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A STUDY OF EMISSIONS FROM LIGHT DUTY VEHICLES IN LOS ANGELES

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ABSTRACT

This report presents and summarizes an emissions test program and other related information obtained in the testing and inspection of in-use passenger cars. The test fleet consisted of 1979-81 automobiles and trucks. The test vehicles were obtained randomly from private owners in the Los Angeles and Orange County areas. The testing was completed March 17, 1982.

Each vehicle was tested in the as-received condition and given an underhood emissions control component inspection. The test sequence consisted of the 1978 Federal Test Procedure, a Highway Fuel Economy test, a Bagged Idle test, a 50 MPH Cruise test, a Four-Speed Idle test and a Loaded Two-Mode test. Thirty-one 1981 vehicles received an evaporative emissions test using the SHED technique. Thirty of the 150 vehicles received restorative maintenance repairs and additional testing.

ACKNOWLEDGEMENTS

Automotive Environmental Systems, a Division of Clayton Manufacturing Company, wishes to extend its appreciation and special thanks to Mr. John Shelton, Project Officer, for providing counsel, technical guidance, and understanding throughout the program.

We also wish to recognize the assistance of the manufacturers of the automobiles which were tested in this project.

CONTENTS

SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency (EPA), through authority provided by the Clean Air Act, is responsible for the control and prevention of air pollution. As provided by the Act, one of the charges of the EPA is the design, conduct and promotion of surveys and studies of the sources of air pollution. The Emission Control Technology Division (ECTD) of the EPA develops, implements and administers a national program to characterize, quantify and reduce the air pollution caused by mobile sources. Included in the division's responsibilities is the collection of emissions data from in-use vehicles and the development and evaluation of alternatives for the control of vehicle emissions. These in-use vehicle data are utilized by the EPA in calculating and projecting motor vehicle emissions from light duty vehicles. The emission factors generated by this process are also used in developing transportation control procedures and contingency programs to cover emergency situations. Outside of the EPA, these data and the emission control alternatives are used by various state and local agencies in their air pollution control programs. In carrying out its responsibilities, the EPA regularly conducts in-use vehicle emission factors programs and emission control alternative studies. In order to support the States in their efforts to implement their air quality programs, the Emission Control Technology Division will use the data generated by this project to assess the effectiveness of new technology vehicle exhaust emissions systems in Los Angeles.

This report describes a program conducted by Automotive Environmental Systems (AESi) to gather information on light duty vehicles in the Los Angeles area. The testing was performed from August 1981 through March 1982.

Section 2 of this report describes the objectives, design, and conduct of the program. Section 3 presents a list of figures outlining the important phases of the testing project. Data packets with EPA-defined data formats were submitted to the Project Officer.

SECTION 2

TECHNICAL DISCUSSION

2.1 PROGRAM OBJECTIVES

This report describes a program conducted by Automotive Environmental Systems (AESi), a Division of Clayton Manufacturing Company, to gather information on passenger cars and light duty trucks in the Los Angeles area. The testing was conducted between August 1981 and March 1982.

2.2 PROGRAM DESIGN

Each vehicle received a Federal Test Procedure (FTP) test, a Highway Fuel Economy test (HFET), a Bagged Idle test, a 50 MPH Cruise test, a Four-Speed Idle test and a Loaded Two Mode test. A total of 31 vehicles received an Evaporative Emissions test.

2.3 TEST VEHICLE PROCUREMENT

EPA provided a vehicle matrix which specified test vehicle make, model, year and in some cases, engine size. The procurement effort focused on two important aspects for the selection and processing of test vehicles; procedures were utilized to secure an unbiased random sample and also, all mailing contacts were further explored by a series of follow-up phone calls to improve the response rate.

2.3.1 Test Vehicle Selection

In efforts to secure an unbiased random sample of vehicles that would be representative of Los Angeles, AESi contacted a marketing firm which provided a vehicle registration list (a subset) that was proportional to the universe of vehicle registrations in their files. This subset was a random selection of vehicles within each segment (Chevrolet, Pontiac, etc.) of the vehicle matrix.

2.3.2 Sample Vehicle Control Log

A sample vehicle control log was used to monitor the results of the mailings made with the randomized vehicle registration lists.

Each mailing candidate was assigned a number which was entered by his/her name in both the control log and the business reply post card which the candidate received. The disposition of each mailing candidate was noted in the control log. Following the initial mail response, up to 2 follow-up phone calls were made to secure the candidate vehicle for testing. The results of these calls were also entered in the control log.

2.3.3 Incentives for Participation

The owner of a suitable test vehicle was provided the following incentives for his participation:

> A $100 U.S. Savings Bond. Bonds were mailed to participants within one month following the test on their vehicle.
>
> The use of a late-model, fully insured loaner automobile during the time their vehicle was undergoing testing.
>
> The owner's automobile was returned with a full tank of fuel.

2.3.4 Test Vehicle Handling

In most cases, the vehicle was scheduled to be delivered to AESi in Westminster by appointment. In some cases, vehicles were picked up and/or delivered at a participant's home or place of business. An inspection was performed to ensure proper vehicle match and to establish the physical condition of the vehicle. A loan vehicle exchange agreement, the savings bond application and the Vehicle Owner Use Questionnaire were also completed at this time. The vehicle was accepted or rejected for testing according to the sequence illustrated in Figure 1.

2.4 FACILITIES AND EQUIPMENT

2.4.1 Test Location

All tests were performed at AESi's test facility at 7300 Bolsa Avenue in Westminster, California. The facility is located approximately 25 miles south of downtown Los Angeles at an elevation of 45 feet above sea level.

The test facility environment, including test and vehicle soak areas, was maintained at the required ambient temperature for all phases of testing. The vehicle soak area is located inside the same building as the test area and both are free from precipitation.

2.4.2 Constant Volume Sampler

A positive displacement pump type constant volume sampler (CVS) built by AESi was used in this program. This CVS meets or exceeds all specifications defined in the Code of Federal Regulations Title 40, Part 86, Subparts A and B (40 CFR Part 86). The system contains six bags switched by computer in sample/background pairs for all dilute exhaust sample testing.

All plumbing in the sampling, analytical and calibration systems is either stainless steel or teflon. This includes all sample, calibration and zero gas lines and the valves and regulators for NO gases. Leak-tight stainless steel convoluted tubing is used between the CVS and the vehicle tail pipe for exhaust gas sampling. An appropriate leak-tight boot was used to connect the tail pipe to the convoluted tubing. A stainless steel heat exchanger with a temperature controlled cold water inlet was used to provide essentially a constant exhaust gas temperature through the entire test.

2.4.3 Emission Analysis Console

An AESi exhaust gas analytical system meeting or exceeding the specifications of 40 CFR Part 86, was used for dilute gas measurements. Similar laboratory type instrumentation, with additional ranges, was used for analysis of raw NO and CO_2 gas. In addition, a Chrysler Model III garage-type analyzer was used for measurement of raw HC and CO. The console contains the following instrument types and ranges:

Analyzer	Ranges
Bendix Model 8501-5C NDIR (Lo CO - Dilute Exhaust)	0-100, 0-500 ppm (11 1/4" Cell Length)
Beckman 315B NDIR (Hi CO - Dilute Exhaust)	0-.3% (5 1/4" Cell Length) 0-3% (1.8" Cell Length)
Beckman 315B NDIR (CO_2 - Dilute Exhaust)	0-2.5%, 0-4% (1/8" Cell Length)
Beckman 315B NDIR (CO_2 - Raw Exhaust)	0-15% (1/8" Cell Length)
Beckman 400 FID (Lo HC - Dilute Exhaust)	0-50, 0-100, 0-300 ppm Carbon
Beckman 400 FID (Hi HC - Dilute Exhaust)	0-1,000, 0-3,000 ppm Carbon
Teco 10AR Chemiluminescent (NOx - Dilute Exhaust)	0-100, 0-250, 0-1,000, 0-2,500 ppm
Teco 10AR Chemiluminescent (NO - Raw Exhaust)	0-100, 0-1,000, 0-2,500, 0-4,000 ppm

Chrysler Model III Garage	
(HC - Raw Exhaust)	0-300, 0-2,000 ppm Hexane Equivalent
(CO - Raw Exhaust)	0.5%, 0-10%

2.4.3.1 Laboratory Standard Calibration & Working Gases

Laboratory standard calibration gases, previously approved by EPA, were used for defining instrument calibration curves and assigning concentration values for the working gases. Each cylinder of standard gas and each working gas cylinder was equipped with its own pressure regulator as specified by the contract. All gases were plumbed to a quick-disconnect panel for ease in selecting the gas desired during calibration and testing.

Calibration gases for each range of the HC and NOx analyzers were chosen such that three points were used across the curve (zero and approximately 45% and 90% of full scale concentration). CO and CO_2 calibration points were at zero and approximately 15, 30, 45, 60, 75 and 90 percent of full scale. All span gases were 80-100 percent of full scale.

The diluents used in the calibration and working gases are:

HC, ppmC	Propane in HC free air
NOx, ppm	In zero grade nitrogen
CO, mole %	In zero grade nitrogen
CO_2, mole %	In zero grade nitrogen

2.4.4 Sealed Housing for Evaporative Determinations (SHED)

Evaporative emissions tests were performed using an AESi SHED and its associated operator console. The SHED meets all requirements in "Evaporative Emission Regulations for Light-Duty Vehicles and Trucks" as described in Federal Register 164, dated Monday, August 23, 1976. The console includes a Beckman 400 FID analyzer with ranges of 0-100, 0-300, 0-1000 and 0-3000 ppmC; a Linear Instruments chart recorder for analyzer output; a Leeds and Northrup SPEEDOMAX multipoint temperature recorder; and a variable voltage source and heating element (blanket) for applying heat to the vehicle gas tank for the diurnal heat build. A cooling package is installed to ensure operation of the SHED within the temperature range of 68°F to 86°F.

2.4.5 Chassis Dynamometer

The chassis dynamometer was equipped to simulate vehicle inertia and road load horsepower as required in 40 CFR Part 86.

The dynamometer used is a Clayton ECE-50 with remote controlled lift, 17 1/4 inch roll center spacing, 89 inch overall roll length and 4000 lb axle weight capacity. Direct drive variable inertia loading weights were employed, with 125 pound increments from 1000 through 8875 lbs.

A speed meter which indicates mi/hr was used to monitor the speed of the dynamometer roll. The rear dynamometer roll is equipped with a tachometer generator which provides the speed signal during testing. The meter response was linear with speed and the accuracy was within ±2.0 km/hr (±1.2 mph) over the range of 0-95 km/hr (0-59 mph). The dynamometer is equipped to measure actual distance traveled for each segment of the FTP testing sequence.

The power absorption unit was monitored by a power meter accurate and readable to ±0.25 hp (.187 kw) over the range of intended use.

2.4.6 Data Acquisition System

Data was obtained from the analyzers, CVS and dynamometer via an AESi Data Acquisition Control Computer (DACC). The Data General NOVA computer was also used for generation of driver traces for the various driving schedules, for sample bag management and for calculation and presentation of the emission test results. The data was printed by a Data General Dasher printer immediately following sample analysis.

The output from the analyzers was also wired to the inputs of four Hewlett-Packard Model 7130A two-pen recorders. One recorder was used for dilute HC and NOx, one for dilute CO and CO_2, one for undiluted HC and CO and one for undiluted NO and CO_2.

2.4.7 Driver's Aid

An AESi designed two-pen Hewlett-Packard Model 7130A Driver's Aid (speed vs time recorder) and Clayton speed power meters were employed to permanently record the driver's performance during the test. The Hewlett-Packard Recorder is mounted in the Driver's Aid box. The box itself is situated on a 4-piece moveable boom so that it can be easily moved when testing vehicles such as ones with front wheel drive. The driving trace was generated by the NOVA computer on this recorder in agreement with the specifications of 40 CFR Part 86.

2.4.8 Miscellaneous Equipment

Miscellaneous equipment used in conjunction with the major items of equipment included the following:

Two Teco Model 100 NOx Generators. The generator in the raw gas analysis bench was not used since only NO is reported.

One Rustrak Chart Recording Psychrometer, Model 2133B with continuous recording of wet/dry bulb temperatures.

One Rustrak Chart Recorder, Model AD 101-462-2A for continuous recording of CVS temperature.

One Weathermeasure M701 continuous recording temperature recorder for soak area temperature.

One Princo mercurial Barometer.

One Meriam 50 MC2-4SF Laminar Flow Element for CVS calibration.

One Sartorius Model 2257 Balance used for weighing the propane cylinders for propane recovery tests.

One Strobotach for dynamometer speed calibration.

Horiba GSM and MEXA 300A garage analyzers were used for inspection by the mechanic.

2.5 EQUIPMENT QUALIFICATION, CALIBRATION AND CROSSCHECK

This section describes the qualification, calibration, and crosscheck procedures utilized by AESi and verified by EPA technical personnel to ensure that valid test data were generated throughout the test program. Initial qualification included complete demonstration of individual instrument calibration, stability, response time, zero air and nitrogen purity, CVS calibration, dynamometer calibration, and inspection of all daily, weekly and monthly logs.

2.5.1 Constant Volume Sampler

The CVS was calibrated with a laminar flow element (Meriam Model 50-MC 2-45F) using the basic procedures specified in the Federal Register. CVS air flow, measured using the laminar flow element on the inlet side of the mass pump (CVS blower), was controlled by throttling. Air flow rates were measured at five incremental changes in pump differential pressure on each side of the normal operating point. Flow rates at a total of at least ten points were measured. The nominal air flow of the CVS is 345 cfm. Auxiliary devices employed in the calibration included a mercury barometer to measure absolute ambient pressure, a close tolerance mercury thermometer to measure pump inlet air temperature, a U-tube water manometer to measure pressure drop across the pump and pump inlet pressure and a close tolerance inclined water manometer to measure pressure drop across the laminar flow element. Once this calibration was completed, data from these devices were computer processed and the mid-range blower operating point was determined. Propane recovery tests using instrument grade propane were made after the calibration to confirm its accuracy. A copy of the calibration data was provided to the EPA Project Officer as a part of the qualification data package.

Calibration of the laminar flow element (LFE) is traceable to the National Bureau of Standards, and a certified copy of the LFE calibration curve was furnished to the Project Officer at the time of Laboratory Qualification.

Daily propane recovery tests were made to confirm continued calibration of the CVS system. The measured propane mass recovered by the CVS had to be within ±2.0 percent of the injected mass of up to 20 grams of instrument grade propane as determined gravimetrically. The recovered amount of propane was measured on the 0-300 ppmC FID range. A Rustrak chart recorder was used to continuously record CVS temperature during these tests.

2.5.2 Emission Analysis Console

2.5.2.1 Dilute Exhaust Analysis Console

Complete calibrations of the mass emission analysis console instruments were performed initially and checked each week thereafter until testing was completed. Calibration curves for the mass emission analysis console CO, CO_2, HC and NOx instruments were established using the gases previously identified. The CO and CO_2 instruments were calibrated at seven somewhat evenly spaced points (zero and six upscale points) across each operating range. Calibration of the HC and NOx instruments was performed at three somewhat evenly spaced points (zero and two upscale points) across each operating range. Calibration of these instruments was established and maintained within one percent of full scale for each range, respectively, or five percent of the measured value, whichever was smaller. A computer program provided by the EPA was used in the generation of the calibration curves.

In connection with each test, the CVS sample bags were purged with nitrogen, evacuated and leak-checked. These operations were performed in a bag evacuate, N_2 purge, evacuate and leak-check sequence by means of a manual push-button selection of solenoids located within the CVS. A leak in the system is indicated by a non-zero flow in the flow meters on the operator's console.

Other activities included setting zero and span points immediately prior to exhaust sample analysis and zero and span point verifications immediately following exhaust sample analysis. Strip chart recorders were operated throughout the zero and span set-point calibration, sample analysis and zero and span verification sequence. Verification tolerances were maintained within ±1 deflection from the set-point for the range in use. Converter efficiency of the NOx converter was maintained above 90 percent. The noise level of analyzer outputs as indicated on the strip chart was maintained within ±0.5 percent of full scale for the range used during both calibration and analysis.

2.5.2.2 Raw Exhaust Analysis Console

The NO and CO_2 instruments used in the undiluted (raw) emission analysis console are laboratory instruments calibrated using the same gases, calibration points, tolerances and verification frequency described above in connection with the NOx and CO_2 instruments used in the mass emission analysis console.

The tail pipe HC/CO measurement instrument was operated in accordance with the manufacturer's recommendations except that this instrument was zeroed with nitrogen and the HC and CO span-points calibrated with appropriate gases immediately prior to each test. Each analyzer was checked for zero and span point drift immediately following each test. Verification tolerances were maintained within ±2 deflections from the set-point for the range in use.

2.5.2.3 Daily Qualification Checks

Daily qualification checks included:

Leak-check of each instrument as well as the system.

Recording of zero, gain and tune, as applicable, for each instrument.

Hang-up and leak-checks for background and sample bags and sample line.

NOx analyzer vacuum and converter efficiency checks.

Propane recovery tests to ensure proper FID operation as well as verification of the CVS calibration.

Recording of FID fuel and air pressure.

Recording of cylinder number, concentration, deflection, cylinder pressure for each working gas.

In addition to the above daily checks, weekly calibration curve checks were made for each range of each instrument.

Appropriate calibrations, leak-checks, etc., were also made whenever maintenance was performed which could change instrument or system operation.

2.5.3 Sealed Housing for Evaporative Determinations (SHED)

The volume of the SHED used was determined by physical measurement. Calibration of thermocouples used in the SHED was verified by an ASTM thermometer as was the temperature recording instrument. Calibration curves were generated for each range of the Beckman 400 FID used in the analytical console. These curves were verified weekly.

For initial calibration, the FID was zeroed on zero grade prepurified air and calibrated at two upscale points (i.e. 45% and 90% of full scale) on each of the ranges used. The same hydrocarbon gas standards previously described were employed for this calibration. Curve fit tolerances and verification frequency were the same as those applied to the dilute emission analysis console instruments.

The SHED was subjected to a background hydrocarbon check, a calibration check and a retention check prior to testing the first vehicle.

The background emissions check was performed by sealing the enclosure and allowing it to remain sealed for a period of four hours. Initial and final hydrocarbon readings were taken. The background emission rate was acceptable when it was less than the maximum increase of 0.4 grams for the four hours, as defined in 41 Federal Register 164, dated Monday, August 23, 1976.

The SHED was calibrated by first purging with fresh air and then sealing the enclosure. Approximately 4 grams of instrument grade propane was injected into the enclosure after the enclosure was sealed. The mixing fans were operating during this injection. After five minutes of mixing, the stabilized hydrocarbon level of the enclosure was measured and the mass calculated. The quantity of the calculated recovery was within ±2% of the injected amount.

The propane retention (leak) check was performed following the calibration. In this check the SHED was allowed to remain sealed for a minimum of four hours with the mixing blowers operating. At the end of this period the hydrocarbon level of the enclosure was measured and the mass calculated. For this check, the hydrocarbon level was within ±4% of the initial reading as calculated. The SHED calibration and retention tests were performed monthly thereafter.

2.5.4 ECE-50 Chassis Dynamometer

Dynamometer speed was verified initially and bi-weekly with a Strobotach. Road load force was determined using calibrated weights. Coastdowns were performed initially and bi-weekly thereafter to verify the road load force versus inertia weight relationships as given in 40 CFR Part 86.

2.5.5 Data Acquisition System

The data acquisition system was verified by performing manual checks of equipment performance and hand calculations from strip chart data and comparing these with the data provided by the DACC. This activity is verified by a Quality Assurance inspection for each test. A reasonableness check is performed for each critical data element. Any suspect data was verified by strip chart or calculation. Any data found to be in error is independently recalculated wherever possible or the test is rejected.

2.5.6 Miscellaneous Equipment

All miscellaneous equipment was calibrated or verified according to manufacturer's recommended practices. The CVS laminar flow element and barometers were calibrated by Meriam Instruments Company.

2.6 TEST PROCEDURES

2.6.1 Vehicle Preparation

Each vehicle received a preliminary safety inspection as part of the procurement activity. This was done to ensure that the vehicle was safe to operate on the street or dynamometer. Upon acceptance for testing, the vehicle's fuel tank was drained and refueled with appropriate test fuel to 40% of tank capacity. At this time all vehicles received a liquid chemical lead test and a plumbtesmo lead test. Vehicles to receive SHED tests were prepared by fitting the gas tank with a Type J Thermocouple by soldering it to the side of the tank at the approximate mid-point of the 40% fuel volume. To ensure that test fuel had purged the fuel system, the vehicle was driven for ten minutes on city streets or on the dynamometer for the first 505 seconds of the FTP. After the preconditioning run, the vehicle was driven or pushed into the soak area for the required 12 to 36 hour soak at temperatures between 68°F and 86°F. Drive wheel tire pressure was set to 45 psi prior to dynamometer testing to prevent tire damage.

Figures 1 and 2 present flow charts of vehicle preparation and testing activities.

2.6.1.1 Driveability Evaluation

An evaluation of the driveability of each vehicle was performed prior to and during each FTP. The evaluation is essentially the same as that performed on previous EPA light duty vehicle projects.

2.6.2 Equipment Preparation

Prior to the first test of the day and following any shut-down, equipment which had been idle or in a stand-by condition was activated to begin warm-up. This included the CVS water heater and mass pump and each of the analytical instruments. Following the warm-up of the respective instruments, efficiency of the NOx instrument thermal converter was checked and the propane recovery test involving the CVS sample system and the FID hydrocarbon instrument was conducted. Subsequent to these checks, analyzer outputs as indicated by the strip chart recorders and the DACC computer and printer, were checked for correlation by calibrating at zero and five volts. Prior to the first exhaust emissions test of the day or following any extended shut-down, the dynamometer was warmed-up. The prescribed 15 minutes of 30 mile per hour operation of the dynamometer was the warm-up procedure followed. Following warm-up, the speed calibration of the dynamometer, driver's aid recorder and associated indicating devices were also checked and calibrated as necessary.

Prior to each test, all charts were properly stamped to show, among other things, the vehicle number, run number, date and persons involved in the test.

2.6.3 Federal Exhaust Emission Test Procedure

The Federal Test Procedure as described in 40 CFR Part 86 was performed on all vehicles in the as-received condition. The evaporative emission portion of the procedure was performed on 31 vehicles in this program. The exhaust emission portion of the Federal Test Procedure is comprised of cold transient, cold stabilized and hot transient phases. The cold transient portion is 505 seconds long, covering a distance of 3.59 miles with an average speed of 25.6 mph. The cold stabilized portion is 869 seconds in length, 3.91 miles in distance and a 16.2 mph average speed. The hot transient portion is identical to the cold transient portion except that it is preceded by a 10 minute soak. The evaporative emissions testing consisted of the SHED technique as described in 41 Federal Register 164, dated Monday, August 23,

1976. Vehicles that failed the SHED test by greater than twice the standard were further diagnosed by using a Beckman 400 FID as a sniffer to locate the leak in each particular vehicle.

The cold soak period used for the test vehicles was 12 to 36 hours. The starting procedures and shift points used for the test vehicles were as recommended by each manufacturer.

2.6.4 Bagged Idle

This test immediately follows the FTP. The test begins with a 6 minute "engine-off" soak period with the cooling fan off and the hood closed. At the end of the soak period the engine is restarted and operated for 3 minutes at idle in drive (manual transmission vehicles in neutral with the clutch engaged). During the 3 minutes a dilute sample is collected and then analyzed. The sample period begins when the starter is engaged and includes crank time. However, if an evaporative emissions test was performed on the test vehicle, this test is preceded by a preconditioning cycle consisting of the first 505 seconds of the FTP driving cycle.

2.6.5 50 MPH Cruise

This test takes advantage of the 3 minute preconditioning run before the HFET. Tail pipe emissions are recorded and measured continuously throughout the period although the official sampling period ends 30 seconds after the speed and load have stabilized at 50 MPH.

2.6.6 Highway Fuel Economy Test

Starting with each vehicle in a warmed-up condition (at least 7.5 miles of cyclic operation within the last thirty-five minutes) each vehicle was operated on the chassis dynamometer at 50 miles per hour for three minutes. Within one minute after the end of the 50 mile per hour cruise period, the vehicle commenced operation over the 10.242 mile, 765 second driving schedule. A CVS sample bag was used to gather the dilute exhaust for emissions analysis and fuel economy calculations. HC, CO, CO_2 and NOx emissions were measured and reported in grams per mile. Fuel economy was calculated by the carbon balance method and reported in miles per gallon.

2.6.7 Four-Speed Idle Test

This test followed the HFET and required additional analytical instruments, aside from those required for the basic FTP test, to measure undiluted exhaust emissions. The instruments used for measurement of undiluted HC, CO, NO and CO_2 emissions are specified in Section 2.4.3.

This short test consisted of volumetric sampling of undiluted exhaust emissions during four steady state operating conditions, with the hood open and the cooling fan on. The first operating mode was basic idle with the transmission in neutral. The second operating mode was at 2500 engine RPM, also in neutral. The third mode was again normal curb idle in neutral and the fourth mode (automatic transmission vehicles only) was curb idle in drive with brakes applied.

Four-Speed Idle tests were preceded by a 6 minute idle soak period with the transmission in neutral, the hood open and the auxiliary cooling fan on. At the end of the soak period the vehicle was operated sequentially through the four modes. Equilibrium of engine speed and the CO, HC, NO and CO_2 analyzer output meters was maintained for 30 seconds before the readings were recorded. Engine RPM from the last idle mode was written on the Driver's trace for each particular vehicle.

2.6.8 Loaded Two Mode Test

The six minute soak period and the undiluted exhaust analysis instruments described under the Four-Speed Idle test were also used for this test. This test followed the HFET and Four-Speed Idle test so the engine, dyno and analyzers were at normal operating temperature. Inertia weight was set at 1750 pounds. The dynamometer load was set to 9.0 actual horsepower at 30 miles per hour regardless of vehicle weight. Using drive for automatic and third gear for manual transmissions, the vehicle was operated at 30 miles per hour roll speed. The concentrations of HC, CO, CO_2 and NO emissions were recorded continuously during this time and analyzed after a maximum of 30 seconds or when stabilized. Following this, the vehicle was allowed to idle until emissions once again stabilized or for a maximum of 30 seconds before the concentrations were again analyzed.

2.6.9 After-Test Procedures

After the completion of testing and acceptance of the data by Quality Assurance, each vehicle was taken to the inspection and maintenance area. Here the mechanic completed an emission component imspection with engine parameters which included initial timing, idle speed, undiluted idle CO and undiluted idle HC emissions. When possible the procedures outlined in the owner's manual and on the vehicle's emission sticker were followed in performing these inspections. If the owner's manual and emissions sticker were missing, the shop manual, or other available publication was used to determine vehicle specifications. In some cases, the vehicle manufacturer was called upon to aid in determining specifications.

Prior to returning the vehicle to the owner, tire pressure was set to manufacturer's specifications, and the fuel tank was filled to full capacity with fuel currently being marketed in the test area. this fuel was suitable for use in the particular vehicle.

2.6.9.1 Propane Gain

Vehicles other than 3-way closed loop received a Propane Gain Test.

2.6.9.2 Maladjustment and Disablement Inspection

All vehicles were given an extensive underhood inspection to determine the condition and proper installation of each emission control component. Procedures used were those detailed in manufacturer's shop manuals. These procedures were supplemented by other manufacturer supplied information where necessary. The systems inspected and the inspection results and the results of the many subsystem inspections were submitted to EPA but are not listed in this report.

2.6.10 Restorative Maintenance

Thirty vehicles were subjected to the RM-1 test sequence. The testing included repair of all maladjusted and disabled emission control components, replacement of defective emission control parts, and a major tune-up as specified by the appropriate manufacturer's maintenance schedule for such tune-up. The vehicles were retested following all repairs using the as-received dynamometer test sequence. The One-Step Restorative Maintenance sequence is presented in Figure 3.

2.6.11.1 Failure Criteria For R/M Sequence

A. Vehicle fails any of its FTP standards by more than 100%.
B. Vehicles fails any mode of the following short tests using cutpoints of 1.2% CO and 220 ppm Hexane.
    *50 Cruise
    *4-Speed Idle
    *Loaded 2-Mode
C. Vehicle has a check engine light on or a trouble code stored in its memory.

2.6.12 Daily Test Schedule

Test shifts were generally limited to the first and second shifts of the day. Vehicles scheduled for test the next day were usually preconditioned on the second shift. Daily calibration checks and system preparation (as described in Section 2.5) were performed prior to the first test of the day and tests were scheduled with this in mind.

2.7 DATA HANDLING

2.7.1 Data Collection

All emission results and appropriate test parameters neces- sary to compute emissions were reported on data forms supplied by the Con- tract Officer. These are presented in Figure 4.

2.7.2 Data Processing

Diluted exhaust emissions test results include ambient temperature, barometric pressure, humidity, and concentrations of HC, CO, CO_2, and NOx. Undiluted exhaust emissions were recorded as ppm Hexane for hydrocarbons, % CO for carbon monoxide, ppm NO for nitric oxides and % CO_2 for carbon dioxide.

All of the exhaust emissions data were collected at the time of test by the AESi DACC. This computer was checked at least monthly using independent calculations from the analyzer strip charts to ensure its validity.

2.7.3 Quality Control

The quality assurance program applied to this project moni- tors every aspect of each emissions test. This includes operator and driver performance, the sampling system, ambient test conditions, analyzer performance, gases, fuel, dynamometer settings and all data processing. In addition, all other data submitted as part of this project received the inspection of the Quality Assurance section. Any discrepancies noted during the review process were resolved in an appropriate manner.

Figure 5 presents a flow chart of the Quality Assurance activities.

SECTION 3

LIST OF FIGURES

FIGURE 1

VEHICLE PROCUREMENT FLOW CHART

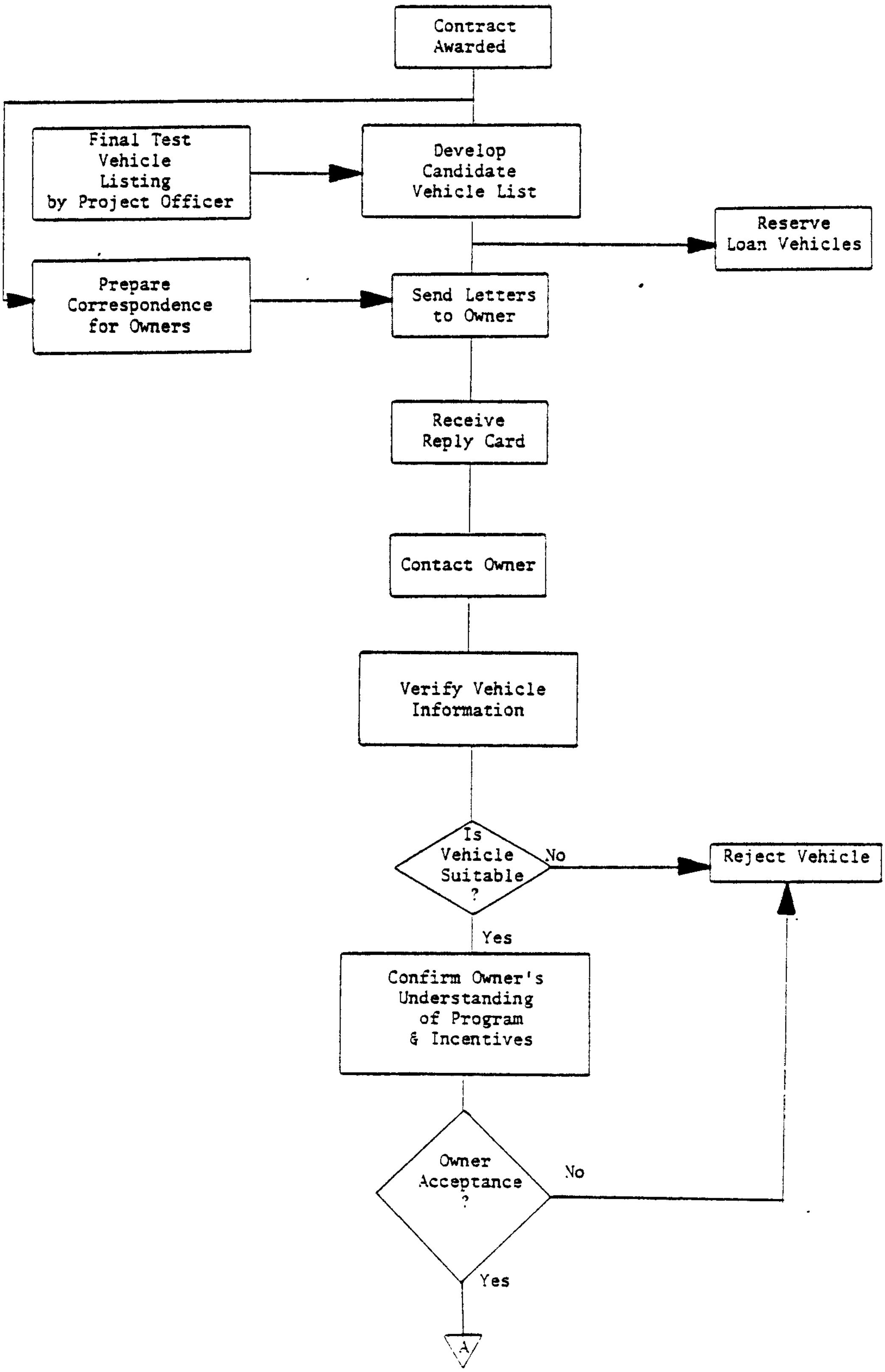

FIGURE 1

VEHICLE PROCUREMENT FLOW CHART

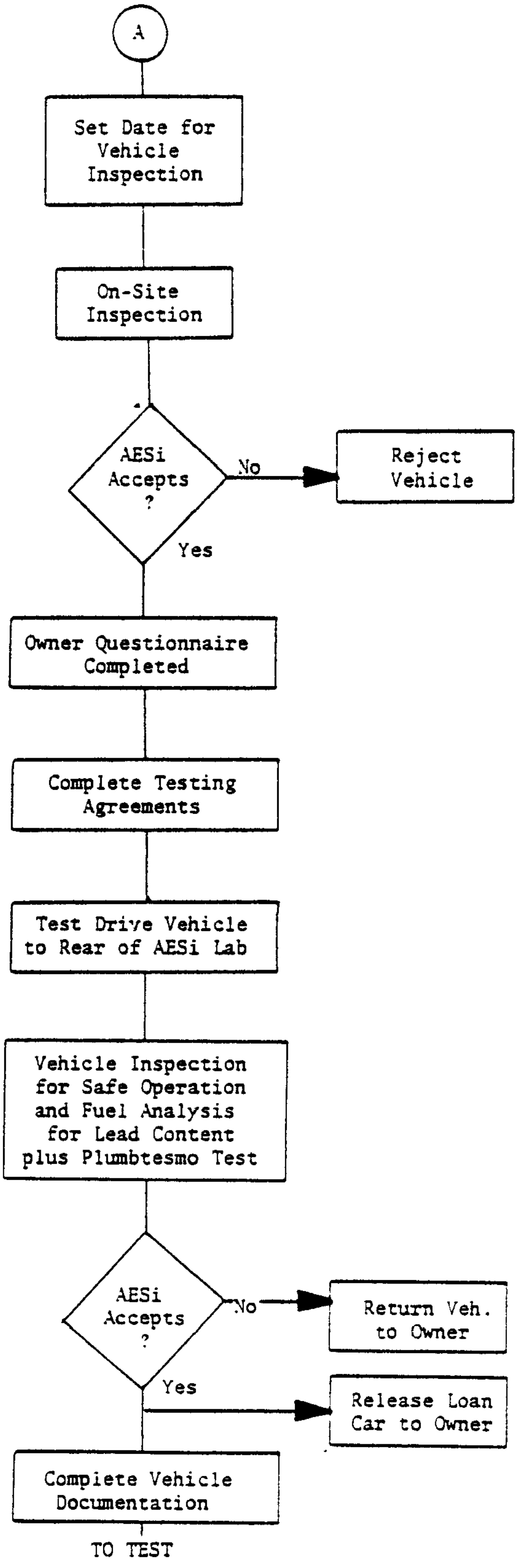

FIGURE 1 CONTINUED

FIGURE 2

TESTING FLOW CHART

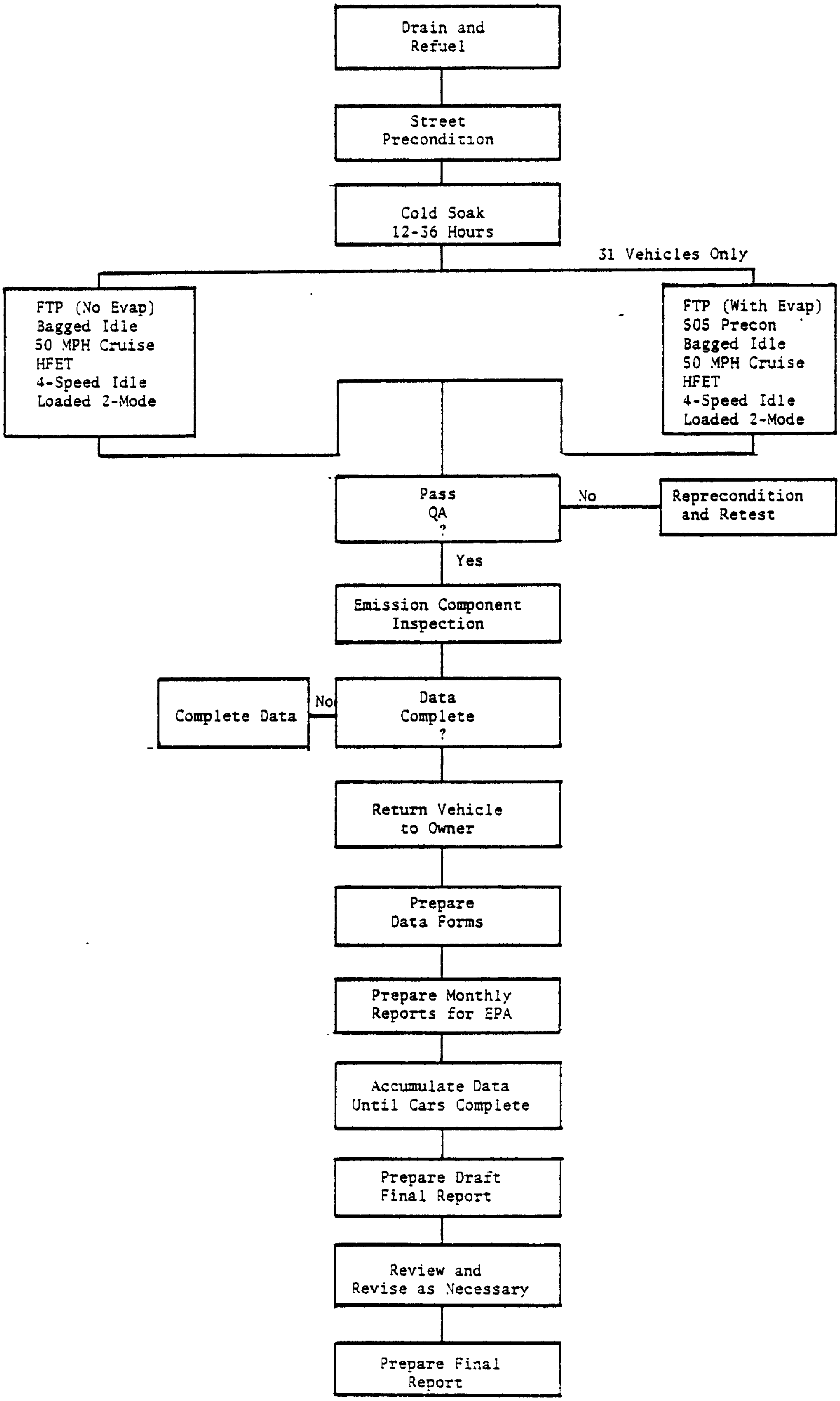

FIGURE 2

TESTING FLOW CHART

FIGURE 3

ONE-STEP RESTORATIVE MAINTENANCE TESTING FLOW CHART

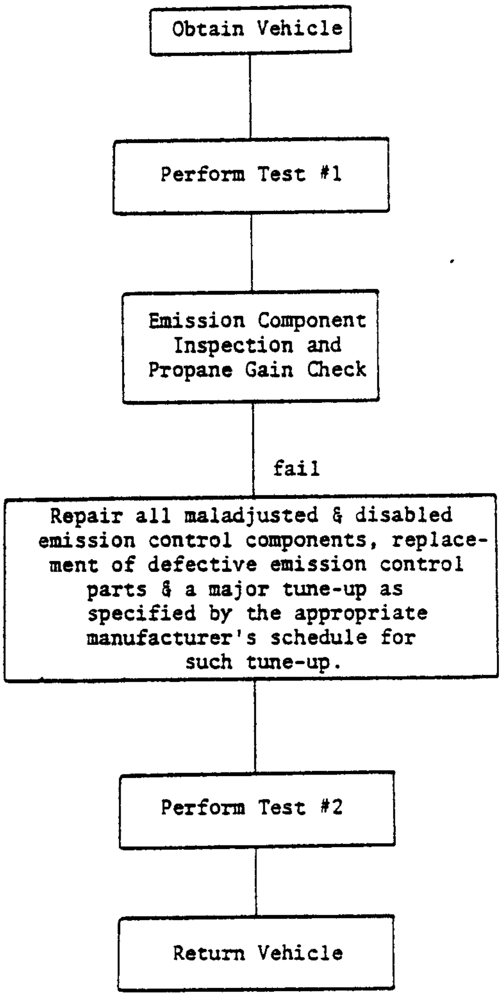

FIGURE 3

ONE-STEP RESTORATIVE MAINTENANCE
TESTING FLOW CHART

FIGURE 4

DATA FORMS

VEHICLE INFORMATION DATA SHEET

IDENT
CONTRACT NUMBER: 3 0 2 3
TASK NUMBER: 0 3
TEST SITE: 0 4
VEH NUMBER
TEST TYPE: 0 2
TEST SEQ
V
5 10 15 20

CARD-V1
VEH MATCH
METHOD OF PROCUREMENT
VEH. TYPE
ENGINE TYPE
MODEL YEAR
MFR CODE
MAKE CODE
MODEL CODE
ENGINE DISP. CID
OVERDRIVE
TRANS TYPE
TRANS SPEEDS
CARB BBLS
VARB VENTURI
TURBO
CYLINDERS
DRIVETRAIN
GROSS VEH WEIGHT RATING lb
A/C
SUPP AIR
5 10 15 20 25 30 35

CATALYST
CAT. CONFIG
BUILD DATE: Y Y M M
VIN (LEFT JUSTIFY)
STANDARDS
ACTUAL STANDARDS
HC gm/mi ●
CO gm/mi ●
NOX gm/mi ●
V
45 50 55 60 65 70 75

CARD-V2
CONTRACTOR RUN NUMBER
FUEL TANK CAPACITY gal
LEAD CONTENT OF FUEL gms/gal ●
PLUMBTESMO
FUEL FILLER NECK DAMAGE
EPA FUEL ECONOMY (GUIDE): CITY MPG, HWY. MPG
AXLE RATIO ●
TIRE SIZE (LEFT JUSTIFY)
5 10 15 20 25 30 35

TIRE MANUFACTURER (LEFT JUSTIFY)
TIRE PRESSURE (psi)
MEASURED: LF, RF, LR, RR
SPEC: FRONT, REAR
TIRE WEAR: LF, RF
VEH TESTED PREVIOUSLY
PREVIOUS CONTRACT NUMBER
TASK NUMBER
LAST CONTRACT VEHICLE NUMBER
V
45 50 55 60 65 70 75

CARD-V3
ENGINE FAMILY (LEFT JUSTIFY)
EMISSION STICKER PART NUMBER (LEFT JUSTIFY)
5 10 15 20 25 30 35

EGR VALVE PART NUMBER (LEFT JUSTIFY)
CARBURETOR PART NUMBER (LEFT JUSTIFY)
V
45 50 55 60 65 70

CARD-V4
DISTRIBUTOR PART NUMBER (LEFT JUSTIFY)
TIME
INSPECTION: HRS ● MIN
REPAIR: HRS ● MIN
COST
CONV.
3-WAY
V
5 10 15 20 25 30

ENGINE PARAMETER DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ		
IDENT	3 0 2 3	0 3	0 4		0 3			G 0
	5		10	15		20		8

	TEST DATE Y Y M M D D	ODOMETER MILES	ENGINE IDLE SPEED MEAS rpm	ENGINE IDLE SPEED SPEC rpm	INITIAL TIMING MEAS VAC LINE DISC deg	INITIAL TIMING MEAS VAC LINE CONN deg	INITIAL TIMING SPEC deg	IDLE % CO
CARD G1								●
	5	10	15	20	25		30	35 4

IDLE HC ppm/hex	FUEL INJ	CHOKE NOTCHES MEAS ±	CHOKE NOTCHES SPEC ±		
					G 1
45		50			8

FTP AND EVAP TEST DATA SHEET

Page (1 of 2)

FTP TEST DATA

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ		
IDENT	3 0 2 3	0 3	0 4		0 5		F	0
	5		10	15		20		80

	INERTIA WEIGHT lbs	ROAD LOAD H.P.	EXTRA 10%		
CARD F1		●		F	1
	5	10			80

	VOLUME OF GAS (Vo) ft³	NUMBER OF REVOLS	BAROM "HG	INLET PRESS "HG	CVS TEMP °F	VMIX	
BAG 1	●		●	●			
	5	10	15	20	25	30	40

CONCENTRATION OF DILUTION AIR

WET BULB °F	DRY BULB °F	DISTANCE MILES	HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm		
		●	●	●	●	●	●	F	2
45		50	55	60	65	70	75		80

CONCENTRATION OF DILUTE EXHAUST SAMPLE

HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
●	●	●	●	●	
5	10	15	20	25	30 40

	VOLUME OF GAS (Vo) ft³	NUMBER OF REVOLS	BAROM "HG	INLET PRESS "HG	CVS TEMP °F	VMIX		
BAG 2	●		●	●			F	3
	45	50	55	60	65	70		80

CONCENTRATION OF DILUTION AIR

WET BULB °F	DRY BULB °F	DISTANCE MILES	HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
		●	●	●	●	●	●	
5		10	15	20	25	30	35	40

CONCENTRATION OF DILUTE EXHAUST SAMPLE

HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm			
●	●	●	●	●		F	4
45	50	55	60	65	70		80

BAG IDLE AND 50 MPH CRUISE TESTS DATA SHEET

BAG IDLE TEST DATA

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 7		B 0
	5	10		15		20	80

	VOLUME OF GAS (Vo) ft³	NUMBER OF REVOLS	BAROM "HG	INLET PRESS "HG	CVS TEMP °F	VMIX	
BAG 1	●		●	●			
	5	10	15	20	25	30	40

WET BULB °F	DRY BULB °F	SECONDS OF TEST	CONCENTRATION OF DILUTION AIR HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
			●	●	●	●	●	B 1
45		50	55	60	65	70	75	80

CONCENTRATION OF DILUTE EXHAUST SAMPLE HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
●	●	●	●	●	B 2
5	10	15	20	25	30 / 80

50 MPH CRUISE DATA

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ
IDENT	3 0 2 3	0 3	0 4		0 8	
	5	10		15		20 / 40

	INERTIA WEIGHT lb	ACTUAL H.P.	ENGINE SPEED rpm	50 MPH CRUISE HC ppm/hex	% CO	% CO2	NO ppm	
CARD 50		●			●	●		5 0
	45	50	55	60	65	70	75	80

FTP AND EVAP TEST DATA SHEET

Page (2 of 2)

FTP TEST DATA (continued)

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 5		F
	5	10		15	20		8

	VOLUME OF GAS (Vo) ft³	NUMBER OF REVOLS	BAROM "HG	INLET PRESS "HG	CVS TEMP °F	VMIX	
BAG 3	●		●	●			
	5	10	15	20	25	30	35

WET BULB °F	DRY BULB °F	DISTANCE MILES	CONCENTRATION OF DILUTION AIR HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
		●	●	●	●	●	●	F 5
	45	50	55	60	65	70	75	8

CONCENTRATION OF DILUTE EXHAUST SAMPLE HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
●	●	●	●	●	F 6
5	10	15	20	25	30

EVAP TEST DATA

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 6		E
	5	10		15	20		8

	NET ENCLOSURE VOLUME ft³	DIURNAL HC CONC INIT ppm/carbon	FINAL ppm/carbon	BAROM PRESS INIT "HG	FINAL "HG	AMB TEMP INIT °F	FINAL °F
CARD E1	1 6 8 2	●	●	●	●		
	5	10	15	20	25	30	

	HOT SOAK HC CONC INIT ppm/carbon	FINAL ppm/carbon	BAROM PRESS INIT "HG	FINAL "HG	AMB TEMP INIT °F	FINAL °F	
	●	●	●	●			E 1
	50	55	60	65	70		8

HIGHWAY FUEL ECONOMY TEST DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ		
IDENT	3 0 2 3	0 3	0 4		0 9		H	0
	5		10		15	20		80

	VOLUME OF GAS (Vo) ft³	NUMBER OF REVOLS	BAROM "HG	INLET PRESS "HG	CVS TEMP °F	VMIX
BAG 1	●		●	●		
	5	10	15	20	25	30 35 40

			CONCENTRATION OF DILUTION AIR					
WET BULB °F	DRY BULB °F	DISTANCE MILES	HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
		●	●	●	●	●	●	H 1
	45	50	55	60	65	70	75	80

CONCENTRATION OF DILUTE EXHAUST SAMPLE					
HC ppm	CO ppm	% CO2	NOX ppm	CH4 ppm	
●	●	●	●	●	H 2
5	10	15	20	25	30 80

FOUR MODE IDLE AND LOADED TWO MODE TESTS DATA SHEET

FOUR MODE IDLE TEST DATA

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		1 0		M 0

5 10 15 20 80

FIRST IDLE READING IN NEUTRAL

	ENGINE SPEED rpm	HC ppm/hex	% CO	% CO2	NO ppm
CARD-M1			●	●	

5 10 15 20 25 40

2500 RPM

HC ppm/hex	% CO	% CO2	NO ppm	
	●	●		M 1

45 50 55 60 65 80

SECOND IDLE READING IN NEUTRAL

	ENGINE SPEED rpm	HC ppm/hex	% CO	% CO2	NO ppm
CARD-M2			●	●	

5 10 15 20 25 40

FINAL IDLE READING IN DRIVE

ENGINE SPEED rpm	HC ppm/hex	% CO	% CO2	NO ppm	
		●	●		M 2

45 50 55 60 65 80

LOADED TWO MODE TEST DATA

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		1 1		L 0

5 10 15 20 80

30 MPH MODE

	INERTIA WEIGHT lbs	ACTUAL H.P.	ENGINE SPEED rpm	HC ppm/hex	% CO	% CO2	NO ppm
CARD-L1	1 7 5 0	9 ● 0			●	●	

5 10 15 20 25 30 40

IDLE MODE IN NEUTRAL

ENGINE SPEED rpm	HC ppm/hex	% CO	% CO2	NO ppm	
		●	●		L 1

45 50 55 60 65 80

DRIVEABILITY EVALUATION DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ
IDENT	3 0 2 3	0 3	0 4	☐☐☐	1 3	☐☐
	5		10	15		20 ... 40

AMBIENT TEMPERATURE °F	☐☐☐	(41-4
ROAD CONDITION (1-DRY 2-WET 3-ICY 4-SNOW)	1 2 3 4	(44)

CONSTANT SPEED PHASE

NUMBER OF STALLS, PASS-OUTS UPON PART THROTTLE ACCELERATION TO ROAD SPEED	☐	(45)
ACCELERATION QUALITY	1 2 3 4 5	(46)
CRUISE QUALITY	1 2 3 4 5	(47)
SLIGHT ACCELERATION RESPONSE (PASSING)	1 2 3 4 5	(48)
IDLE QUALITY AT STOP WITH A/C 'ON'	1 2 3 4 5 9	(49)
IDLE QUALITY AT STOP WITH A/C 'OFF'	1 2 3 4 5	(50)

ACCELERATION FROM STOP PHASE

QUALITY OF ACCELERATION UNDER 1/4 THROTTLE	1 2 3 4 5	(51)
QUALITY OF ACCELERATION UNDER 1/2 THROTTLE	1 2 3 4 5	(52)
QUALITY OF ACCELERATION UNDER 2/3 THROTTLE	1 2 3 4 5	(53)
QUALITY OF ACCELERATION UNDER 3/4 THROTTLE	1 2 3 4 5	(54)

RESTART PHASE

CRANKING TIME TO START AFTER 10 MIN (IN SECONDS)	☐☐	(55-5
IDLE QUALITY AFTER RESTART	1 2 3 4 5	(57)

COLD START AND IDLE PHASE (DYNAMOMETER)

INITIAL CRANKING TIME (IN SECONDS)	☐☐	(58-5
NUMBER OF ENGINE IDLE-OUTS AFTER START	☐	(60)
NUMBER OF ENGINE STALLS AFTER GEAR SELECTION	☐	(61)
HESITATION, LAG UPON SLIGHT ACCELERATION (1-YES 2-NO)	1 2	(62)
IDLE QUALITY	1 2 3 4 5	(63)

DRIVE AWAY PHASE (DYNAMOMETER)

NUMBER OF STALLS, PASS-OUTS UPON SLIGHT ACCELERATION TO ROAD SPEED	☐	(64)
ACCELERATION QUALITY	1 2 3 4 5	(65)
IDLE QUALITY AFTER 0.2 MILE FROM STOP	1 2 3 4 5	(66)
NUMBER OF STALLS, PASS-OUTS UPON SLIGHT ACCELERATION TO ROAD SPEED	☐	(67)
ACCELERATION QUALITY	1 2 3 4 5	(68)
IDLE QUALITY AFTER 0.4 MILES FROM STOP	1 2 3 4 5	(69)

QUALITY CODE D D (79-8

9=IF NOT EQPD, 5=EXCELLENT, 4=GOOD, 3=FAIR, 2=POOR, 1=FAIL

PROPANE GAIN DATA SHEET

Page (1 of 2)

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		1 2		P 0
	5	10		15		20	80

3-WAY CLOSED LOOP

		IN NEUTRAL	IN DRIVE
STEP 1	PRESET FLOW RATE		
STEP 2	RECORD: a) FLOW RATE	☐ 1	☐ 2
	b) RPM	5	10
	c) IDLE %CO	● 15	● 20
STEP 3	INDUCE PROPANE, OBSERVE VEHICLE BEHAVIOR		
	RECORD ONE: a) RPM RISES SMOOTHLY TO	25	30
	b) RPM FALLS SMOOTHLY TO	35	40
	c) ENGINE RUNS ROUGH AND THEN STABILIZES (1-YES)	☐ 43	☐ 44
	d) ENGINE DIES (1-YES)	☐ 45	☐ 46
	e) RPM STAYS THE SAME (1-YES)	☐ 47	☐ 48
STEP 4	WHEN ENGINE STABILIZES, RECORD:		
	a) RPM	50	55
	b) IDLE %CO	● 60	● 65
			P 1 80
	(Continues on Next Page)		

PROPANE GAIN DATA SHEET

Page (2 of 2)

	CONTRACT NUMBER		TASK NUMBER		TEST SITE	VEH NUMBER		TEST TYPE		TEST SEQ		
IDENT	3 0 2 3		0 3		0 4	☐☐☐		1 2		☐☐		P 0
		5			10		15			20		80

3-WAY CLOSED LOOP (Continued)

		IN NEUTRAL	IN DRIVE
STEP 5	WITHDRAW PROPANE, OBSERVE VEHICLE BEHAVIOR		
	RECORD ONE: a) RPM RISES SMOOTHLY TO	☐☐☐☐ 5	☐☐☐☐ 10
	b) RPM FALLS SMOOTHLY TO	☐☐☐☐ 15	☐☐☐☐ 20
	c) ENGINE RUNS ROUGH AND THEN STABILIZES (1-YES)	☐ 21	☐ 22
	d) ENGINE DIES (1-YES)	☐ 23	☐ 24
	e) RPM STAYS THE SAME (1-YES)	☐ 25	☐ 26
STEP 6	WHEN ENGINE STABILIZES, RECORD:		
	a) RPM	☐☐☐☐ 30	☐☐☐☐ 35
	b) IDLE %CO	☐☐●☐☐ 40	☐☐●☐☐ 45
			P 2 80

VEHICLES OTHER THAN 3-WAY CLOSED LOOP

TRANS SPEC		RPM SPEC LEAN DROP OR PROPANE		IN DRIVE			IN NEUTRAL			IN NEUTRAL W/O PROPANE		
				RPM W/O PROPANE	RPM W/ PROPANE		RPM W/O PROPANE	RPM W/ PROPANE		IDLE HC ppm	IDLE %CO	
☐		☐☐☐☐		☐☐☐☐	☐☐☐☐		☐☐☐☐	☐☐☐☐		☐☐☐☐	☐☐☐●☐☐	P 3
	5		10	15		20	25		30		35	8

EMISSION COMPONENTS DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 4	0 1	0 0
	5	10		15		20	80

	SUB SYS PERF CODE	SUB SYS COMPONENT CODE	SYS PERF CODE	
INDUCTION SYSTEM				5
a) HEATED AIR DOOR ASSEMBLY				10
b) TEMPERATURE SENSORS				15
c) AIR FILTER ELEMENT				20
d) HOSES				25
e) OTHER				30
CARBURETOR AND FUEL SYSTEM - FUEL SUBSYSTEM				35
a) CARBURETOR ASSEMBLY				40
b) IDLE MIXTURE ADJUSTMENT LIMITING DEVICE				45
c) IDLE MIXTURE				50
d) IDLE SPEED				55
e) IDLE SPEED SOLENOID				60
f) FUEL INJECTION COMPONENTS				65
g) HOSES, LINES, WIRES				70
h) OTHER				75
			0 1	80

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 4	0 1	C 0

CARBURETOR AND FUEL SYSTEM - CHOKE SUBSYSTEM	SUB SYS PERF CODE	SUB SYS COMMENT CODE	SYS PERF CODE	
				5
a) CHOKE ADJUSTMENT (NOTCHES)				10
b) CHOKE ADJUSTMENT (VACUUM BREAK)				15
c) CHOKE ADJUSTMENT LIMITING DEVICE				20
d) FAST IDLE SPEED				25
e) VACUUM DIAPHRAGMS				30
f) ELECTRICAL CONTROLS				35
g) EXHAUST HEAT CONTROL VALVE ASSEMBLY				40
h) HOSES, LINES, WIRES				45
i) OTHER				50
				55
				60
				65
				70
				75
			C 2	80

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 4	0 1	0
							80

	SUB SYS PERF CODE	SUB SYS COMPONENT CODE	SYS PERF CODE
IGNITION SYSTEM			
			5
a) DISTRIBUTOR ASSEMBLY			
			10
b) INITIAL TIMING			
			15
c) INITIAL TIMING LIMITING DEVICE			
			20
d) SPARK PLUGS AND WIRES			
			25
e) VACUUM ADVANCE ASSEMBLY			
			30
f) SPARK DELAY DEVICES			
			35
g) SPARK KNOCK DETECTOR			
			40
h) ELECTRONIC TIMING MODULE			
			45
i) COOLANT TEMPERATURE SENSORS (TVS)			
			50
j) HOSES, LINES, WIRES			
			55
k) OTHER			
			60
			65
			70
			75
		C	3
			80

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST [illegible]	TEST [illegible]		
IDENT	3 0 2 3	0 3	0 4		0 4	0 1	C 0	80

	SUB SYS PERF CODE	SUB SYS COMPONENT CODE	SYS PERF CODE
EGR SYSTEM			5
a) EGR VALVE ASSEMBLY	☐	☐ ☐	10
b) BACK PRESSURE TRANSDUCER	☐	☐ ☐	15
c) DELAY SOLENOID	☐	☐ ☐	20
d) VACUUM AMPLIFIER	☐	☐ ☐	25
e) VACUUM RESERVOIR	☐	☐ ☐	30
f) COOLANT TEMPERATURE SENSOR (TVS)	☐	☐ ☐	35
g) HOSES, LINES, WIRES	☐	☐ ☐	40
h) OTHER	☐	☐ ☐	45
	☐ ☐ ☐ ☐ ☐		50
	☐ ☐ ☐ ☐ ☐		55
	☐ ☐ ☐ ☐ ☐		60
	☐ ☐ ☐ ☐ ☐		65
	☐ ☐ ☐ ☐ ☐		70
	☐ ☐ ☐ ☐ ☐		75
	☐ ☐ ☐ C 4		80

EMISSION COMPONENTS DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 4	0 1	C 0
	5		10	15		20	80

	SUB SYS PERF CODE	SUB SYS COMMENT CODE	SYS PERF CODE	
AIR INJECTION SYSTEM				5
a) AIR INJECTION ASSEMBLY				10
b) AIR BYPASS VALVE				15
c) AIR DIVERTER VALVE				20
d) CHECK VALVE				25
e) DRIVE BELT				30
f) HOSES, LINES, WIRES				35
g) OTHER				40
PCV SYSTEM				45
a) PCV VALVE				50
b) PCV FILTER				55
c) HOSES				60
d) OTHER				65
				70
				75
			C 5	80

EMISSION COMPONENTS DATA SHEET Page (6 [illegible])

	CONTRACT NUMBER		TASK NUMBER		TEST SITE		VEH NUMBER		TEST TYPE		TEST SEQ		
IDENT	3 0 2 3	▨	0 3	▨	0 4	▨		▨	0 4	▨	0 1	▨	0 0
		5			10			15			20		80

	SUB SYS PERF CODE	SUB SYS COMMENT CODE	SYS PERF CODE	
EXHAUST SYSTEM	▨	▨		5
a) MANIFOLD, TAILPIPE, MUFFLERS			▨	10
b) CATALYST			▨	15
c) OTHER			▨	20
EVAPORATIVE CONTROL SYSTEM	▨	▨		25
a) CANISTER			▨	30
b) CANISTER FILTER			▨	35
c) CANISTER PURGE SOLENOID/VALVE			▨	40
d) HOSES, LINES, WIRES			▨	45
e) OTHER			▨	50
ENGINE ASSEMBLY	▨	▨		55
a) ENGINE ASSEMBLY			▨	60
b) COOLING SYSTEM			▨	65
c) VALVE ADJUSTMENT			▨	70
d) BELT TENSIONS			▨	75
e) HOSES, LINES, WIRES			C 6	80

EMISSION COMPONENTS DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ		
IDENT	3 0 2 3	0 3	0 4		0 4	0 1	[illegible] 0	80

	SUB SYS PERF CODE	SUB SYS COMPONENT CODE	SYS PERF CODE	
f) OTHER	☐	☐		5
3-WAY SYSTEM			☐	10
a) ELECTRONIC CONTROL UNIT	☐	☐		15
b) OXYGEN SENSOR	☐	☐		20
c) BAROMETRIC PRESSURE SENSOR	☐	☐		25
d) LOAD SENSOR (THROTTLE POSITION, MANIFOLD VACUUM, ETC.)	☐	☐		30
e) ENGINE SPEED SENSOR	☐	☐		35
f) COOLANT TEMPERATURE SENSOR	☐	☐		40
g) CRANKSHAFT POSITION SENSOR	☐	☐		45
h) EGR POSITION SENSOR	☐	☐		50
i) EGR CONTROL SOLENOID(S)	☐	☐		55
j) AIR/FUEL CONTROL ACTUATOR (SOLENOID, STEPPER MOTOR)	☐	☐		60
k) AIR BYPASS SOLENOID/VALVE	☐	☐		65
l) AIR DIVERTOR SOLENOID/VALVE	☐	☐		70
m) THROTTLE KICKER ACTUATOR	☐	☐		75
n) IDLE SPEED CONTROL SYSTEM	☐	☐	C 7	80

	CONTRACT NUMBER	TASK NUMBER		TEST SITE		VEH NUMBER		TEST TYPE		TEST SEQ			
IDENT	3 0 2 3	0 3	▨	0 4	▨		▨	0 4	▨	0 1	▨	C	0

	SUB SYS PERF CODE	SUB SYS COMMENT CODE		SYS PERF CODE
o) HOSES, LINES, WIRES				▨
p) DIAGNOSTIC BULB CHECK				▨
q) DIAGNOSTIC WARNING				▨
r) DIAGNOSTIC SYSTEM CODE(S)				▨
	▨			▨
	▨			▨
	▨			▨
	▨			▨
s) OTHER				▨
			C	8

COMMENTS

	CONTRACT NUMBER		TASK NUMBER		TEST SITE		VEH NUMBER		TEST TYPE		TEST SEQ		
IDENT	3 0 2 3		0 3		0 4				1 4				N 0

5 10 15 20 80

5 10 15 20 25 30 35 40

45 50 55 60 65 70 75 80 N 1

5 10 15 20 25 30 35 40

45 50 55 60 65 70 75 80 N 2

5 10 15 20 25 30 35 40

45 50 55 60 65 70 75 80 N 3

5 10 15 20 25 30 35 40

45 50 55 60 65 70 75 80 N 4

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

19 NOV 1980

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 1	0 1	Q 0

1) What is the brand name of the fuel you normally use (see list below)?	☐☐☐☐	(1-4)
2) Have you, or others, ever noticed a hydrogen sulfide (rotten eggs) odor in the vehicle exhaust?	1 (never) 2 (seldom) 3 (occasionally) 4 (frequently) 5 (don't know)	(5)
3) Have you ever used gasohol in this vehicle?	1 (never) 2 (seldom) 3 (occasionally) 4 (frequently) 5 (don't know)	(6)
4) If you have used gasohol, a) Have you noticed any difference in the vehicle performance?	1 (never used gasohol) 2 (perf. is better) 3 (perf. is worse) 4 (no difference) 5 (don't know)	(7)
b) Have you noticed any difference in fuel economy?	1 (never used gasohol) 2 (fuel economy better) 3 (fuel economy worse) 4 (no difference) 5 (don't know)	(8)
5) How long ago did you purchase the vehicle to be tested?	1 (0-3 months) 2 (3-12 months) 3 (1-2 years) 4 (over 2 years)	(9)

DATA ENTRIES FOR QUESTION #1

ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME	ENTER	BRAND NAME
AMOC	AMOCO	CLAR	CLARK	FINA	FINA	MOBI	MOBIL	SHEL	SHELL	UNIO	UNION
ARCO	ARCO	CONO	CONOCO	GEMC	GEMCO	MOTO	MOTOR	SINC	SINCLAIR	VICK	VICKERS
ASHL	ASHLAND	CROW	CROWN	GULF	GULF	PENN	PENNEYS	SITE	SITE	WARD	WARDS
BONA	BONAFIDE	DERB	DERBY	HESS	HESS	PHIL	PHILLIPS	SKEL	SKELLY	ZEPH	ZEPHYR
BP	BP	ENCO	ENCO	HUDS	HUDSON	SCOT	SCOTT	STAN	STANDARD	**	OTHER
CHEV	CHEVRON	ESSO	ESSO	MARS	MARS	SEAR	SEARS	SUNO	SUNOCO	UNKN	UNKNOWN
CITC	CITCO	EXXO	EXXON	MART	MARTIN	SHAM	SHAMROCK	TEXA	TEXACO	VARI	VARIOUS

** IF BRAND IS 'OTHER', THEN ENTER THE FULL BRAND NAME VEHICLE OWNER USES.

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

19 NOV 1980

	CONTRACT NUMBER		TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
DENT.	3 0 2 3		0 3	0 4		0 1	0 1	b b
		5		10	15		20	80

5) On a yearly basis, how many thousands of miles is this vehicle driven?		1 (0-5) 2 (5-10) 3 (10-15) 4 (15-20) 5 (20-30) 6 (over 30)	(10)
) Where is the driving done? almost all: >75% most: 75-51% some: 50-21% little or none: < 20%	a) City expressways	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(11)
	b) Major city streets	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(12)
	c) Other city streets	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(13)
	d) Rural expressways	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(14)
	e) Other rural roads	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(15)
How is the driving done? almost all: >75% most: 75-51% some: 50-21% little or none: < 20%	a) To and from work	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(16)
	b) Shopping and errands	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(17)
	c) Business (not to and from work)	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(18)
	d) Other (social, vacations, etc.)	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(19)
How did you get here today?		1 (city streets only) 2 (some expressway) 3 (primarily expressways)	(20)
	Approx. miles	☐☐	(21-22)

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

19 NOV 1980

	CONTRACT NUMBER					TASK NUMBER			TEST SITE			VEH NUMBER				TEST TYPE		TEST SEQ				
IDENT	3	0	2	3		0	3		0	4						0	1	0	1		Q	0
					5					10					15				20			80

10) How is this vehicle used? almost all: 75% most: 75-51% some: 50-21% little or none: 20%	a) Driver only	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(23)
	b) Driver and one passenger	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(24)
	c) Driver and 2 or more passengers	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(25)
	d) Driver only with heavy cargo	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(26)
	e) Driver, passenger and cargo	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(27)
	f) Towing a trailer	1 (almost all) 2 (most) 3 (some) 4 (little or none)	(28)
11) On a typical day, how many trips are made with this vehicle? (One trip is defined as starting the engine, traveling some distance and stopping the engine).		☐☐	(29-3
12) On a weekly basis, how often is full throttle acceleration used?		1 (seldom) 2 (once or twice) 3 (3-6 times) 4 (every day)	(31)
13) Do you now experience any engine performance problems with this vehicle?	a) Hard starting	1 (yes) 2 (no)	(32)
	b) Stalling	1 (yes) 2 (no)	(33)
	c) Rough idle	1 (yes) 2 (no)	(34)
	d) Engine misfiring	1 (yes) 2 (no)	(35)
	e) Poor acceleration	1 (yes) 2 (no)	(36)
	f) Stumbling	1 (yes) 2 (no)	(37)
	g) Hesitation	1 (yes) 2 (no)	(38)
	h) Engine knock or ping	1 (yes) 2 (no)	(39)
	i) Dieseling (after run)	1 (yes) 2 (no)	(40)

VEHICLE OWNE ESTIONNAIRE
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19 NOV 1980

	CONTRACT NUMBER		TASK NUMBER		TEST SITE		VEH NUMBER		TEST TYPE	TEST SEQ		
IDENT	3 0 2 3		0 3		0 4				0 1	0 1		0 0
		5			10			15		20		80

.4) Overall, are you reasonably satisfied with the engine performance of this vehicle?	1 (yes) 2 (most of the time) 3 (no)	(41)
.5) How long ago was the last oil change?	1 (too new, not due) 2 (due, but not yet done) 3 (0-6 months ago) 4 (6-12 months ago) 5 (Over 1 year ago) 6 (don't know)	(42)
16) If you purchased the vehicle under warranty, how many times has it been returned for warranty repairs?	1 (no warranty) 2 (never returned) 3 (twice) 4 (3 or more) 5 (don't know)	(43)
17) What was the nature of the warranty repair?	1 (no warranty) 2 (never returned) ~~3 (recall)~~ 4 (driveability) 5 (other)	(44)
18) Have you had any repairs to your vehicle for the correction of driveability problems?	1 (yes) 2 (no problems)	(45)
19) What repairs were performed on your vehicle to correct the driveability problems? Specify ____________________	1 (none) 2 (carburetor) 3 (engine) 4 (emission control system) 5 (ignition system) 6 (other) 7 (don't know)	(46)
20) How long ago were these repairs accomplished?	1 (no repairs) 2 (0-3 months) 3 (3-6 months) 4 (over 6 months) 5 (don't know)	(47)
:1) Were these repairs effective in correcting the driveability problems?	1 (no repairs) 2 (yes) 3 (no)	(48)
2) Is this vehicle operated regularly on unpaved roads, in competitive events, or in hauling or transporting loads heavier than for which it was designed?	1 (yes) 2 (no) 3 (don't know)	(49)

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

19 NOV 1980

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IDENT	3 0 2 3	0 3	0 4		0 1	0 1	2 0

5 10 15 20 80

23) Has the vehicle ever had major damage in any of the following areas?	a) Engine	1 (yes) 2 (no)	(50)
	b) Cooling system	1 (yes) 2 (no)	(51)
	c) Fuel system	1 (yes) 2 (no)	(52)
	d) Exhaust system	1 (yes) 2 (no)	(53)
	e) No damage	1 (yes) 2 (no)	(54)
	f) Don't know	1 (yes) 2 (no)	(55)
24) Has the catalytic converter ever been replaced on this vehicle?		1 (no catalyst) 2 (yes) 3 (no) 4 (don't know)	(56)
25) Was the vehicle tested in a previous EPA program?		1 (yes) 2 (no)	(57)
26) Was any maintenance performed since the last test?		1 (yes) 2 (no) 3 (not tested)	(58)
27) What type of maintenance was performed?		1 (warranty) 2 (tune-up) 3 (none) 4 (not tested)	(59)
28) How much did the maintenance cost? 1 : no maintenance 2 : don't know 3 : not tested		☐☐☐	(60-62)
29) Who performed the maintenance?		1 (no maintenance) 2 (dealer) 3 (independent garage) 4 (tune-up clinic) 5 (yourself) 6 (not tested)	(63)

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

19 NOV 1

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
DENT	3 0 2 3	0 3	0 4		0 1	0 1	0 0

5 10 15 20 [illegible] [illegible] [illegible] [illegible]

30) Do you accurately keep records of the fuel economy on this vehicle?	1 (yes) 2 (no)	(64)
31) Are you concerned with the fuel economy of this vehicle?	1 (yes) 2 (no)	(65)
32) Date of last city or state inspection a) Month	☐☐	(66-67)
$\frac{99}{99}$: don't know $\frac{88}{88}$: not required $\frac{00}{00}$: never inspected b) Year	☐☐	(68-69)
33) Did your vehicle pass or fail the inspection?	1 (pass) 2 (fail) 3 (don't know) 4 (not required) 5 (never inspected)	(70)
34) a) Does your odometer indicate the true number of miles on your car?	1 (yes) 2 (no)	(1)
b) *If no, specify approximate total number of miles this vehicle has been driven.*	☐☐☐☐☐☐	(2-7)

0
80

VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
IT	3 0 2 3	0 3	0 4		0 1	0 1	Q 0

5 10 15 20 80

A) How often is the car we are testing tuned up?	1 (at least every six) months) 2 (7 to 12 months) 3 (Less often than once per year) 4 (According to owners manual) 5 (Too new to be tuned) 6 ("When Needed") 7 (Other) 8 (Don't Know) 9 (Not Applicable)	(1)
B) How long ago was the last tune up?	1 (6 months or less) 2 (7 to 12 months) 3 (longer than 12 months) 8 (Don't Know) 9 (Not Applicable)	(2)
C) Who did the last tune up?	1 (car dealer) 2 (service station) 3 (independent garage) 4 (self or other family member) 7 (Other) 8 (Don't Know) 9 (Not Applicable)	(3)

D) We are interested in the fuel economy people actually get with their cars. How many miles per gallon do you get with this car?	a) in the city?	☐☐	(4-5)
	b) on the highway	☐☐	(6-7)
	c) combined city & highway	☐☐	(8-9)
(Enter "98" if Don't Know) (Enter "99" if Not Applicable)			

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VEHICLE OWNER QUESTIONNAIRE
DATA SHEET

	CONTRACT NUMBER	TASK NUMBER	TEST SITE	VEH NUMBER	TEST TYPE	TEST SEQ	
NT	3 0 2 3	0 3	0 4		0 1	0 1	Q 0

5 10 15 20 80

E)	Has unleaded gasoline usually been used in this car?		1 (Yes) 2 (No) 8 (Don't Know) 9 (Not Applicable)	(10)
F)	Unleaded gas is more expensive than leaded and at times has been hard to find.	a) Have you ever used leaded gasoline in this car?	1 (yes) 2 (no) 8 (don't know) 9 (Not Applicable)	(11)
		b) If yes, how often?	50 (50 or more) 51 (Never) 52 (Seldom) 53 (Occasionally) 54 (Frequently) 99 (Don't Know or not Applicable)	(12-13
G)	Is regular or premium used?		1 (Regular) 2 (Premium) 7 (Other) 8 (Don't Know) 9 (Not Applicable)	(14)

Q 2
80

FIGURE 5

QUALITY ASSURANCE ACTIVITY

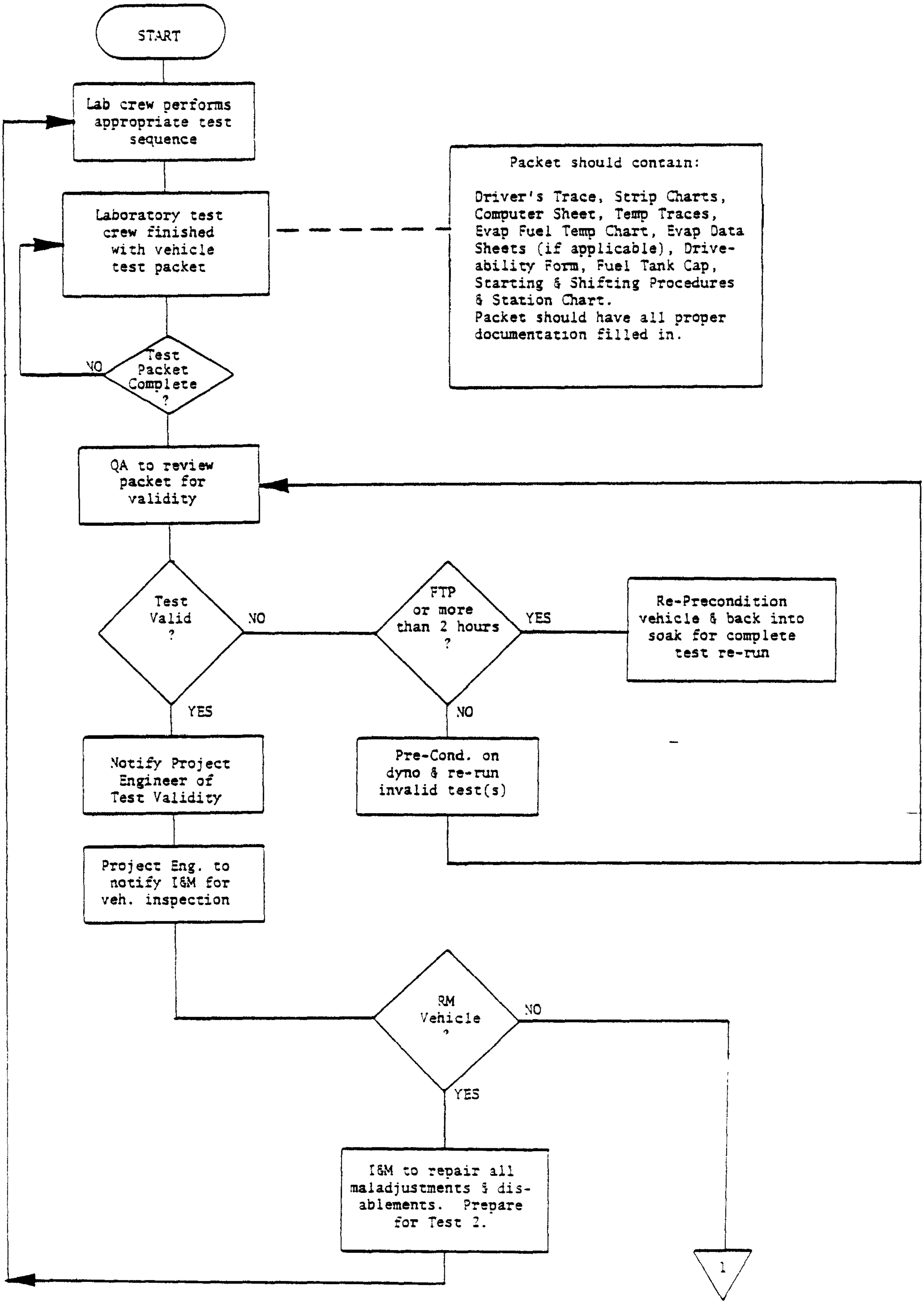

FIGURE 5

QUALITY ASSURANCE ACTIVITY FLOW CHART

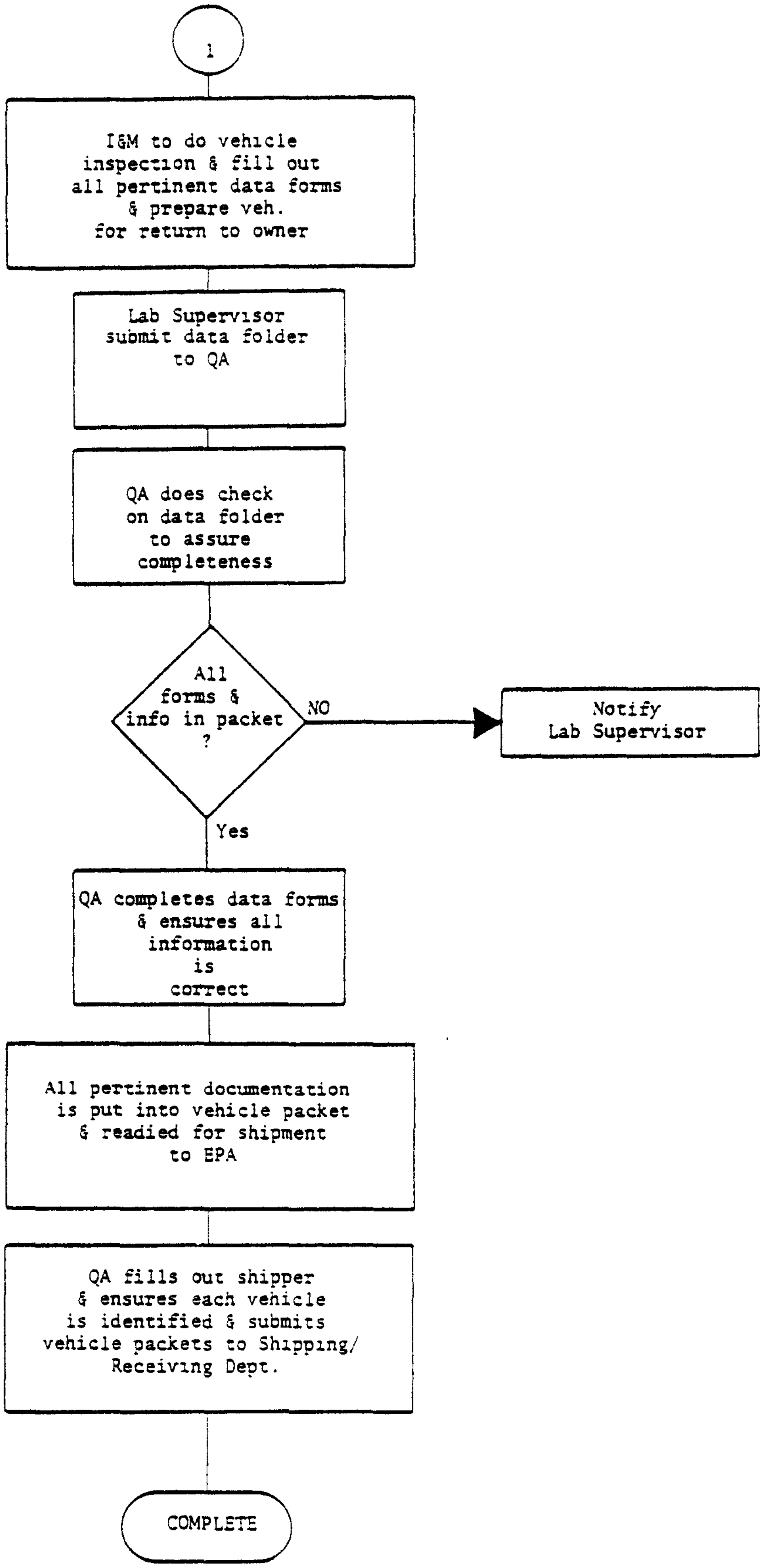

FIGURE 5 CONTINUED