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Controlled Speed Accessory Drive Demonstration Program

Frank W. Hoehn

October 15, 1981

Prepared for
U.S. Department of Energy
Through an Agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
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The work described in this report was carried out as part of the Vehicle Systems Project at the Jet Propulsion Laboratory, California Institute of Technology, and was sponsored by the U.S. Department of Energy through an interagency agreement with the National Aeronautics and Space Administration.

ABSTRACT

One phase of the U.S. Department of Energy's (DOE) effort to improve the fuel economy of passenger cars has been the investigation of a Controlled Speed Accessory Drive (CSAD) System. The objective of this specific program, initiated by DOE in association with the General Services Administration (GSA), was to demonstrate concept feasibility and evaluate the performance of a typical system during actual road driving conditions. The CSAD system can be described as a mechanical device which limits engine accessory speeds, thereby reducing parasitic horsepower losses and improving overall vehicle fuel economy. Fuel consumption data was compiled throughout the nation for fleets of GSA vehicles. Various motor pool locations were selected, each representing different climatic conditions. On the basis of a total accumulated fleet usage of nearly three million miles, an overall fuel economy improvement of 5 to 7% has been demonstrated.

Coincident chassis dynamometer tests were accomplished on selected vehicles to establish the effect of different accessory drive systems on exhaust emissions, and to evaluate the magnitude of the mileage benefits which could be derived. These real benefits are not now totally accounted for in the Environmental Protection Agency's (EPA) Federal Test Procedures (FTP). The actual mileage improvement observed during the extensive fleet tests was more than three times that measured during the FTP dynamometer test. It is believed that introduction of CSAD-type devices should be encouraged by the EPA and the other governmental agencies.

ACKNOWLEDGMENTS

This work was sponsored by the U.S. Department of Energy through an interagency agreement, DE-AI01-80CS50194, with the National Aeronautics and Space Administration (Task RD 152, Amendment 165).

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This report was prepared with the support of George Courville who, for most of the project, was the Task Manager. Eugene Baughman, Manager of the Vehicle Systems Task of the Jet Propulsion Laboratory for guidance and critiques and to Theodore Price and Milton Noel for individual contributions and helpful suggestions throughout this effort.

Appreciation is also expressed to the following people and their respective organizations who directly supported this program:

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Boston, Massachusetts

Dallas and Fort Worth, Texas

Denver, Colorado

Los Angeles and San Diego, California

U.S. Department of Transportation, Transportation Systems Center

W. Harriet

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EXECUTIVE SUMMARY

This report has been prepared for the U.S. Department of Energy (DOE), Office of Transportation Programs, Division of Automotive Technology Development, Vehicle Systems Branch. The work was conducted by the NASA Jet Propulsion Laboratory (JPL) in association with the General Service Administration (GSA) National Automotive Center, Vehicle Engineering Branch on the basis of an interagency agreement between DOE and GSA. The report presents a summary of work conducted under NASA Contract NAS7-100 from February 1978 to October 1981. The overall program objective was to evaluate the fuel economy improvement associated with the Controlled Speed Accessory Drive (CSAD) system when installed on passenger cars. A flowchart (Figure 1) shows the overall program organization.

Results of a comprehensive study and tests previously performed by AiResearch for ERDA (Reference 1), and information supplied to DOE by the Morse Chain Division of the Borg Warner Corporation, indicated that controlling the accessories speed had the potential for a fuel economy improvement of 5 to 10% over conventional variable-speed drive systems. The Morse Chain Division designed and built the prototype CSAD system to replace the fixed-ratio water-pump drive unit that was stock for Ford Pinto automobiles. The CSAD unit is designed to operate the accessories[1] at a nearly constant and more optimum speed, for most engine speeds within the normal vehicle driving range. This results in improved overall fuel economy due to the reduction of parasitic losses and the horsepower required to drive the engine-driven accessories.

In addition to the obvious interest in the fuel economy potential of the CSAD system, there is an indirect benefit attainable from the test program represented here. The existing Federal Test Procedure (FTP) is not designed to thoroughly account for the fuel economy improvements derived from accessory drive systems. To create the incentive for the automobile manufacturing industry to install similar devices, using the CSAD concept, the industry should be given full credit toward meeting the federally mandated fuel economy standards. The statistical fleet test data collected during this program will make a significant contribution toward the required background information necessary to establish the value or credit for those vehicles with CSAD systems installed.

The baseline units were purchased by DOE from Morse Chain. The effectiveness of the CSAD system was determined by comparing fleet fuel economy data from factory produced vehicles with similar data obtained to identical vehicles equipped with CSAD units. The test fleet consisted of more than 300 GSA-owned vehicles from 5 different nationwide geographical locations to provide data from various climatic conditions. The

[1]Automobile components termed "accessories" include the air conditioning (A/C) compressor, water-pump, radiator fan, air pump, alternator, and the power-steering pump. The term is derived from the fact that these components are driven by the engine crankshaft.

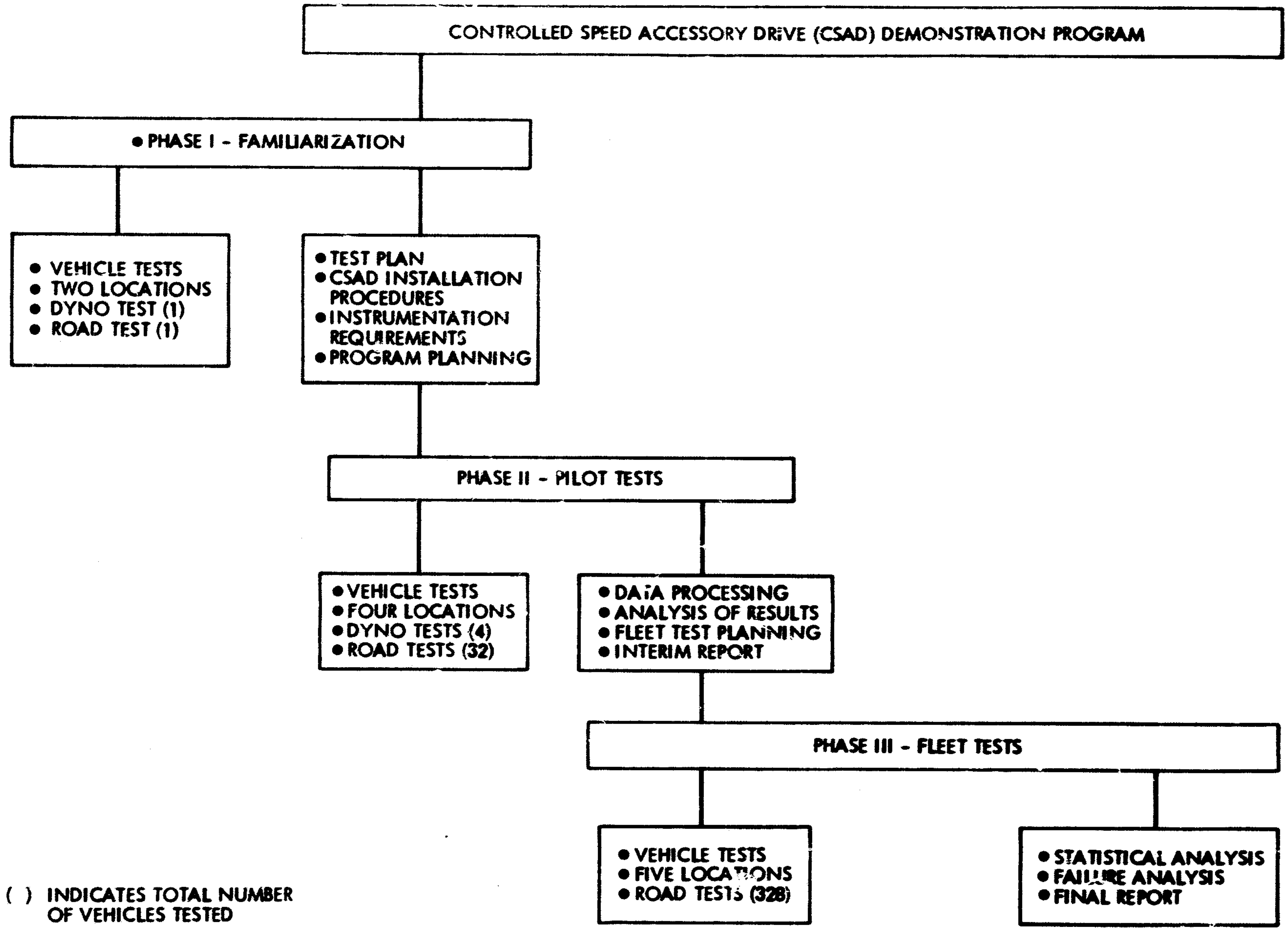

Figure 1. CSAD Demonstration Program

program effort consists of three phases concerned with the evaluation of a CSAD system for reducing the power required to operate engine-driven accessories. All three phases were successfully completed and the program objectives were accomplished.

The objectives of Phase I were to become familiar with the Morse Chain CSAD unit and the test vehicles; to determine the installation and instrumentation requirements, and to establish test procedures. Two vehicles and two prototype CSAD units were tested concurrently. One vehicle was tested at JPL in Pasadena, California; the other vehicle was tested at the U.S. Department of Transportation's Transportation Systems Center (TSC) in Boston, Massachusetts. Data were collected from both chassis dynamometer and on-the-road tests, at both locations. Dynamometer fuel economy improvements of 2 to 4% were obtained with the vehicle accessories (headlights and A/C) OFF, and 6 to 8% when these accessories were ON. Data from the road tests showed a mean improvement of 5.5% over the stock condition.

The objective of Phase II was to establish the criteria for the full-scale fleet tests schedules as the final program phase. For this purpose a pilot test program was conducted that involved 32 vehicles. To support this activity GSA and DOE entered into an interagency agreement to test 1977 and 1978 model Ford Pintos. Four GSA motor pools were selected for the effort. The motor pools were located in Boston, Massachusetts; Kennedy Space Center, Florida; Dallas/Fort Worth, Texas; and Denver, Colorado. Specifically, 4 pairs of matching vehicles were randomly selected at each location and were monitored for a 4-month period starting in January 1979. The results of these tests are presented in this report. The average percent improvement in fuel economy measured during road tests was 6.5%.

Fuel economy improvements between motor pool locations varied from -4.0 to 13.0%. It was concluded that these variations in average fuel economy were probably related to the differing driver profiles, regional driving conditions, and other possible unknown regional factors. A statistical analysis concluded that for a 95% confidence interval, the mean improvement in fuel economy ranged from 0.40 to 2.16 mpg. This corresponded with a 1.9 to 10.5% improvement over the mean stock fuel economy. The statistical average improvement in fuel economy was 1.32 mpg (6.4%).

In addition to the road test, a limited evaluation was conducted on the chassis dynamometer. The average fuel economy improvement measured on the dynamometer with the CSAD unit varied from 2.1 to 8.1%, depending upon the test condition and driving cycle. The largest improvement was during the highway driving cycle with the A/C and headlights ON. Exhaust emissions were also measured, and in general the oxides of nitrogen (NO_x) decreased while the unburned hydrocarbons and carbon monoxide increased.

The final program, Phase III, used a fleet of 328 GSA vehicles supplied by the previously mentioned motor pool locations plus two additional locations in Southern California. About one-half of the vehicles were modifed with CSAD units, the remaining stock vehicles were monitored as the control group. Fuel consumption data was recorded and monitored for each vehicle for a period of about 1 year.

The major objective of Phase III was to determine the level of fleet fuel economy improvement with the CSAD system during an extended time period. The total miles driven during the last phase was nearly 2.9 million miles, with an average accumulated miles-per-vehicle of about 8700. The overall mass weighted average improvement in mpg for the entire data sample was 7.0%, with a range in operational sites from 5.6 to 9.4%. A multiple regression analysis was again performed to obtain error bounds on the mean improvement in fuel economy and to correct for the bias caused by the unbalanced sample (e.g., no 1977 stock vehicles in Florida). Results of the analysis indicate that automobiles modified with CSAD units achieved a statistically significant value of 1.18 mpg more than unmodified vehicles. The 95% confidence interval about this value provides a range of 0.83 to 1.52 mpg for the expected improvement. This corresponds with a 4.0 to 7.3% improvement over the stock vehicle configuration.

Several types of hardware failures were observed during the vehicle fleet tests. The most frequent problems were related to the drive belts and water-pump pulleys. The belt failures were a result of excessive wear that reduced the width of the belts causing slippage to occur. It should be noted, of course, that the test units were prototypes and not designed for production quality. In addition, in some of the early models, water-pump pulleys failed because of manufacturing flaws.

SECTION I

INTRODUCTION

A. BACKGROUND

Improved automotive fuel economy is the prime objective of the Controlled Speed Accessory Drive (CSAD) system. Automotive accessories are typically driven under variable-speed conditions at some fixed ratio relative to engine crankshaft speed. A comprehensive ERDA/DOE-funded study was undertaken by Rottler (Reference 1) of the AiResearch Manufacturing Company to evaluate the technique of accessory-speed control by incorporating a variable ratio drive device between the engine and the various accessories. Some of the results of this work provide background information and are therefore repeated below. The referenced Summary Report contains additional details of this earlier study program.

Typical power requirements for the commonly driven accessories are shown in Figure 1-1 as a function of engine speed. It was determined in the previous study that most of the accessories operate at marginal speeds during idle and low vehicle speeds; however, actual requirements are exceeded during higher vehicle speed operation. As shown in Figure 1-1, the air conditioning (A/C) compressor has the highest accessory power requirement, followed by the fan, and alternator, respectively. The power requirements for the latter depends, of course, upon the electrical current (amperage) demand.

As part of the referenced study, the effects on engine load and fuel economy for a 1975 Mustang II baseline vehicle were estimated analytically and verified by experimental test. As shown in Figure 1-2, accessories were determined to produce a 12 to 23% loss in fuel economy and represented 25 to 60% of the total engine load. The actual percentage degradation depends upon vehicle speed (see Reference 1).

Studies to improve the match of accessory loads indicated a higher-than-engine-speed requirement below 1200 rpm and a relatively constant speed requirement from this condition to about 3600 rpm engine speed. These requirements are shown in Figure 1-3 where a maximum power saving of about 17 horsepower (hp) is predicted using the constant speed device. These results suggest that automobile accessory loads could be significantly impacted by the use of such a device and thereby maximize vehicle fuel economy.

The baseline unit evaluated during the current Jet Propulsion Laboratory (JPL) program was a Morse Chain CSAD system. The units were tested on both chassis dynamometers and in vehicle fleet service for nearly 3 million miles. A Variable Ratio Accessory Drive (VRAD) unit and a Mechanical Accessory Drive System (MADS) were additionally supplied by the FMC Corporation Chain Division, and by the AiResearch Manufacturing Company, respectively. The evaluation at JPL of the latter unit was accomplished on the dynamometer only.

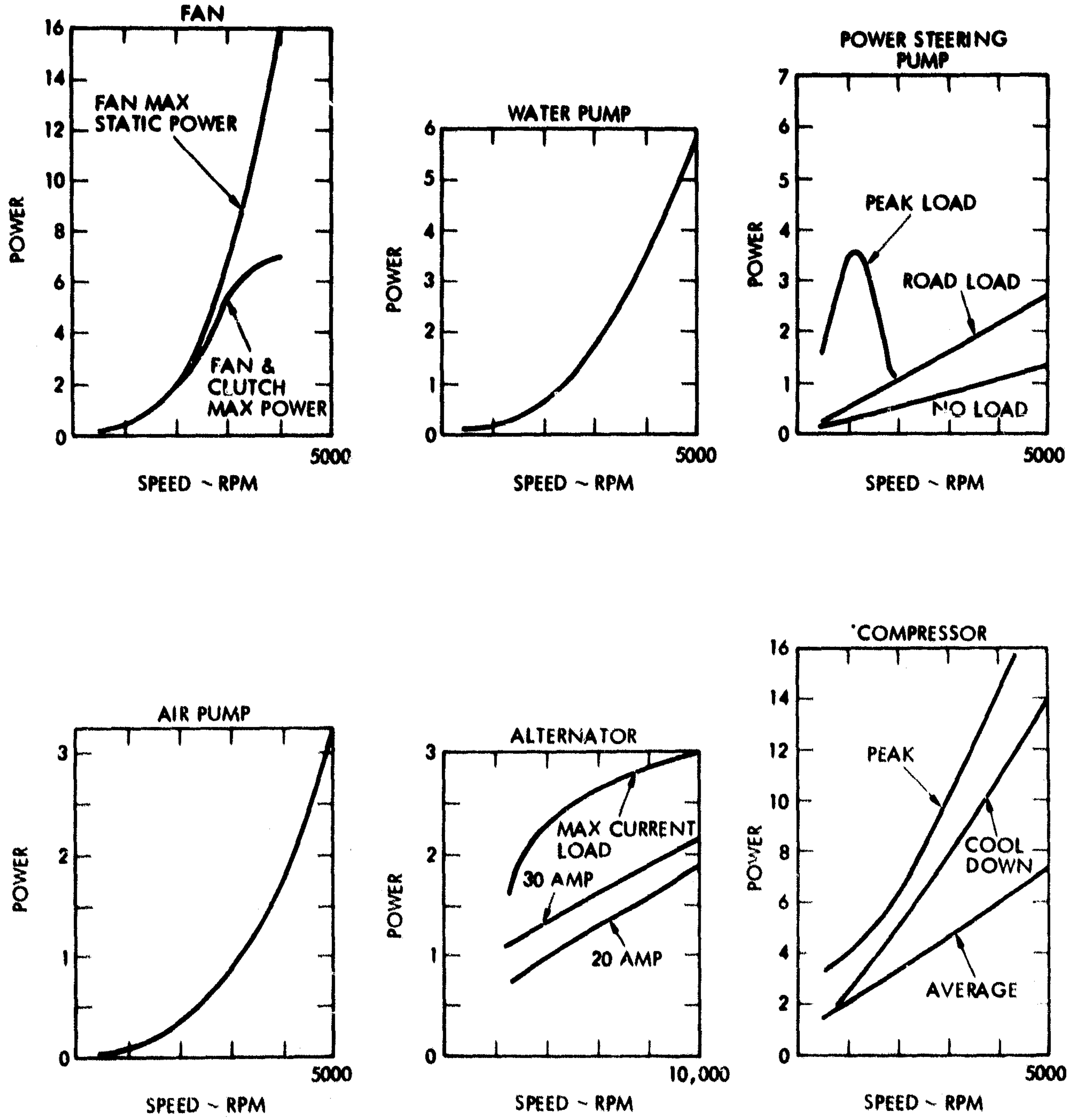

Figure 1-1. Typical Automotive Accessory Loads

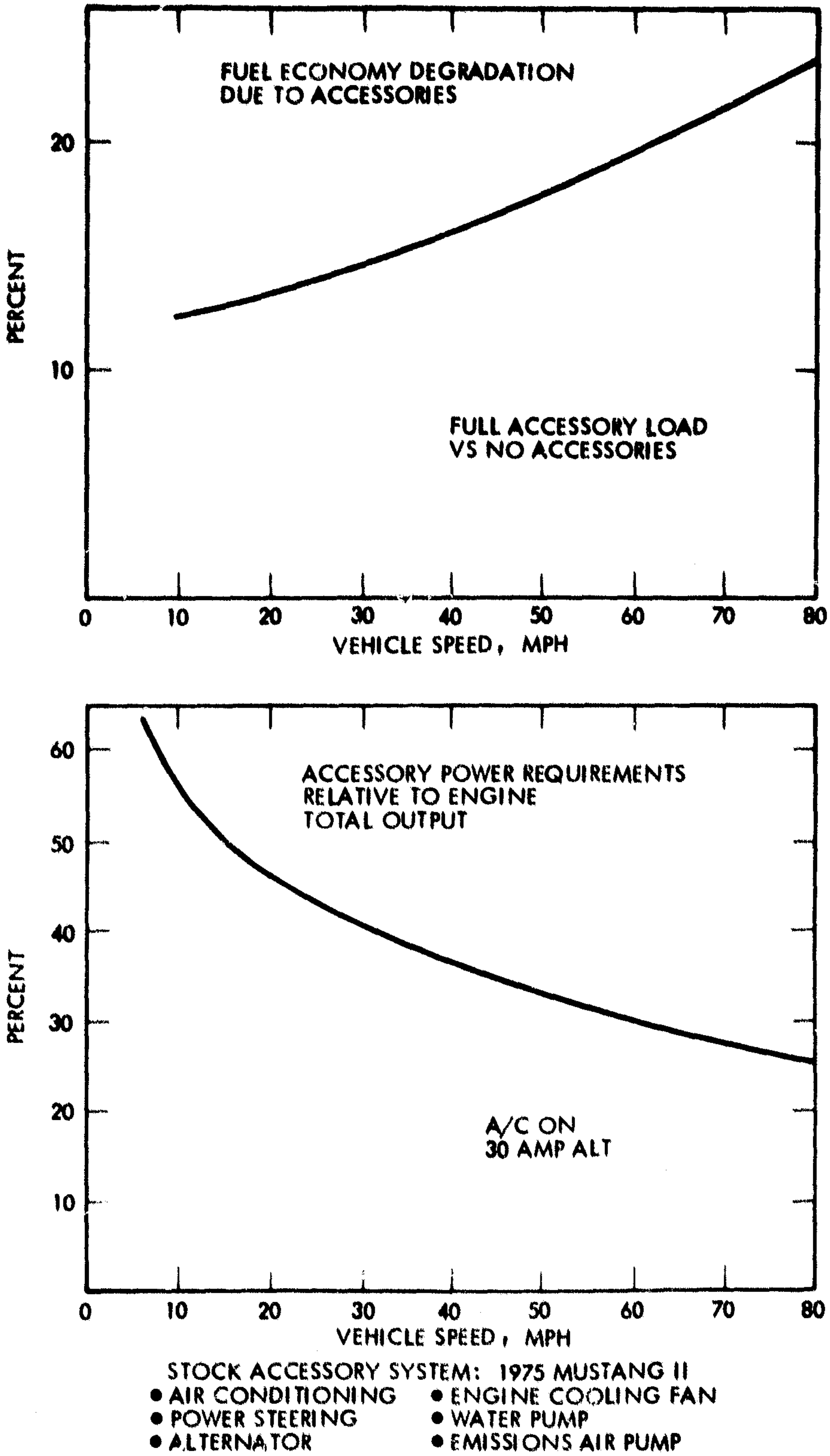

Figure 1-2. Performance Penalty Caused by Accessory Loads

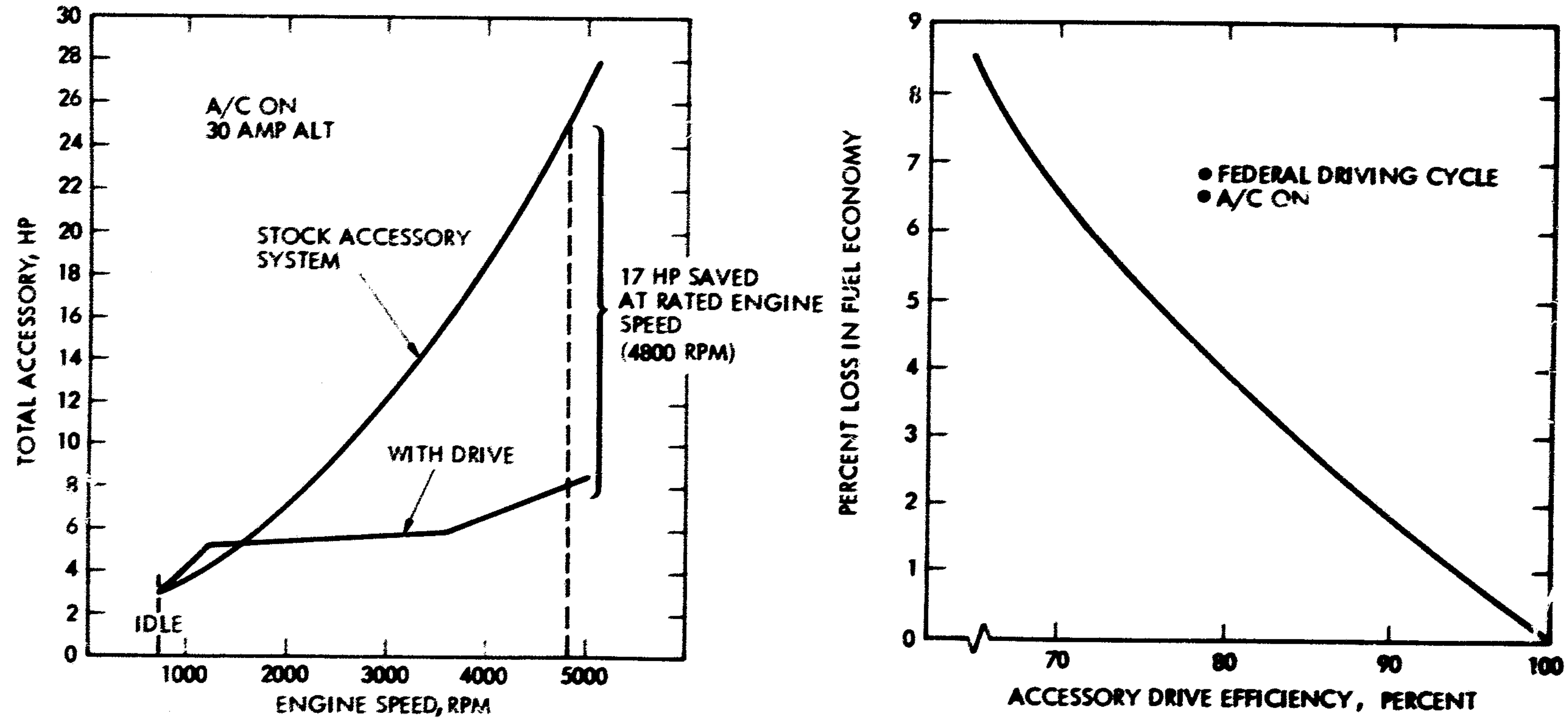

Figure 1-3. Accessory Drive Performance Trade Studies

B. PREVIOUS TEST RESULTS

1. Morse Chain CSAD Unit

To demonstrate the potential of the Morse Chain CSAD unit an experimental evaluation was completed earlier in the EPA laboratory in Ann Arbor, Michigan (Reference 2). Both FTP and vehicle road tests were conducted.

For the road test evaluation, CSAD systems were installed on 8 different vehicles from three major American automotive manufacturers. Seven of the test vehicles were compact, intermediate or larger sedans with V-8 engines; the remaining vehicle was a compact with a 4-cylinder engine. The tests were conducted year-round to expose the CSAD units to a wide range of road and ambient conditions. All tests were run on the same closed course, 151 miles long, at an average speed of 47 mph. The type of driving consisted of the following:

Town and City (Urban)	7%
Two Lane (Suburban)	29%
Four Lane (Interstate)	64%

The results of these road tests are presented in Table 1-1. In all cases the CSAD unit improved fuel economy. The greatest gains were with the heaviest accessory loads (A/C operating). The compact car with the 4-cylinder engine showed the greatest fuel economy improvement (11.2%); the larger cars showed 9.9% improvement as a maximum.

Table 1-1. Road Test Fuel Economy[1]

Vehicle	Ambient Temperature °F	A/C ON		Improvement with CSAD,	A/C OFF		Improvement with CSAD,
		Stock	CSAD		Stock	CSAD	
1976 Ford Pinto 2.3 Liter I-4	76 to 85	21.5	23.9	11.2	24.2	25.2	4
1974 Chevrolet Nova 350 CID V-8	40 to 4	15.5	16.9	9.0	16.9	17.6	4
1975 Chevrolet Nova 350 CID V-8	54 to 76	16.7	18.1	8.3	18.3	18.6	2
1976 Plymouth Fury 360 CID V-8	18 to 53	15.6	16.5	6.0	16.1	16.7	4
1977 Ford LTD II 351 CID V-8	60 to 94	17.1	18.8	9.9	19.1	19.6	2.6

[1]See Reference 2.

The standard FTP simulates A/C load by increasing the specified road load horsepower absorbed by the dynamometer by only 10%. This method of setting the dynamometer load should be modified because it does not reflect the true load associated with engine accessories under normal driving conditions. A more realistic dynamometer test was devised to better evaluate the CSAD by setting the A/C controls at the maximum cooling condition. The results of this type of test are presented in Table 1-2. Trends in previous road tests were confirmed by the dynamometer tests; that is, greater relative improvement in fuel economy occurs with greater accessory loads. Also, the subcompact car showed the greatest gain, with 13.4% improvement.

Table 1-2. Dynamometer Test Fuel Economy[1]

		A/C and Bright Lights ON			Basic Accessory Load		
Vehicle	Ambient, °F	Stock	CSAD	Improvement with CSAD, %	Stock	CSAD	Improvement with CSAD, %
1976 Subcompact 2.3 Liter I-4	72	18.6	21.1	13.4	22.2	23.3	5.0
1975 Compact 5 Liter V-8	85-91	14.3	15.1	5.6	16.7	16.7	0
1977 Midsize 5.8 Liter V-8	72	13.3	14.5	8.9	14.7	15.3	4.1

[1]See Reference 2.

2. AiResearch Mechanical Accessory Drive System

This unit was tested by the Automotive Testing Laboratories, Denver, Colorado using a 1975 Mustang II vehicle. The complete test results were reported by Rottler (see Reference 1). Initial MADS tests proved the functionality of the design concept and its capability of achieving all design goals. The tests determined vehicle emissions and fuel economy for the Federal Urban Driving Cycle (LA-4) and the EPA Highway Fuel Economy Driving Cycle. A summary of these dynamometer test results is given in Table 1-3.

The vehicle was instrumented to determine accessory operating parameters and their effects on fuel economy. The instrumentation measured: vehicle, engine and accessory speeds; alternator load; cooling system temperatures and pressures; A/C system parameters; emission air-pump pressure; power-steering pump pressure and temperature; fuel consumption; and normal engine status parameters.

The average improvement noted in Table 1-3 using the MADS units (with the A/C ON) was about 3.8% for the EPA Highway Fuel Economy test.

Table 1-3. Emission and Fuel Economy Test Data Summary[1]

	Emissions, g/mi				Fuel Economy	mpg
Stock Vehicle Condition	HC	CO	NO_x	CO_2	Carbon Balance	Fuel Flow
Cold Transient	2.25	27.81	3.97	565.3	14.40	15.15
Cold Stabilized	0.73	3.55	1.99	598.7	14.63	14.87
Hot Transient	0.95	4.68	3.26	507.2	17.15	16.92
1975 Urban Composite	1.11	8.85	2.74	566.9	15.19	15.44
HWFET	0.45	3.26	3.41	397.4	21.97	22.23
MADS Vehicle Condition	HC	CO	NO_x	CO_2	Carbon Balance	Fuel Flow
Cold Transient	1.88	25.97	3.49	557.2	14.69	15.29
Cold Stabilized	0.77	3.15	2.01	596.4	14.70	14.89
Hot Transient	0.94	4.30	2.73	500.4	17.40	17.21
1975 Urban Composite	1.05	8.16	2.51	562.1	15.35	15.55
HWFET	0.47	2.16	2.78	383.3	22.92	22.94

[1]See Reference 1.

SECTION II

DESCRIPTION OF CSAD HARDWARE

The CSAD mechanically-operated device consists of a variable-speed belt and pulley system. The standard automotive crankshaft pulley is replaced by a torque-sensitive drive pulley which responds to load demands by adjusting the side forces that are applied to the belt with minimal changes to the drive ratio. The variable-speed belt drives a speed-sensitive pulley mounted on the water-pump shaft. This variable-diameter pulley responds to speed changes by increasing or decreasing its effective diameter as the water-pump speed increases or decreases. A sketch of the Morse Chain CSAD unit is shown in Figure 2-1. A photograph showing the unit installed on one of the test cars is given in Figure 2-2.

The driver unit which contains a control spring with flyweights, is mounted on the engine crankshaft. The driven unit, which is mounted on the water-pump, could also be mounted on another accessory or separate jackshaft. Both driver and driven units contain diaphragm-type disc or belleville springs. The spring in the driven unit maintains sheave pressure on the main drive belt. Because the driver is the control unit and is mounted on the input end, response is very quick; therefore, a constant output speed can be maintained through the designed speed range.

The static sheave position shown in Figure 2-1 could give the same accessory speed ratios as the vehicle would have without a CSAD. However, if increased cooling capacity at idle were desired, the initial drive ratio in the variable-speed sheaves could be stepped up to increase water-pump and fan speeds. Or, if increased alternator or A/C capacity were desired, their respective variable-speed belt pulley diameters could be downsized. The operation of the Morse Chain CSAD unit is described as follows:

When the engine accelerates to a predetermined speed, generally between 1000 to 1500 rpm, the CSAD will start to shift speed ratios between the engine and water-pump from which the other accessories are driven. The initial preload of the control spring against its sliding sheave and the size of the flyweights determines the rpm at which the ratio change begins. As the crankshaft speed increases, the flyweights fastened to the control spring exert a moment on it and unload its force against the sliding sheave. Belt tension maintained by the driven pressure spring, causes the sliding sheave on the driver to move away from its fixed sheave, hence, the belt runs at a smaller pitch diameter on the driver pulley. Simultaneously at the driven end, the sliding sheave moves toward its fixed flange which gives the belt a larger pitch diameter. On engine deceleration, the reverse occurs. These changes in pitch diameters, governed by the force from the two springs, result in the controlled speed output at the driven end.

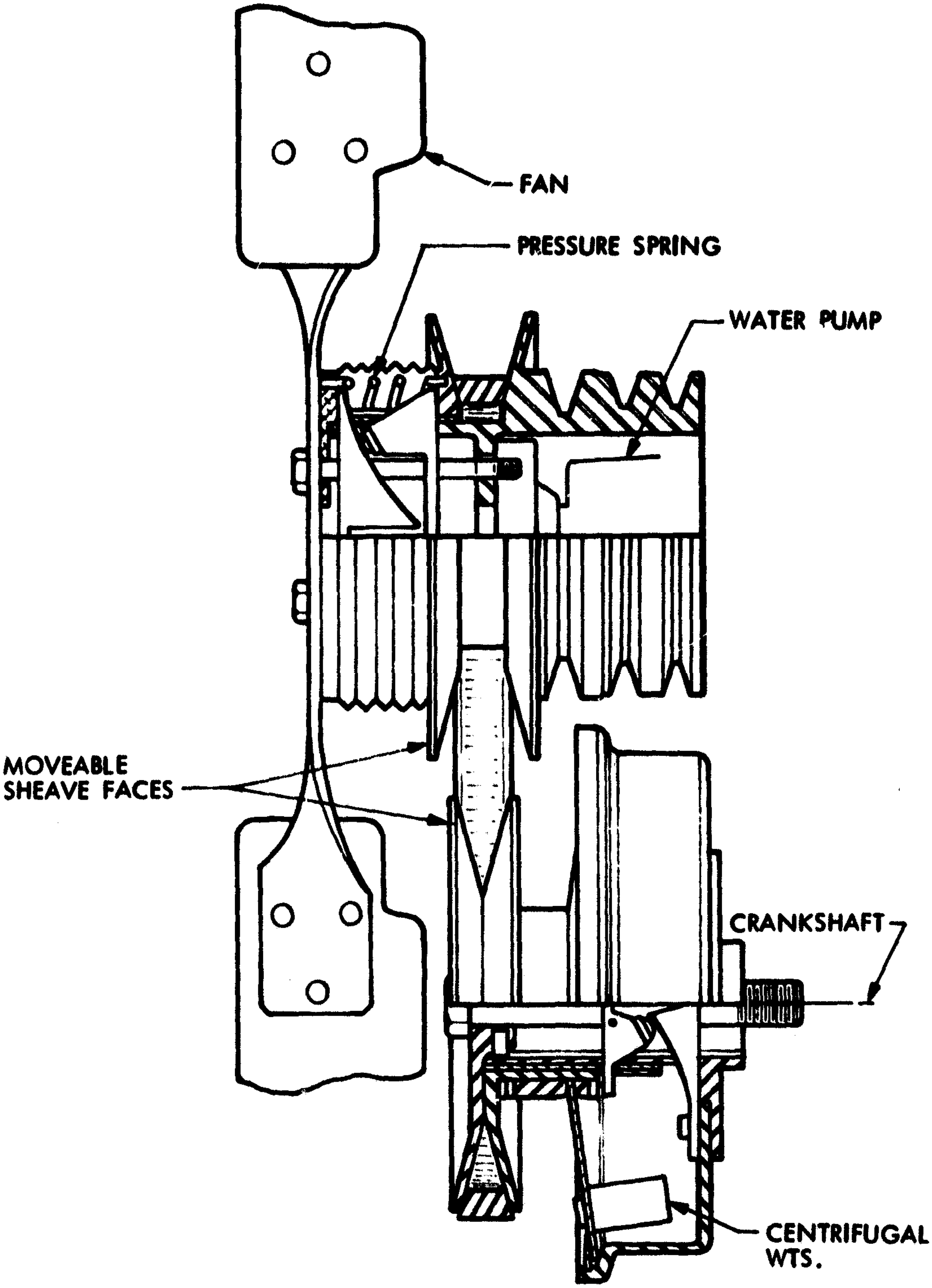

Figure 2-1. Morse Chain CSAD System

Figure 2-2. CSAD Installation in Test Vehicle

Two other CSAD systems were also investigated. A Variable Ratio Accessory Drive (VRAD) was procured from the FMC Corporation Chain Division, located in Indianapolis, Indiana. The VRAD system is basically a variable-speed belt and pulley system similar in principle to the Morse Chain system. A major difference in the FMC unit is that the ratio of speed changes of the accessories is controlled by a speed-sensitive water-pump pulley; the standard crankshaft pulley is replaced by a torque-sensitive driving pulley.

The drive pulley responds to the load demands by adjusting the slide forces that are applied to the belt. As in the other systems, when the engine speed increases, the drive ratio decreases resulting in a slowing of the accessory speeds and reduction of the parasitic losses, thus giving an improvement in the fuel economy. Tests of this unit were also conducted at JPL, and consisted of both chassis dynamometer and actual on-the-road driving performance. The VRAD unit was evaluated using the same test procedures as those used for the CSAD systems. A drawing of the VRAD is given in Figure 2-3.

The third device was identified as MADS and was supplied by AiResearch. This unit, which was also simillar in construction, incorporated a flywheel governor speed-control sheave mounted on the engine crankshaft, and a spring-loaded belt-tension sheave on the water-pump shaft. The mechanical details for this unit are shown in Figures 2-4 and 2-5.

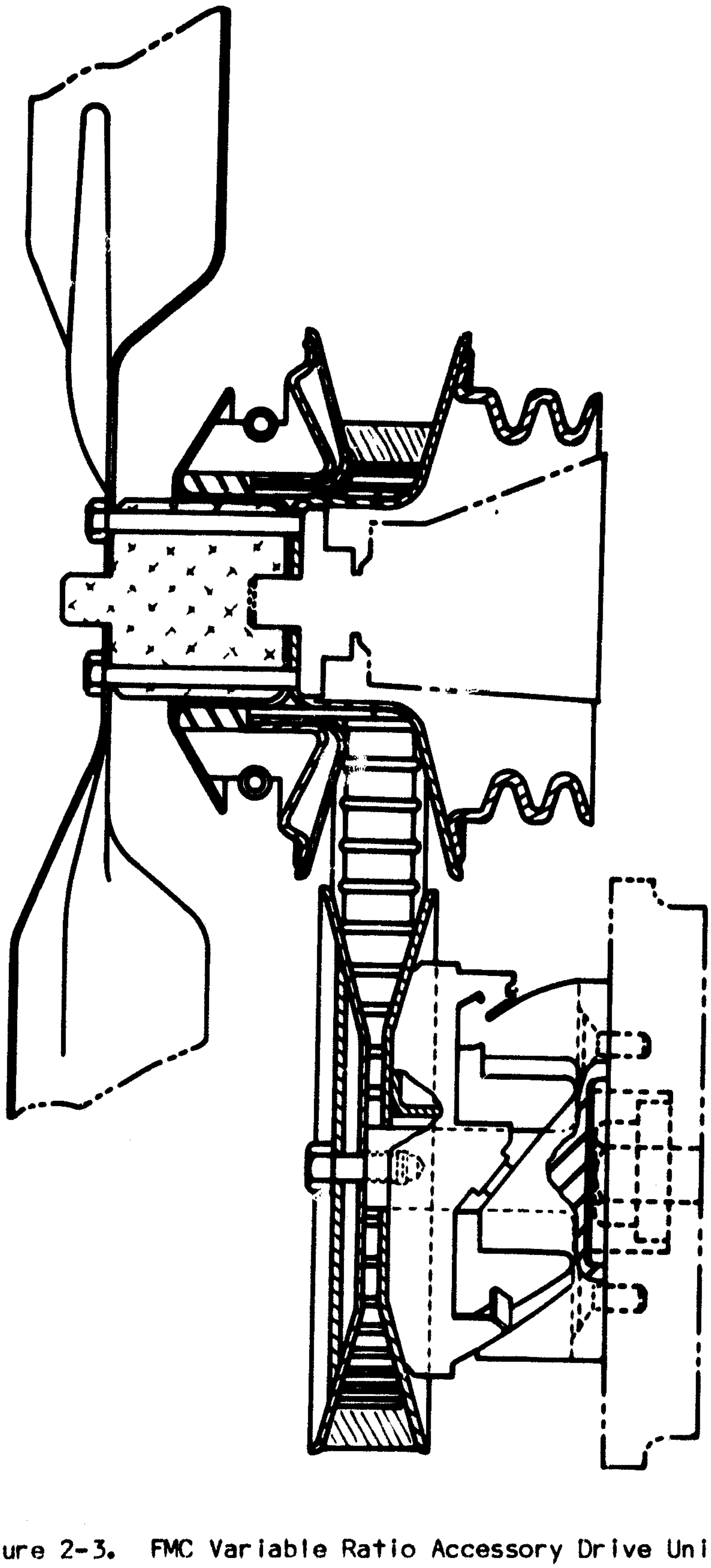

Figure 2-3. FMC Variable Ratio Accessory Drive Unit

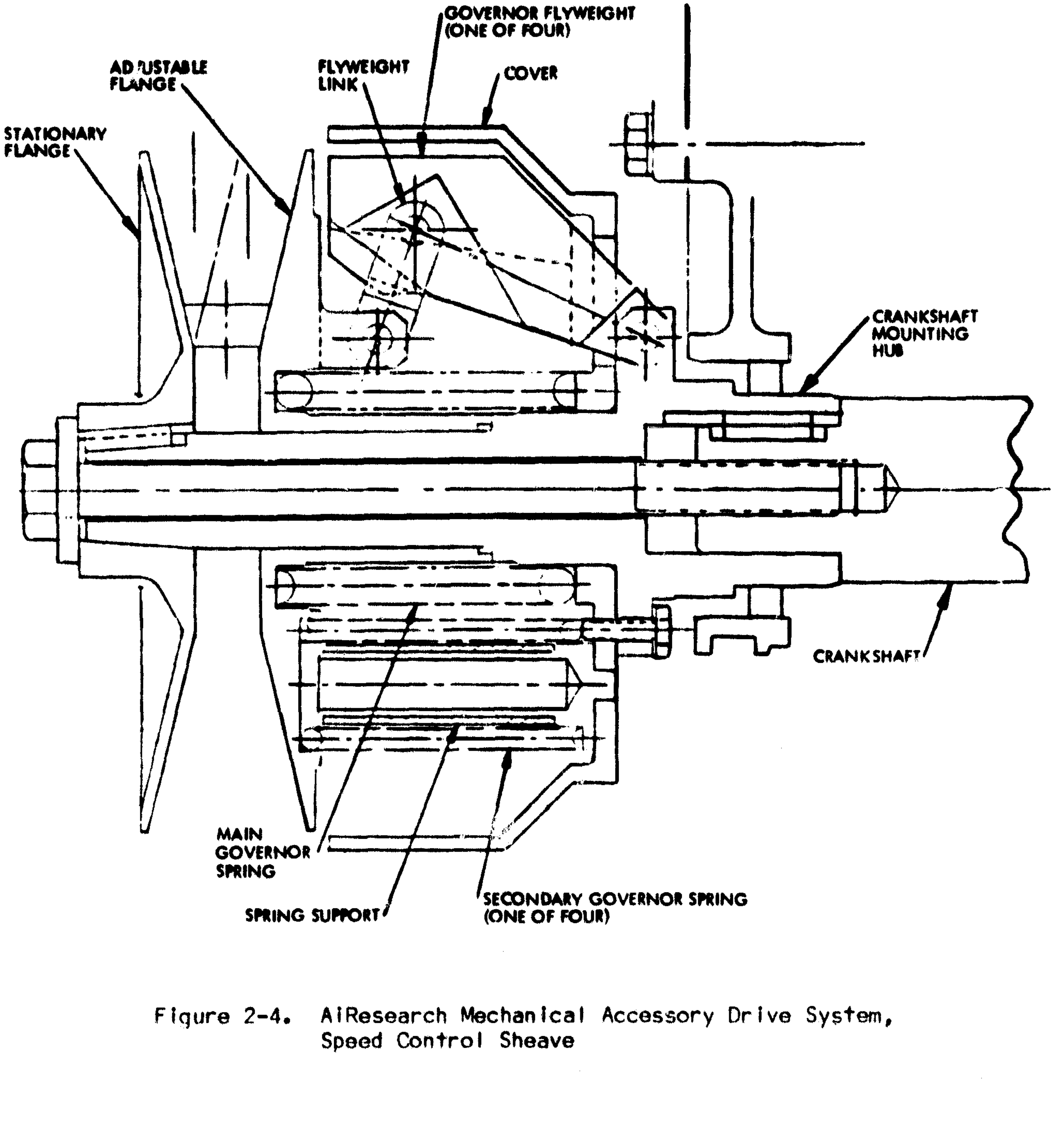

Figure 2-4. AiResearch Mechanical Accessory Drive System, Speed Control Sheave

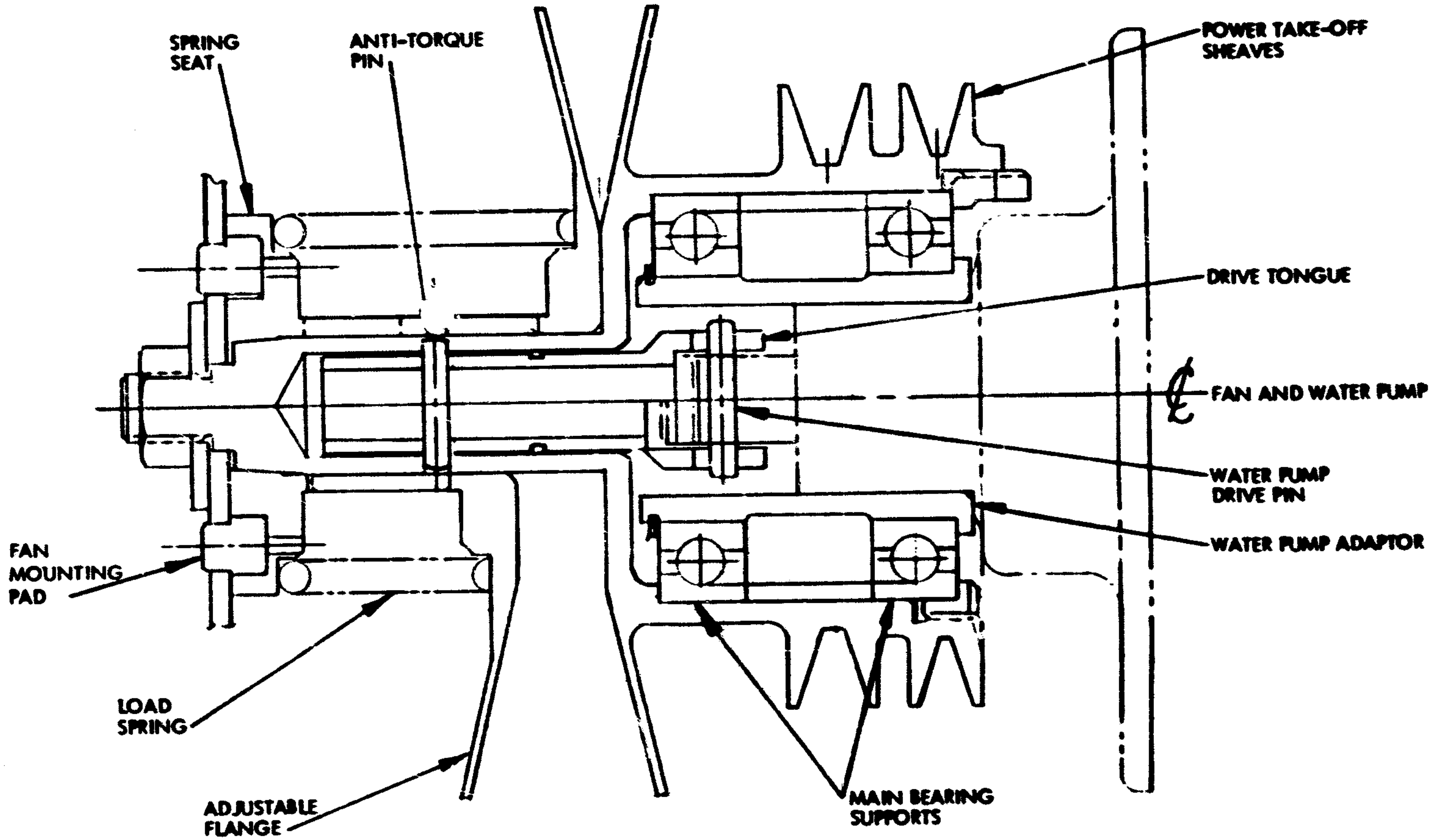

Figure 2-5. AiResearch Mechanical Accessory Drive System, Output Sheave

SECTION III

TEST PROGRAM

Early in 1974, DOE (then the Energy Research and Development Administration), initiated a program with the AiResearch Manufacturing Company (a Division of the Garrett Corporation) to define a reliable and efficient CSAD system that would minimize engine-driven accessory power consumption, and significantly improve the overall vehicle fuel economy. As a result of this initial trade-off study, a mechanically-operated, variable ratio belt-driven system was selected for further development (see Reference 1). Based upon company-funded work at the Borg-Warner Corporation, Morse Chain Division, a CSAD system was developed so that hardware could be made available for extensive evaluation tests. Because of these combined efforts, DOE proceeded with hardware procurement from Morse Chain and requested JPL to plan and implement a test program to evaluate the performance of the CSAD system. The test program which evolved consisted of three phases: (1) familiarization; (2) pilot test; and (3) fleet test. The experimental results obtained during each phase of this overall test program are described in the following paragraphs.

A. PHASE I: FAMILIARIZATION

The specific objectives of Phase I were to:

(1) Become familiar with the vehicle selected for testing.

(2) Become familiar with the Morse Chain CSAD unit.

(3) Establish a preliminary installation procedure.

(4) Determine instrumentation requirements for fleet tests.

(5) Determine the parameters to be recorded.

(6) Establish a preliminary fleet test procedure.

All of the objectives planned in Phase I were achieved.

The test vehicle was a 1978 Ford Pinto "Runabout" with a 2.3 liter, 4-cylinder engine and automatic transmission. Two vehicles with prototype CSAD units were tested concurrently. One vehicle was tested in the JPL Automotive Research Laboratory and the other at the U.S. Department of Transportation's TSC, Boston, Massachusetts. Using similar test procedures, data were collected from both chassis dynamometer and on-the-road tests at each location. Fuel economy improvements during dynamometer tests of 2 to 4% were obtained with the accessories (headlights and A/C OFF and 6 to 8% when the accessories were ON. Data from the road tests showed a mean improvement of 5.5% over the stock condition.

The requirement to have a standardized installation procedure was necessary to modify all vehicles uniformly and efficiently. An installation procedure was therefore written for this purpose and a copy is given in Appendix A.

B. PHASE II: PILOT TESTS

The objectives of Phase II were to:

(1) Determine the final fleet test procedure.

(2) Establish standard data sheets and data recording procedures.

(3) Develop a computer program to sort and store data.

(4) Finalize the installation procedures.

(5) Estimate the cost of installation.

(6) Obtain a limited, preliminary verification of Phase I results.

To support the Phase II and Phase III efforts, GSA and DOE entered into an interagency agreement to conduct tests of the required number of CSAD systems on 1977 and 1978 model Ford Pintos. Four GSA motor pools were selected for the Phase II effort. The motor pools were located in Boston, Massachusetts; Kennedy Space Center, Florida; Dallas/Fort Worth, Texas; and Denver, Colorado. Four pairs of matching Pinto automobiles were randomly selected at each location and were monitored for 4 months starting in January 1979. Preliminary results obtained with these 32 vehicles have been previously reported by Courville (Reference 4).

1. Chassis Dynamometer Test Results

At the start of Phase II, the U.S. Department of Transportation's TSC in Boston, conducted chassis dynamometer tests on 4 of the 8 vehicles. The cars were randomly selected for tests from the local GSA motor pool. Each vehicle was diagnostically checked to assure proper operation, and baselined with a standard Federal Test Procedure (FTP) for urban and highway emissions and fuel economy. Two test conditions were used: (1) accessories OFF; and (2) accessories ON. The vehicles were modified by the installation of CSAD units. The FTP test cycles were repeated on the chassis dynamometer using the same two test conditions (accessories OFF/ON). Fuel economy was calculated by carbon balance techniques as described in the FTP. Table 3-1 shows the weighted FTP urban fuel economy results. Similar results for highway fuel economy are shown in Table 3-2. The average fuel economy improvement with the CSAD for the 4 vehicles tested is shown in Table 3-3. The improvements vary from 2.1 to 8.1% depending on the test condition and cycle driven. It was concluded from the FTP chassis dynamometer test of these vehicles that the improvements were directly related to engine speed and load. Specifically, the largest improvement noted was in the highway driving cycle with the A/C and headlights on.

Table 3-1. Weighted FTP Urban Fuel Economy, mpg

Vehicle Number	Stock: A/C and Lights OFF	Stock: A/C and Lights ON	CSAD: A/C and Lights OFF	CSAD: A/C and Lights ON
661	19.3	16.7	19.4	16.8
2311	19.1	16.2	19.3	17.3
615	19.2	16.8	20.2	17.4
2302	19.2	15.9	19.4	17.6
Average	19.2	16.4	19.6	17.3

Table 3-2. Highway Fuel Economy, mpg

Vehicle Number	Stock: A/C and Lights OFF	Stock: A/C and Lights ON	CSAD: A/C and Lights OFF	CSAD: A/C and Lights ON
661	26.8	22.9	27.3	25.2
2311	25.5	23.5	28.7	26.1
615	25.8	23.8	27.2	25.4
2302	25.5	23.4	26.7	24.5
Average	25.9	23.4	27.5	25.3

Table 3-3. Average Fuel Economy Improvements with CSAD, Percent

Urban		Highway	
A/C and Lights OFF	A/C and Lights ON	A/C and Lights OFF	A/C and Lights ON
2.1	2.5	6.2	8.1

Table 3-4 represents the weighted mass emissions and percent changes in emissions for the FTP urban cycle. Figure 3-1 summarizes these results for the stock and modified vehicle in relation to the 1978, 49-state EPA Emission Standard. In general, the oxides of nitrogen (NO_x) decreased while the unburned hydrocarbons (HC) and carbon monoxide (CO) increased.

After reviewing the results from the chassis dynamometer test and the emission/exhaust system of this model vehicle, it was concluded that the small changes were caused by the following:

(1) A reduction of air-pump speed reduced the rate of air flow to the catalytic converter, thus producing an increase in HC and CO emissions.

(2) A reduction of accessory speeds reduced the parasitic load on the engine. Therefore, the decrease in NO_x can be attributed to the reduced peak combustion temperature.

These tests were conducted at TSC on a large single-roll chassis dynamometer; the previous Phase I tests were conducted at JPL on a smaller twin-roll dynamometer. The data from both locations are in close agreement. No attempt was made to establish an absolute correlation between single- and double-roll chassis dynamometers because the main interest was in fuel economy improvement (mpg) on the modified (CSAD-installed) vehicles. The complete emission and fuel economy data are noted in the computer printouts in Appendix B.

Table 3-4. Weighted FTP Mass Emissions (g/mi) and Percent Change with CSAD

Emission	A/C and Lights	Stock	Modified	Change, %
HC	OFF	.45	.50	+11
	ON	.46	.56	+20
NO_x	OFF	1.18	0.86	-27
	ON	2.25	1.75	-22
CO	OFF	1.40	1.93	+37
	ON	1.93	2.08	+ 8

2. Pilot Road Test Results

The major purpose of the methodology developed for the program was to quantify the overall difference between the stock and modified vehicles by measuring the miles driven and volume of gasoline used. The original plan also considered cost, high-priority data selection, and ease of implementation (i.e., minimal impact on regular operations at GSA motor pools) as important considerations. However, the mutual agreement among DOE, GSA and JPL was that only a vehicle-to-vehicle (stock versus modified) fuel economy comparison would be used to evaluate the CSAD units.

A recording instrument was purchased and evaluated in Phase I for vehicle road testing. The recorder was installed in the rear of the vehicle to record the accessory status (ON/OFF), vehicle speed, total mileage driven, and the time of day the vehicle was in use.

It was determined, however, that the cost of the recording device and associated data reduction was excessive, and that a log sheet filled out by a test technician was by far the most efficient and cost-effective.

The collection and recording of Phase II data began in January 1979. A data log sheet, sample copy of which is shown in Appendix C, was prepared and subsequently used for recording the fleet data. The data sheets were maintained by each GSA motor pool and forwarded to JPL. The data processing flowchart is shown in Figure 3-2. A computer program was developed to handle and update the large amount of input information. The data was sorted for each vehicle and arranged in chronological order. A daily record of vehicle mileage and fuel consumption was maintained and stored in the computer. From the stored data, the computer calculated the mpg for each vehicle, the average mpg of all the vehicles for a given location, and the percent improvement in fuel economy. The performance

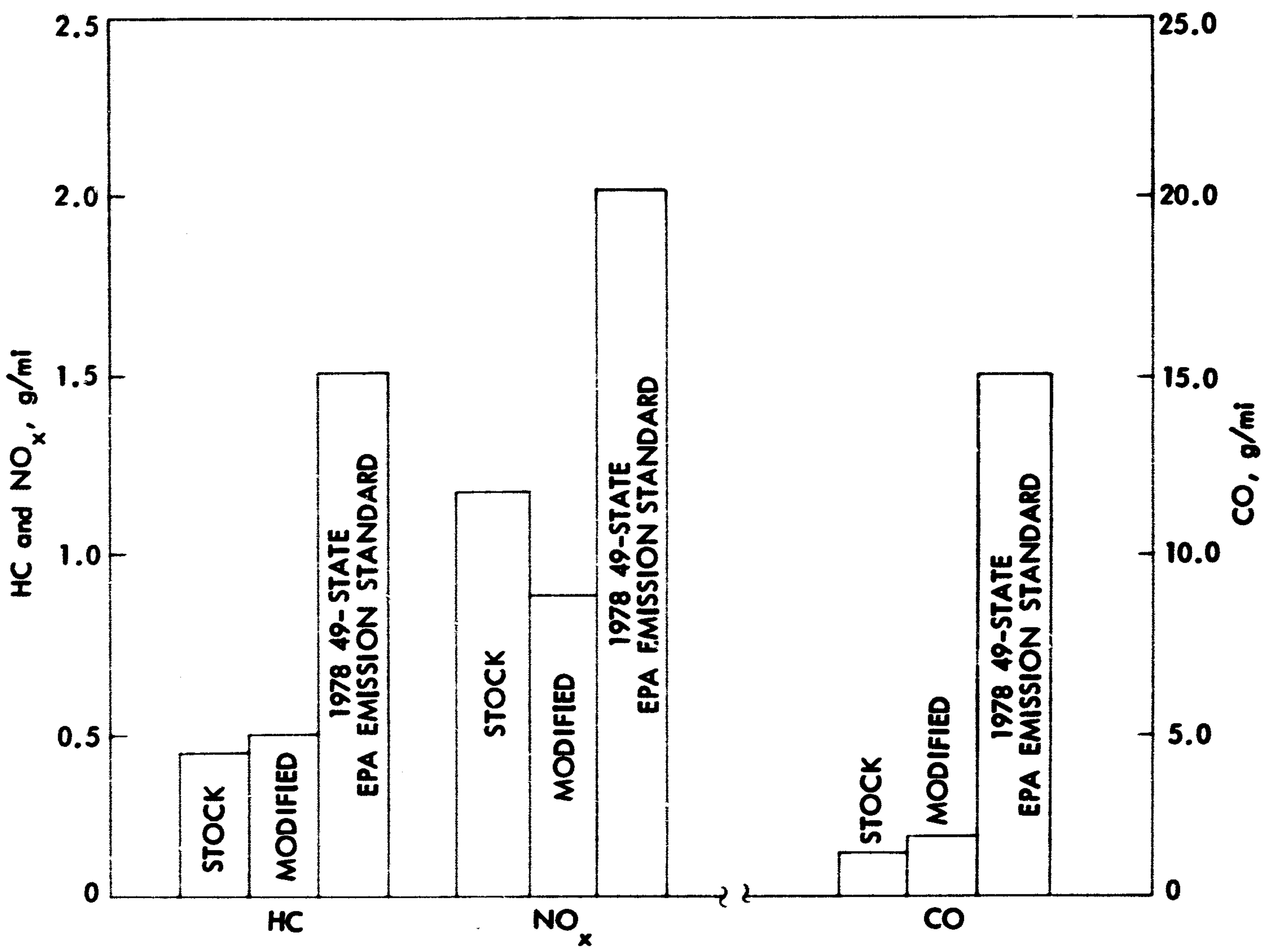

Figure 3-1. FTP Mass Emissions: TSC Data Results

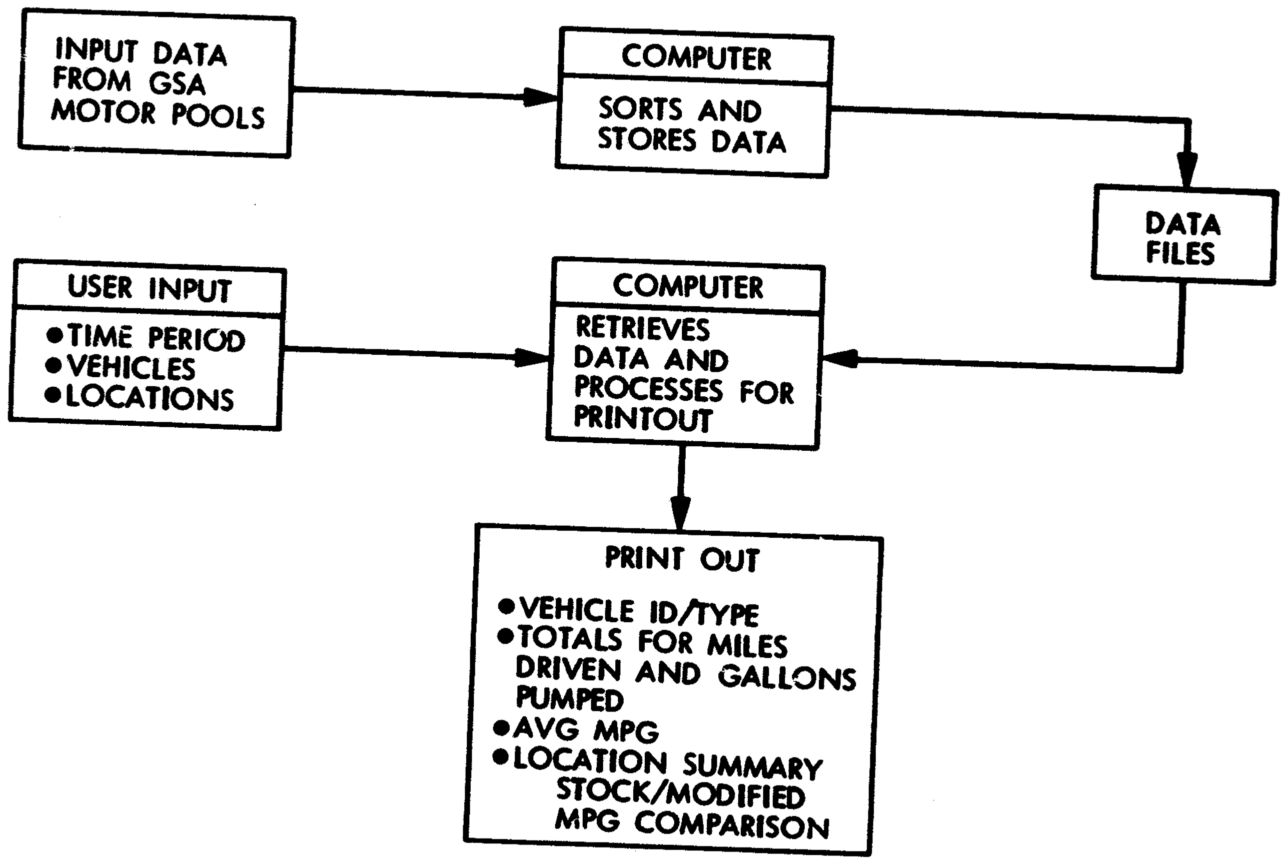

Figure 3-2. Data Processing Flowchart

(total mileage, total gallons, and average mpg) record for each vehicle was thus maintained and continuously updated with each new data input received.

A summary of the road data compiled in Phase II is shown in Table 3-5. The information tabulated in the computer printout gives location, vehicle number, total test miles driven, total gallons used and the average mpg for each of the 32 Ford Pinto vehicles. A summary of the data is at the bottom of Table 3-5. The average mpg of the stock and modified vehicles at the four test locations is shown in Figure 3-3. The average percent improvement in fuel economy at each location is shown in Figure 3-4.

Based upon an analysis of the raw data, a 6.5% average fuel economy improvement for the total fleet was calculated (see Figure 3-4). Fuel economy improvements between motor pool locations varied from -4.0 to +13.0%. It was concluded that these variations in average fuel economy are probably related to the differing driver profiles, regional driving conditions, and other possible unknown regional factors.

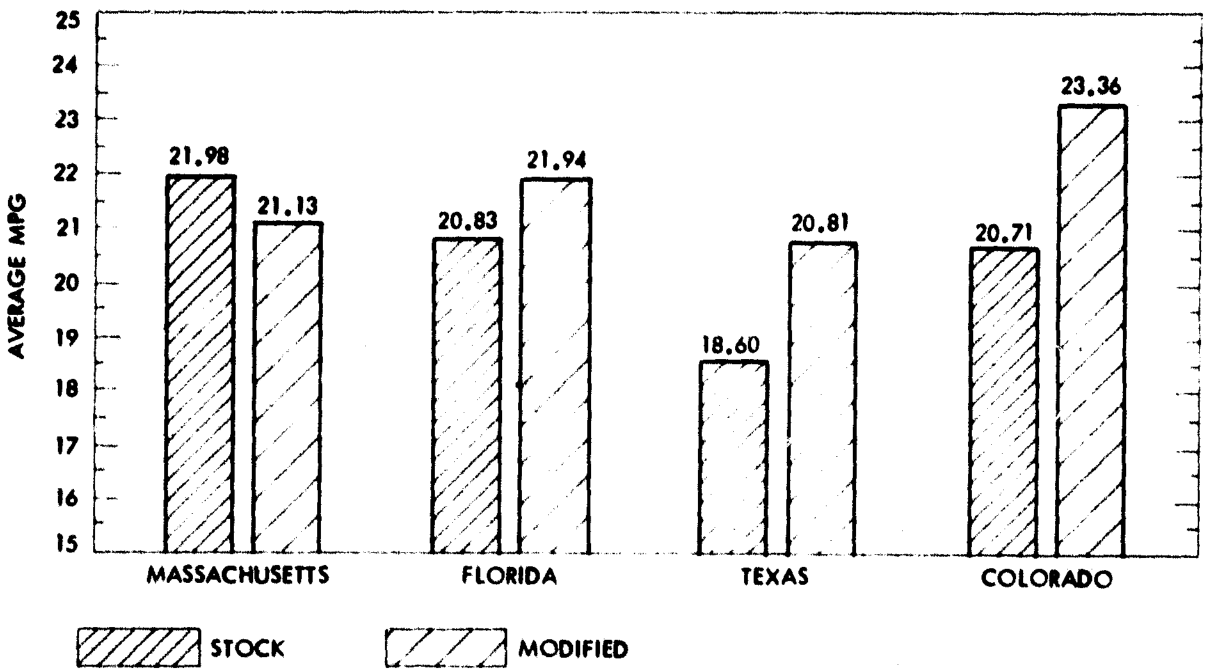

Figure 3-3. Phase II Results, Miles Per Gallon

Table 3-5. Phase II Data Computer Printout

			Miles Driven			Gallons Used			MPG		% City	
Site	Vehicle	Type	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation	Average	Standard	Mean	Standard Deviation
MASS	2310	Stock	2513.	209.	58.	112.	9.	2.	22.36	2.26	37.08	25.98
MASS	2317	Stock	1601.	160.	45.	68.	7.	2.	23.68	4.33	31.60	30.88
MASS	2324	Stock	3974.	209.	47.	179.	9.	2.	22.17	3.40	44.21	14.27
MASS	2325	Stock	2857.	159.	67.	145.	8.	3.	19.70	2.27	45.56	16.53
MASS	2303	Mod	2581.	184.	67.	125.	9.	3.	20.60	2.05	38.21	28.93
MASS	2311	Mod	3254.	171.	85.	148.	8.	4.	21.97	4.54	31.84	27.60
MASS	615	Mod	1538.	192.	147.	70.	9.	4.	21.98	5.19	32.50	20.35
MASS	616	Mod	1553.	173.	61.	78.	9.	3.	19.99	3.21	33.89	23.42
FLA	4088	Stock	4616.	178.	71.	213.	8.	3.	21.71	1.64	44.23	33.16
FLA	4089	Stock	3484.	194.	44.	158.	9.	2.	22.05	1.71	49.17	43.66
FLA	4091	Stock	5298.	189.	40.	264.	9.	2.	20.08	2.15	35.32	35.94
FLA	4092	Stock	3894.	195.	26.	200.	10.	1.	19.50	1.69	54.25	43.42
FLA	4084	Mod	3906.	178.	72.	170.	8.	3.	22.95	3.18	37.45	31.16
FLA	4085	Mod	3589.	239.	46.	149.	10.	1.	24.04	3.34	35.00	44.12
FLA	4086	Mod	3677.	153.	39.	179.	7.	2.	20.48	3.44	30.62	40.09
FLA	4087	Mod	3599.	212.	24.	177.	10.	1.	20.29	2.62	11.76	26.69
TEXAS	1304	Stock	5882.	178.	38.	310.	9.	2.	19.00	3.42	34.70	31.10
TEXAS	1306	Stock	6243.	184.	30.	349.	10.	1.	17.88	1.64	27.06	23.90
TEXAS	1295	Stock	3620.	165.	29.	195.	9.	1.	18.59	2.15	13.64	22.79
TEXAS	1299S	Stock	3895.	195.	35.	206.	10.	1.	18.93	3.26	22.50	25.52
TEXAS	1290	Mod	4509.	215.	51.	220.	10.	1.	20.48	5.29	57.24	34.82
TEXAS	1302	Mod	5086.	203.	44.	247.	10.	2.	20.57	1.91	33.20	24.15
TEXAS	1279	Mod	6706.	210.	37.	316.	10.	1.	21.25	3.31	27.50	26.49
TEXAS	1297	Mod	6552.	199.	56.	313.	9.	2.	20.93	3.29	40.00	23.32

Table 3-5. (Cont'd)

			Miles Driven			Gallons Used			MPG		% City	
Site	Vehicle	Type	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation	Average	Standard	Mean	Standard Deviation
COLO	736	Stock	4248.	163.	47.	213.	8.	2.	19.92	3.28	22.27	26.15
COLC	751	Stock	4351.	189.	28.	219.	10.	1.	19.88	2.74	25.43	33.08
COLO	5327A	Stock	5540.	205.	80.	245.	9.	4.	22.61	4.88	21.33	32.19
COLO	5339	Stock	4983.	199.	34.	244.	10.	1.	20.42	3.71	34.04	31.88
COLO	731	Mod	3488.	205.	42.	146.	9.	1.	23.96	2.97	27.06	33.98
COLO	745	Mod	6546.	218.	51.	294.	10.	2.	22.27	3.15	42.33	23.92
COLO	5328	Mod	3422.	214.	41.	149.	9.	2.	22.96	4.39	37.19	37.59
COLO	5329	Mod	4327.	206.	60.	178.	8.	2.	24.24	3.79	35.81	37.37

	Average MPG			
Site	Stock	Modified	Delta MPG	% Change
MASS	21.98	21.13	-.84	-3.84
FLA	20.83	21.94	1.11	5.31
TEXAS	18.60	20.81	2.21	11.86
COLO	20.71	23.36	1.65	12.80

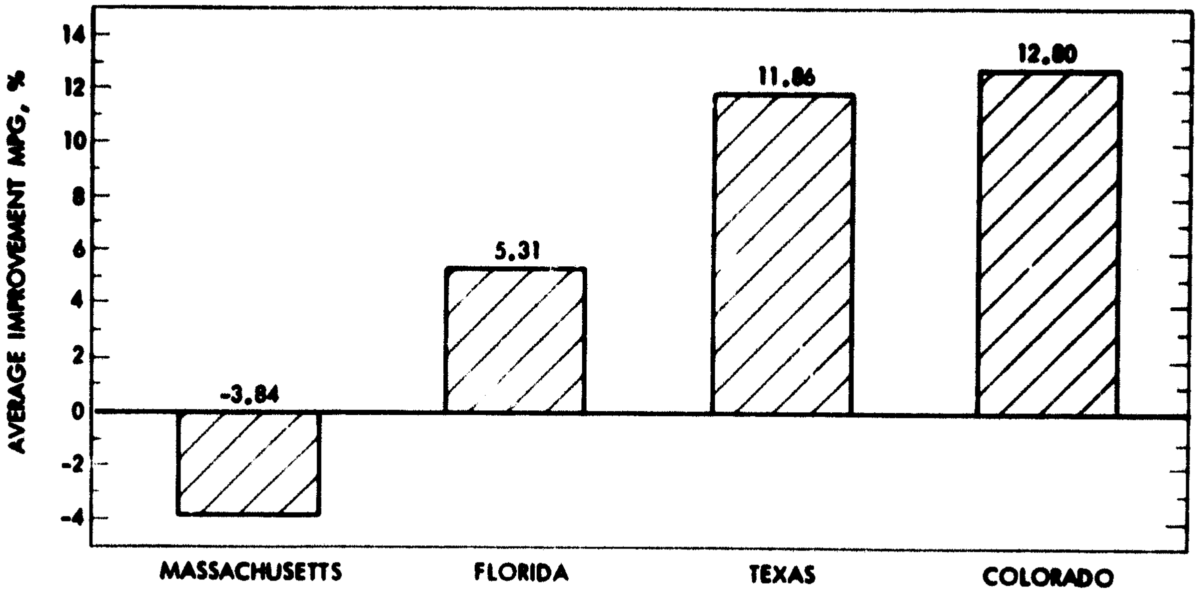

Figure 3-4. Phase II Results, Percent Improvement

The observed variation in fuel economy among motor pool locations led to a review of the program plan and analysis techniques; it was decided that some statistical analyses were needed. The data recorded did not provide information necessary to quantitatively estimate the components of error variations (odometer errors, gas-pump errors, tire pressure, etc.). Although it is not clear in which direction (if any) the data may be biased, statistical analysis does provide bounds on the combined impact of these errors as the study was structured to examine the differences between the stock and modified vehicles.

3. Statistical Analysis of Pilot Test Results

The Operations Research Group at JPL used the information presented in Table 3-5 to conduct the analysis. The response variable of interest is fuel economy measured as miles per gallon. The sample consisted of 32 vehicles, 8 from each motor pool location, 16 of which were modified with a CSAD system. The selection of the modified cars was random, as verified by representatives from each motor pool.

The statistically-analyzed data did not provide the information needed to quantitatively estimate the components of error variation. The results summarized in Figure 3-5 represent sample differences only. To provide grounds for inferring beyond the sample, or to determine whether or not the sample differenco could be explained by chance variation, a two-way standard analysis of variance (ANOVA) was used. The ANOVA model allowed a test for effect on miles per gallon due to vehicle type (stock versus modified), location, and the interaction of vehicle type with location. The analysis indicated a significant difference in miles per gallon between stock and modified vehicles. The statistical analysis, and the general analysis, indicated a significant interaction, demonstrating that the difference in fuel economy between stock and modified vehicles is also dependent upon the location of the vehicle.

Although the data analyzed did not provide the information required to quantitatively estimate the components of error variation, the ANOVA provided an estimate of the combined impact of errors. The statistical analysis concluded that for a 95% Confidence Interval, the mean improvement in fuel economy (Δ) is 0.40 <Δ<2.16, in miles per gallon. This corresponded with a 1.9 to 10.5% improvement over the mean stock fuel economy. The average improvement in fuel economy was 1.32 mpg (6.4%).

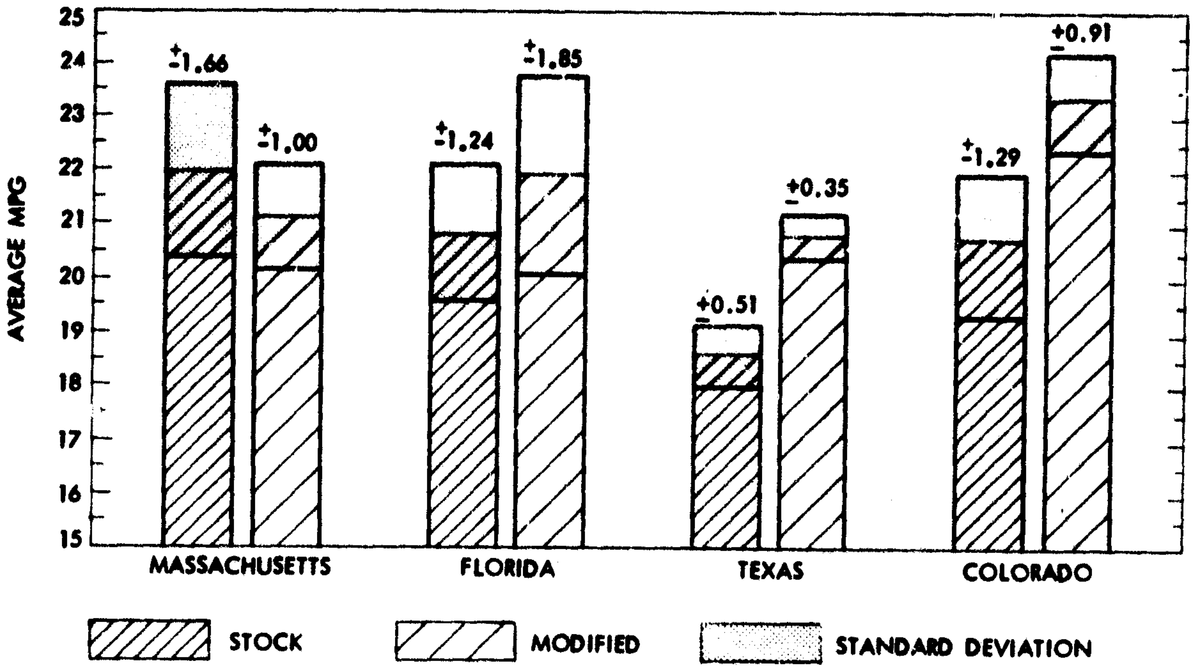

Figure 3-5. Statistical Analysis Results, Miles Per Gallon and Standard Deviation

C. PHASE III: FLEET TESTS

Phase III involved 328 GSA vehicles at 7 different motor pool locations nationwide. The control group was comprised of 144 monitored vehicles. Data were continuously recorded and monitored on each vehicle. The data acquired and analyzed in Phase III, included, but were not limited to, the amount of fuel used, mileage driven, and additional maintenance costs (if any) associated with the use of the CSAD. The major objective was to determine over a 1-year period the level of fuel economy improvement with the CSAD system.

1. Experimental Results

The GSA motor pool locations involved in the fleet test program included the previously mentioned sites, i.e., Boston, Kennedy Space Center, Fort Worth, Dallas, and Denver. However, the geographical area was expanded with the addition of two Southern California locations: Los Angeles and San Diego.

The vehicles used in the test program were 1977 and 1978 Ford Pintos. All vehicles had automatic transmissions, A/C, and air reactor pumps. A tabulation of the detailed test results for 1977 and 1978 Ford Pintos is given in Appendixes D and E, respectively. A summary of these data is presented for each model-year vehicle in Tables 3-6a, 3-6b, 3-7a and 3-7b. The fuel economy data is summarized in two different ways: (1) the average accumulated mpg for each vehicle, and (2) the overall average based upon the total miles driven and the total fuel consumed for all vehicles from each motor pool location.

The test fleet accrued mileage at a rate greater than 100,000 miles per month. The total mileage recorded during the test progam was nearly 2.9 million miles. The average total mileage driven for each motor pool location and vehicle model year is given in Table 3-8. The overall average miles driven per vehicle is about 8700 miles, a figure somewhat lower than the expected national average for privately-owned passenger automobiles.

Table 3-6a. Summary of Phase III Test Results: 1977 Vehicles - Average for Each Vehicle

Site	Average mpg: Stock	Average mpg: Modified	Delta mpg	Change, %
Massachusetts	20.44	22.06	1.63	7.95
Florida	.00	20.04	20.04	.00
Texas	19.77	21.38	1.61	8.14
Colorado	20.98	23.17	2.20	10.47
California	20.19	21.64	1.44	7.14

Table 3-6b. Summary of Phase III Test Results: 1977 Vehicles - Average mpg from Total Miles/Total Gallons

		Site	Average mpg		Delta, mpg	Change, %
			Stock	Modified		
Stock Total Miles	Stock Total Gallons	Modified Total Miles	Modified Total Gallons			
		MASS	20.67	22.16	1.49	7.23
206586.	9994.	201847.	9107.			
		FLA	.00	20.26	20.26	.00
0.	0.	457041.	22557.			
		TEXAS	19.61	21.36	1.75	8.90
107773.	5495.	208738.	9773.			
		COLO	21.02	23.19	2.17	10.32
139261.	6626.	118195.	5098.			
		CALIF	20.33	21.63	1.30	6.38
97149.	4779.	149580.	6916.			

Table 3-7a. Summary of Phase III Test Results: 1978 Vehicles - Average for Each Vehicle

Site	Average mpg: Stock	Average mpg: Modified	Delta mpg	Change, %
Massachusetts	22.46	23.04	.58	2.57
Florida	20.29	21.99	1.70	8.37
Texas	21.24	22.23	.99	4.67
Colorado	22.14	23.88	1.73	7.83
California	20.90	22.09	1.20	5.72

Table 3-7b. Summary of Phase III Test Results: 1978 Vehicles - Average mpg from Total Miles/Total Gallons

Site	Average mpg: Stock	Average mpg: Modified	Delta, mpg	Change, %	Stock Total Miles	Stock Total Gallons	Modified Total Miles	Modified Total Gallons
MASS	22.37	23.05	.68	3.06	111916.	5004.	109622.	4756.
FLA	20.45	21.73	1.28	6.28	309805.	15150.	101091.	4652.
TEXAS	21.01	21.77	.76	3.63	93942.	3995.	86029.	3951.
COLO	22.30	23.99	1.69	7.60	61495.	2758.	81246.	3386.
CALIF	20.74	22.12	1.38	6.64	138969.	6699.	97645.	4414.

Table 3-8. Distribution of Total Fleet Miles Driven

	1977		1978	
Location	Stock	Modified	Stock	Modified
Massachusetts	206586	201847	111916	109622
Florida	--	457041	309805	101091
Texas	107773	208738	83942	86029
California	97149	149580	138969	97645
Colorado	139261	118195	61495	81246
Totals	550769	1135401	706127	475633
Average Miles/Vehicle	8605	8870	8826	8493

Table 3-9 gives information on the test fleet and lists the number of vehicles by model year for each location, the vehicle type (stock or modified) and their overall average mpg. From information gathered at the start of the program, two assumptions were made: (1) the average mpg of the 1977 and 1978 Ford Pintos were identical; and (2) the selection of the vehicles that were modified was random. However, the selection of vehicles by year was not random, as there were no 1977 stock vehicles in the Florida motor pool. Also, there was an unbalanced distribution of 1977 and 1978 vehicles at each of the other motor pools.

A summary of the data compiled in Phase III is shown in Figure 3-6. The average mpg for the stock and modified vehicles is shown by model year for each test location. As discussed in Phase II data analysis, there are apparent variations in both the mpg averages between locations and between the 1977 and 1978 model-year vehicles.

Table 3-9. Fleet Distribution and mpg Averages

	1977 Stock		1977 Modified		1978 Stock		1978 Modified	
Site	Vehicles	mpg[a]	Vehicles	mpg[a]	Vehicles	mpg[a]	Vehicles	mpg[a]
Massachusetts	17	20.67	18	22.16	12	22.37	1	23.05
Florida	0	No data	46	20.26	28	20.45	7	21.73
Texas	13	19.61	22	21.36	9	21.01	13	21.77
California	20	20.33	29	21.63	25	20.74	19	22.12
Colorado	14	21.02	13	23.19	6	22.30	7	23.99
Totals	64		128		80		56	

[a]Data based upon total miles driven and total gallons of fuel consumed for each vehicle model year and site location.

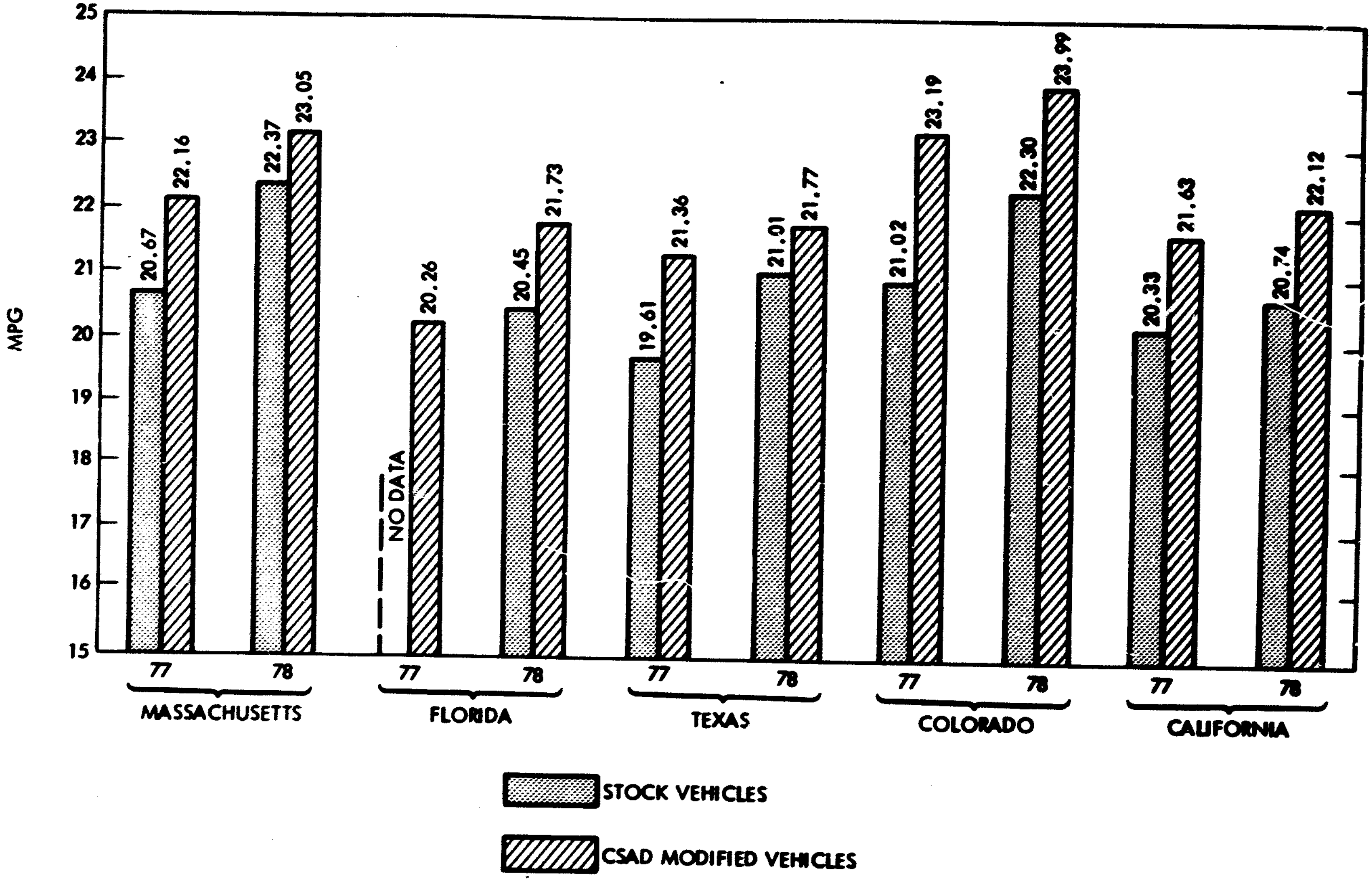

Figure 3-6. CSAD Phase III Fleet Averages

The variation in mpg averages between locations seems to be related to the different driver profiles and regional driving conditions. However, regardless of the variations in mpg averages, the importance of this data is that in all cases the modified vehicles demonstrated a fuel economy improvement relative to the stock configuration.

The percent improvement in fuel economy for each location and model year is represented in Figure 3-7. Analysis of the data indicates that the observed variation at each location is similar to the results obtained in Phase II.

It is clear that the 1977 model vehicles showed a greater mileage improvement with CSAD modification than did the corresponding 1978 model cars. This observation suggests that factory improvements, such as timing and/or carburetor adjustments were made on the production line for the 1978 Pintos. These adjustments (if any) also provided some improvements in the observed fleet mileage data. This comparison, of course, cannot be made for the Florida vehicles since the fleet did not contain any 1977 model cars. The overall mass weighted average improvement in mpg for the entire data sample is 7.0%, with a range in operational sites from 5.6 to 9.4%.

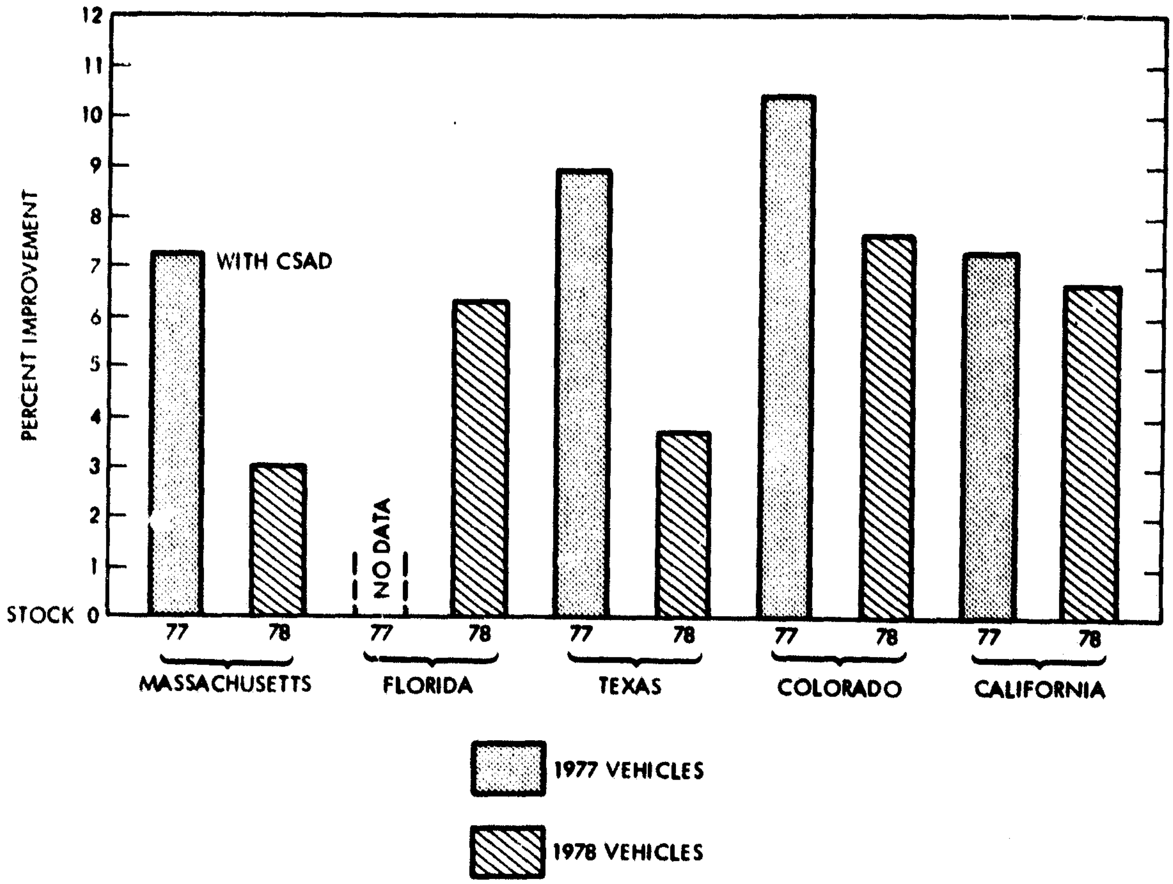

Figure 3-7. Fleet Mileage Improvement Due to CSAD Modifications

One additional comparison can be made as shown by the results of Figure 3-8. In this case the percent improvement in fuel economy is indicated for each site, first due to some model change improvement and second by the CSAD modification (relative to the new 1978 baseline). The effect of the model change is less apparent in California and this could possibly be related to the emission control requirements for vehicles in that state.

In order to obtain error bounds on the mean improvement in fuel economy and to correct for the bias caused by the unbalanced sample (e.g., no 1977 stock vehicles in Florida), a multiple regression analysis was again performed. The results of this statistical analysis are given in the next section.

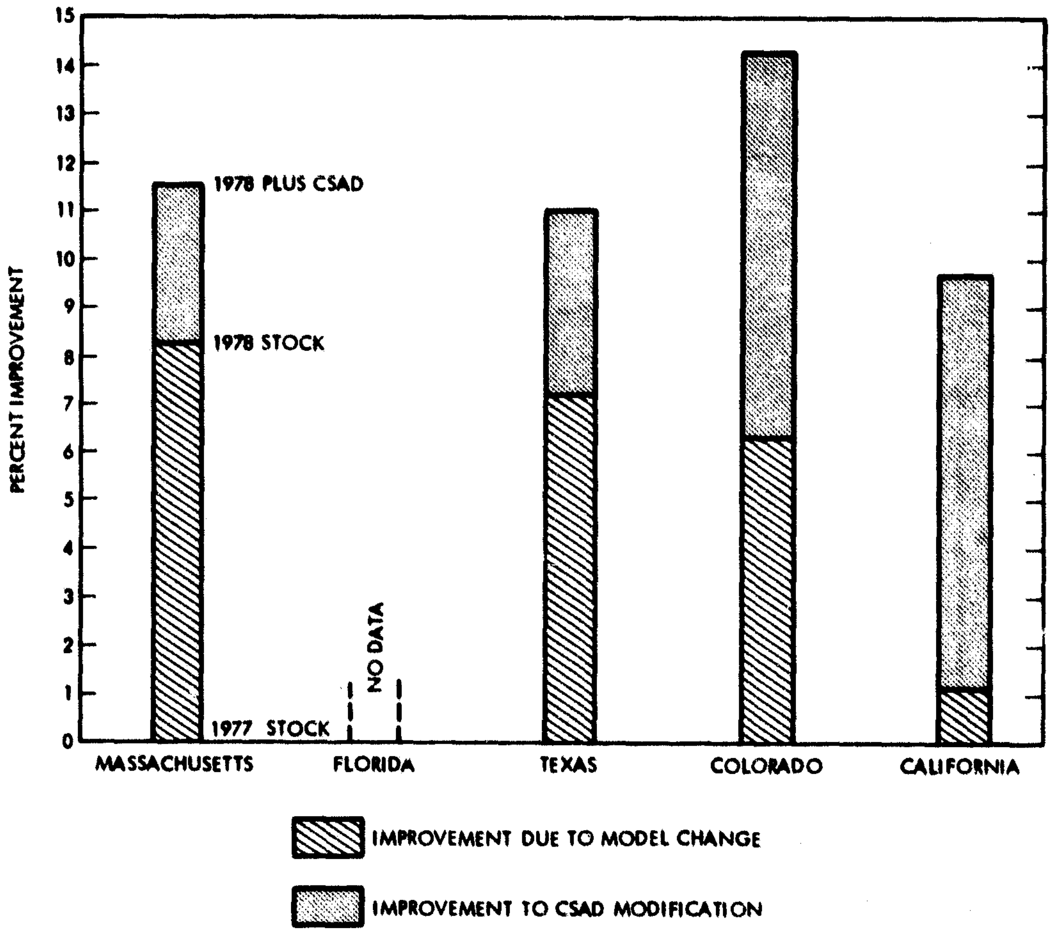

Figure 3-8. Fleet Mileage Improvement Due to Model Change and CSAD Modifications

2. Statistical Analysis of Fleet Test Results

The statistical analysis was performed to better assess the effect of CSAD on fuel economy. Results of the analysis indicate that automobiles modified with the CSAD achieved a statistically significant value of 1.18 mpg more than unmodified vehicles. The 95% confidence interval about this value provides a range of 0.83 to 1.52 mpg for the expected improvement. This corresponds with a 4.0 to 7.3% improvement over the stock vehicle configuration. Figure 3-9 provides a summary of sample means and regional standard deviations by region for stock and modified vehicles. Each region showed an improvement in mileage for modified vehicles ranging from a low of 0.03 mpg in Florida, to a high of 1.86 mpg in Colorado.

A regression analysis was performed to obtain error bounds on the improvement in fuel economy and other variables. The regression also served to correct for certain biases that may have been caused by unbalanced data (e.g., more automobiles in one region than another). The resulting regression equation is:

$$\text{mpg} = \underset{(0.176)}{1.179T} + \underset{(0.176)}{1.085Y} + \underset{(0.250)}{0.426C_1} - \underset{(0.228)}{0.931C_2} - \underset{(0.253)}{0.047C_3} + \underset{(0.305)}{1.166C_4} + 20.11 \quad (1)$$

where T represents the type of automobile, Y represents the model year, and C_1, C_2, C_3, and C_4 represent the locations Massachusetts, Florida, Texas, and Colorado, respectively. These variables are dummy variables (0 or 1) which represent the presence or absence of some condition. The influence of California in the regression equation is accounted for by the constant term.

That is, the value of T = 1 indicates that the vehicle has been modified (T = 0 for stock cars). Similarly, Y = 1 for 1978 automobiles and Y = 0 for 1977. $C_i = 1$ if the car is from the i_{th} location; otherwise it is 0. The standard errors are shown in parentheses beneath the estimated coefficients. The coefficient of T in the regression equation represents the mileage improvement due to modification. That is, a modified automobile (T = 1) results in a 1.18 increased mpg.

An Analysis of Variance (ANOVA) was also performed to investigate possible interactions between or among the variables of location of test, model year, and modification of the test automobile. The test showed a significant difference between stock and modified cars, between regions, and for the model year of the automobiles (i.e., the main effects were all significant). There were no significant interactions between any two individual factors (e.g., region with model year) nor among all three.

Fuel consumption numbers were derived for each automobile in the sample by dividing total miles driven during the test period by total gallons consumed. The data for each automobile were edited by arbitrarily excluding any particular data point for which the mpg was outside the range of 13 to 30 mpg (inclusive). The time period from which data was used in the analysis was 12 months, but the data did not necessarily traverse the entire time period for every automobile.

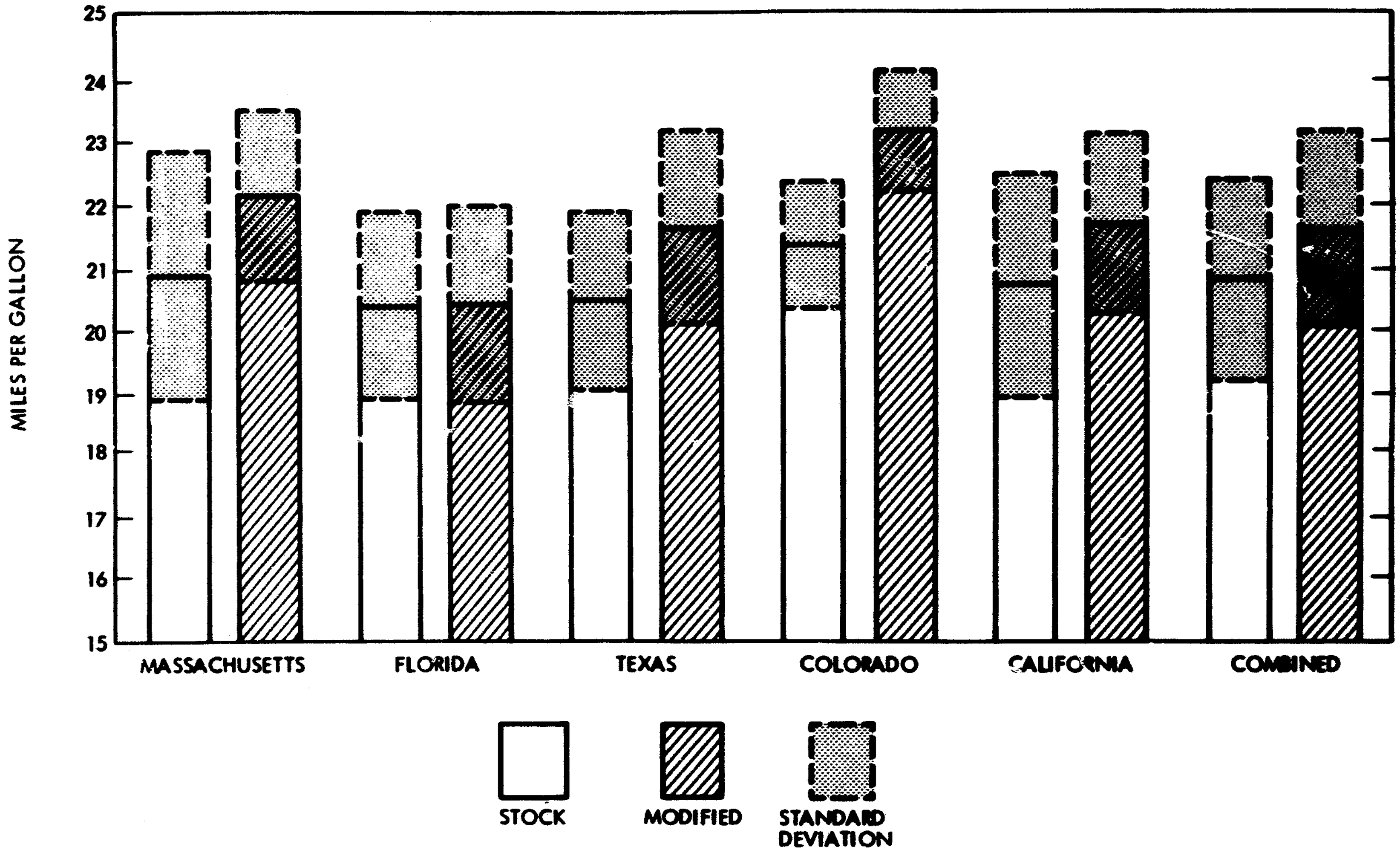

Figure 3-9. Combined Statistical Analysis Results of Fleet Tests

In addition, a least-squares regression analysis was conducted to determine seasonal effects on mpg. The four seasons were conventionally defined by calendar date; weather information was not available from the input data.

Initial analysis of seasonal variation indicated that there were no statistically significant mpg differences between the four calendar seasons. This observation motivated an approach in which two seasons were combined as one rather than using four separate cases. This strategy resulted in a statistically significant difference between the adjusted "seasons."[1]

The resultant unweighted regression equation for mpg is given by Equation (2). Equation (2) indicates that the automobiles modified with the CSAD achieved a statistically significant expected value of 1.20 mpg (rounded) more than unmodified vehicles. The 95% confidence interval about this value provides a range of 0.93 to 1.46 mpg for the expected improvement.

$$mpg = 1.199T + 1.044Y + 0.429C_1 - 0.850C_2 + 1.217C_3 - 0.319S + 20.24 \quad (2)$$

$$(0.132) \quad (0.133) \quad (0.172) \quad (0.152) \quad (0.210) \quad (0.125) \quad (0.162)$$

where S represents the seasonal adjustment factor.

If the season is winter or spring, then S = 1, otherwise the value is set to 0. The other terms in the regression equation have been previously defined (see Equation 1). The 95% confidence interval for the seasonal variation provides a range of 0.07 to 0.56 mpg for the expected effect. If the season is winter, for example, the expected mpg would be 0.32 mpg less (on the average) compared to either fall or summer.

Multiple regression is a general statistical technique which can analyze the relationship between a dependent variable (e.g., miles per gallon), and a set of independent variables (e.g., model year, region of the test, and modified versus stock). Multiple regression may be viewed as a descriptive tool, or as an inferential tool through which a linear equation is developed to quantify the relationship between the dependent and independent variables. In the current analysis regression has been used as a inferential tool.

D. COMPONENT DURABILITY

During this program records were maintained concerning the reliability of the CSAD hardware. It must be emphasized that the test units

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[1]Statistical significance also was obtained for the case in which the two "seasons" were defined as winter and summer-fall-spring. The term "statistically significant" indicates there was a change in the mpg, associated with seasonal changes, of a magnitude greater than can be attributed to random fluctuations alone (at a 95% level of confidence).

were prototypes and not of proven production quality. Several types of failures were noted during the vehicle fleet tests. The most frequent problems were related to the drive belts and water-pump pulleys.

About 27% of the CSAD units required belt replacements. This was caused by excessive belt wear which reduced the belt width to the extent that the units could not operate properly. The CSAD unit could no longer adjust to maintain belt tightness, which in some cases resulted in belt slippage. During hot weather this condition resulted in several cases of vehicle overheating. Belt wear in some units was accelerated due to rough pulley surfaces.

As noted by Butterfield (Reference 5) of Morse Chain, with friction in the system there is a hysteresis which causes the belt to become slack momentarily upon rapid acceleration. This belt slack occurs when the driver sliding flange overcomes friction and opens suddenly. When this happens the drive changes from an overdrive to an underdrive ratio, meaning that the driven unit must slow down (Figure 3-10). Because the driven sliding sheave is controlled by a torque cam, it overruns, allowing the belt to slacken. As soon as the driven unit slows to the correct speed (corresponding to the driver speed times the underdrive ratio) the belt tightens and power is again transmitted. Because the driven sliding flange must close to re-engage the belt, some slippage occurs and there may be an audible belt "squawk." This slippage is slight and lasts for only about 1 second, but undoubtedly contributes to eventual failure of some belts. It should be noted, however, that because of the geometry of the system, it is virtually impossible for the belt to come off unless breakage occurs during operation.

In addition, 12 CSAD water-pump pulleys failed during the fleet tests. Figure 3-11 shows the water-pump pulley and the observed location of failure. In every case the angled sheave face or flange became detached from the hub section. The detached ring section remained on the hub between the A/C belt pulley groove and the sliding flange. The result of this type of pulley fracture was eventual loss of all accessory function of the vehicle. However, with regard to safety, the fractured piece could not become separated from the pulley and become a hazard. The severed pulley-half moved back against the A/C pulley groove, the pulley system still functioned but at a greatly reduced capacity. Eventually the final run-out of the severed pulley-half and its slippage destroyed the belt, causing the loss of all accessory function.

Analysis of early failures indicated the fracture could be caused by insufficient material thickness at the radius as shown in Figure 3-11. However, additional failures also occurred on pulleys with adequate material thickness at the radius. Further investigation of unused pulleys revealed forming flaws on some parts. Examinations of 100 parts and the tooling used for manufacturing, revealed the source of the problem. The rolling tool radius was found to be correct but the backing mandrel radius (at the back side of the sheave) was incorrect. Normal metal spinning practice dictates that the outside radius of a part be equal to the inside radius plus material thickness; the rolling tool and the man-

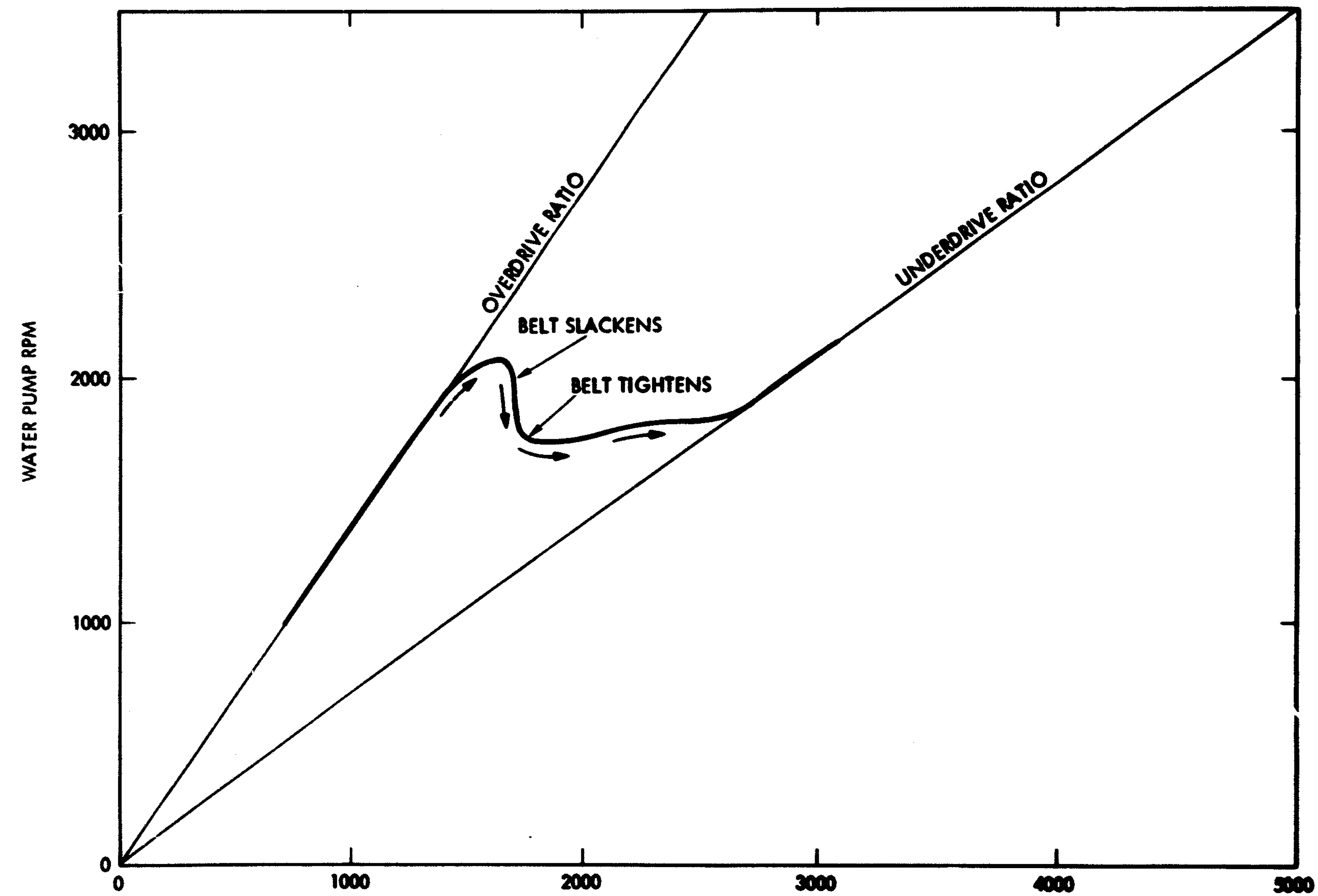

Figure 3-10. Typical CSAD Shift During Fast Acceleration

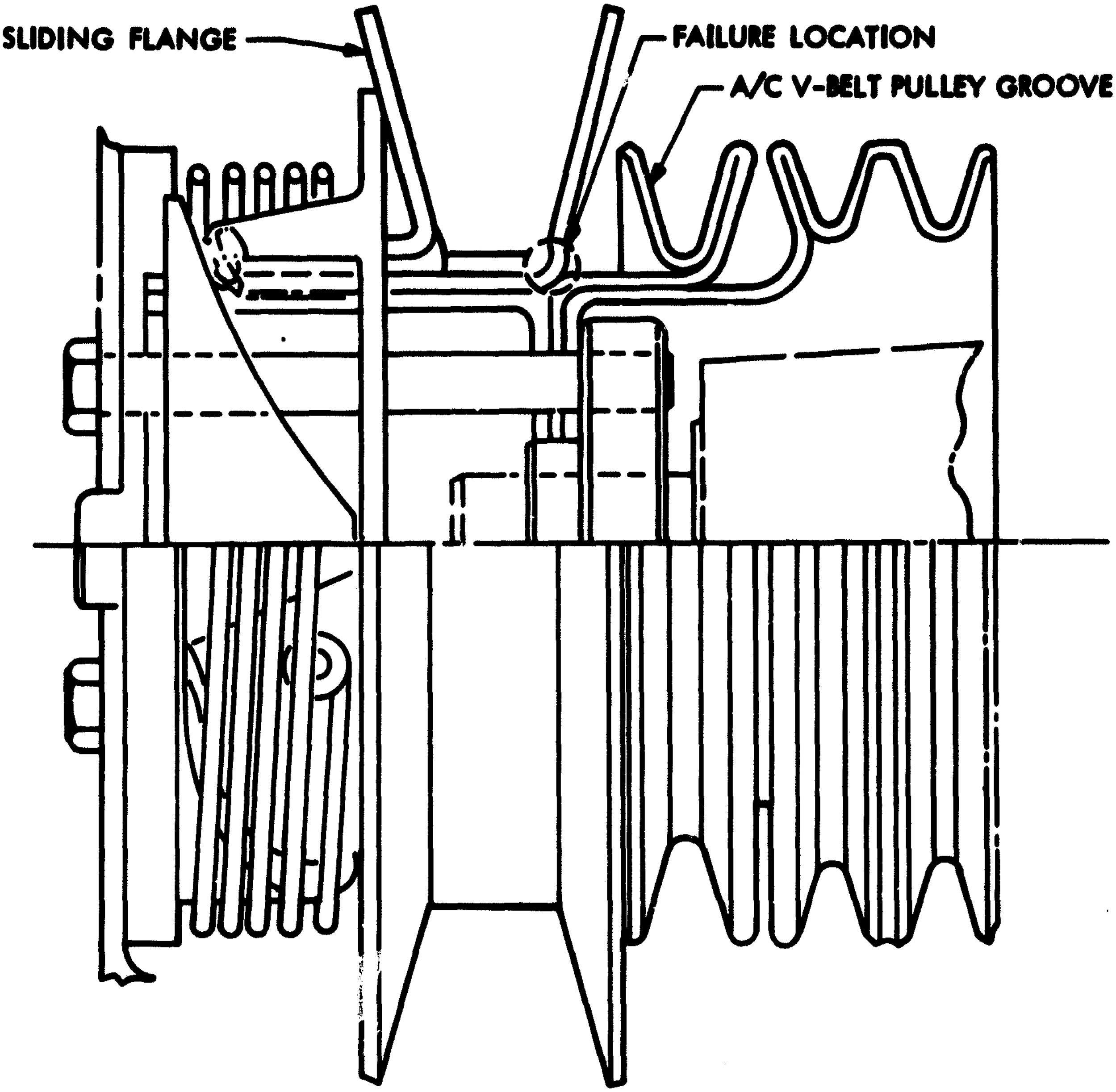

Figure 3-11. Location of Water-Pump Pulley

drel in these cases had equal radii. Consequently, severe looping of metal, thinning, and excessive grain elongation to the point of shearness occurred. What externally appears to be a smoothly formed radius is seen in Figure 3-12 under 62X magnification to be a raggedly formed part. Also shown is a series of cracks in the critical radius area. It should be stated that this type of problem would not be expected with fully developed production units. In addition, a few miscellaneous malfunctions occurred because of problems with the units not "shifting" properly, believed due primarily to dirt or corrosion.

The last problem relates to some cases of vehicle overheating. An investigation conducted by Woollard (Reference 6) of Morse Chain, identified the following four factors, which when combined, could contribute to overheating:

(1) The engine idle solenoid must be functioning properly to insure a fast idle speed when the A/C is in operation.

(2) Fan tip losses could be excessive when a downsized fan is installed inside the larger stock fan shroud.

(3) All vehicles equipped with A/C should have coolant recovery tanks.

(4) The CSAD unit must ensure at least the minimum specified engine speed during idle conditions.

E. COMPARISON WITH HEAVIER VEHICLE AND ALTERNATE UNITS

In addition to the CSAD fleet tests, the performance of two other CSAD units were evaluated during limited tests. The FMC VRAD system was tested at JPL on both the chassis dynamometer and during on-the-road driving. The same test procedures and equipment were used as for the Morse Chain CSAD units.

The mpg values shown in Table 3-10 were obtained from chassis dynamometer FTP urban driving cycle tests. The Pinto test vehicle was diagnostically checked to assure proper operation, and the fuel economy was calculated by carbon balance techniques. Two test conditions were used: (1) accessories OFF; and (2) accessories ON. After 4 months of road tests the chassis dynamometer tests were repeated. As noted, very close agreement in fuel measurements were recorded. Tabulated results from these tests show a 3.3% improvement with accessories OFF, and 11.7% when the accessories were ON. The on-the-road driving test results are shown in Table 3-11. About 3,500 miles were accumulated during that period. With about 80% highway driving, the average fuel economy was 26.9 mpg which represents an improvement of more than 11%.

This percent improvement measured for the VRAD unit is greater than that previously observed with the other systems. The data must be considered, however, as less significant since the results are based upon considerably fewer accumulated miles.

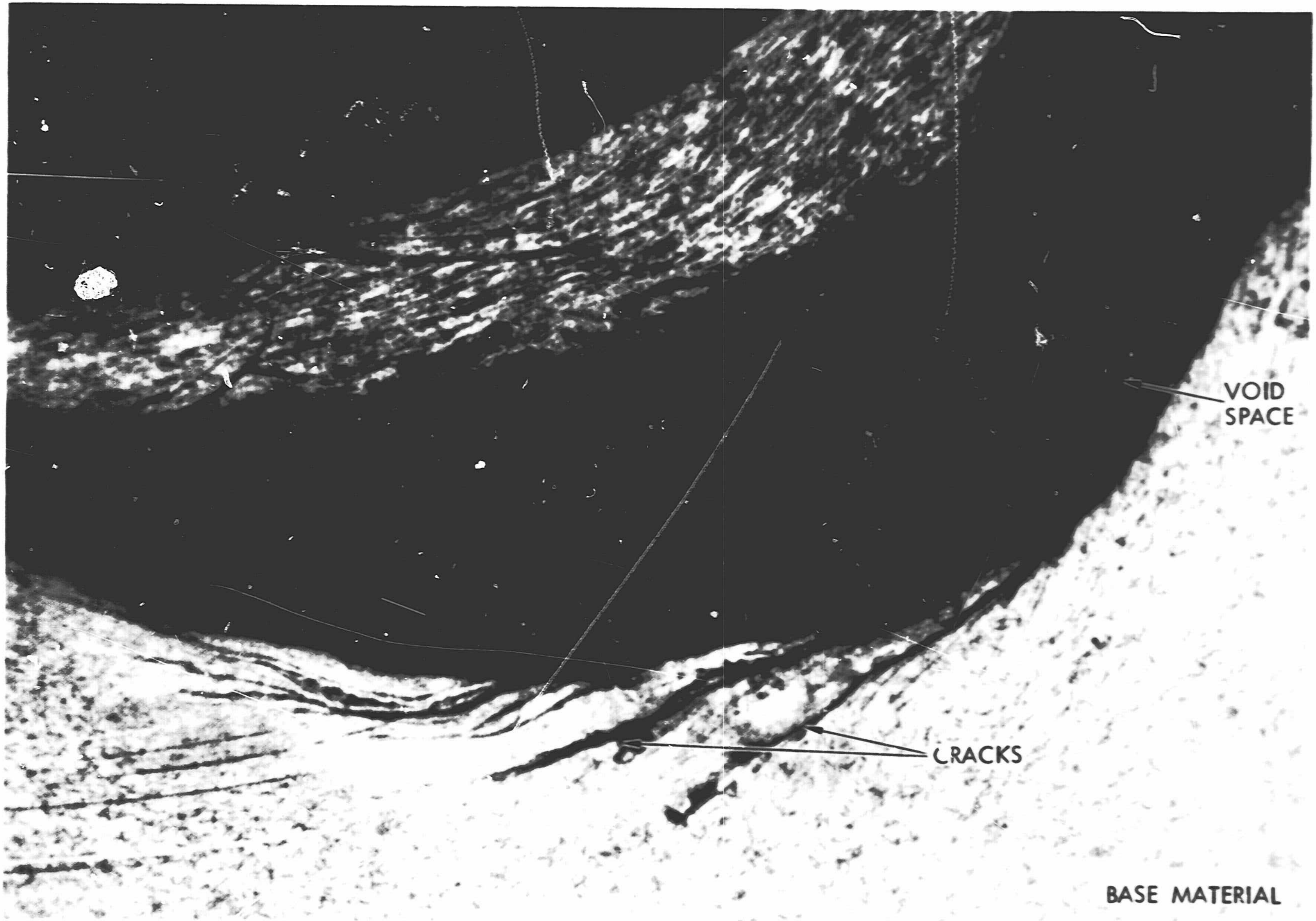

Figure 3-12. Enlarged Photograph of Critical Radius Area

Table 3-10. Fuel Economy Data - FTP Urban Driving Cycle

Vehicle Configuration	A/C and Lights OFF, mpg	A/C and Lights ON, mpg
Fixed Ratio (Stock)	19.73	16.49
FMC (VRAD)	20.26	18.36
After 3,457 Miles		16.44
Fixed Ratio (Stock)	19.45	18.43
FMC (VRAD)	20.22	
Average % Improvement	3.3%	11.7%

Table 3-11. On-the-Road Driving Results

Time Period	Total Mileage	Type of Driving, %	Average mpg
August 2, 1979 through November 15, 1979	3,457	80 Highway 20 Urban	26.99
Stock Vehicle: Similar Driving Conditions			24.26
Fuel Economy Improvement			11.25%

In addition, a Mustang II vehicle (3,500 lbs) was tested on the dynamometer to measure the effect of a 27% heavier weight change. The variable-speed drive system that was available to fit this heavier vehicle was the AiResearch MADS unit. Because this system represents another design approach it is not possible to draw any quantitative comparisons. However, Figure 3-13 shows that the larger vehicle with a variable ratio accessory drive also shows a significant improvement over the stock vehicle.

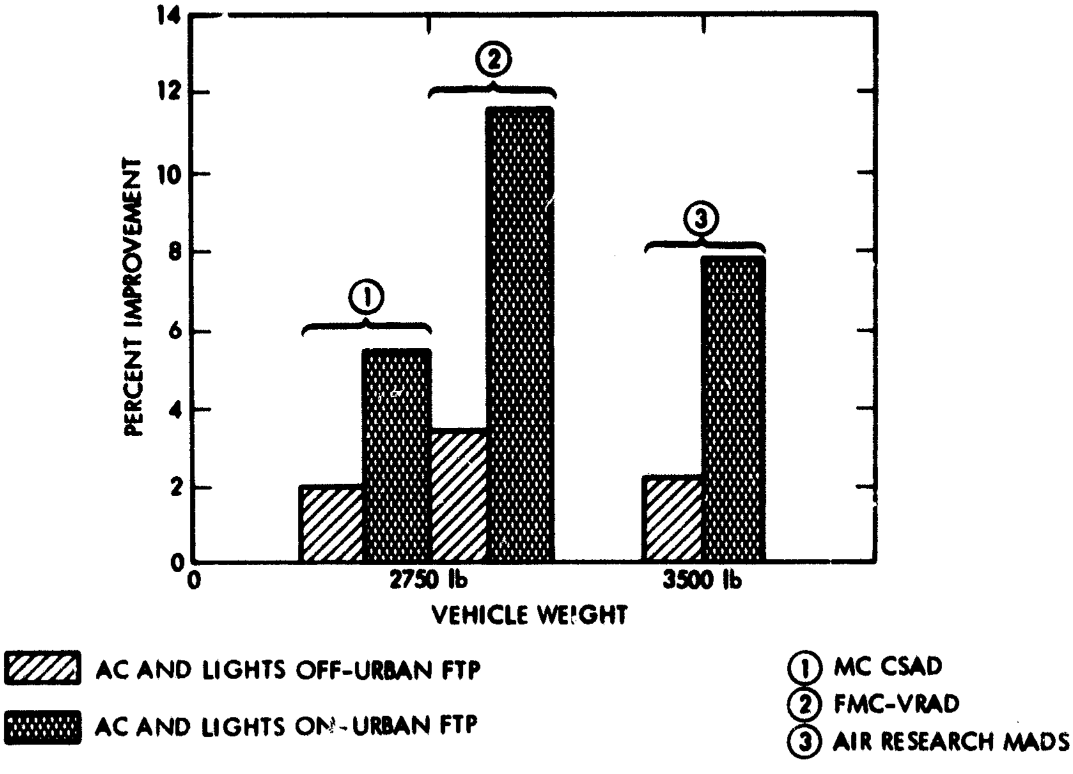

Figure 3-13. Comparison with Heavier Vehicle and Alternate Units

F. SENSITIVITY OF FUEL ECONOMY TO DYNAMOMETER LOAD

The actual mileage improvement observed during the extensive fleet tests was more than three times that measured during the FTP dynamometer test. The EPA urban test procedure obviously does not give adequate credit for these devices. To provide the necessary incentive to further develop the concept for general use, a specific technique should be proposed to give more visibility to the real increase in fuel economy.

Discussions with automotive engineers within the industry indicated great reluctance to any suggested changes in the FTP. One possible solution, that does not change the FTP, would be to make an adjustment to the horsepower setting on the chassis dynamometer's power absorption unit (PAU).

In order to determine the magnitude of change required in the PAU dynamometer sensitivity tests were performed at JPL. The stock Pinto vehicle was tested (with A/C and lights OFF) on a standard urban FTP with a range of PAU settings between 6 and 12 hp. Figure 3-14 shows that the PAU horsepower would need to be reduced from the nominal 10.1 hp to 4.8 hp to provide an equivalent 7% credit in fuel economy.

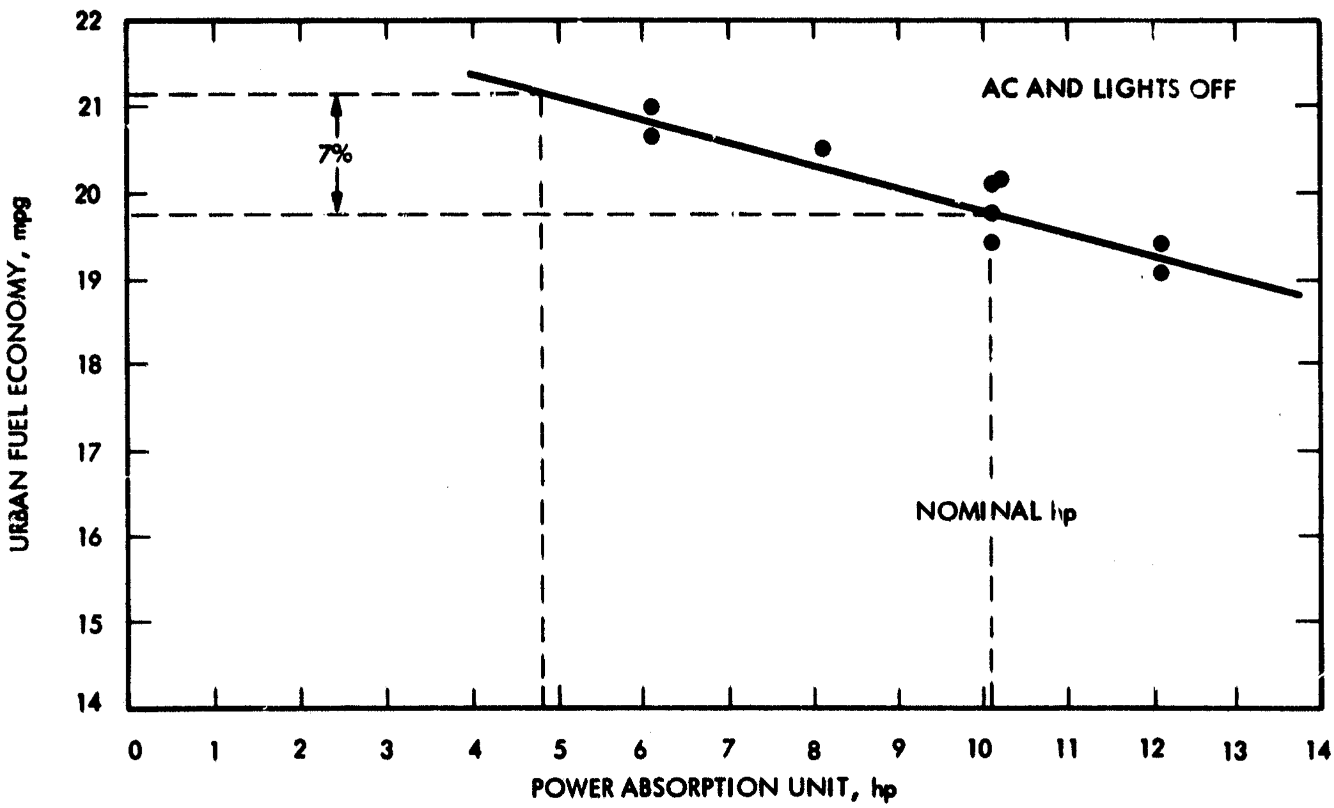

Figure 3-14. Sensitivity of Fuel Economy to PAU-HP for Pinto Vehicles

SECTION IV

CONCLUSIONS

Several conclusions can be made regarding the fuel economy potential of CSAD systems based on the test results obtained during this effort.

The fuel economy improvements achieved with the CSAD modifications and measured during this three-phase program are summarized in Table 4-1. The percent improvement is shown for the FTP dynamometer and road tests for each phase. The FTP results are shown separately for the urban and highway portions of the driving cycle. The road test results represent the mileage improvements based upon the weighted average data and the statistical mean values for the 95% confidence level.

As planned, a relatively small number of miles were accumulated on the two vehicles tested during the Phase I effort. The average improvement noted during this limited road test evaluation was 5.5%. On the other hand, the 32 vehicles that were evaluated during the road tests in Phase II accumulated more than 130,000 miles; the measured improvement in mileage attributed to CSAD is 6.5%. Results of the statistical analysis yielded an almost identical improvement of 6.4%. This similarity is undoubtedly due to the uniform vehicle distribution of the test fleet. The most significant results were obtained during Phase III because the fleet size for this case consisted of 328 vehicles, and the total mileage accumulation was more than 2.8 million miles.

The fuel economy improvement results based upon the weighted average data for Phase III was 7.0%. The corresponding value determined by statistical analysis for the total fleet was 5.7%. The lower statistical value reflects the nonuniform distribution of vehicles within the fleet. The important conclusion is that all of these results show a significant improvement in fuel economy using the CSAD concept. The overall benefit has been demonstrated to be about 6 to 7%. This observed result cannot be explained by chance variation; therefore, the modification has a definite positive effect on fuel economy.

Similar results were obtained during limited dynamometer tests using the FTP. Realistic results can only be obtained, however, by running the test with the dynamometer load changed from the presently specified value. For this reason the data shown in Table 4-1 were obtained with the accessories both OFF and ON. The impact of PAU settings on the fuel economy results were also investigated during this task. The same benefit in fuel economy can be achieved by reducing the PAU setting from the normal 10 hp to about 5 hp. The later test should be run, of course, with the accessory loads OFF. One of the key factors in the commercialization process is whether the urban FTP will fully credit a vehicle that includes a CSAD device by showing an appropriate increase in fuel economy. Options to provide this credit need continued work with EPA.

Table 4-1. Summary of Combined Fuel Economy Test Results, Percent Improvement

	Dynamometer		Road Test	
	Urban	Highway	Weighted Average	Statistical Mean
PHASE I				
Accessories OFF	2	4		
Accessories ON	6	8		
Normal Operation			5.5	
PHASE II				
Accessories OFF	2.1	6.2		
Accessories ON	5.5	8.1		
Normal Operation			6.5	6.4
PHASE III				
Normal Operation			7.0	5.7

In addition, the CSAD concept was demonstrated with three different designs, all of which showed significant fuel economy improvements. One possible concern in durability of the prototype CSAD unit has been associated with excessive wear rates which limit the life of the main drive belts. Further work is needed in this area to improve hardware durability.

Significant fuel economy improvements have been demonstrated for the CSAD concept. Recent automotive design trends toward transverse engine installations make the CSAD modification more difficult because of space limitations. Utilization of the concept should be encouraged whenever practical to conserve energy.

SECTION V

REFERENCES

1. Rottler, A.D., "Program Summary Report, Study on Reduction of Accessory Horsepower Requirements", AiResearch Manufacturing Company, ERDA Contract EY-76-C-03-1095, 1974-1977.

2. "Controlled-Speed Accessory Drive", report prepared by Morse Chain Division, Borg-Warner Corporation for the Semiannual Highway Vehicle Systems Contractors Coordination Meeting, October 4, 1977.

3. Avramidis, S.A., "FMC Variable-Ratio Automotive Accessory Drive," Unpublished Paper.

4. Courville, G., "Controlled Speed Accessory Drive, Interim Technical Report Phase II: Pilot Test," JPL Internal Document 5030-371, September 19, 1979.

5. Butterfield, R., Letter from Morse Chain to G. Courville, JPL, October 6, 1978.

6. Woollard, G., Letter from Morse Chain to G. Courville, JPL, October 24, 1979.

APPENDIX A

CSAD INSTALLATION PROCEDURE

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CSAD INSTALLATION PROCEDURE

INTRODUCTION

The purpose of this document is to provide an easy-to-follow description of the procedure for installation of a CSAD system on a 1977 or 1978 Ford Pinto with a 2.3 liter engine and air conditioning. Each of the steps outlined is written for a specific assembly and is intended to eliminate the task of referring to other documents to "get the job done." The intent is to provide detailed instructions on the "how to" and still allow ample freedom to adjust to changing environments.

SCOPE

This procedure establishes the equipment, material and instructions necessary for installing a CSAD system in a 1977 or 1978 Ford Pinto, 2.3 liter, 4-cylinder engine with air conditioning.

General Description

The CSAD system consists of a pair of centrifugally controlled variable pitch belt pulleys mounted on the crankshaft and water-pump of the engine. See Figures A-1 and A-2.

In addition to the two variable pulleys there is a main drive belt, A/C v-belt, alternator v-belt, and idler tensioner for the A/C v-belt. No special tooling is required for the installation other than the standard American and metric 1/4 in. and 1/2 in. drive socket sets. Estimated installation time is 2.5 hours. Reference drawings available are Morse Chain Division Drawings C-312818 and E-312819. A complete parts list is included in this document.

Instructions

The following is a step-by-step procedure with wrench sizes and torque value requirements. The vehicle engine should be cool enough to allow contact with the engine block without injury.

STEP 1 Raise hood, remove radiator cap and drain radiator coolant into catch pan for later retrieval. See Figure A-3.

STEP 2 Remove coil wire from center of coil.

STEP 3 Disconnect radiator hoses from radiator and disconnect hoses from engine. (Use a 5/8 in. and 3/8 in. nut driver or equivalent for loosening clamp bolts.) Shown in Figure A-3.

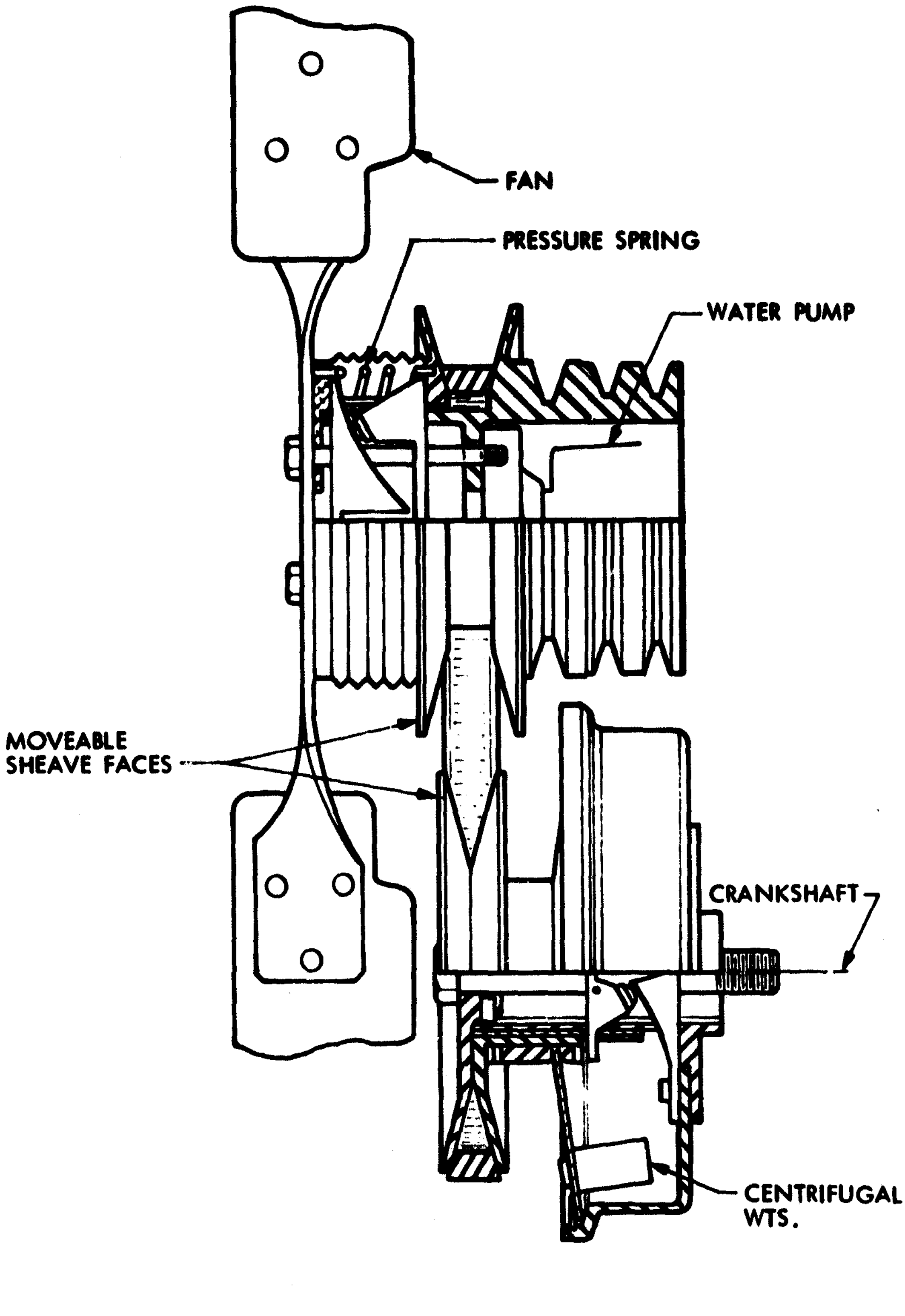


Figure A-1. Controlled Speed Accessory Drive System

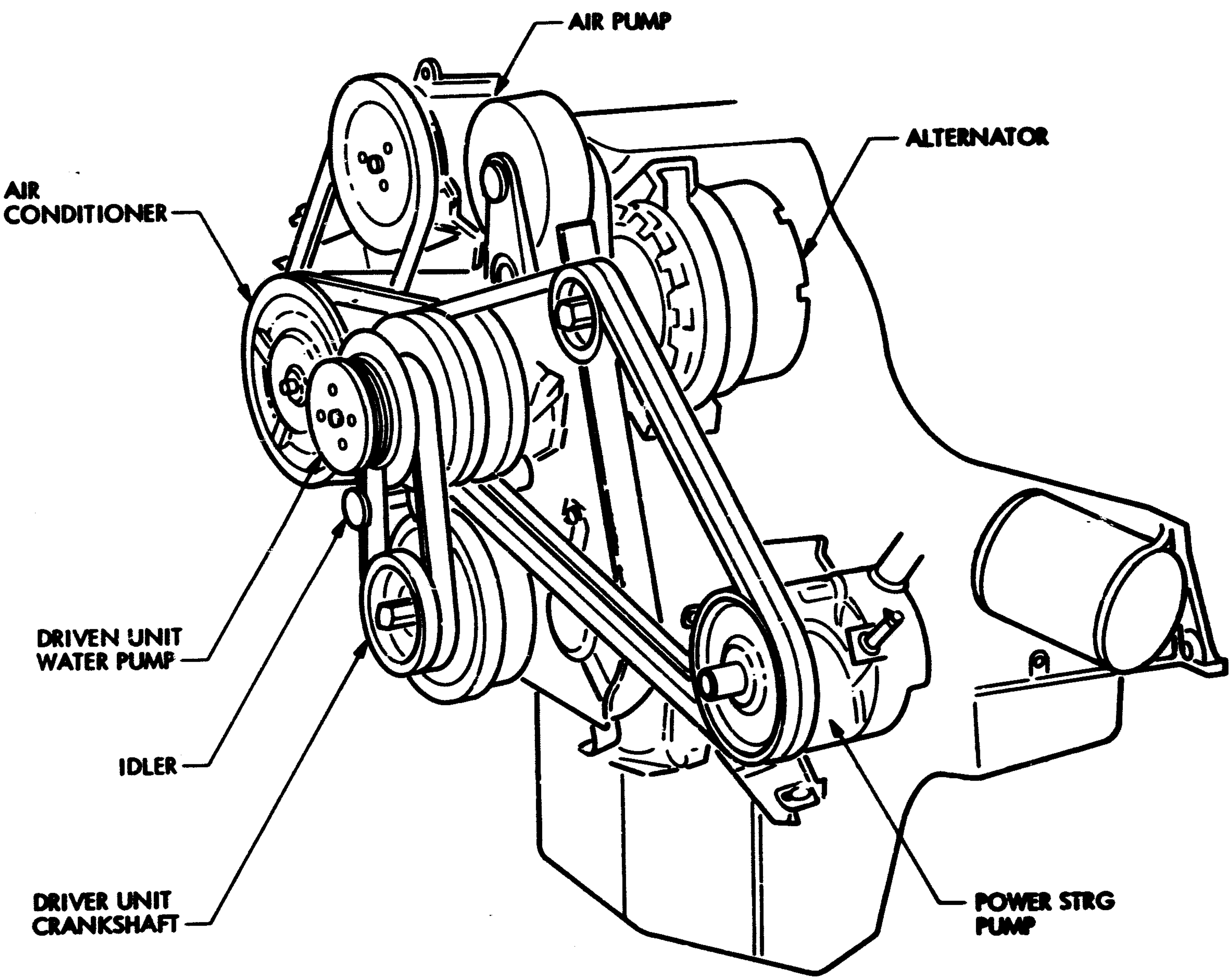


Figure A-2. CSAD Engine Installment

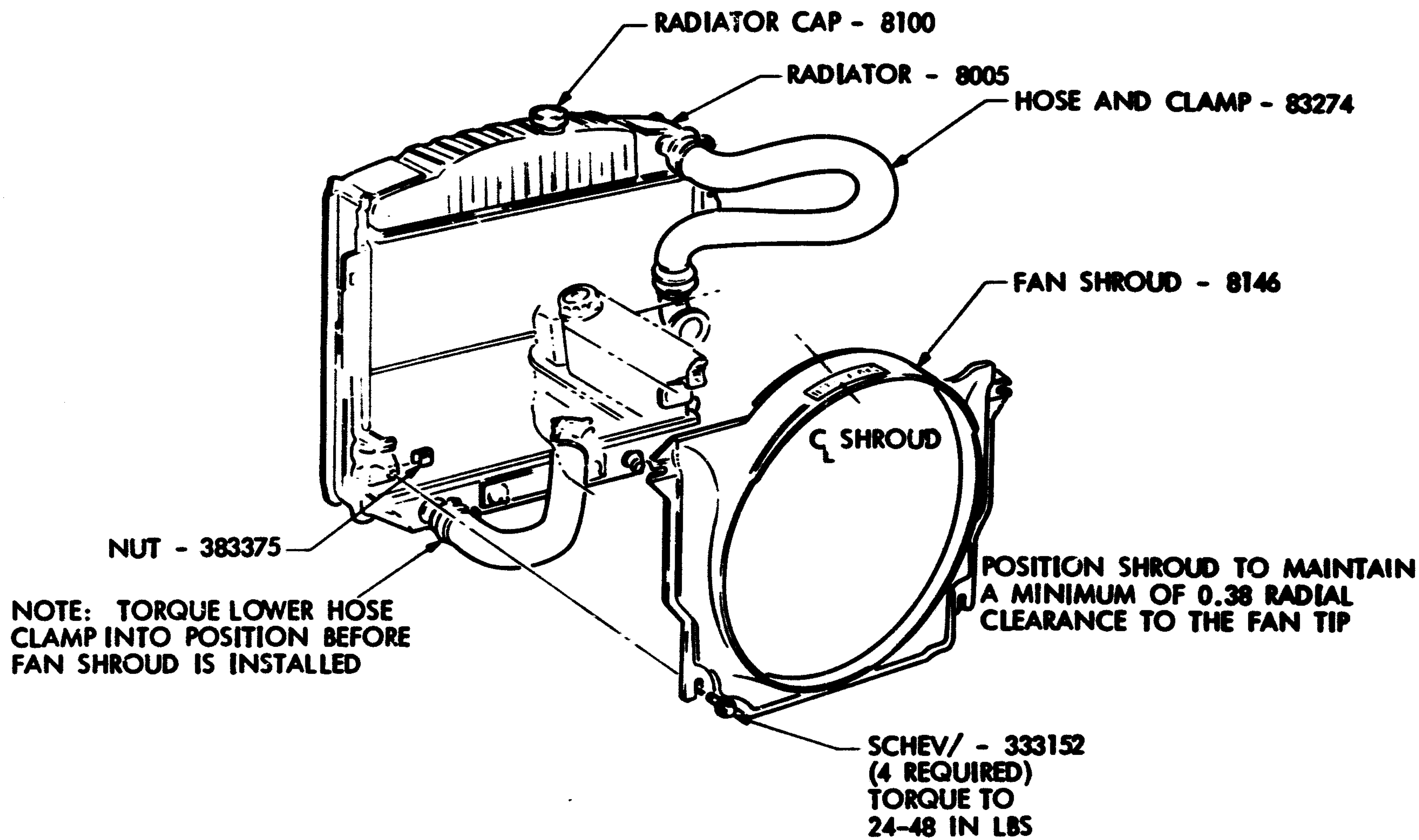


Figure A-3. Radiator and Shroud

STEP 4 On vehicles with an automatic transmission, disconnect the automatic transmission fluid cooler inlet and outlet lines from the radiator. CAUTION: place catch pan under fluid lines to catch transmission fluid that will drain from tubing. (Use a 5/8 in. open end wrench.)

STEP 5 Remove the 4 bolts holding fan shroud to radiator. NOTE: fan shroud cannot be removed from vehicle. When radiator has been removed, lay fan shroud over fan blades (7/16 in. socket or equivalent is required.)

STEP 6 Remove the 4 radiator mounting bolts and remove radiator from vehicle. CAUTION: threaded radiator clips are sometimes loose and may fall off (1/2 in. socket or equivalent is required.)

STEP 7 Remove fan shroud disconnected in Step 5 above from vehicle.

STEP 8 Disconnect heater hose from water-pump.

STEP 9 Remove two bolts from air conditioner v-belt tensioner. Remove air conditioner v-belt tensioner and air conditioner v-belt. (9/16 in. socket or equivalent is required.)

STEP 10 Loosen bolts that lock alternator in place. Relieve alternator v-belt tension. (5/8 in. and 9/16 in. socket or equivalent are required.)

STEP 11 Remove the alternator v-belt.

STEP 12 Remove 4 bolts that hold fan blades to water-pump.

STEP 13 Remove fan blades and water-pump pulley. (13 mm socket or equivalent is required.)

STEP 14 Remove center bolt holding crankshaft pulley. NOTE: An impact wrench or tool to hold crankshaft pulley from turning may be required if vehicle has automatic transmission. See Figure A-4. (22 mm socket or equivalent is required.)

STEP 15 Remove crankshaft pulley.

STEP 16 Remove the bolts holding outer timing belt cover to engine block and remove outer timing belt cover. (10 mm socket or equivalent and Phillips head screwdriver are required.) See Figure A-4.

STEP 17 Remove 3 bolts holding water-pump to engine block and remove water-pump. Clean gasket surface on both engine block and water-pump. (13 mm socket or equivalent is required.) See Figure A-5.

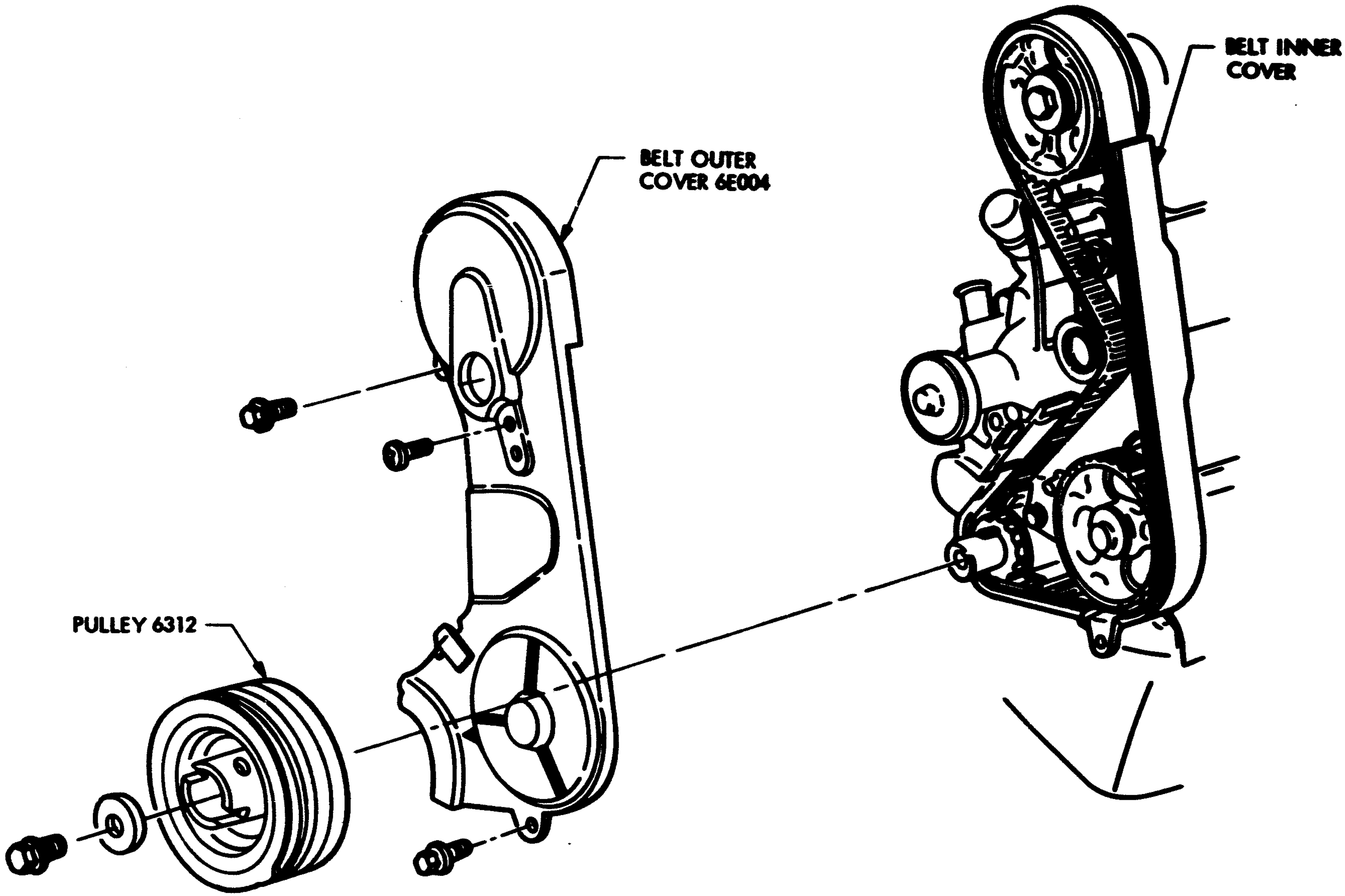
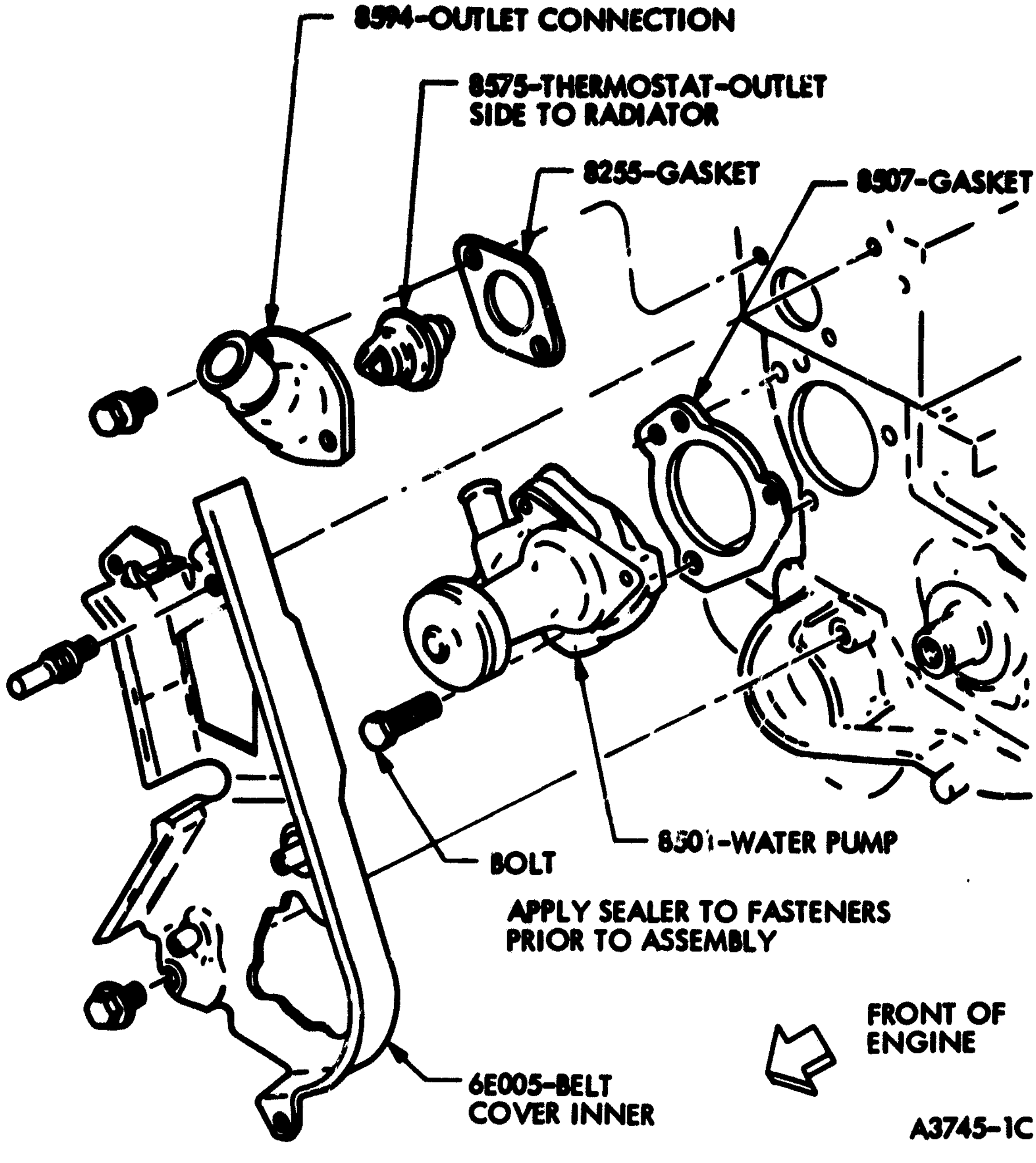


Figure A-4. Crankshaft Pulley Installation



WATER PUMP REMOVAL ILLUSTRATION

PROVISION FOR WRENCH CLEARANCE HAS BEEN MADE IN THE TIMING BELT INNER COVER, SO ONLY THE OUTER COVER MUST BE REMOVED IN ORDER TO REPLACE THE WATER PUMP

Figure A-5. Water-Pump Installation

STEP 18 Using templets supplied with kit for both fan shroud and outer timing belt cover, modify both outer timing belt cover and fan shroud by removing material as shown in Figures A-6 and A-7.

STEP 19 Install gasket and water-pump supplied with kit. Torque bolts from 14 - 20 ft-lbs. NOTE: apply standard gasket cement to gasket before installation.

STEP 20 Install modified outer timing belt cover. Torque bolts from 10 - 12 ft-lbs.

STEP 21 Install crankshaft pulley supplied with kit. Torque center bolt to 100-120 ft-lb. CAUTION: Assure that front half of pulley on crankshaft is free to turn before inserting center bolt and torquing. NOTE: an impact wrench or support retention tool on crankshaft pulley is required for vehicles with automatic transmission. NOTE: align yellow marks before torquing center bolt.

STEP 22 Install water-pump pulley supplied with kit. NOTE: align the 4 bolt holes with those on the water-pump flange. Place fan blades supplied with kit over water-pump pulley pilot, once again aligning the four bolts holes. Insert the 4 bolts supplied with kit and torque bolts to 20 ft-lbs. NOTE: torque bolts in a criss-cross sequence.

STEP 23 Install the two v-belts supplied with kit as follows:

(a) The shorter 3/8 in. wide belt goes on first. Loop it over the fan blades and then place in the middle water-pump pulley groove and the alternator pulley. Tension belt properly and tighten alternator bolts. (v-belt tension is 120-140 lbs.)

(b) The 1/2 in. wide, longer belt is then similarly installed, inserting in the air conditioning pulley and front water-pump pulley groove. The air conditioner belt tensioner runs against the backside of this v-belt. Tension v-belt to proper tension and torque tensioner bolts. (v-belt tension is 120-140 lbs., torque 5/16 in. idler bolts to 15 ft-lbs.)

STEP 24 Install 3/4 in. wide main drive belt supplied with kit, on crankshaft pulley and water-pump pulley per the following:

(a) Loop belt over fan blades.

(b) Open water-pump pulley by winding the forward pulley half, counterclockwise. Assure that forward half of pulley is extended to full open.

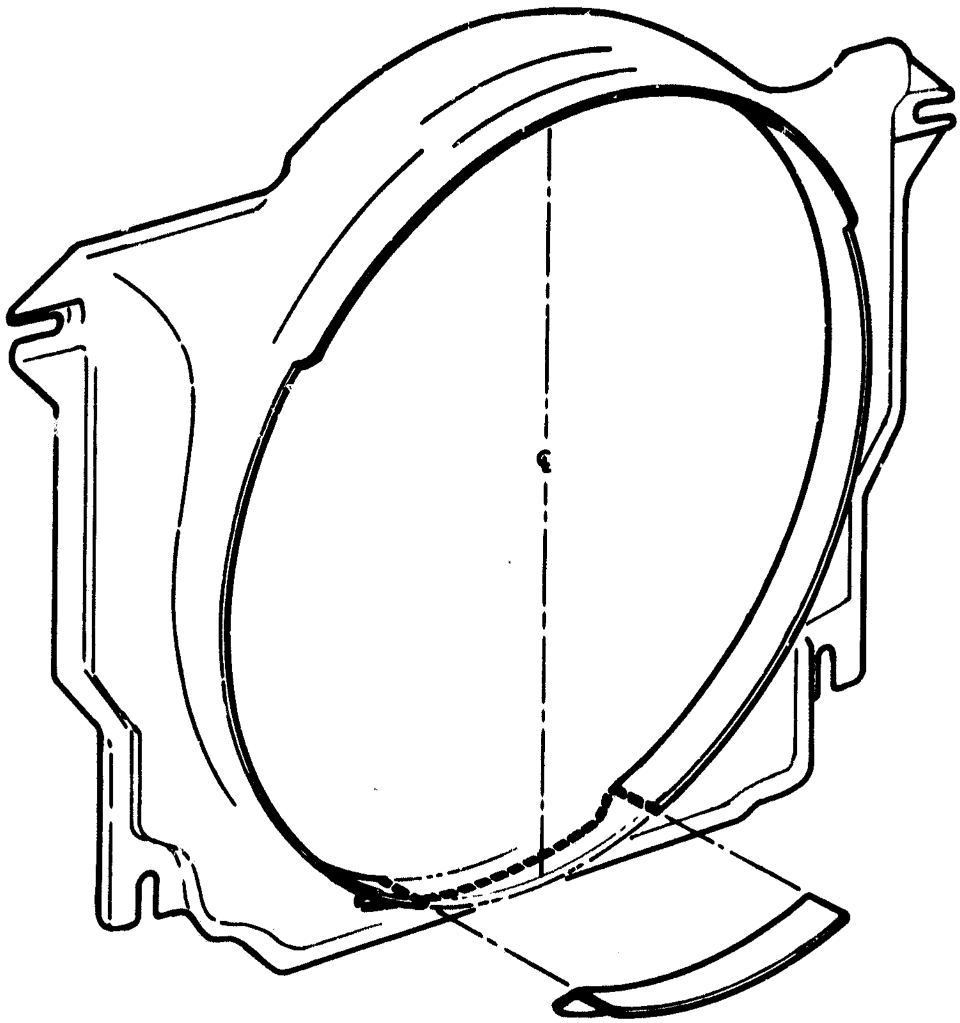
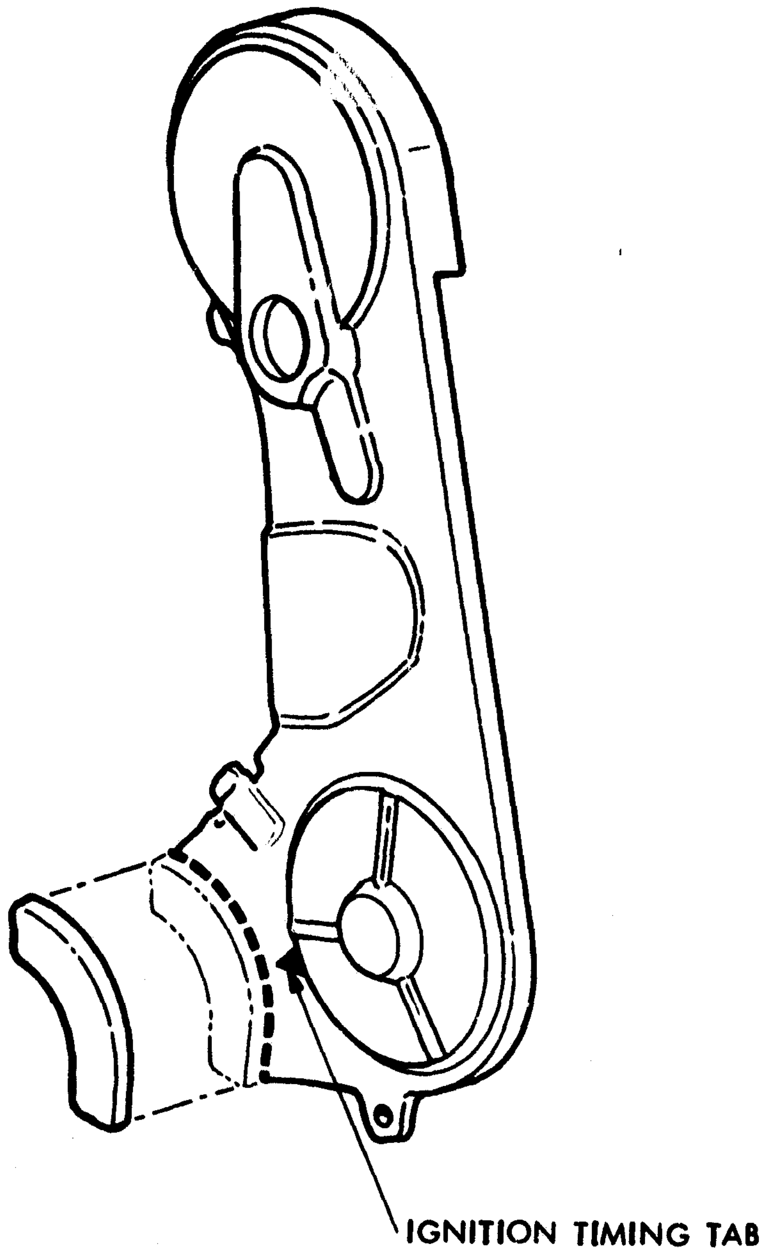


Figure A-6. Shroud Modifications



NOTE: IGNITION TIMING TAB
MUST BE TRIMMED ABOUT 1/8 in.,
TO ELIMINATE INTERFERENCE
WITH CSAD MAIN DRIVE PULLEY

Figure A-7. Ignition Timing Tab

(c) Place belt in the bottom of the groove of water-pump pulley and wrap belt around crankshaft pulley. NOTE: If unable to wrap belt around crankshaft pulley manually, verify that ignition coil wire has been removed and with ignition key turn engine over 2 or 3 times.

STEP 25 Check belt position by assuring forward half of water-pump pulley is fully released. Belt is automatically tensioned by the spring load in the water-pump pulley.

STEP 26 Replace upper water-pump hose.

STEP 27 Place modified fan shroud over fan blades and lay on engine block.

STEP 28 Replace radiator and connect radiator hoses, heater hose, and transmission cooler lines.

STEP 29 Place fan shroud in proper position on radiator and bolt in place.

STEP 30 Add coolant to radiator, and fluid to automatic transmission (if required).

STEP 31 Reconnect ignition coil wire.

STEP 32 Start engine and check for leaks.

STEP 33 Accelerate engine and assure main drive belt is moving up on water-pump pulley guides as the engine speed increases.

STEP 34 Package all removed stock auto parts in boxes kit parts were delivered in, and write vehicle license number on boxes.

STEP Tune vehicle to the proper Ford specification. NOTE: Assure all fluid levels (i.e., radiator, engine and transmission fluid, etc.) are to specification.

STEP 36 Installation is now complete and vehicle is ready for operational use.

LISTING OF MAJOR COMPONENTS

This section lists the major components in a CSAD system. Included is a parts list of the CSAD unit.

Major Components

1. Controlled speed accessory drive unit.

2. Water-pump with Morse Chain conversion.

3. Fan Blades.

4. Idler bracket.

5. Idler.

6. V-belt for alternator (3/8 in. x 30 in. x 38 in.).

7. V-belt for air conditioner (1/2 in. x 35 in. x 28 in. - SPL).

CONTROLLED SPEED ACCESSORY DRIVE UNIT PARTS LIST

PI-IT 2.3L CSAD   Assembly No. C-312860   Revision 6/2/78

Part	Required	Nomenclature
C-312860		PI-IT 2.3L Unit Assembly
	1	Spring Retainer (Cover) Unit Subassembly Driver
A-312820	1	Drive Belt
A-312829	1	Crankshaft Bolt
A-312873	1	Washer (Fixed Flange) Driver
B-312775	1	Snap Ring (Spring Retainer)
B-312861	1	Spring Retainer (Cover) Assembly
B-312796	1	Driver Shaft
C-312848	1	Spring Retainer-Stamping
B-312845	1	Driver Cam
A-312779	4	Cam Mtg. Screw
B-312907	1	Sliding Flange Assembly
B-312908	1	Sliding Flange Stamping Drawing
B-312909	1	Sliding Flange Machine Drawing
A-312867	1	Dust Cover Retaining Ring
A-312772	2	Thrust Washer
A-312869	2	Inboard Fulcrum
A-312811	1	Snap Ring-Dr Sliding Flange
B-312870	1	Driver Cam Follower
A-312854	3	Cam Follower Pad-Driver
A-312774	2	Driver Bearing
A-312866	1	Driver Spring Subassembly
B-312766	1	Driver Spring

Part	Required	Nomenclature
A-312767	18	Driver Spring Wt.
A-312769	18	Driver Spring Wt. Screw
B-312910	1	Fixed Flange Dr. Stamping Dwg
*	1	Dust Cover
	1	Driven-Unit Subassembly
A-312828	4	Fan Bolts
C-312850	1	Fixed Flange And Hub
B-312875	1	Sliding Flange Assembly
A-312844	3	Dn Follower Pad
B-312830	1	Torque Cam Spring-Dn
A-312881	1	Spring Mounting Screw
A-312857	1	Dust Cover Mounting Ring-Dn
A-312886	6	Dust Cover Screw
8	1	Dust Cover
A-312902	1	Lock Washer

* No Morse Drawing

APPENDIX B

PHASE II TEST RESULTS

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/12/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH.ID: G13-615 VEH.TYPE: 6 DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	780.1	16.2	0.0	2896	5.69	80.0 4.0	49.0 1.0	454.0 29.	1.16 .05	1.13	1.62	11.56	473.63	17.90
	PARTIC MGS IN= .80		FLOURATE(LPM)= .0			BAG-TIME (SEC)= 0		CORR.PARTIC.GMS.=8888		PGPM=88888				
BAG 2	780.1	16.2	6.0	4920	6.10	7.0 3.0	11.0 .0	20.0 11.	.74 .04	.09	.30	.41	473.39	18.69
	PARTIC MGS IN= .80		FLOURATE(LPM)= .0			BAG-TIME (SEC)= 0		CORR.PARTIC.GMS.=8888		PGPM=88888				
BAG 3	780.1	16.9	6.0	2988	5.62	17.0 1.2	45.0 .0	19.0 4.0	1.00 .04	.22	1.53	.17	415.97	21.27
	PARTIC MGS.IN= .80		FLOURATE(LPM)= .0			BAG-TIME (SEC)= 0		CORR.PARTIC.GMS.=8888		PGPM=88888				
BAG 4	779.5	16.9	7.0	4285	16.11	24.0 3.0	98.0 .0	32.0 4.0	1.50 .04	.15	1.72	.40	343.06	25.77
	PARTIC MGS IN= 80		FLOURATE(LPM)= 0			BAG-TIME (SEC)= 0		CORR.PARTIC.GMS.=8888		PGPM=88888				

WEIGHTED 3-BAG VALUES: WHCGPM= .34 WNOGPM= 1.06 WCOGPM= 2.66 WC2GPM=457.8 WMPG=19.15

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/13/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-2311 (REG) .VEH TYPE: G DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	773 4	17 5	24	2057	5 66	140 0 6 0	39 0 0	335 0 4 0	1 13 04	1 70	1 30	0 87	460.54	18 47
BAG 2	773 2	18 4	24	6071	6 07	14 0 2 0	10 0 0	7 1 3 0	75 94	.26	.57	18	477 14	18 54
BAG 3	773 1	18 7	24	2038	5 62	22 0 2 5	35 0 0	11 0 3 0	1 05 04	26	1.25	22	427.18	20.71
BAG 4	773 2	18 0	25	4196	16 10	39 0 3 5	77 0 0	50 0 3 0	1 63 05	25	1.42	77	345 19	25 54

WEIGHTED 3-BAG VALUES: WHCGPM= 57 WNOGPM= 92 WCOGPM= 1 99 WC2GPM=460 0 WMPG=19 07

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE 1/13/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-615(AC&LTS) VEH TYPE: G DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	774 0	17 7	20	2466	5 70	74 0 4 0	70 0 0	235 0 34	1 20 .05	.93	2 72	5.45	510.43	16 73
BAG 2	774 4	17 0	19	4044	6 13	12 5 3 5	43 0 0	10 0 2 0	89 .05	19	2 35	.34	556.41	15.91
BAG 3	774 4	17.7	20	2030	5 67	16.0 3 5	86 0 0	14 0 2 0	1 17 04	17	2 97	.32	472.37	18.73
BAG 4	779 5	16 9	7 0	4256	16 12	19.0 3.0	160 0	16 0 4 0	1 72 04	11	2 79	.10	371.40	23.83

WEIGHTED 3-BAG VALUES: WHCGPM= .34 WNOGPM= 2 60 WCOGPM= 1 40 WC2GPM=529 5 WMPG=16 77

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/13/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-2311(AC&LT) VEH TYPE: G DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	772 6	17 7	12	2022	5 62	130 0 4 0	69 0 0	295 0 4 0	1 32 .04	1 67	2 33	7 76	530.06	15 96
BAG 2	767 2	20 1	8 0	4700	6 10	15 0 2 0	39 0 0	2 5 1 0	92 04	.27	2 04	.07	570.62	15 30
BAG 3	767 6	21 4	7 0	2700	5 65	20 0 1 0	76 0 0	12 0 2 0	1 21 04	.25	2.49	.27	[illegible]	[illegible]
BAG 4	772 0	10 4	24	4143	16 10	26 0 2 0	110 0	9 5 3 0	1 79 .04	.16	2 14	.09	377.19	23 47

WEIGHTED 3-BAG VALUES: WHCGPM= .55 WNOGPM= 2 22 WCOGPM= 1 71 WC2GPM=543.9 WMPG=16.17

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/15/78 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-2303 (REG) VEH TYPE: G DRIVER: 40

	PB	PD	RH	VMIX	KR	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	767 0	10.4	10	2009	5 66	15[illegible] 0 6 0	46 0 0	335 0 4.0	1 16 .04	1.69	1.33	0.73	465.59	10.30
BAG 2	760 0	10 4	10.	4001	6.09	12 0 2 0	13 0 0	6 0 2.0	76 04	.21	.69	17	475.26	10.62
BAG 3	760 2	10 7	10	2002	5 65	10 0 2.0	44.0 0	0 0 1 5	1.05 .05	.21	1.46	17	415.40	21.30
BAG 4	760 6	10 4	10	4129	16 04	25.0 3 5	05 0 0	5 5 1.5	1.65 .04	.15	1.46	06	346.99	23.32

WEIGHTED 3-BAG VALUES: WHCGPM= .32 WNOGPM= 1.07 WCOGPM= 1.95 WC2GPM=436.9 WMPG=19.21

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/15/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-2303 (AC&LT) VEH TYPE: G DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	773 0	20 1	10	2047	5 65	105 0 6 0	77 0 0	300 0 5 0	1 33 04	1 32	2 60	0 11	564.07	15 01
BAG 2	773 0	19 7	10	4705	6 03	15 0 4 0	53 0 0	4 0 2 0	92 04	.24	2 02	09	504.39	15.15
BAG 3	772 6	19 1	10	2008	5 60	20 0 2 0	82 0 0	12 5 2 0	1.24 04	.24	2.75	.20	503.95	17 56
BAG 4	760 0	18 7	10	4099	16 05	21 0 2 5	135 0	7 0 1 0	1 01 04	.13	2 31	00	370 56	23 39

WEIGHTED 3-BAG VALUES: WHCGPM= 46 WNOGPM= 2 76 WCOGPM= 1 01 WC2GPM=553 9 WMPG=15 09

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REF

TEST-DATE: 1/17/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-2303 CSADSTD , VEH TYPE: G DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	766.4	17.7	19	2020	5.69	86.0 4.0	35.0 0	335.0 6.0	1.15 .05	1.07	1.16	8.67	457.02	18.71
BAG 2	766.2	16.9	12	4011	6.17	10.0 2.0	9.0 0	17.5 5.0	.76 .04	.17	.97	.53	470.31	18.80
BAG 3	765.6	17.2	12	2085	5.65	18.0 3.0	34.0 0	21.0 0.0	1.03 .04	.20	1.13	.36	411.50	21.48
BAG 4	763.0	16.9	12	4151	16.09	21.5 2.5	68.0 0	32.5 5.0	1.57 .04	.13	1.10	.30	330.58	26.74

WEIGHTED 3-BAG VALUES: WHCGPM= .36 WNOGPM= .79 WCOGPM= 2.16 WC2GPM=451.6 WMPG=19.44

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/13/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-2303 CSACLT VEH TYPE: G DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	761 1	19 3	7 0	2809	5 69	110 0 6 0	59 0 0	348 0 3 0	1 22 .04	1 36	1.93	9 05	407.77	17 52
BAG 2	761 1	19 3	7 0	4764	6 15	13 0 3 5	45 0 0	3 0 1 0	85 .04	20	2.31	08	529 53	16.05
BAG 3	762 0	19 3	7 0	2792	5 65	20 0 3 5	66 0 0	22 0 2 0	1.15 .04	22	2.16	.53	459.65	19 23
BAG 4	764 8	17 3	11	4129	16 05	16 0 2 0	101 0	11 0 4 0	1.72 .04	10	1.74	10	362.01	24.47

WEIGHTED 3-BAG VALUES: WHCGPM= .44 WNOGPM= 2 15 WCOGPM= 2 06 WC2GPM=499.0 WMPG=17.58

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE 1/19/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-2311 CSAGSTD VEH TYPE: G DRIVER: AD

	PE	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	769 6	18 7	0 0	2842	5 58	130 0 6 0	35 0 0	375 0 0 0	1 12 04	1 67	1 18	9.94	460.43	18.42
BAG 2	769 5	18 7	0 0	4023	6 00	12 0 3 0	0 0 0	12 0 3 0	74 04	19	.43	39	471.37	18.76
BAG 3	769 5	19 0	0 0	2822	5 54	20 0 3 0	33 0 0	18 0 2.5	1 02 04	23	1.12	42	418.03	21.14
BAG 4	748 0	22 2	20	4033	16 00	10 5 2 0	77 0 0	6 0 1 0	1.51 05	.11	1.30	.07	388.48	20.71

WEIGHTED 3-BAG VALUES: WHCGPM= 31 WNOGPM= 77 WCOGPM= 2.38 WC2GPM=454.5 WMPG=19.28

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE 1/22/79 VEH MAKE&MODEL: FORD PINTO (GSW) VEH ID: G13-2311 CSWCLT VEH TYPE: G DRIVER: AD

	FE	FC	RH	VMIX	KM	HCPPM		NOXPPM		COPPM		CO2%		HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	747.4	21.8	20	2741	5.63	74.0	2.0	56.0	0	228.0	3.0	1.27	.04	.92	1.93	5.02	501.30	17.27
BAG 2	747.5	21.0	20	4603	6.10	12.5	3.0	27.0	0	9.0	2.0	.90	.05	.20	1.47	.29	547.36	16.17
BAG 3	747.0	21.0	20	2733	5.64	27.0	5.0	55.0	0	36.0	1.0	1.15	.05	.25	1.89	.90	447.11	19.73
BAG 4	747.0	22.0	20	4027	16.02	17.0	2.0	118	0	15.0	2.0	1.66	.05	.10	1.96	.18	339.15	26.10

WEIGHTED 3-BAG VALUES: WHCGPM= .37 WNOGPM= 1.66 WCOGPM= 1.60 WC2GPM=510.4 WMPG=17.25

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/22/79 VEH MAKE&MODEL: FORD PINTO (GSA) VEH ID: G13-615 CSACLT VEH TYPE: G DRIVER: AD

	PB	PG	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	749.1	19.3	22	2736	5.61	86.0 6.0	61.0 .0	375.0 2.0	1.26 .04	1.04	2.12	9.74	502.30	17.02
BAG 2	749.4	19.3	22	4686	6.04	13.0 3.0	33.0 .0	14.0 2.0	.86 .04	.21	1.81	.50	532.50	16.61
BAG 3	745.8	20.7	20	2742	5.68	18.0 3.5	67.0 .0	19.0 2.0	1.15 .04	.20	2.31	.45	455.37	19.42
BAG 4	766.7	21.4	12	4130	15.91	10.0 2.0	130 .0	7.0 1.0	1.64 .04	.06	2.30	.0*	340.43	25.43

WEIGHTED 3-BAG VALUES: WHCGPM= .38 WNOGPM= 2.81 WCOGPM= 2.40 WC2GPM=505.2 WMPG=17.38

DOT/TSC CHASSIS-DYNO FTP-HWY EMISSIONS REPORT

TEST-DATE: 1/22/79   VEH MAKE&MODEL: FORD PINTO (GSA)   VEH ID: G13-615 CSADSTD .   VEH TYPE: G   DRIVER: AD

	PB	PD	RH	VMIX	KM	HCPPM	NOXPPM	COPPM	CO2%	HCGPM	NOXGPM	COGPM	CO2GPM	MPG
BAG 1	766 5	22 9	14	2006	5 61	62 0 4 0	40 0 0	107 0 2 0	1.10 .04	.77	1.30	2.79	444.07	19.67
BAG 2	766 6	22 1	14	4001	6 06	10 0 2 0	10 6 0	10 0 1 0	.72 .04	.17	.54	.30	451.23	19 66
BAG 3	766 7	22 1	14	2017	5 59	13.0 2 0	40 0 0	16 0 1 0	.99 .04	.15	1.39	.40	401.25	22 [illegible]
BAG 4	770 0	20 1	7 0	4192	15 00	12 0 3.0	74.0 0	7 0 2 0	1.51 .04	06	1.30	.07	325.00	27.2[illegible]

WEIGHTED 3-BAG VALUES: WHCGPM= .29   WNOGPM= .95   WCOGPM= .89   WC2GPM=436.1   WMPG=20.23

APPENDIX C

INPUT DATA SHEET

APPENDIX D

PHASE III TEST RESULTS

1977 VEHICLES

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OF POOR QUALITY

VEHICLE SUMMARY

SITE	VEH	TYPE	* MILES DRIVEN TOTAL	MN	SD	**GALLONS USED** TOTAL	MN	SDEV	M P G AVG	SD	** %CITY MN	SD *
MASS	613	STOCK	12361.	188.	80.	622.	9.	1.	19.88	1.70	66.33	18.93
MASS	619	STOCK	7966.	199.	38.	350.	9.	2.	21.66	1.98	20.36	26.74
MASS	620	STOCK	17815.	196.	48.	826.	9.	2.	20.63	2.10	24.49	7.01
MASS	621	STOCK	8017.	196.	117.	396.	10.	7.	20.23	2.23	40.02	22.44
MASS	622	STOCK	13808.	203.	30.	646.	10.	1.	20.91	2.06	60.00	20.97
MASS	2301	STOCK	2337.	193.	37.	116.	10.	1.	20.14	2.99	10.03	9.00
MASS	2305	STOCK	11094.	201.	65.	501.	9.	2.	22.00	4.02	19.65	27.49
MASS	2306	STOCK	9151.	197.	35.	338.	9.	1.	15.91	3.16	87.43	15.21
MASS	2310	STOCK	29097.	287.	37.	1316.	10.	1.	22.14	2.12	10.95	16.09
MASS	2316	STOCK	8936.	203.	55.	433.	10.	2.	20.63	3.31	29.53	38.09
MASS	2317	STOCK	16168.	170.	46.	760.	8.	1.	21.20	3.06	46.86	20.07
MASS	2319	STOCK	15670.	196.	36.	800.	10.	1.	19.58	2.02	30.68	6.31
MASS	2320	STOCK	11300.	299.	62.	514.	10.	2.	22.00	4.39	37.07	30.01
MASS	2321	STOCK	8457.	134.	89.	519.	9.	1.	16.20	3.46	70.91	26.41
MASS	2323	STOCK	7741.	196.	39.	375.	9.	1.	20.66	3.42	45.18	33.80
MASS	2324	STOCK	13353.	202.	49.	580.	9.	2.	22.71	2.70	22.08	22.07
MASS	2325	STOCK	10854.	208.	49.	904.	10.	2.	20.56	5.07	24.30	10.99
MASS	2326	STOCK	2590.	235.	40.	113.	10.	1.	22.90	2.61	40.99	20.35
MASS	2357	STOCK	10020.	189.	70.	446.	8.	3.	22.59	2.60	34.63	27.65
MASS	2360	STOCK	18163.	213.	33.	869.	10.	1.	21.30	2.56	77.63	6.69
MASS	2361	STOCK	10972.	213.	46.	465.	9.	2.	23.37	3.33	19.18	13.82
MASS	2362	STOCK	11030.	196.	38.	529.	9.	1.	20.86	2.29	59.41	22.63
MASS	2364	STOCK	6025.	183.	42.	250.	8.	2.	24.12	3.93	17.70	10.13
MASS	2367	STOCK	11033.	182.	52.	556.	9.	2.	21.29	3.12	29.93	36.19
MASS	3652	STOCK	4336.	181.	63.	190.	8.	2.	22.36	3.94	17.12	13.63
MASS	3653	STOCK	13194.	160.	50.	607.	7.	2.	21.67	4.40	26.59	26.40
MASS	3656	STOCK	16383.	221.	44.	669.	9.	2.	24.03	2.03	19.80	16.67
MASS	3659	STOCK	10973.	207.	90.	485.	9.	2.	22.62	3.69	36.05	38.65
MASS	3663	STOCK	2221.	202.	41.	101.	9.	2.	22.03	3.45	41.36	41.19
MASS	612	MOD	9690.	196.	64.	420.	9.	3.	23.05	3.19	23.73	22.54
MASS	615	MOD	11690.	170.	70.	530.	8.	3.	21.73	3.52	20.93	27.07
MASS	616	MOD	14963.	199.	61.	664.	9.	2.	22.51	3.05	20.60	25.73
MASS	617	MOD	10768.	211.	136.	472.	9.	6.	22.80	3.30	26.47	20.08
MASS	618	MOD	7475.	187.	54.	359.	9.	2.	20.80	3.00	30.25	32.00
MASS	623	MOD	9298.	202.	61.	427.	9.	3.	21.79	3.12	20.48	29.26
MASS	2302	MOD	6602.	174.	54.	320.	8.	2.	20.61	4.56	37.10	31.20
MASS	2303	MOD	15599.	200.	70.	656.	9.	2.	23.77	4.57	31.80	32.19
MASS	2304	MOD	14460.	201.	53.	650.	9.	2.	22.25	3.04	39.52	26.40
MASS	2307	MOD	13373.	223.	60.	595.	10.	2.	22.40	4.21	32.13	22.33
MASS	2308	MOD	8329.	185.	53.	410.	9.	2.	20.34	4.35	27.06	31.79
MASS	2309	MOD	7945.	204.	63.	360.	9.	2.	22.08	4.91	29.80	27.76
MASS	2311	MOD	15302.	160.	50.	706.	8.	3.	21.67	3.00	37.71	33.69
MASS	2312	MOD	12266.	183.	65.	581.	9.	3.	21.10	3.40	23.30	22.10
MASS	2313	MOD	8536.	182.	56.	385.	8.	2.	22.17	4.30	22.76	27.00
MASS	2314	MOD	14657.	208.	71.	609.	8.	3.	24.06	3.77	30.60	29.53
MASS	2318	MOD	10923.	195.	86.	503.	9.	4.	21.71	3.70	30.60	20.23
MASS	2322	MOD	9981.	200.	45.	451.	9.	2.	22.14	2.73	24.86	25.00
MASS	2355	MOD	8221.	175.	61.	351.	7.	2.	23.41	4.29	23.91	30.19
MASS	2358	MOD	11019.	220.	60.	458.	9.	2.	24.08	2.53	29.04	21.32
MASS	2359	MOD	9860.	190.	47.	462.	9.	2.	21.34	3.63	36.05	36.60

VEHICLE SUMMARY

SITE	VEH	TYPE	* MILES DRIVEN			** GALLONS USED			** M P G		** % CITY	*
			* TOTAL	HW	CD	** TOTAL	HW	CD	AVG	CD	** HW	CD *
MASS	2303	MOD	11239.	190.	63.	470.	8.	2.	23.61	4.30	18.34	18.73
MASS	3691	MOD	10900.	190.	75.	458.	9.	3.	23.28	3.90	33.67	35.16
MASS	3694	MOD	13992.	201.	76.	593.	10.	3.	23.50	4.09	38.68	20.33
MASS	3695	MOD	10985.	209.	63.	493.	9.	3.	22.30	3.38	26.90	30.29
MASS	3696	MOD	9958.	203.	40.	462.	9.	2.	21.52	3.11	26.00	20.79
MASS	3600	MOD	12975.	206.	63.	520.	9.	3.	23.05	3.10	25.69	29.60
MASS	3602	MOD	11279.	201.	63.	501.	9.	2.	22.41	3.40	29.96	29.61
FLA	4079	STOCK	7021.	190.	27.	330.	9.	1.	21.29	1.66	14.70	25.09
FLA	4080	STOCK	6041.	185.	30.	290.	9.	1.	20.44	1.65	7.00	21.69
FLA	4081	STOCK	13097.	201.	32.	678.	9.	2.	22.09	2.71	23.33	24.09
FLA	4082	STOCK	16090.	194.	30.	739.	9.	2.	21.99	2.22	24.00	24.40
FLA	4083	STOCK	16177.	190.	28.	726.	9.	2.	22.34	2.06	20.39	23.37
FLA	4088	STOCK	23021.	209.	37.	1021.	9.	2.	22.59	2.67	24.93	20.49
FLA	4089	STOCK	12560.	187.	32.	632.	10.	2.	19.87	3.73	9.75	10.99
FLA	4090	STOCK	6649.	176.	36.	333.	9.	2.	20.50	2.05	24.36	59.26
FLA	4091	STOCK	20038.	187.	45.	1052.	9.	2.	19.90	2.93	6.70	10.80
FLA	4092	STOCK	16760.	197.	31.	810.	10.	1.	20.94	2.60	4.53	16.58
FLA	4093	STOCK	7015.	195.	36.	357.	10.	1.	19.70	2.09	.00	.00
FLA	6100	STOCK	8570.	206.	37.	396.	9.	1.	21.77	4.05	.00	.00
FLA	6101	STOCK	18010.	176.	30.	1033.	9.	1.	18.29	2.01	.00	.00
FLA	6102	STOCK	9863.	183.	10.	530.	10.	1.	18.61	2.20	.00	.00
FLA	6103	STOCK	20705.	211.	31.	972.	10.	1.	21.29	1.60	20.11	24.21
FLA	6104	STOCK	7950.	164.	30.	392.	9.	1.	20.22	1.82	.00	.00
FLA	6105	STOCK	11900.	190.	20.	565.	9.	1.	21.09	1.03	.00	.00
FLA	6106	STOCK	3326.	166.	36.	173.	9.	1.	19.18	1.37	.00	.00
FLA	6107	STOCK	11989.	210.	39.	552.	10.	1.	21.72	2.79	.00	.00
FLA	6108	STOCK	2855.	178.	25.	150.	9.	1.	19.00	.72	.00	.00
FLA	6109	STOCK	9685.	179.	32.	513.	10.	1.	18.86	2.24	.00	.00
FLA	6110	STOCK	9061.	157.	31.	481.	6.	2.	18.80	1.75	.00	.00
FLA	6111	STOCK	2677.	191.	23.	132.	9.	1.	20.23	1.95	.00	.00
FLA	6112	STOCK	13232.	195.	23.	672.	10.	1.	19.69	1.32	.00	.00
FLA	6113	STOCK	3029.	189.	20.	156.	10.	1.	19.30	1.95	.63	2.90
FLA	6114	STOCK	2014.	201.	22.	103.	10.	1.	19.59	1.13	.63	.00
FLA	6116	STOCK	19395.	194.	28.	978.	10.	1.	19.83	2.13	.00	.00
FLA	6117	STOCK	8717.	178.	00.	449.	9.	2.	19.42	2.20	.00	.00
FLA	175	MOD	11066.	205.	39.	506.	9.	2.	21.97	1.23	.00	.00
FLA	2076	MOD	13617.	210.	22.	619.	10.	1.	21.02	1.20	.00	.00
FLA	2077	MOD	8252.	201.	27.	392.	10.	1.	21.07	1.47	.00	.00
FLA	2078	MOD	13251.	192.	23.	679.	10.	1.	19.51	2.13	.00	.00
FLA	2079	MOD	8401.	205.	69.	399.	10.	2.	21.05	2.39	.00	.00
FLA	2080	MOD	2192.	212.	25.	303.	10.	1.	20.27	1.02	.00	.00
FLA	2081	MOD	20450.	197.	34.	996.	9.	1.	20.74	2.00	.00	.00
FLA	2082	MOD	3962.	189.	49.	203.	10.	2.	19.51	2.02	.00	.00
FLA	2083	MOD	7091.	192.	27.	346.	9.	1.	20.51	.89	.00	.00
FLA	2084	MOD	9619.	196.	30.	460.	9.	1.	20.90	1.59	.00	.00
FLA	2085	MOD	8671.	177.	35.	406.	8.	2.	21.33	1.73	.00	.30
FLA	2086	MOD	5345.	223.	29.	263.	11.	1.	20.32	1.96	.00	.00
FLA	2087	MOD	9492.	167.	29.	485.	9.	1.	19.50	1.60	.00	.00
FLA	2088	MOD	12505.	192.	30.	616.	9.	1.	20.29	1.87	.00	.00
FLA	2089	MOD	9459.	200.	37.	465.	9.	2.	21.43	1.67	.00	.00

VEHICLE SUMMARY

SITE	VEH	TYPE	* MILES DRIVEN TOTAL	MN	SD	** GALLONS USED ** TOTAL	MN	SD	M P G AVG	SD	** %CITY MN	SD *
FLA	2101	MOD	9808.	190.	18.	463.	10.	1.	20.04	1.37	.00	.00
FLA	2102	MOD	9327.	194.	33.	467.	10.	1.	20.30	1.91	.00	.00
FLA	2103	MOD	13293.	205.	21.	673.	10.	1.	19.76	1.12	.00	.00
FLA	2104	MOD	10636.	201.	41.	475.	9.	2.	22.39	1.49	.00	.00
FLA	2105	MOD	3621.	172.	23.	220.	11.	1.	16.13	1.90	.00	.00
FLA	2106	MOD	15487.	191.	19.	826.	10.	1.	18.92	1.61	.00	.00
FLA	2107	MOD	2608.	168.	23.	150.	10.	1.	17.08	1.96	.00	.00
FLA	2108	MOD	7497.	187.	30.	383.	10.	1.	19.59	2.14	.00	.00
FLA	2109	MOD	15325.	213.	26.	754.	10.	1.	20.36	1.09	.00	.00
FLA	2110	MOD	12008.	168.	16.	618.	10.	1.	19.43	1.84	.00	.00
FLA	2111	MOD	14745.	197.	23.	729.	10.	1.	20.23	1.13	.00	.00
FLA	2112	MOD	14702.	204.	34.	650.	9.	1.	22.60	2.34	.00	.00
FLA	2113	MOD	6674.	180.	29.	381.	10.	1.	17.51	1.81	.00	.00
FLA	2114	MOD	5566.	191.	29.	277.	10.	1.	20.08	1.06	.00	.00
FLA	2115	MOD	11800.	206.	34.	566.	10.	1.	19.78	2.06	.00	.00
FLA	2116	MOD	11255.	188.	31.	539.	9.	1.	20.87	1.39	.00	.00
FLA	2117	MOD	29041.	186.	26.	1537.	10.	1.	19.36	1.48	.00	.00
FLA	2118	MOD	9791.	181.	33.	512.	9.	2.	19.18	1.66	.00	.00
FLA	2119	MOD	13174.	169.	32.	636.	8.	1.	20.79	2.29	.00	.00
FLA	2120	MOD	8648.	170.	32.	469.	9.	1.	18.48	2.70	.00	.00
FLA	2121	MOD	7255.	202.	28.	357.	10.	1.	20.33	1.21	.00	.00
FLA	2122	MOD	6159.	181.	22.	336.	10.	1.	18.45	.92	.00	.00
FLA	2123	MOD	6529.	192.	32.	314.	9.	1.	20.77	1.31	.00	.00
FLA	2124	MOD	4649.	194.	33.	261.	10.	1.	18.35	3.04	.00	.00
FLA	2125	MOD	4670.	173.	41.	254.	9.	1.	18.48	3.36	.00	.00
FLA	2377	MOD	3494.	182.	62.	186.	10.	2.	18.53	4.19	30.15	46.15
FLA	2378	MOD	6729.	198.	40.	306.	9.	1.	22.60	2.32	6.70	17.02
FLA	2379	MOD	12473.	208.	47.	577.	10.	2.	21.60	2.73	.33	1.01
FLA	2380	MOD	11626.	194.	26.	577.	10.	1.	20.15	1.32	.42	3.23
FLA	2381	MOD	24643.	207.	32.	1109.	10.	1.	21.60	1.59	16.59	16.28
FLA	2382	MOD	3727.	143.	24.	211.	8.	1.	17.60	1.49	.00	.00
FLA	4077	MOD	7724.	217.	30.	349.	10.	2.	22.15	1.70	9.17	21.16
FLA	4078	MOD	7665.	220.	36.	327.	10.	1.	22.06	1.55	15.30	26.22
FLA	4084	MOD	15676.	201.	63.	664.	9.	2.	23.66	3.45	25.70	25.24
FLA	4085	MOD	10029.	276.	40.	403.	10.	1.	22.42	2.99	2.60	10.02
FLA	4086	MOD	24393.	203.	50.	1075.	8.	2.	22.69	2.16	2.06	10.00
FLA	4087	MOD	29350.	202.	25.	1473.	10.	1.	19.92	1.50	.69	5.06
FLA	4115	MOD	6357.	193.	35.	311.	9.	2.	20.45	1.11	.00	.00
TEXAS	1277	STOCK	4595.	255.	101.	209.	12.	5.	22.03	4.02	66.39	11.40
TEXAS	1281	STOCK	356.	178.	18.	19.	10.	0.	18.26	2.00	40.00	14.14
TEXAS	1282	STOCK	12661.	187.	40.	596.	9.	1.	21.62	2.76	9.06	1.20
TEXAS	1283	STOCK	1325.	166.	30.	65.	8.	2.	20.29	1.56	11.25	6.35
TEXAS	1284	STOCK	7490.	192.	52.	382.	10.	2.	19.62	3.59	35.00	26.53
TEXAS	1285	STOCK	3040.	202.	39.	170.	10.	1.	19.37	3.01	55.53	22.96
TEXAS	1288	STOCK	5002.	200.	35.	240.	10.	2.	20.84	1.70	10.79	7.07
TEXAS	1295	STOCK	13348.	173.	43.	719.	9.	2.	18.56	3.61	36.95	23.00
TEXAS	1296	STOCK	5767.	262.	68.	314.	14.	5.	18.37	3.59	35.91	35.14
TEXAS	12998	STOCK	4275.	196.	36.	228.	10.	1.	18.70	3.37	20.45	25.16
TEXAS	1301	STOCK	3094.	177.	31.	169.	9.	1.	20.66	2.10	10.45	2.13
TEXAS	1304	STOCK	21888.	182.	43.	1095.	9.	2.	20.17	4.20	20.73	27.30

VEHICLE SUMMARY

SITE	VEH	TYPE	MILES DRIVEN TOTAL	HW	SD	GALLONS USED TOTAL	HW	SD	M P G AVG	SD	% HW	% CITY
TEXAS	1306	STOCK	23696.	179.	48.	1200.	10.	2.	18.40	2.90	40.83	21.20
TEXAS	3054	STOCK	20116.	201.	34.	1110.	10.	1.	21.75	1.03	31.38	13.49
TEXAS	3055	STOCK	16400.	187.	61.	873.	7.	2.	18.63	4.03	76.81	39.09
TEXAS	3056	STOCK	4185.	178.	37.	210.	9.	2.	19.63	2.07	95.16	11.04
TEXAS	3062	STOCK	4204.	191.	40.	204.	9.	1.	20.54	2.70	23.18	10.74
TEXAS	3063	STOCK	3640.	214.	43.	170.	9.	1.	22.70	2.93	23.23	24.19
TEXAS	3067	STOCK	5529.	240.	18.	259.	11.	0.	21.71	1.01	31.04	39.73
TEXAS	3068	STOCK	4066.	214.	40.	184.	10.	1.	22.11	2.04	38.99	32.04
TEXAS	3069	STOCK	14457.	213.	25.	650.	10.	1.	21.90	1.39	30.19	23.00
TEXAS	3073	STOCK	7187.	216.	50.	324.	10.	2.	21.90	3.06	23.04	23.72
TEXAS	1268	MOD	1353.	303.	273.	62.	13.	10.	22.02	3.03	01.98	40.20
TEXAS	1276	MOD	4121.	275.	108.	206.	14.	9.	20.01	4.33	20.09	26.04
TEXAS	1279	MOD	22454.	210.	47.	1073.	10.	1.	20.92	3.26	39.77	20.77
TEXAS	1280	MOD	6678.	202.	43.	317.	9.	2.	21.69	2.78	67.83	48.70
TEXAS	1285	MOD	11777.	173.	40.	600.	9.	2.	19.37	3.20	40.99	15.41
TEXAS	1287	MOD	7750.	210.	20.	360.	10.	1.	21.60	1.07	11.22	18.06
TEXAS	1288	MOD	9610.	216.	44.	431.	10.	2.	22.31	.88	24.04	2.37
TEXAS	1290	MOD	7860.	215.	59.	373.	10.	1.	21.06	9.37	42.31	30.94
TEXAS	1291	MOD	10691.	206.	30.	540.	10.	1.	19.65	2.60	39.30	19.90
TEXAS	1292	MOD	6620.	236.	71.	277.	10.	3.	23.19	2.91	11.11	25.36
TEXAS	1293	MOD	5086.	316.	108.	210.	16.	6.	23.19	6.89	44.09	20.38
TEXAS	1297	MOD	9909.	202.	39.	459.	10.	2.	20.48	3.20	20.63	23.79
TEXAS	1299	MOD	3965.	197.	29.	198.	10.	1.	20.10	2.70	70.97	22.00
TEXAS	1302	MOD	15509.	210.	35.	719.	10.	2.	21.63	2.70	30.99	26.20
TEXAS	1303	MOD	6853.	202.	27.	330.	10.	1.	20.29	2.10	40.97	19.06
TEXAS	1305	MOD	5795.	181.	33.	276.	9.	2.	21.01	3.06	20.18	31.01
TEXAS	1307	MOD	9929.	200.	33.	477.	10.	3.	20.92	3.41	22.72	29.00
TEXAS	1308	MOD	13550.	226.	32.	596.	10.	2.	22.82	2.20	17.13	0.37
TEXAS	1309	MOD	15904.	219.	43.	715.	10.	2.	22.39	3.19	37.67	14.20
TEXAS	1311	MOD	15150.	211.	40.	707.	10.	2.	21.20	2.63	47.03	0.30
TEXAS	1312	MOD	18384.	213.	47.	794.	9.	2.	23.00	1.84	40.02	27.31
TEXAS	1313	MOD	3917.	196.	32.	202.	10.	2.	19.40	2.03	49.00	10.09
TEXAS	1402	MOD	3456.	203.	30.	163.	10.	1.	21.10	2.92	49.99	17.06
TEXAS	1403	MOD	8727.	230.	33.	370.	10.	1.	23.59	1.70	71.83	32.32
TEXAS	1404	MOD	8800.	280.	27.	413.	10.	1.	21.33	1.61	34.38	16.10
TEXAS	3051	MOD	221.	205.	51.	31.	8.	0.	26.32	0.51	60.00	.00
TEXAS	3053	MOD	4064.	214.	30.	190.	10.	2.	20.53	2.26	19.74	27.95
TEXAS	3056	MOD	3653.	193.	33.	296.	9.	2.	21.46	3.71	29.39	31.09
TEXAS	3057	MOD	1309.	216.	31.	66.	9.	1.	22.04	2.54	31.63	14.66
TEXAS	3059	MOD	8446.	206.	38.	439.	10.	2.	20.19	1.61	46.00	27.72
TEXAS	3061	MOD	2634.	240.	31.	114.	10.	1.	23.20	2.73	40.00	20.59
TEXAS	3066	MOD	12661.	207.	38.	661.	10.	2.	20.06	2.60	40.96	27.11
TEXAS	3069	MOD	14075.	247.	29.	606.	11.	1.	23.24	2.27	31.32	23.97
TEXAS	3070	MOD	9306.	209.	68.	419.	9.	2.	22.40	3.71	29.31	26.93
TEXAS	3071	MOD	5375.	188.	37.	237.	8.	2.	22.64	2.91	26.07	29.70
COLO	730	STOCK	6039.	187.	30.	307.	9.	1.	20.23	2.89	19.71	39.06
COLO	735	STOCK	9931.	188.	35.	457.	9.	2.	21.51	3.53	20.77	36.97
COLO	736	STOCK	10179.	184.	47.	498.	9.	2.	21.32	3.00	19.87	26.49
COLO	737	STOCK	6407.	174.	33.	360.	9.	2.	18.35	2.03	34.70	39.47
COLO	739	STOCK	8862.	206.	41.	418.	10.	2.	21.21	2.99	23.62	33.09

VEHICLE SUMMARY

SITE	VEH	TYPE	* MILES DRIVEN TOTAL	HW	SD	**GALLONS USED** TOTAL	HW	SD	M P G AVG	SD	** CITY HW	SD *
COLO	748	STOCK	9696.	211.	30.	441.	10.	2.	21.97	3.36	20.07	30.77
COLO	751	STOCK	10968.	194.	37.	989.	9.	1.	21.06	3.61	21.99	29.00
COLO	756	STOCK	10087.	198.	47.	473.	9.	2.	21.38	3.49	22.96	31.67
COLO	765	STOCK	7888.	189.	49.	394.	9.	2.	21.98	3.19	20.17	26.19
COLO	767	STOCK	10155.	185.	43.	496.	9.	2.	20.99	2.89	22.72	31.03
COLO	768	STOCK	7530.	215.	53.	348.	10.	2.	21.62	3.70	29.00	35.16
COLO	774	STOCK	10803.	193.	57.	503.	9.	2.	21.12	2.63	23.14	30.03
COLO	792	STOCK	6071.	237.	29.	278.	10.	1.	21.81	1.66	.00	.00
COLO	1666	STOCK	6909.	181.	56.	341.	6.	3.	20.24	3.22	20.90	29.12
COLO	1676	STOCK	8308.	189.	66.	367.	9.	3.	21.69	2.63	35.11	29.72
COLO	9326	STOCK	9942.	218.	52.	435.	9.	2.	22.84	2.06	23.40	38.96
COLO	9327	STOCK	20790.	221.	50.	916.	10.	3.	22.71	3.08	19.99	20.59
COLO	9337	STOCK	7991.	228.	35.	368.	10.	1.	21.70	2.41	18.24	27.05
COLO	9339	STOCK	13194.	217.	86.	691.	10.	3.	21.90	3.99	31.17	30.40
COLO	9398	STOCK	1500.	215.	37.	69.	10.	2.	21.81	4.16	18.89	17.13
COLO	731	MOD	14911.	204.	51.	640.	9.	2.	23.24	3.54	27.03	34.70
COLO	738	MOD	9051.	235.	33.	402.	10.	1.	23.36	2.46	22.96	36.00
COLO	743	MOD	9065.	227.	35.	389.	10.	1.	23.33	3.23	22.02	26.31
COLO	745	MOD	23738.	214.	55.	1030.	9.	2.	23.03	4.24	24.15	30.05
COLO	746	MOD	10933.	243.	56.	479.	11.	2.	22.82	2.97	20.20	20.63
COLO	763	MOD	7897.	208.	52.	351.	9.	2.	22.52	2.96	32.60	33.66
COLO	772	MOD	6392.	220.	52.	258.	9.	1.	24.70	4.29	18.62	28.20
COLO	775	MOD	4511.	205.	53.	195.	9.	2.	23.16	3.67	0.00	21.59
COLO	799	MOD	8176.	215.	61.	367.	10.	2.	22.29	4.30	36.03	41.63
COLO	800	MOD	4127.	217.	66.	168.	9.	2.	24.57	3.09	20.98	20.92
COLO	1665	MOD	7480.	174.	64.	335.	6.	3.	22.39	4.04	46.63	38.90
COLO	1680	MOD	10221.	179.	81.	425.	7.	3.	24.16	3.93	30.55	30.00
COLO	9328	MOD	19290.	224.	48.	785.	9.	2.	24.58	3.58	29.51	39.61
COLO	9329	MOD	21900.	216.	54.	878.	9.	2.	24.00	3.40	18.08	20.87
COLO	9334	MOD	9672.	220.	50.	424.	10.	2.	22.80	2.57	34.70	41.93
COLO	9332	MOD	8312.	225.	39.	342.	9.	2.	24.33	2.64	23.60	35.19
COLO	9335	MOD	10323.	206.	44.	461.	9.	1.	22.37	3.21	20.39	31.13
COLO	9336	MOD	7403.	218.	40.	316.	9.	2.	23.40	3.49	29.61	36.56
COLO	9338	MOD	4666.	222.	42.	188.	9.	2.	24.87	3.15	16.23	29.39
COLO	9396	MOD	903.	226.	69.	42.	10.	5.	21.59	3.69	3.00	4.76
CALIF	441	STOCK	1379.	230.	62.	61.	10.	1.	22.45	5.89	66.02	20.47
CALIF	442	STOCK	3033.	170.	44.	163.	10.	2.	18.59	2.91	30.00	37.21
CALIF	443	STOCK	2921.	140.	31.	157.	9.	2.	16.05	1.47	40.41	36.38
CALIF	444	STOCK	5458.	189.	45.	275.	9.	2.	20.98	2.92	42.73	36.90
CALIF	445	STOCK	5067.	180.	23.	261.	10.	1.	19.42	2.40	47.67	26.05
CALIF	446	STOCK	4307.	187.	59.	216.	9.	2.	19.92	3.41	32.96	31.08
CALIF	447	STOCK	1244.	178.	47.	61.	9.	1.	20.30	4.05	19.16	19.12
CALIF	449	STOCK	3695.	194.	68.	169.	9.	2.	21.84	3.72	32.36	31.96
CALIF	450	STOCK	7745.	184.	56.	395.	9.	2.	19.62	4.10	35.11	29.92
CALIF	451	STOCK	6570.	173.	71.	309.	5.	3.	21.29	4.20	13.05	19.30
CALIF	453	STOCK	6302.	172.	74.	306.	6.	3.	20.60	3.49	25.40	32.96
CALIF	455	STOCK	7520.	188.	33.	383.	10.	2.	19.65	2.25	51.32	26.60
CALIF	463	STOCK	12076.	252.	44.	540.	11.	2.	22.36	1.53	46.25	17.21
CALIF	466	STOCK	4644.	179.	43.	248.	10.	2.	18.74	2.99	42.11	33.31
CALIF	467	STOCK	5320.	161.	92.	259.	6.	4.	20.51	3.61	30.64	34.41

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VEHICLE SUMMARY

SITE	VEH	TYPE	MILES DRIVEN TOTAL	MN	SD	GALLONS USED TOTAL	MN	SD	M P G AVG	SD	%CITY MN	SD
CALIF	471	STOCK	2614.	163.	66.	125.	8.	3.	20.95	3.51	57.16	41.96
CALIF	472	STOCK	4841.	151.	89.	238.	7.	4.	20.30	4.68	37.50	27.34
CALIF	473	STOCK	6865.	176.	70.	330.	8.	3.	20.79	2.76	24.86	17.66
CALIF	475	STOCK	3992.	138.	80.	195.	7.	4.	20.48	3.55	26.66	29.94
CALIF	666	STOCK	1668.	185.	41.	87.	10.	2.	19.11	4.16	78.88	27.12
CALIF	1970	STOCK	4344.	197.	69.	198.	9.	3.	21.94	3.66	18.63	32.24
CALIF	1976	STOCK	2799.	187.	30.	138.	9.	1.	20.22	1.86	56.00	25.01
CALIF	1983	STOCK	3481.	205.	40.	164.	10.	2.	21.16	1.59	21.47	23.77
CALIF	1985	STOCK	9094.	211.	48.	425.	10.	1.	21.39	4.41	35.67	31.76
CALIF	1988	STOCK	2959.	197.	68.	155.	10.	3.	19.12	3.10	39.00	30.25
CALIF	1989	STOCK	6662.	230.	69.	326.	11.	3.	20.43	3.37	10.01	11.35
CALIF	1998	STOCK	4997.	178.	39.	264.	9.	2.	18.94	2.91	57.10	40.24
CALIF	1999	STOCK	6980.	194.	64.	312.	9.	2.	22.36	4.21	22.36	30.48
CALIF	2000	STOCK	10303.	169.	78.	473.	8.	3.	21.79	3.87	47.15	34.51
CALIF	2001	STOCK	6336.	167.	100.	322.	8.	4.	19.70	3.56	39.86	26.59
CALIF	5656	STOCK	14923.	223.	28.	689.	10.	1.	21.66	1.97	48.24	21.47
CALIF	5657	STOCK	4032.	212.	46.	182.	10.	1.	22.16	3.30	53.00	27.59
CALIF	5662	STOCK	678.	169.	51.	30.	8.	2.	22.48	7.67	41.85	48.02
CALIF	5664	STOCK	11818.	236.	30.	564.	11.	1.	20.96	1.33	52.60	22.48
CALIF	5854	STOCK	5867.	235.	71.	269.	11.	3.	21.84	1.51	37.20	18.88
CALIF	5857	STOCK	1483.	212.	42.	67.	10.	2.	22.20	1.40	30.00	15.86
CALIF	5859	STOCK	1622.	203.	56.	80.	10.	0.	20.25	5.33	44.99	27.87
CALIF	5863	STOCK	8552.	219.	29.	397.	10.	1.	21.52	1.54	4.89	14.27
CALIF	5866	STOCK	1986.	221.	22.	95.	11.	1.	20.79	3.60	8.89	3.33
CALIF	5868	STOCK	1546.	155.	54.	76.	8.	2.	20.42	3.86	31.00	13.70
CALIF	5869	STOCK	5345.	198.	42.	252.	9.	1.	21.22	3.53	40.74	17.74
CALIF	5875	STOCK	9862.	210.	34.	464.	10.	1.	21.27	1.82	25.61	21.78
CALIF	5879	STOCK	702.	234.	42.	32.	11.	3.	22.09	1.93	13.33	2.89
CALIF	5882	STOCK	4568.	183.	32.	220.	9.	1.	20.80	1.46	26.00	13.15
CALIF	5883	STOCK	12620.	175.	30.	715.	10.	2.	17.66	1.29	65.35	14.35
CALIF	5896	STOCK	229.	229.	0.	11.	11.	0.	20.05	.00	65.00	.00
CALIF	458	MOD	1499.	187.	71.	69.	9.	3.	21.63	2.60	35.00	26.19
CALIF	460	MOD	2951.	155.	62.	149.	8.	2.	19.80	4.42	37.08	42.92
CALIF	461	MOD	2899.	145.	72.	140.	7.	3.	20.77	3.06	12.25	21.06
CALIF	462	MOD	3865.	184.	58.	182.	9.	2.	21.26	3.90	19.05	31.09
CALIF	469	MOD	5255.	175.	84.	230.	8.	3.	22.83	3.38	23.63	29.80
CALIF	474	MOD	5513.	149.	73.	250.	7.	3.	22.03	2.90	34.20	34.41
CALIF	660	MOD	3344.	176.	51.	156.	8.	2.	21.46	4.40	19.79	24.76
CALIF	661	MOD	2655.	156.	55.	125.	7.	2.	21.17	2.61	1.47	6.06
CALIF	662	MOD	3071.	205.	94.	149.	10.	4.	20.67	2.22	32.00	24.55
CALIF	664	MOD	6781.	174.	47.	340.	9.	2.	19.94	2.52	25.26	9.80
CALIF	1951	MOD	7835.	201.	58.	361.	9.	2.	21.72	4.30	39.22	36.00
CALIF	1952	MOD	8276.	176.	58.	363.	8.	2.	22.77	2.94	23.20	29.51
CALIF	1953	MOD	1719.	191.	32.	83.	9.	1.	20.64	1.76	24.43	35.28
CALIF	1954	MOD	6122.	170.	55.	348.	10.	4.	17.60	2.57	36.19	34.17
CALIF	1955	MOD	7225.	168.	65.	364.	8.	3.	19.86	3.20	33.25	33.41
CALIF	1956	MOD	8747.	203.	63.	398.	9.	3.	21.96	4.69	39.76	31.01
CALIF	1957	MOD	5803.	200.	62.	262.	9.	2.	22.18	2.77	34.65	27.51
CALIF	1958	MOD	6029.	201.	65.	263.	9.	2.	22.90	3.57	18.23	26.33
CALIF	1959	MOD	8975.	224.	65.	358.	9.	2.	25.07	4.43	34.26	35.48

C-2

VEHICLE SUMMARY

SITE	VEH	TYPE	MILES DRIVEN TOTAL	MN	SD	GALLONS USED TOTAL	MN	SD	M P G AVG	SD	%CITY MN	SD
CALIF	1960	MOD	3664.	193.	63.	159.	8.	3.	22.99	3.64	31.36	36.79
CALIF	1961	MOD	2850.	220.	82.	121.	9.	3.	23.53	4.66	38.00	30.90
CALIF	1962	MOD	6676.	190.	65.	319.	9.	3.	21.16	4.30	31.91	28.56
CALIF	1963	MOD	7605.	206.	76.	343.	9.	3.	22.15	2.72	44.72	36.96
CALIF	1964	MOD	2919.	194.	57.	150.	8.	3.	19.42	2.03	16.63	34.94
CALIF	1965	MOD	6567.	177.	54.	336.	9.	2.	19.55	2.51	66.63	37.62
CALIF	1966	MOD	4320.	216.	75.	183.	9.	3.	23.56	4.00	34.19	33.94
CALIF	1967	MOD	7660.	196.	59.	334.	9.	2.	22.95	1.27	26.20	26.17
CALIF	1968	MOD	3743.	197.	71.	159.	8.	3.	23.59	3.90	36.67	38.80
CALIF	1969	MOD	5002.	200.	54.	225.	9.	2.	22.24	3.25	24.56	21.61
CALIF	1986	MOD	5986.	200.	43.	275.	9.	2.	21.73	2.62	30.02	37.32
CALIF	1988	MOD	2875.	205.	52.	136.	10.	2.	21.16	2.18	6.79	12.65
CALIF	1990	MOD	6931.	193.	44.	319.	9.	2.	21.98	2.50	40.02	31.57
CALIF	1991	MOD	4792.	158.	56.	217.	9.	2.	22.04	2.44	15.20	24.63
CALIF	1992	MOD	4406.	157.	53.	222.	8.	2.	19.83	4.31	22.66	26.58
CALIF	1993	MOD	6919.	187.	56.	338.	9.	2.	20.70	2.98	30.86	37.25
CALIF	1994	MOD	5632.	209.	63.	240.	6.	2.	23.47	3.37	24.51	20.07
CALIF	1995	MOD	6176.	187.	55.	287.	9.	2.	21.49	2.50	36.36	31.56
CALIF	1996	MOD	1000.	200.	53.	46.	9.	1.	21.70	3.91	51.98	48.27
CALIF	1997	MOD	6090.	209.	77.	250.	9.	2.	24.20	4.72	29.30	32.57
CALIF	2025	MOD	3267.	172.	50.	150.	8.	3.	21.81	3.60	2.69	11.46
CALIF	5851	MOD	2213.	201.	45.	98.	9.	2.	22.54	2.41	16.02	23.69
CALIF	5852	MOD	2586.	215.	56.	114.	9.	2.	22.67	3.59	30.00	38.55
CALIF	5853	MOD	3420.	201.	61.	142.	8.	2.	24.00	3.17	10.76	21.69
CALIF	5856	MOD	4350.	190.	16.	215.	10.	1.	20.25	.98	49.09	4.26
CALIF	5870	MOD	0.	0.	0.	0.	0.	0.	.00	.00	.00	.00
CALIF	5876	MOD	12119.	263.	30.	527.	11.	1.	22.98	.90	15.80	13.69
CALIF	5878	MOD	4078.	185.	61.	194.	9.	2.	20.97	3.17	14.38	21.06
CALIF	5894	MOD	13047.	176.	35.	572.	8.	1.	22.81	2.48	24.59	27.35
CALIF	5902	MOD	1802.	180.	55.	77.	8.	2.	23.47	3.41	16.80	35.53

SITE	AVG MPG STK	AVG MPG MOD	DELTA MPG	%CHG
MASS	21.27	22.41	1.14	5.35
FLA	20.29	20.30	.01	.03
TEXAS	20.37	21.70	1.33	6.51
COLO	21.32	23.42	2.10	9.84
CALIF	20.62	21.82	1.20	5.82

AVERAGE MPG FROM TOTAL MILES/TOTAL GALS

SITE	AVG MPG STK	AVG MPG MOD	DELTA MPG	%CHG	STK TOT MI	STK TOT GALS	MOD TOT MI	MOD TOT GALS
MASS	21.24	22.47	1.23	5.80	318904.	15016.	311468.	13862.
FLA	20.45	20.52	.07	.35	310276.	15176.	558639.	27239.
TEXAS	20.20	21.48	1.28	6.34	191850.	9499.	294767.	13724.
COLO	21.39	23.51	2.12	9.90	201136.	9403.	199441.	8484.
CALIF	20.60	21.82	1.22	5.94	240932.	11698.	247225.	11330.

SITE	#STOCK	#MOD
MASS	29	28
FLA	26	53
TEXAS	22	35
COLO	20	20
CALIF	46	48

END SUMMARY (06/11/81 13:51:51)

APPENDIX E

PHASE III TEST RESULTS

1978 VEHICLES

PRECEDING PAGE BLANK NOT FILMED

VEHICLE SUMMARY

SITE	VEH	TYPE	MILES DRIVEN TOTAL	MILES DRIVEN MN	MILES DRIVEN SD	GALLONS USED TOTAL	GALLONS USED MN	GALLONS USED SD	M P G AVG	M P G SD	%CITY MN	%CITY SD
MASS	2356	STOCK	2590.	235.	40.	113.	10.	1.	22.98	2.61	44.99	28.35
MASS	2357	STOCK	10020.	189.	76.	444.	8.	3.	22.59	2.68	34.43	27.85
MASS	2360	STOCK	12163.	213.	33.	569.	10.	1.	21.38	2.56	77.63	6.69
MASS	2361	STOCK	10972.	215.	46.	465.	9.	2.	23.57	3.33	19.12	15.22
MASS	2362	STOCK	11090.	194.	32.	549.	9.	1.	20.86	2.29	59.41	22.63
MASS	2364	STOCK	6025.	183.	42.	250.	8.	2.	24.12	3.93	17.70	18.13
MASS	2367	STOCK	11833.	182.	52.	556.	9.	2.	21.29	3.12	29.93	34.19
MASS	3652	STOCK	4334.	181.	63.	194.	8.	2.	22.36	3.96	17.12	15.83
MASS	3653	STOCK	13154.	160.	58.	607.	7.	2.	21.67	4.40	26.59	26.44
MASS	3656	STOCK	16583.	221.	44.	690.	9.	2.	24.03	2.03	19.20	16.67
MASS	3659	STOCK	10973.	207.	50.	485.	9.	2.	22.62	3.89	36.05	32.85
MASS	3663	STOCK	2221.	208.	41.	101.	9.	2.	22.03	3.45	41.34	41.19
MASS	2355	MOD	8221.	175.	61.	351.	7.	2.	23.41	4.29	23.51	30.19
MASS	2358	MOD	11019.	220.	60.	458.	9.	2.	24.08	2.53	29.94	21.32
MASS	2359	MOD	9860.	190.	47.	462.	9.	2.	21.34	3.83	36.85	36.60
MASS	2363	MOD	11233.	190.	63.	474.	8.	2.	23.61	4.30	18.94	18.33
MASS	3651	MOD	10900.	198.	75.	452.	9.	3.	23.22	3.98	33.67	35.16
MASS	3654	MOD	13992.	241.	76.	593.	10.	3.	23.58	4.25	32.65	28.33
MASS	3655	MOD	10985.	200.	61.	493.	9.	3.	22.30	3.32	28.90	32.29
MASS	3658	MOD	9958.	203.	48.	442.	9.	2.	22.52	3.11	26.48	20.79
MASS	3660	MOD	12575.	206.	63.	528.	9.	3.	23.83	3.10	25.69	25.60
MASS	3662	MOD	11279.	201.	63.	501.	9.	2.	22.51	3.48	29.96	29.41
FLA	4079	STOCK	7021.	190.	27.	330.	9.	1.	21.25	1.66	13.78	25.09
FLA	4080	STOCK	6091.	185.	30.	298.	9.	1.	20.44	1.65	7.88	21.89
FLA	4081	STOCK	15457.	201.	52.	678.	9.	2.	22.80	2.71	25.33	29.09
FLA	4082	STOCK	16699.	194.	38.	759.	9.	2.	21.99	2.22	24.88	24.48
FLA	4083	STOCK	16177.	190.	48.	724.	9.	2.	22.34	2.84	28.39	23.37
FLA	4088	STOCK	23021.	209.	57.	1021.	9.	2.	22.55	2.67	24.93	24.49
FLA	4089	STOCK	12960.	187.	52.	658.	10.	2.	19.27	3.73	5.75	18.95
FLA	4090	STOCK	6849.	176.	36.	333.	9.	2.	20.58	2.05	24.36	29.26
FLA	4091	STOCK	20938.	187.	45.	1058.	9.	2.	19.90	2.93	6.78	18.20
FLA	4092	STOCK	16768.	197.	31.	814.	10.	1.	20.58	2.60	4.53	16.52
FLA	4093	STOCK	7815.	195.	36.	397.	10.	1.	19.70	2.09	.00	.00
FLA	4100	STOCK	5970.	206.	57.	256.	9.	1.	21.77	4.85	.00	.00
FLA	4101	STOCK	18918.	174.	38.	1035.	9.	1.	18.29	2.61	.00	.00
FLA	4102	STOCK	9863.	183.	18.	536.	10.	1.	18.41	2.20	.00	.00
FLA	4103	STOCK	20705.	211.	31.	972.	10.	1.	21.29	1.60	28.11	24.21
FLA	4104	STOCK	7920.	184.	30.	392.	9.	1.	20.22	1.22	.00	.00
FLA	4105	STOCK	11908.	198.	28.	565.	9.	1.	21.09	1.03	.00	.00
FLA	4106	STOCK	3326.	166.	36.	173.	9.	1.	19.18	1.37	.00	.00
FLA	4107	STOCK	11989.	210.	39.	552.	10.	1.	21.72	2.79	.00	.00
FLA	4108	STOCK	2855.	178.	25.	150.	9.	1.	19.00	.72	.00	.00
FLA	4109	STOCK	9685.	179.	32.	515.	10.	1.	18.86	2.48	.00	.00
FLA	4110	STOCK	9081.	157.	31.	481.	8.	2.	18.88	1.75	.00	.00
FLA	4111	STOCK	2677.	191.	23.	132.	9.	1.	20.25	1.95	.00	.00
FLA	4112	STOCK	13232.	195.	23.	672.	10.	1.	19.69	1.32	.00	.00
FLA	4113	STOCK	3029.	189.	20.	156.	10.	1.	19.34	1.95	.63	2.50
FLA	4114	STOCK	2014.	201.	22.	103.	10.	1.	19.59	1.13	.00	.00
FLA	4116	STOCK	19399.	194.	28.	978.	10.	1.	19.83	2.13	.00	.00
FLA	4117	STOCK	8717.	178.	40.	449.	9.	2.	19.42	2.28	.00	.00

VEHICLE SUMMARY

SITE	VEH	TYPE	* MILES DRIVEN TOTAL	MN	SD	**GALLONS USED** TOTAL	MN	SD**	M P G AVG	SD	** %CITY MN	SD *
FLA	4077	MOD	7729.	219.	38.	349.	10.	2.	22.15	1.70	9.17	21.16
FLA	4078	MOD	7469.	226.	36.	327.	10.	1.	22.86	1.59	15.30	26.22
FLA	4084	MOD	15676.	201.	63.	664.	9.	2.	23.60	3.49	23.70	29.24
FLA	4085	MOD	10429.	226.	40.	463.	10.	1.	22.42	2.99	2.60	10.02
FLA	4086	MOD	24393.	183.	50.	1075.	8.	2.	22.69	2.16	2.86	10.08
FLA	4087	MOD	29390.	202.	25.	1473.	10.	1.	19.92	1.50	.69	5.06
FLA	4115	MOD	6397.	193.	35.	311.	9.	2.	20.49	1.11	.00	.00
TEXAS	3054	STOCK	24318.	221.	34.	1118.	10.	1.	21.75	1.05	31.32	13.49
TEXAS	3055	STOCK	16258.	137.	61.	873.	7.	2.	18.63	4.03	70.21	39.49
TEXAS	3058	STOCK	4129.	172.	37.	210.	9.	2.	19.65	2.67	55.16	11.80
TEXAS	3062	STOCK	4204.	191.	40.	204.	9.	1.	20.58	2.78	63.18	18.74
TEXAS	3063	STOCK	3860.	214.	43.	170.	9.	1.	22.70	2.55	23.33	24.19
TEXAS	3067	STOCK	5929.	240.	18.	255.	11.	0.	21.71	1.41	31.64	35.73
TEXAS	3068	STOCK	4060.	214.	48.	184.	10.	1.	22.11	2.64	32.09	32.44
TEXAS	3069	STOCK	14457.	213.	25.	658.	10.	1.	21.96	1.35	30.15	25.00
TEXAS	3073	STOCK	7129.	216.	50.	324.	10.	2.	21.98	3.54	23.64	23.72
TEXAS	1442	MOD	3450.	203.	34.	163.	10.	1.	21.18	2.92	49.99	17.06
TEXAS	1443	MOD	8727.	230.	33.	370.	10.	1.	23.59	1.74	71.93	32.32
TEXAS	1444	MOD	8808.	220.	27.	413.	10.	1.	21.33	1.61	34.38	16.16
TEXAS	3051	MOD	821.	205.	51.	31.	8.	0.	26.32	6.51	60.00	.00
TEXAS	3053	MOD	4066.	214.	38.	198.	10.	2.	20.53	2.20	19.74	27.95
TEXAS	3056	MOD	5455.	195.	53.	254.	9.	2.	21.46	3.71	29.39	31.69
TEXAS	3057	MOD	1509.	216.	31.	66.	9.	1.	22.84	2.54	31.43	14.64
TEXAS	3059	MOD	8840.	206.	38.	439.	10.	2.	20.15	1.61	46.00	47.72
TEXAS	3061	MOD	2635.	240.	31.	114.	10.	1.	23.20	2.73	40.00	28.55
TEXAS	3064	MOD	12861.	207.	38.	641.	10.	2.	20.06	2.64	40.96	27.11
TEXAS	3065	MOD	14075.	247.	29.	606.	11.	1.	23.24	2.27	31.32	23.97
TEXAS	3070	MOD	9396.	209.	42.	419.	9.	2.	22.42	3.71	25.31	26.95
TEXAS	3071	MOD	5375.	185.	37.	237.	8.	2.	22.64	2.91	24.07	29.79
COLO	792	STOCK	6071.	217.	29.	278.	10.	1.	21.81	1.68	.00	.00
COLO	5326	STOCK	9942.	212.	52.	435.	9.	2.	22.84	2.86	23.88	34.94
COLO	5327	STOCK	20790.	221.	50.	916.	10.	3.	22.71	3.02	19.99	29.59
COLO	5337	STOCK	7991.	228.	35.	368.	10.	1.	21.70	2.41	18.24	27.85
COLO	5339	STOCK	15194.	[illegible]	86.	691.	10.	3.	21.98	3.99	31.17	34.49
COLO	5392	STOCK	1508.	215.	37.	69.	10.	2.	21.82	4.16	12.29	17.13
COLO	5328	MOD	19290.	224.	48.	789.	9.	2.	24.58	3.54	29.51	38.61
COLO	5329	MOD	21580.	216.	56.	870.	9.	2.	24.80	3.40	18.08	28.27
COLO	5330	MOD	9472.	220.	58.	424.	10.	2.	22.80	2.57	34.70	41.95
COLO	5332	MOD	8312.	225.	39.	329.	9.	2.	24.33	2.64	23.64	35.19
COLO	5335	MOD	10329.	206.	44.	461.	9.	1.	22.37	3.21	20.39	31.13
COLO	5336	MOD	7403.	212.	48.	316.	9.	2.	23.40	3.49	29.61	36.56
COLO	5338	MOD	4464.	222.	48.	188.	9.	2.	24.87	3.15	14.23	29.39
CALIF	1976	STOCK	2799.	187.	30.	138.	9.	1.	20.22	1.86	56.00	25.01
CALIF	1983	STOCK	3481.	205.	40.	164.	10.	2.	21.16	1.59	21.47	23.77
CALIF	1985	STOCK	9094.	211.	48.	425.	10.	1.	21.39	4.41	35.67	31.76
CALIF	1988	STOCK	2958.	197.	68.	155.	10.	3.	19.12	3.10	39.00	30.25
CALIF	1989	STOCK	6662.	230.	69.	326.	11.	3.	20.43	3.37	10.01	11.35
CALIF	1998	STOCK	4997.	178.	39.	264.	9.	2.	18.94	2.91	57.10	40.24
CALIF	1999	STOCK	6580.	194.	64.	312.	9.	2.	22.36	4.21	27.36	30.40
CALIF	2000	STOCK	10303.	169.	78.	473.	8.	3.	21.79	3.87	47.15	30.51

VEHICLE SUMMARY

SITE	VEH	TYPE	* MILES DRIVEN TOTAL	MN	SD	** GALLONS USED ** TOTAL	MN	SD	** M P G AVG	SD	** %CITY MN	SD *
CALIF	2001	STOCK	6336.	167.	100.	322.	8.	4.	19.70	3.56	30.26	26.59
CALIF	9656	STOCK	14923.	223.	28.	689.	10.	1.	21.66	1.97	42.24	21.47
CALIF	9657	STOCK	4032.	212.	46.	182.	10.	1.	22.16	3.30	53.00	27.59
CALIF	9662	STOCK	674.	169.	51.	30.	8.	2.	22.40	7.67	41.25	40.02
CALIF	9664	STOCK	11818.	236.	30.	564.	11.	1.	20.96	1.33	52.60	22.46
CALIF	9854	STOCK	5667.	235.	71.	269.	11.	3.	21.64	1.51	37.20	19.06
CALIF	9857	STOCK	1483.	212.	42.	67.	10.	2.	22.20	1.40	30.00	15.28
CALIF	9859	STOCK	1622.	203.	56.	80.	10.	0.	20.25	5.33	44.99	27.67
CALIF	9863	STOCK	8952.	219.	29.	397.	10.	1.	21.58	1.54	9.49	14.27
CALIF	9866	STOCK	1986.	221.	22.	95.	11.	1.	20.79	3.60	8.09	3.33
CALIF	9868	STOCK	1984.	159.	54.	76.	8.	4.	20.40	3.86	31.00	13.70
CALIF	9869	STOCK	5349.	198.	42.	252.	9.	1.	21.22	3.53	40.76	17.75
CALIF	9873	STOCK	9862.	210.	34.	464.	10.	1.	21.27	1.62	29.61	21.76
CALIF	9879	STOCK	702.	234.	42.	32.	11.	3.	22.09	1.93	13.33	2.49
CALIF	9882	STOCK	4568.	183.	32.	220.	9.	1.	20.80	1.46	26.00	13.18
CALIF	9883	STOCK	12620.	175.	30.	715.	10.	2.	17.66	1.29	65.35	14.35
CALIF	9896	STOCK	229.	229.	0.	11.	11.	0.	20.09	.00	65.00	.00
CALIF	1988	MOD	5986.	200.	43.	273.	9.	2.	21.73	2.07	34.02	37.22
CALIF	1986	MOD	2875.	205.	52.	136.	10.	2.	21.14	2.12	6.79	12.65
CALIF	1990	MOD	6931.	193.	44.	319.	9.	2.	21.90	2.56	40.62	31.97
CALIF	1991	MOD	4792.	192.	56.	217.	9.	2.	22.04	2.44	19.20	24.63
CALIF	1992	MOD	4406.	157.	93.	222.	8.	2.	19.63	4.31	22.60	26.56
CALIF	1993	MOD	6915.	187.	56.	334.	9.	2.	20.70	2.98	30.86	37.25
CALIF	1994	MOD	5632.	209.	63.	240.	9.	2.	23.47	3.31	24.51	30.67
CALIF	1995	MOD	6176.	187.	55.	287.	9.	2.	21.49	2.56	36.36	31.56
CALIF	1996	MOD	1000.	200.	53.	46.	9.	1.	21.70	3.91	54.00	46.27
CALIF	1997	MOD	6050.	209.	77.	250.	9.	2.	24.20	4.72	29.30	32.57
CALIF	2025	MOD	3267.	172.	58.	150.	8.	3.	21.81	3.60	2.69	11.46
CALIF	9851	MOD	2213.	201.	45.	98.	9.	2.	22.54	2.41	16.82	23.69
CALIF	9852	MOD	2584.	215.	58.	114.	9.	2.	22.67	3.59	30.00	36.55
CALIF	9853	MOD	3420.	201.	61.	142.	8.	2.	24.00	3.17	10.76	21.49
CALIF	9858	MOD	4350.	198.	16.	215.	10.	1.	20.25	.98	49.09	4.26
CALIF	9870	MOD	0.	0.	0.	0.	0.	0.	.00	.00	.00	.00
CALIF	9876	MOD	12119.	263.	30.	527.	11.	1.	22.98	.90	15.80	13.69
CALIF	9878	MOD	4078.	185.	61.	194.	9.	2.	20.97	3.17	14.32	21.06
CALIF	9894	MOD	13047.	176.	35.	572.	8.	1.	22.81	2.48	26.59	27.37
CALIF	9902	MOD	1802.	180.	55.	77.	8.	2.	23.47	3.41	16.80	39.53

VEHICLE SUMMARY

SITE	VEH	TYPE	* MILES DRIVEN TOTAL	MN	SD	** GALLONS USED ** TOTAL	MN	SD	** M P G AVG	SD	** %CITY MN	SD *

SITE	AVG MPG STK	AVG MPG MOD	DELTA MPG	%CHG
MASS	22.46	23.04	.58	2.58
FLA	20.29	22.01	1.72	8.48
TEXAS	21.24	22.23	.99	4.67
COLO	22.14	23.89	1.73	7.83
CALIF	20.90	22.09	1.19	5.71

AVERAGE MPG FROM TOTAL MILES/TOTAL GALS

SITE	AVG MPG STK	AVG MPG MOD	DELTA MPG	%CHG
MASS	22.37	23.05	.68	3.06
FLA	20.45	21.74	1.30	6.35
TEXAS	21.01	21.77	.76	3.63
COLO	22.30	23.99	1.69	7.60
CALIF	20.75	22.13	1.38	6.65

STK TOT MI	STK TOT GALS	MOD TOT MI	MOD TOT GALS
118318.	5288.	109682.	4758.
310278.	15170.	101798.	4682.
83948.	3995.	86029.	3951.
61495.	2758.	81246.	3386.
139438.	6721.	97663.	4414.

SITE	#STOCK	#MOD
MASS	12	10
FLA	28	7
TEXAS	9	13
COLO	6	7
CALIF	25	19

END SUMMARY (08/11/81 18:45:51)