | | |
| License | 459CFV | Make | Honda | Model | Accord | Year | 1979 |
| Value | 500 | Odometer | 173000 | Date | 02/14/92 | | |
| Repairs | Repaired exhaust leak in manifold, repaired, replaced and rerouted vacuum lines. | | | | | | |

| | |
|---|---|
| Cost | 122.57 |
| Reason | Tampered with, and accidental neglect |
| Comments | Vehicle tampered with. Vacuum hoses were incorrectly routed. F/U 3/18/92. Moved. no other information. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 3.80 | Co_idle_ar | 0.54 | Mpgbefore | 24 |
| Hc_idle | 1300.0 | Hc_idle_ar | 165.0 | | |
| Co_2500 | 5.50 | Co_2500_ar | 2.43 | | |
| Hc_2500 | 1300.0 | Hc_2500_ar | 375.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1295.65(3) | Co_after | **** | Mpgafter | * |
| Hc_before | 104.84(3) | Hc_after | **** | | |

```
Name         Jon L Hoagland
Address      800 S Canyon Dr  Springville, Ut 84663
County       Ut         Telephone 489-5470  W 377-2212
License      461DTD     Make      Cadillac     Model  Seville   Year      1980
Value            3500  Odometer        121000 Date   02/01/92
Repairs      Installed regulator kit.  16psi on tbi, spec is 10psi.



Cost            82.00
Reason       Accidental neglect and tampering
Comments     tampered vehicle.  Steel ball found in return line to
             fuel tank. Follow-up 3/18/92, running better.


Co_idle       0.05       Co_idle_ar   0.05      Mpgbefore      15
Hc_idle       200.0      Hc_idle_ar   200.0
Co_2500       8.60       Co_2500_ar   0.80
Hc_2500       400.0      Hc_2500_ar   130.0

On-Road data in grams/gallon (Number of measurements)
Co_before     791.53(5)  Co_after     206.25(1) Mpgafter       17
Hc_before     102.43(3)  Hc_after      44.15(1)
```

```
Name         Peggy Batty
Address      200E 600N Spanish Fork, UT. 84660
County       Ut         Telephone 798-8802
License      590ADE     Make      ford         Model  galaxy    Year      1966
Value             200  Odometer        153000 Date   12/06/91
Repairs      Install power valve, float set,adjust timing, set points



Cost            38.88
Reason       Normal wear and tear
Comments     excessive engine blowby.Follow-up 3/18/92, appreciated work.



Co_idle       6.40       Co_idle_ar   1.60      Mpgbefore       9
Hc_idle       300.0      Hc_idle_ar   200.0
Co_2500       5.20       Co_2500_ar   1.80
Hc_2500       440.0      Hc_2500_ar   250.0

On-Road data in grams/gallon (Number of measurements)
Co_before    1565.67(1)  Co_after    2273.73(8) Mpgafter       11
Hc_before       ****     Hc_after     131.85(7)
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Scot Bridge | | | | | | |
| Address | 341 E 950 S Springville, Ut., 84663 | | | | | | |
| County | Ut | Telephone 489-7252 | | | | | |
| License | 611ECW | Make | Chev | Model | Nova | Year | 1979 |
| Value | 1000 | Odometer | 170000 | Date | 02/13/92 | | |
| Repairs | Cam Shaft, lifters, timing chains and gears | | | | | | |

Cost 550.00
Reason Tampered with and normal wear and tear
Comments Tampered. Air pump gone. Flat cam repaired, emissions lowered. F/U 3/18/92."Made me a very happy man". MPG improved greatly.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 5.39 | Co_idle_ar | 0.01 | Mpgbefore | 9 |
| Hc_idle | 2000.0 | Hc_idle_ar | 87.0 | | |
| Co_2500 | 7.87 | Co_2500_ar | 0.77 | | |
| Hc_2500 | 2000.0 | Hc_2500_ar | 182.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1388.86(4) | Co_after | 88.06(1) | Mpgafter | 17 |
| Hc_before | 577.58(1) | Hc_after | 87.47(1) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | James Brady | | | | | | |
| Address | 1260N 800W Mapleton, Ut | | | | | | |
| County | Ut | Telephone 489-7516 | | | | | |
| License | 613AKS | Make | Pont | Model | 6LE | Year | 1983 |
| Value | 2500 | Odometer | 117573 | Date | 12/06/91 | | |
| Repairs | Install M/C solenoid, repair broken wire, in harness. Air fuel Hi and lo air fuel mix adjusted. | | | | | | |

Cost 186.87
Reason Normal wear and tear
Comments Blowby is excessive, oil leak in engine. 2/12/92 follow-up. Pleased with repairs, brought to UVCC for minor adjustments. Runs much better.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 11.00 | Co_idle_ar | 0.00 | Mpgbefore | 12 |
| Hc_idle | 600.0 | Hc_idle_ar | 41.0 | | |
| Co_2500 | 9.00 | Co_2500_ar | 0.10 | | |
| Hc_2500 | 550.0 | Hc_2500_ar | 14.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 2324.08(1) | Co_after | 174.96(3) | Mpgafter | * |
| Hc_before | -8.62 (1) | Hc_after | 145.90(3) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Byron Moos | | | | | | |
| Address | 531 S - 1500 E Spanish Fork,Ut 84660 | | | | | | |
| County | Ut | Telephone 798-3076 W489-3672 | | | | | |
| License | 621EFF | Make | Plymouth | Model | van | Year | 1988 |
| Value | 8000 | Odometer | 96000 | Date | 02/02/92 | | |
| Repairs | No repairs-emissions within range | | | | | | |

Cost 20.18
Reason no repairs
Comments emissions within limits. Probable hi Co reading, operating under load.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 1.00 | Co_idle_ar | 1.00 | Mpgbefore | * |
| Hc_idle | 180.0 | Hc_idle_ar | 180.0 | | |
| Co_2500 | 0.80 | Co_2500_ar | 0.80 | | |
| Hc_2500 | 140.0 | Hc_2500_ar | 140.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1305.14(1) | Co_after | **** | Mpgafter | * |
| Hc_before | **** | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Anthony K Snow | | | | | | |
| Address | 1115 E 900 N Mapleton,Ut., 84664 | | | | | | |
| County | Ut | Telephone 489-8288 | | | | | |
| License | 640DPT | Make | Pontiac | Model | Gra | Year | 1979 |
| Value | 700 | Odometer | 60000 | Date | 02/06/92 | | |
| Repairs | Catalytic converter replaced, carb adjusted, float lead cleaned | | | | | | |

Cost 172.00
Reason Normal wear and tear
Comments Catalyst in converter not controlling emissions. follow-up 3/18/92. Appreciated work done. No long trips mileage not checked, but thinks improved.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.06 | Co_idle_ar | 0.00 | Mpgbefore | 18 |
| Hc_idle | 131.0 | Hc_idle_ar | 29.0 | | |
| Co_2500 | 3.30 | Co_2500_ar | 1.70 | | |
| Hc_2500 | 144.0 | Hc_2500_ar | 118.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 992.92(5) | Co_after | **** | Mpgafter | * |
| Hc_before | 39.56(4) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Robert Hall | | | | | | |
| Address | 627 S 100 E  Payson, Ut., 84651 | | | | | | |
| County | Ut | Telephone | 465-9392  W374-9765 | | | | |
| License | 646DRE | Make | Plym | Model | Voyager | Year | 1985 |
| Value | 4500 | Odometer | 165000 | Date | 02/13/92 | | |

Repairs: Rebuilt carb, air filter, plugs, emissions still high. Refer to Work order. Carb re-done at separate shop at additional cost, replace power valve and check valve, carb gasket

Cost: 643.07
Reason: normal wear and tear
Comments: Repaired by dealership, emissions higher than before repairs. no guarantee. stating rebuilt carbs unreliable.taken to another shop, carb re-done,co’s lowered drastically. See work orders

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.95 | Co_idle_ar | 0.00 | Mpgbefore | 24 |
| Hc_idle | 150.0 | Hc_idle_ar | 10.0 | | |
| Co_2500 | 4.69 | Co_2500_ar | 0.39 | | |
| Hc_2500 | 216.0 | Hc_2500_ar | 12.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 2562.70(6) | Co_after | 1059.29(4) | Mpgafter | * |
| Hc_before | 135.33(4) | Hc_after | 146.64(5) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Dennis Steele/W. Jensen | | | | | | |
| Address | 267 E State Rd #5  Pleasant Grove,Ut | | | | | | |
| County | Ut | Telephone | W373-9262 H785-8907 | | | | |
| License | 659ENL | Make | Ford | Model | Granada | Year | 1977 |
| Value | 500 | Odometer | 139000 | Date | 02/26/92 | | |

Repairs: Replace 2 spark plugs,checked and adjusted timing,remove carb, replace power valve, install air pump belt.  Flooding. Returned,carb overhaul.

Cost: 358.69
Reason: accidental neglect
Comments: Car in bad repair. Air filter plugged solid.Refer mechanic caution on work order

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 5.59 | Co_idle_ar | 0.01 | Mpgbefore | 14 |
| Hc_idle | 2201.0 | Hc_idle_ar | 82.0 | | |
| Co_2500 | 5.64 | Co_2500_ar | 0.01 | | |
| Hc_2500 | 2201.0 | Hc_2500_ar | 0.7 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 2528.85(4) | Co_after | **** | Mpgafter | * |
| Hc_before | 165.04(4) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Steven/Andrea Hargrove | | | | | | |
| Address | 1468 S - 600 E Springville, Ut, 84663 | | | | | | |
| County | Ut | Telephone 489-5982 W373-2630 | | | | | |
| License | 686AJB | Make | Merc | Model | Topaz | Year | 1985 |
| Value | 2000 | Odometer | 125000 | Date | 03/11/92 | | |
| Repairs | Replace ECU computer,ISC motor,fuel injector,pcv valve,plugs. | | | | | | |

| | |
|---|---|
| Cost | 521.10 |
| Reason | Normal wear and tear |
| Comments | F/U 3/31 wonderful performance. Very pleased. Doesn’t race at 80 mph now in idle. Mileage not tracked. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 2.04 | Co_idle_ar | 0.27 | Mpgbefore | 20 |
| Hc_idle | 304.0 | Hc_idle_ar | 159.0 | | |
| Co_2500 | 3.50 | Co_2500_ar | 0.58 | | |
| Hc_2500 | 249.0 | Hc_2500_ar | 96.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1343.51(4) | Co_after | 684.10(4) | Mpgafter | 25 |
| Hc_before | 39.94(3) | Hc_after | 144.67(3) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Matthew Lyman | | | | | | |
| Address | 11085 N 5600 W Highland, Ut | | | | | | |
| County | Ut | Telephone 756-3119 | | | | | |
| License | 6877AH | Make | Dodge | Model | pickup | Year | 1986 |
| Value | 2600 | Odometer | 61000 | Date | 03/11/92 | | |
| Repairs | Air filter and plugs, adjustments. | | | | | | |

| | |
|---|---|
| Cost | 66.01 |
| Reason | Normal wear and tear |
| Comments | F/U 3/27 3/31 runs fine |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 9.10 | Co_idle_ar | 0.02 | Mpgbefore | 20 |
| Hc_idle | 600.0 | Hc_idle_ar | 0.0 | | |
| Co_2500 | 6.40 | Co_2500_ar | 0.03 | | |
| Hc_2500 | 280.0 | Hc_2500_ar | 0.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 2810.87(1) | Co_after | **** | Mpgafter | * |
| Hc_before | 31.49(1) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Forrest Smith | | | | | | |
| Address | 369 S 100 W Santequin, Ut | | | | | | |
| County | Ut | Telephone 754-3257 | | | | | |
| License | 696ANC | Make | Ford | Model | StaWagon | Year | 1980 |
| Value | 1000 | Odometer | 152000 | Date | 03/09/92 | | |
| Repairs | Carb overhaul, reroute vacuum lines,catalytic converter. | | | | | | |

| | |
|---|---|
| Cost | 383.40 |
| Reason | normal wear and tear |
| Comments | catalyst in converter not working to control emissions. F/U 3/23 Running good, gas mileage not tracked. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 4.42 | Co_idle_ar | 0.85 | Mpgbefore | 15 |
| Hc_idle | 504.0 | Hc_idle_ar | 325.0 | | |
| Co_2500 | 3.78 | Co_2500_ar | 2.40 | | |
| Hc_2500 | 718.0 | Hc_2500_ar | 176.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1697.91(2) | Co_after | 632.97(3) | Mpgafter | * |
| Hc_before | 119.11(1) | Hc_after | 127.96(3) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Julie Collings | | | | | | |
| Address | 6248 E 200 N Springville, Ut., 84663 | | | | | | |
| County | Ut | Telephone 489-7956 | | | | | |
| License | 706DRF | Make | Ford | Model | LTD | Year | 1974 |
| Value | 1200 | Odometer | 131000 | Date | 02/12/92 | | |
| Repairs | valve grind. # 7 cylinder low compression 25PSI. | | | | | | |

| | |
|---|---|
| Cost | 480.71 |
| Reason | Normal wear and tear |
| Comments | Offered to buy rather than fix, not interested in selling. Repaired No rental for this period of repair. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 2.33 | Co_idle_ar | 1.60 | Mpgbefore | 12 |
| Hc_idle | 1230.0 | Hc_idle_ar | 272.0 | | |
| Co_2500 | 0.89 | Co_2500_ar | 0.29 | | |
| Hc_2500 | 443.0 | Hc_2500_ar | 82.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1862.74(5) | Co_after | 964.35(2) | Mpgafter | * |
| Hc_before | 317.41(4) | Hc_after | 20.63(2) | | |

Name Roland Lewis
Address 670 E 900 N Mapleton Ut.,84664
County Ut Telephone W370-6531 H489-7442
License 746DLN Make Pontiac Model Bon Year 1982
Value 1600 Odometer 98000 Date 02/26/92
Repairs Tune-up, before and after emissions, dyno tested.

Cost 79.95
Reason Normal wear and tear
Comments Needs computer sensors replaced. Emissions lowered without replacing them. F/U 3/23 and 3/31 no answer

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 9.99 | Co_idle_ar | 1.00 | Mpgbefore | 15 |
| Hc_idle | 1383.0 | Hc_idle_ar | 110.0 | | |
| Co_2500 | 9.99 | Co_2500_ar | 1.10 | | |
| Hc_2500 | 603.0 | Hc_2500_ar | 200.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1537.64(4) | Co_after | 609.39(3) | Mpgafter | * |
| Hc_before | 138.35(4) | Hc_after | 210.52(2) | | |

Name Kathy Sorensen
Address 678 S 800 W #3 Payson, Ut 84651
County Ut Telephone 465-4421 W374-7729
License 798CFT Make Chev Model Nova Year 1976
Value 900 Odometer 118000 Date 03/03/92
Repairs Carb overhaul and float adjustment. Tune-up, air filter, fuel filter.

Cost 225.17
Reason Normal wear and tear
Comments F/U 3/18/92.Runs real good.Happy with results. MPG improved but not measured. Refills less frequent.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 9.99 | Co_idle_ar | 1.16 | Mpgbefore | 15 |
| Hc_idle | 1395.0 | Hc_idle_ar | 220.0 | | |
| Co_2500 | 2.06 | Co_2500_ar | 1.66 | | |
| Hc_2500 | 269.0 | Hc_2500_ar | 171.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 632.26(5) | Co_after | 647.38(5) | Mpgafter | * |
| Hc_before | 68.42(4) | Hc_after | 101.35(5) | | |

Name Mary Reese
Address 530 E 200 S Spanish Fork, Ut., 84660
County Ut Telephone 798-6348 W489-3253
License 826DWM Make olds Model csu Year 1977
Value 700 Odometer 96655 Date 02/13/92
Repairs Tune-up, carburetor overhaul, catalytic converter

Cost 385.70
Reason Normal wear and tear
Comments Catalyst in converter not working to keep emissions down.
F/U 3/18/92. Very pleased with work.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 9.68 | Co_idle_ar | 0.01 | Mpgbefore | 12 |
| Hc_idle | 2201.0 | Hc_idle_ar | 64.0 | | |
| Co_2500 | 2.44 | Co_2500_ar | 0.36 | | |
| Hc_2500 | 125.0 | Hc_2500_ar | 79.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1175.10(4) | Co_after | 722.81(2) | Mpgafter | 14 |
| Hc_before | 163.66(2) | Hc_after | 65.71(2) | | |

Name Jan S Gray
Address 108 N Main, Mapleton, UT., 84664
County UT Telephone 489-3570
License 862BKH Make Toyota Model wagon Year 1978
Value 500 Odometer 122000 Date 02/03/92
Repairs Air pump bracket missing, and replaced. Enrichment diaphragm on carb replaced. Vacuum hoses rerouted. 4/3 backfiring returned to shop for repair of cracked manifold.

Cost 176.13
Reason Clearly tampered with
Comments Vehicle had been tampered with. Vacuum lines routed incorrectly. Follow-up 3/18/92. Runs pretty good. Backfires repaired cracked manifold.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 3.00 | Co_idle_ar | 0.07 | Mpgbefore | * |
| Hc_idle | 400.0 | Hc_idle_ar | 43.0 | | |
| Co_2500 | 6.30 | Co_2500_ar | 0.20 | | |
| Hc_2500 | 1100.0 | Hc_2500_ar | 5.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1554.24(2) | Co_after | **** | Mpgafter | * |
| Hc_before | 94.65(1) | Hc_after | **** | | |

```
Name         Luella Farnworth
Address      1558 E 7200 So Spanish Fork, Ut., 84660
County       Ut         Telephone 798-6959
License      888EFH     Make      Olds         Model  Omega     Year      1976
Value             500  Odometer          ***** Date   02/18/92
Repairs      Catalytic converter installed



Cost           158.00
Reason       Normal wear and tear
Comments     catalyst in converter not controlling emissions F/U 3/18, 3/31
             Pleased with repairs, gas mileage not checked.


Co_idle       1.40       Co_idle_ar   0.45      Mpgbefore       *
Hc_idle       157.0      Hc_idle_ar    98.0
Co_2500       0.88       Co_2500_ar   0.93
Hc_2500        49.0      Hc_2500_ar   114.0

On-Road data in grams/gallon (Number of measurements)
Co_before    874.72(4)  Co_after     945.84(2) Mpgafter        *
Hc_before     23.27(3)  Hc_after      32.03(2)




Name         Emma Dennis
Address      601E Swenson Ave 1  Springville, UT.
County       Ut         Telephone 489-0159
License      919DFN     Make      merc         Model  cou       Year      1971
Value             500  Odometer        152567 Date   12/11/91
Repairs      Engine tune-up, PC valve was cleaned.  Needs motor work, smokes
             engine overhaul not practical for value and condition of car.
             Comment:  car fixed at UVCC,only parts were sparkplugs.

Cost            22.50
Reason       Normal wear and tear
Comments     smokes, needs motor overhaul.  Happy with repairs and new car
             rental few days after returned muffler fell off, got a
             ticket, thinks was our fault. Son-in-law claims engine not
             smoking.
Co_idle       5.20       Co_idle_ar   2.20      Mpgbefore       *
Hc_idle       480.0      Hc_idle_ar   421.0
Co_2500       4.90       Co_2500_ar   0.57
Hc_2500       320.0      Hc_2500_ar   210.0

On-Road data in grams/gallon (Number of measurements)
Co_before   1756.21(2)  Co_after       ****    Mpgafter        *
Hc_before     78.55(1)  Hc_after       ****
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Michael Davis(Wendy) | | | | | | |
| Address | 880 W 1600 S Mapleton,Ut, 84664 | | | | | | |
| County | Ut | Telephone W222-1140 H489-9072 | | | | | |
| License | 932CDE | Make | Volks | Model | Van | Year | 1975 |
| Value | 800 | Odometer | 190000 | Date | 03/04/92 | | |
| Repairs | Tune-up. | | | | | | |

| | |
|---|---|
| Cost | 58.95 |
| Reason | normal wear and tear |
| Comments | Volks shop spokesman states volks vans usually have a tough time passing emissions checks.F/U 3/23 pleased with performance. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 4.75 | Co_idle_ar | 0.96 | Mpgbefore | 22 |
| Hc_idle | 170.0 | Hc_idle_ar | 126.0 | | |
| Co_2500 | 2.88 | Co_2500_ar | 1.91 | | |
| Hc_2500 | 152.0 | Hc_2500_ar | 157.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1399.56(3) | Co_after | **** | Mpgafter | * |
| Hc_before | 43.37(2) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Moyle Anderson | | | | | | |
| Address | 750 W 100 S Payson, Ut | | | | | | |
| County | Ut | Telephone 465-4053 | | | | | |
| License | 975BVK | Make | Ford | Model | Mustang | Year | 1976 |
| Value | 500 | Odometer | 122000 | Date | 03/04/92 | | |
| Repairs | Tune-up, diverter valve. 2 cylinders leaking 50% compression. Air filter full of oil, excessive blow by. Fixing to reduce emissions. | | | | | | |

| | |
|---|---|
| Cost | 106.31 |
| Reason | normal wear and tear |
| Comments | Not interested in selling, repaired to reduce emissions. Need overhaul. F/U 3/31 runs fine, and realizes needs more work. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.86 | Co_idle_ar | 0.73 | Mpgbefore | 20 |
| Hc_idle | 628.0 | Hc_idle_ar | 435.0 | | |
| Co_2500 | 3.63 | Co_2500_ar | 2.06 | | |
| Hc_2500 | 221.0 | Hc_2500_ar | 235.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1095.51(1) | Co_after | **** | Mpgafter | * |
| Hc_before | 112.02(1) | Hc_after | **** | | |

```
Name         Cleve/Debra Hatch
Address      92 N 300 W Springville, Ut. 84663
County       Ut        Telephone 489-0693/ W 374-1212
License      9779CM    Make      Intl         Model  Pick-up   Year      1974
Value            1000  Odometer         71000 Date   02/05/92
Repairs      Carb overhaul, tuneup, emissions check


Cost           208.25
Reason       normal wear and tear
Comments     F/U 3/31 Truck performing well. Very happy.


Co_idle       4.71       Co_idle_ar   0.81      Mpgbefore      11
Hc_idle       259.0      Hc_idle_ar    69.0
Co_2500       1.00       Co_2500_ar   0.20
Hc_2500       272.0      Hc_2500_ar     8.0

On-Road data in grams/gallon (Number of measurements)
Co_before   1449.88(4)  Co_after     204.76(3) Mpgafter       15
Hc_before    101.32(2)  Hc_after      46.42(3)



Name         Paul Bartholomew
Address      665 S - 1450 E  Spanish Fork, Ut,84660
County       Ut        Telephone 798-9204  W378-5532
License      AA1458    Make      GMC          Model  pick-up   Year      1972
Value             800  Odometer        135000 Date   02/26/92
Repairs      No repairs.  Emissions were well below state cutoff


Cost            13.00
Reason       no repairs
Comments     Emissions may be higher under load. F/U 3/23, 3/31 running really
             good, no difference in mileage


Co_idle       1.00       Co_idle_ar   1.00      Mpgbefore      10
Hc_idle       108.0      Hc_idle_ar   108.0
Co_2500       0.91       Co_2500_ar   0.91
Hc_2500        85.0      Hc_2500_ar    85.0

On-Road data in grams/gallon (Number of measurements)
Co_before   1736.29(3)  Co_after       ****    Mpgafter       10
Hc_before     14.21(2)  Hc_after       ****
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Kent Crawford | | | | | | |
| Address | 462 Magenaw, Elk Ridge,Ut 84651 | | | | | | |
| County | Ut | Telephone 423-2572 W374-4178 | | | | | |
| License | AB7826 | Make | Dodge | Model | Van | Year | 1978 |
| Value | 2500 | Odometer | 94000 | Date | 02/05/92 | | |
| Repairs | Remove and replace intake manifold choke crossover and adjust carb. | | | | | | |
| Cost | 214.82 | | | | | | |
| Reason | accidental neglect | | | | | | |
| Comments | Choke never fully warmed up causing high Co’s | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 3.10 | Co_idle_ar | 0.59 | Mpgbefore | 12 |
| Hc_idle | 260.0 | Hc_idle_ar | 149.0 | | |
| Co_2500 | 2.00 | Co_2500_ar | 0.99 | | |
| Hc_2500 | 169.0 | Hc_2500_ar | 130.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 984.57(5) | Co_after | 230.49(1) | Mpgafter | 12 |
| Hc_before | 73.44(5) | Hc_after | 89.46(1) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | VF Construction | | | | | | |
| Address | 1020E 1000S Spanish Fork, Ut | | | | | | |
| County | UT | Telephone 377-6600 798-6232 | | | | | |
| License | AC6250 | Make | Ford | Model | Pk | Year | 1979 |
| Value | 2000 | Odometer | 142714 | Date | 12/13/91 | | |
| Repairs | Check tune-up. Adjust choke - stuck closed. | | | | | | |
| Cost | 22.30 | | | | | | |
| Reason | Normal wear and tear | | | | | | |
| Comments | F/U 3/13 no answer 3/31 performance o.k. | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 4.50 | Co_idle_ar | 2.30 | Mpgbefore | 0 |
| Hc_idle | 320.0 | Hc_idle_ar | 2.8 | | |
| Co_2500 | 7.20 | Co_2500_ar | 2.80 | | |
| Hc_2500 | 330.0 | Hc_2500_ar | 240.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 2215.36(1) | Co_after | 1887.96(1) | Mpgafter | 10 |
| Hc_before | 67.26(1) | Hc_after | 79.83(1) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Robert Weaver | | | | | | |
| Address | 20 N 1300 E Springville,Ut.,84663 | | | | | | |
| County | Ut | Telephone | 489-9032 Beep370-5118 | | | | |
| License | AH6935 | Make | Ford | Model | Pickup | Year | 1980 |
| Value | 1000 | Odometer | 76000 | Date | 02/12/92 | | |
| Repairs | Carburetor overhaul | | | | | | |

| | |
|---|---|
| Cost | 251.49 |
| Reason | Normal wear and tear |
| Comments | F/U 3/18,3/31 message on beeper not responded to. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.01 | Co_idle_ar | 0.77 | Mpgbefore | 11 |
| Hc_idle | 567.0 | Hc_idle_ar | 209.0 | | |
| Co_2500 | 4.35 | Co_2500_ar | 1.19 | | |
| Hc_2500 | 324.0 | Hc_2500_ar | 157.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1512.37(3) | Co_after | 1540.69(2) | Mpgafter | * |
| Hc_before | 108.35(3) | Hc_after | 67.65(2) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | William Campbell | | | | | | |
| Address | 730W - 400 S Provo,Ut, 84601 | | | | | | |
| County | UT | Telephone | 374-6723 | | | | |
| License | JUSS | Make | Chev | Model | Spectrum | Year | 1986 |
| Value | 2400 | Odometer | 36146 | Date | 02/07/92 | | |
| Repairs | Checked timing, installed air filter and O2 sensor. | | | | | | |

| | |
|---|---|
| Cost | 144.07 |
| Reason | Normal wear and tear |
| Comments | Emissions variable - emissions would have passed state inspect. When Rpm was increased to 3000 emissions rose drastically CO - 5.8. F/U 3/23 Appreciative and pleased with performance. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.01 | Co_idle_ar | 0.00 | Mpgbefore | 25 |
| Hc_idle | 2.0 | Hc_idle_ar | 3.0 | | |
| Co_2500 | 2.00 | Co_2500_ar | 0.00 | | |
| Hc_2500 | 0.6 | Hc_2500_ar | 9.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1332.73(3) | Co_after | **** | Mpgafter | 30 |
| Hc_before | **** | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | David Argyle | | | | | | |
| Address | 1023 E 120 So. St. Spanish Fork, UT. 846 | | | | | | |
| County | UT | Telephone 798-7646 373-8700 | | | | | |
| License | MF0776 | Make | Ford | Model | PK | Year | 1975 |
| Value | 3000 | Odometer | 163654 | Date | 12/13/91 | | |
| Repairs | Tune-up, vacuum advance | | | | | | |

| | |
|---|---|
| Cost | 59.73 |
| Reason | Normal wear and tear |
| Comments | Has engine blowby. F/U 3/31 left message |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 7.20 | Co_idle_ar | 2.20 | Mpgbefore | * |
| Hc_idle | 1200.0 | Hc_idle_ar | 470.0 | | |
| Co_2500 | 8.30 | Co_2500_ar | 1.70 | | |
| Hc_2500 | 1150.0 | Hc_2500_ar | 350.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1336.02(1) | Co_after | 1028.58(5) | Mpgafter | * |
| Hc_before | 90.28(1) | Hc_after | 115.58(5) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Nicholas Jones | | | | | | |
| Address | 1088 W 860 N Provo,Ut 84604 | | | | | | |
| County | Ut | Telephone H375-4365 W379-6341 | | | | | |
| License | MK2020 | Make | Chev | Model | Van | Year | 1977 |
| Value | 1000 | Odometer | 117000 | Date | 03/11/92 | | |
| Repairs | Ignition adjustments | | | | | | |

| | |
|---|---|
| Cost | 24.95 |
| Reason | Normal wear and tear |
| Comments | F/U 3/31 Very satisfied with performance, has not noticed any improvement in gas mileage. |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 9.57 | Co_idle_ar | 1.60 | Mpgbefore | 17 |
| Hc_idle | 1942.0 | Hc_idle_ar | 199.0 | | |
| Co_2500 | 0.28 | Co_2500_ar | 0.13 | | |
| Hc_2500 | 96.0 | Hc_2500_ar | 70.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1336.34(3) | Co_after | **** | Mpgafter | 17 |
| Hc_before | 29.54(3) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Russell Hanson | | | | | | |
| Address | 70 E Maple # 102 Woodland Hills,Ut. | | | | | | |
| County | Ut | Telephone | 423-2722 W429-5786 | | | | |
| License | MM6139 | Make | Chev | Model | Pick-up | Year | 1972 |
| Value | 2000 | Odometer | 150000 | Date | 03/16/92 | | |
| Repairs | Carb overhaul | | | | | | |
| Cost | 101.90 | | | | | | |
| Reason | Normal wear and tear | | | | | | |
| Comments | F/U 3/27 very pleased with improved performance. New motor one year ago and has approx 16000 miles. | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 6.82 | Co_idle_ar | 3.73 | Mpgbefore | 11 |
| Hc_idle | 315.0 | Hc_idle_ar | 501.0 | | |
| Co_2500 | 5.59 | Co_2500_ar | 0.24 | | |
| Hc_2500 | 183.0 | Hc_2500_ar | 99.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1121.26(4) | Co_after | 257.72(3) | Mpgafter | * |
| Hc_before | 70.88(3) | Hc_after | 11.06(3) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Bonnie Hickman | | | | | | |
| Address | 711 E 200 S Spanish Fork, Ut, 84660 | | | | | | |
| County | Ut | Telephone | 798-8780 | | | | |
| License | MWS165 | Make | Dodge | Model | Aspen | Year | 1977 |
| Value | 600 | Odometer | 175000 | Date | 03/02/92 | | |
| Repairs | Plugged up air filter. New filter, adjust air fuel ratio, repaired hardened vacuum lines. | | | | | | |
| Cost | 33.91 | | | | | | |
| Reason | Normal wear and tear | | | | | | |
| Comments | Appreciated rental, but happy to have own car back. Older lady who was nervous with new car rental. F/U 3/23 runs good, appreciated opportunity to participate in program. | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 5.03 | Co_idle_ar | 0.08 | Mpgbefore | 15 |
| Hc_idle | 170.0 | Hc_idle_ar | 57.0 | | |
| Co_2500 | 2.22 | Co_2500_ar | 2.43 | | |
| Hc_2500 | 76.0 | Hc_2500_ar | 82.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1647.47(1) | Co_after | 1071.19(1) | Mpgafter | * |
| Hc_before | 47.97(1) | Hc_after | 94.63(1) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Wayne Shute | | | | | | |
| Address | 571 Freemont Way, Elkridge, Ut, 84651 | | | | | | |
| County | Ut | Telephone 423-1838 /378-4776 W | | | | | |
| License | NJ5305 | Make | Chev | Model | S-10 | Year | 1985 |
| Value | 3000 | Odometer | 133000 | Date | 02/04/92 | | |
| Repairs | Checked and adjusted carburetor and timing. Installed new catalytic converter. | | | | | | |
| Cost | 206.00 | | | | | | |
| Reason | Normal wear and tear | | | | | | |
| Comments | catalyst in converter not working to control emissions.F/U 3/23/92 Running nicely, no improvement in gas mileage | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 4.70 | Co_idle_ar | 1.50 | Mpgbefore | 20 |
| Hc_idle | 550.0 | Hc_idle_ar | 0.7 | | |
| Co_2500 | 4.10 | Co_2500_ar | 1.00 | | |
| Hc_2500 | 500.0 | Hc_2500_ar | 210.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 626.11(2) | Co_after | 139.98(1) | Mpgafter | 20 |
| Hc_before | 32.12(1) | Hc_after | 160.97(1) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Larry Creer | | | | | | |
| Address | 320 S 400 E Spanish Fork, Ut., 84660 | | | | | | |
| County | Ut | Telephone 798-7440 | | | | | |
| License | RP8323 | Make | Dodge | Model | Pick-up | Year | 1974 |
| Value | 1000 | Odometer | 101773 | Date | 02/13/92 | | |
| Repairs | Replaced distributor and adjust to carb. | | | | | | |
| Cost | 158.85 | | | | | | |
| Reason | Normal wear and tear | | | | | | |
| Comments | F/U 3/18 Returned to shop. adjustments. Was running too lean, runs better. Still having carb problems. | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.80 | Co_idle_ar | 1.25 | Mpgbefore | 9 |
| Hc_idle | 600.0 | Hc_idle_ar | 58.0 | | |
| Co_2500 | 3.50 | Co_2500_ar | 1.87 | | |
| Hc_2500 | 298.0 | Hc_2500_ar | 57.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | 1445.33(2) | Co_after | **** | Mpgafter | 8 |
| Hc_before | 111.32(2) | Hc_after | **** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Phillip Proctor | | | | | | |
| Address | 779 E 250 North Payson,Ut | | | | | | |
| County | Ut | Telephone 465-9804 W378-5523 | | | | | |
| License | WNE704 | Make | Chev | Model | Pickup | Year | 1976 |
| Value | 1500 | Odometer | 100000 | Date | 03/03/92 | | |
| Repairs | Air filter and wire set.Minor tune-up | | | | | | |

Cost 87.95

Reason normal wear and tear

Comments Truck ran quite clean. Shop comment was Chevs' pretty clean. Dodges and Intl bad. F/U 3/18 and 3/23 - unable to contact. 3/31 running good, appreciative of work done.

| | | | | | |
|---|---|---|---|---|---|
| Co_idle | 0.23 | Co_idle_ar | 0.66 | Mpgbefore | 10 |
| Hc_idle | 143.0 | Hc_idle_ar | 82.0 | | |
| Co_2500 | 0.79 | Co_2500_ar | 0.36 | | |
| Hc_2500 | 110.0 | Hc_2500_ar | 22.0 | | |

On-Road data in grams/gallon (Number of measurements)

| | | | | | |
|---|---|---|---|---|---|
| Co_before | **** | Co_after | **** | Mpgafter | * |
| Hc_before | **** | Hc_after | **** | | |