EPA-905/2-79-005

U.S. ENVIRONMENTAL PROTECTION AGENCY
Region V Office
Chicago, Illinois

Contract No. 68-02-2887
Work Assignment No. 7

December 1979

COMPARISON OF PARAMETER AND EXHAUST TESTING APPROACHES FOR A VEHICLE EMISSIONS INSPECTION AND MAINTENANCE PROGRAM IN MICHIGAN

Final Report

Prepared by

Theodore P. Midurski
Frederick Sellars

GCA CORPORATION
GCA/TECHNOLOGY DIVISION
Bedford, Massachusetts

DISCLAIMER

This Final Report was prepared for the Environmental Protection Agency by GCA Corporation, GCA/Technology Division, Burlington Road, Bedford Massachusetts 01730, in fulfillment of Contract No. 68-02-2887, Task Order No. 7. The opinions, findings, and conclusions expressed are those of the authors and not necessarily those of the Environmental Protection Agency. Mention of company or product names is not to be considered as an endorsement by the Environmental Protection Agency.

ABSTRACT

The Michigan Department of State Highways and Transportation is in the process of developing a motor vehicle emissions inspection and maintenance (I/M) program for implementation in various nonattainment areas of the State. To date, the effort has focused on identifying and assessing the various program alternatives available that satisfy the objectives of I/M. A primary issue at this point concerns whether the program should use the emissions measurement concept, or a concept involving parameter inspection.

Assessments of the specific requirements related to implementing I/M in Michigan, including a first level assessment of alternative program approaches, have been developed as part of this initial planning. Based on these initial assessments, the need for a more detailed assessment of the parameter inspection concept was identified.

These detailed analyses of issues related to the parameter inspection concept were performed by GCA/Technology Division, under a contract with the U.S. Environmental Protection Agency. These analyses considered the emissions reduction potential, costs, consumer and repair industry impacts, and administration requirements of four parameter inspection concepts. The results of these analyses are reported here.

CONTENTS

CONTENTS (continued)

FIGURES

TABLES

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of several individuals and organizations to the study effort reported in this document. Much valuable technical information and insight regarding various viewpoints on inspection and maintenance concepts were obtained from the Environmental Activities Staff of General Motors Corporation, and the I/M Technical Staff of the U.S. Environmental Protection Agency's Office of Mobile Source Air Pollution Control. We are particularly indepted to Ms. Susan Mortel of the Bureau of Transportation Planning, Michigan Department of State Highways and Transportation, who served as the State's coordinator throughout the program. Finally, we wish to acknowledge the efforts of Mr. Gary Gulezian and Mr. Carlton Nash of the U.S. Environmental Protection Agency's Region V Office, who provided general direction during the study.

SECTION 1

INTRODUCTION

BACKGROUND

In response to requirements set forth in the Clean Air Act Amendments of 1977 regarding expected nonattainment of air quality standards by the 1982 compliance date, the State of Michigan, through its Department of State Highways and Transportation, is currently involved in the early stages of planning a motor vehicle emissions inspection and maintenance (I/M) program. To date there has been a substantial amount of information published concerning most aspects of I/M programs. Generally, this information focuses on programs that involve measuring tailpipe emissions and comparing the measured concentrations of carbon monoxide and hydrocarbons to standards that reflect the particular emissions control technology used on the tested vehicle. If the emissions concentrations exceed the standards, then some form of adjustment or repair is required. This type of approach is being considered in Michigan.

Several alternatives are also being considered that involve a somewhat different approach in that the emphasis is on individual engine parameters rather than on emissions only. This approach is referred to as parameter inspection. Relatively little data exist regarding this approach to I/M, particularly in terms of direct comparisons with the tailpipe measurement approach.

The decision as to which type of program to implement must be based on the evaluation of a variety of factors such as program cost, emissions reductions achievable, indirect impacts on affected consumers, enforceability, and others. At the present time there appears to be little doubt that both programs represent a viable approach to I/M in terms of effecting desired reductions in the emissions levels of in-use vehicles. To the extent that the two program types can be considered equivalent from the standpoint of emissions benefits, the other factors such as cost, consumer impacts, enforceability, etc. become more important in the overall process of program selection. A necessary step in the I/M planning process is to consider these issues in relative terms for each basic type of program under consideration.

Initial analyses of I/M program issues and requirements for the State of Michigan were recently performed by a consultant under an EPA-sponsored contract.[1] These analyses considered several specific program scenarios in terms of costs, emissions reduction potential, and secondary impacts, and serve as the basis for comparing the impacts of tailpipe measurement programs with the program approaches considered in this document.

PROGRAM OBJECTIVES

At this point in the planning process a decision has not yet been made regarding the basic type of program (i.e., tailpipe measurement or parameter inspection) to be adopted. One obstacle to reaching this decision point is the lack of a clear definition of the implications of selecting one program format over the other, in terms of costs, consumer acceptance, effectiveness in reducing automotive emissions, and other impacts. The specific purpose of this document is to assess the relative impacts associated with the two types of programs and also consider a range of options within each program type. Given that specific program scenarios have not yet been specified, this assessment is most appropriately presented as a discussion of a particular set of issues common to both the parameter inspection and the tailpipe measurement concepts. Further, the emphasis is on defining the relative implications of the two programs rather than considering absolute impacts. Since this effort considers a set of general program concepts, questions that are answered here are also somewhat general in nature; undoubtedly, a different set of more specific questions will evolve once a particular program option or set of options has been defined.

OVERVIEW OF I/M PROGRAMS

Beginning with 1968 model-year vehicles, automobiles manufactured in or imported into the U.S. have had to comply with emissions standards specified in the Federal Motor Vehicle Emission Control Program (FMVECP). Under this program maximum emissions rates are specified for new vehicles, and manufacturers must demonstrate that their vehicles are in compliance with these emissions limits. The emissions standards require progressively more stringent control with each subsequent model year. Ultimately, the standards will require that new vehicles achieve a 90-percent reduction in carbon monoxide and hydrocarbon emissions compared with baseline emissions rates that reflect the 1970 model-year vehicle fleet.

To comply with the emission standards, manufacturers have retained their existing engine design concepts, but developed emission control devices (crank case ventilation control, catalytic converters, etc.) and revised certain system parameter specifications (air-to-fuel ratio, ignition timing, etc.). This approach to emission control ostensibly satisfies the requirements of the FMVECP for new vehicles.

With regard to emissions control in the near-term future, it appears that extensive use will be made of electronic parameter controls that will continuously adjust emissions-critical parameters according to the operating characteristics of the vehicle. Also, continued use will be made of exhaust treatment devices, primarily improved catalysts and air injection. Manufacturers are attempting to design engine components that have limited adjustment ranges in order to reduce the potential impacts of maladjusted parameters and tampering.

Several studies conducted by the U.S. Environmental Protection Agency have demonstrated that in-use vehicles generally emit both carbon monoxide and hydrocarbons at much higher rates than is expected, given the control technology applied. These same studies have shown that the primary reasons for the high emissions rates include improper or inadequate maintenance, and tampering with either the control devices or system settings.

In light of these findings, effort has been expended on developing techniques for reducing the air quality impact of poor maintenance practices and tampering. One result of this effort is the evolution of the inspection and maintenance concept.

In its most basic sense, inspection and maintenance refers to a program where vehicle exhaust emission levels are measured during specified operating conditions and compared with a specified standard for that particular vehicle configuration. If the measured rate exceeds the standard, the need for some form of maintenance, adjustment, or repair is indicated. This is a very simplistic explanation of I/M, but it does serve to define the basic concept involved.

The most widely discussed format for I/M programs involves the tailpipe measurement concept. The primary characteristic of this type of program is that the vehicle either passes or fails the inspection as a result of the levels of carbon monoxide and hydrocarbons measured in the exhaust stream. Failure generally means that the motorist has to have some form of maintenance performed on the vehicle and then return to the inspection station for a retest. Generally, the exact nature of the repairs required is not specified by the inspection results.

Since the overall intent of I/M is to promote better maintenance of in-use vehicles, a more direct approach to this end has been suggested. This approach involves requiring all vehicles to undergo inspection and adjustment of specific components and systems that affect emissions. This concept is referred to as either parameter or functional inspection. The primary characteristic of the parameter inspection concept is that it provides a direct tie between the inspection and maintenance phases. These types of programs are also being considered for implementation in the State of Michigan and are the primary focus of this document.

REPORT ORGANIZATION

Beyond this introductory discussion, the report is organized into six additional major sections. Section 2 provides a detailed explanation of the two specific parameter inspection concepts that have been suggested as viable alternatives to the tailpipe measurement approach to I/M. Specifically, this section considers the actual inspection requirements in terms of the systems and individual components to be inspected, the inspection procedures, and the requirements in terms of time, special equipment and expertise. Following this description of inspection methods and requirements is Section 3, which provides an overview of issues related to the effectiveness of the parameter inspection concept. In discussing effectiveness, issues such as emissions reductions, the expected frequency of failures in various components and systems, and the relationship between the program success and the ability of the inspectors and repair industry to perform satisfactorily are considered.

Section 4 provides a discussion of issues concerning the relative impacts of various types of I/M approaches on consumers. Of particular concern are issues related to protecting the consumer from possible abuse in terms of repair work resulting from the inspections, and also warranty protection afforded through Section 207 of the Clean Air Act Amendments. Section 5 provides a discussion of the potential impacts of I/M on the repair industry. Considered are issues such as training requirements, surveillance and control requirements, and possible shifts in the job market resulting from the implementation of an I/M program. A general discussion of the special administrative requirements imposed by the different approaches is provided in Section 6, while cost analyses for each type of program are presented in Section 7. Section 8 discusses issues related to future emissions control technology, and how this will affect I/M program requirements. Finally, a summary of the various analyses is presented in Section 9. Two appendices are provided. Appendix A is a technical presentation that supports the discussion in Section 2. Appendix B is a glossary of terminology used in connection with I/M.

SECTION 2

TECHNICAL CONSIDERATIONS

INTRODUCTION

The complete definition of a particular I/M program describes several different elements that relate to the inspection procedures, administration, failure rate, geographic coverage, support programs, affected vehicles, and others. The immediate objective with regard to I/M planning in the State of Michigan is to select the basic format that the program will utilize, in terms of the type of inspection to be used (i.e., parameter or tailpipe measurement), and where the inspections will be performed (i.e., private garages or centralized inspection facilities).

The decisions regarding test procedures and test location will have a direct impact on other elements of the program. An estimate of these relative impacts will provide a useful function in the process of selecting a general program format. The objective of this document is to provide an initial assessment of several general parameter inspection scenarios with regard to program cost, consumer protection and acceptance, the repair industry, emissions reduction achievable, the overall administrative requirements, and several indirect impacts. This assessment along with Reference 1 will serve as basic technical support documents for State decision makers responsible for the development of an I/M program in Michigan.

Of primary concern here are four general types of parameter inspection programs that have been proposed for implementation in the State; these include:

- centralized, high option;
- centralized, low option;
- decentralized, high option; and
- decentralized, low option.

In a general sense, the "high options" and "low options" listed above refer to the intensity of the inspection process. More complete definitions of the options are provided in subsequent paragraphs.

The purpose here is to consider the relative impacts of each of the four parameter inspection concepts both with respect to one another, and with respect to tailpipe measurement programs. Since the overall planning effort in the State is not at the point where specific program options have been chosen, the analyses reported here consider general formats that more or less reflect the extremes in the range of possibilities for parameter inspection programs. This being the case, the reader is cautioned that the options discussed in this document are not necessarily those that will be given detailed considerations in subsequent analyses. The intent here is to consider concepts rather than specific program scenarios.

DERIVATION OF CONCEPTS

The four parameter inspection concepts under analysis here were suggested by the Michigan Department of Transportation as those that, in a general sense, would be considered for implementation in the State. The specific concepts were developed by other sources as is indicated below.

At this point each of the four concepts can be discussed in terms of being either a high option or a low option. The high option, whether it is centralized or decentralized, involves a process whereby essentially all engine components, systems, and subsystems that have either a direct or indirect effect on emissions are evaluated by an inspector to ensure that the component, system, or subsystem is functioning or adjusted according to the manufacturer's specifications. Depending on the particular policies established, repairs and adjustments may or may not be performed as part of the inspection process. The low option, on the other hand, involves an inspection of a relatively limited number of engine parameters or components to ensure that they are operating or adjusted properly. The specific parameters are generally those that tend to require repair or adjustment most frequently and also have a significant impact on the emission characteristics of the vehicle.

The parameters inspected under the high option were specified by a consultant working for the State on the development of I/M programs options.[2] These parameters are listed in Table 1. The inspection parameters for the low option were recommended by a major auto manufacturer[3] based on the analysis of preliminary data developed by the U.S. Environmental Protection Agency (EPA) regarding restorative maintenance of in-use vehicles.[4] The parameters included in the low option are listed in Table 2.

From the standpoint that neither option requires unusually expensive, special purpose test equipment or an extraordinarily large floor area in order to perform the inspection, either the private garage or centralized approach can be considered appropriate for both options at this point.

PROGRAM REQUIREMENTS ASSOCIATED WITH PARAMETER INSPECTION

Before discussing each option in detail, a general overview of the parameter inspection concept is in order. As indicated previously, four general parameter inspection formats are considered in this report. It is emphasized, however, that these represent <u>examples</u> of how parameter inspection can be used in an I/M program. Many other scenarios are possible although, in terms of inspection intensity, these would probably reflect some point bounded by the high and low options being considered here.

TABLE 1. INSPECTION PARAMETERS CONSIDERED IN THE HIGH-OPTION SCENARIO FOR THE MICHIGAN I/M PROGRAM

Parameter	Component
Carburetor system	Choke Metering rod Power valve Idle adjustment Float and valve Vacuum break valve
Ignition system	Spark plugs Timing Wires Distributor cap Rotor Vacuum advance Magnetic trigger (electronic ignition)
Thermal air inlet	
Heat riser	
PVC components	
EGR components	
EVAP components	
Air injection system	
Spark delay system	
Three-way catalyst	
Reduction catalyst	
Oxidation catalyst	

TABLE 2. INSPECTION PARAMETERS CONSIDERED IN THE LOW-OPTION SCENARIO FOR THE MICHIGAN I/M PROGRAM

Parameter	Procedure
Visual inspection	Check for obvious disconnects or tampering
Fuel filler inspection	Check for modifications to or removal of filler neck restrictor
Catalytic converter	Visual inspection for presence and general condition of converter
EGR check	Determine that EGR valve responds appropriately
Idle air-to-fuel ratio	Use manufacturer's recommended method to check and/or adjust air/fuel mixture

All I/M programs are established through a legislative process that generally defines which vehicles are to be inspected, which vehicles are exempt from the program requirements, the basis for granting waivers, the inspection frequency, the stringency of the program (often expressed in terms of an allowable failure rate), where the inspections will be performed, how the tests will be performed, etc., and also defines the responsibilities of various agencies in the operation and administration of the program. Actual legislation can (and does) vary widely from state to state regarding what is actually specified. The only requirement by EPA is that the legislation provides adequate legal authority to implement an acceptable I/M program. The specific nature of a state's enabling legislation may not be affected by the type (i.e., parameter or tailpipe inspection) of program selected.

Since most I/M programs are being implemented in response to requirements set forth in the Clean Air Act Amendments of 1977, the actual design of the programs will necessarily be strongly influenced by specific requirements delineated in the Amendments or defined otherwise by EPA policy. Of primary concern here are the requirements specified by EPA policy. These requirements pertain to implementation deadlines, geographic coverage, minimum emissions reduction achievable, and basic program format, and are presented in a memorandum[5] from David G. Hawkins, Assistant Administrator for Air and Waste Management.

With regard to implementation deadlines EPA policy requires the centralized programs to be implemented by 31 December 1981 while decentralized programs must be implemented by 31 December 1980. Under certain circumstances EPA may grant an extension of the implementation date but not beyond 31 December 1982. The primary concern is that the program be implemented as expeditiously as practical. Based on the guidance provided by EPA, it can be assumed that the only factors affecting the final, mandatory implementation of an I/M program are:

- ability to enact appropriate legislation;
- whether the centralized or decentralized approach is utilized;
- if the selected program is centralized, whether it is being added to an existing inspection program (e.g., safety inspection); and
- possible additional factors that would enable the program to be implemented before the final compliance date.

It can be assumed that regardless of whether the program selected for implementation in Michigan is based on the parameter or tailpipe inspection approach, the latest date for implementation that would meet EPA criteria is 31 December 1982. This is not to say that the type of inspection program selected will not affect the actual implementation date since it is quite likely that there would be a difference in the time required to prepare for the implementation, therefore affecting the "earliest" practical implementation date.

Geographic coverage requirements specify the minimum area to be covered by the I/M program. Specifically, EPA policy requires that all nonattainment areas whose urban population is 200,000 or more must implement an I/M program in the urbanized and fringe areas. Also, EPA reserves the right to consider separately nonattainment areas with populations less than 200,000 to determine whether I/M ought to be implemented. While there are no specific requirements regarding geographic coverage that will affect or be affected by the type of program selected, there is a relationship between the actual geographic coverage and the type of program selected based on practicality. Generally, the use of centralized inspection facilities is limited to the more densely developed areas whereas both rural or semirural areas and urban areas can effectively be served by decentralized facilities. The specific geographic coverage may influence the type of inspection process selected, as well. For instance, it may be necessary to minimize the level of sophistication in the testing procedure if very large rural areas are included in the program, because of the likelihood that many rural inspection facilities would not experience sufficient demand to warrant a highly trained specialist. Further, a more sophisticated inspection process generally means that the quality assurance effort will necessarily increase substantially, which will increase the program's cost.

EPA guidance also applies to the expected effectiveness of I/M programs. Specifically, programs should be designed to achieve at least a 25 percent reduction in exhaust hydrocarbon and carbon monoxide emissions from light-duty vehicles by 1987, compared with the emissions that would have been produced by these vehicles in 1987 without an I/M program. EPA has developed and published[6,7] a standard methodology for computing estimates of emissions reductions likely to occur as a result of I/M. These methodologies apply specifically to programs that utilize the tailpipe measurement approach, and therefore are not appliable to parameter inspection. Paragraph 3(d) of Reference 6, which addresses alternative approaches to I/M,* states that "... approaches other than those using an emissions test ... will be acceptable only if sufficient data are provided to justify the emissions reduction claimed." Depending on the exact nature of the substantiation required, any state proposing an alternative approach could be faced with a rather formidable task in supporting its estimates of emissions reduction. It is noted that a pilot study of the effectiveness of an alternative I/M approach proposed by the State of Texas is being planned. This study, which is being sponsored in part by EPA, will require a significant effort over a period of approximately 1 year. A more detailed discussion of the study is provided later, but the point here is that the effort required to evaluate the effectiveness of an alternative approach is significant.

EPA has also defined several requirements for I/M programs in addition to those mentioned above. Reference 5 states that all I/M programs must:

- include regular, periodic inspections for all vehicles for which emission reduction credits are claimed;
- require maintenance and retesting of vehicles that fail the emissions test;
- enforce the program by denying registration, or some equally effective method, to prevent vehicles that fail the inspection from operating on public roads;
- establish quality control regulations and procedures for the inspection system that assure the adequacy of test equipment, require calibration of analyzers, and provide for a specific records keeping procedure;
- provide for either a mechanics training program, or a program to inform the public of repair facilities that have approved emissions analyzers; and
- provide a public information program that will explain the need for and concept of I/M, and identify where inspections can be obtained and the operating hours of the inspection facilities.

EPA also has established additional requirements that apply specifically to programs utilizing the decentralized approach; these requirements are that:

---

*Alternative approaches to I/M imply any approach that does not involve emissions testing to identify vehicles that pass or fail the inspection.

- All official inspection facilities must be licensed. Provisions for the licensing of inspection facilities must ensure that the facility has obtained, prior to licensing, analytical instrumentation that has been approved for use by the appropriate state, local, or regional government agency. A representative of the facility must have received instructions in the proper use of the instruments and in vehicle testing methods and must have demonstrated proficiency in these methods. The facility must agree to maintain records and to submit to inspection of the facility. The appropriate government agency must have provisions for penalties for facilities which fail to follow prescribed procedures and for misconduct.

- Records required to be maintained should include the description (make, year, license number, etc.) of each vehicle inspected, and its emissions test results. Records must also be maintained on the calibration of testing equipment.

- Summaries of these inspection records should be submitted on a periodic basis to the governing agency for auditing.

- The governing agency should inspect each facility periodically to check the facilities records, check the calibration of the testing equipment and observe that proper test procedures are followed.

- The governing agency should have an effective program of unannounced/unscheduled inspections both as a routine measure and as a complaint investigation measure. It is also recommended that such inspections be used to check the correlation of instrument readings among inspection facilities.

- The governing agency should operate a "referee" station where vehicle owners may obtain a valid test to compare to a test from a licensed station. At least one "referee" station must be present in each I/M metropolitan area.

Although there has not been a direct policy statement issued by EPA, it has been indicated that a further requirement for any I/M program using the decentralized approach is that emissions measurements be included. This requirement may be imposed to ensure that repairs or adjustments to vehicles resulting from the inspection process do, in fact, impart a positive impact on individual vehicle emissions.

Assuming that a tailpipe measurement task is an absolute requirement, an argument could be made to use the measurement procedure as a screening device so that only those vehicles that fail to meet the established emission standards have to undergo the maintenance routine prescribed by the program. This approach significantly alters the nature of the program. In fact, it essentially becomes a tailpipe measurement program with the added feature of mandatory parameter repair. Given the basis for many of the arguments supporting parameter inspection over tailpipe measurement, and considering the types of repairs routinely required as a result of failing a tailpipe test, it is not clear that a combined approach would be supported by factions with a strong preference for one type of program over the other.

In summary, it can be stated that many of the basic requirements imposed by EPA regarding tailpipe measurement programs apply directly to parameter inspection programs, as well. There are several differences that should be of concern to those contemplating parameter programs. These concern the need for substantiating estimates of emissions reductions achievable with the parameter program, and the possible requirement to include emissions measurement as part of the program in order to receive EPA approval. With regard to basic program requirements, it appears that most significant differences occur as a function of whether a centralized or decentralized approach is used rather than whether parameter inspection or tailpipe measurement is selected.

TECHNICAL ASPECTS OF THE HIGH OPTION

General

It is of interest to discuss the technical aspects of the four parameter inspection concepts under consideration here. The specific topics treated in this section relate directly to the inspection process in terms of what components are inspected, how they are inspected, the possible rationale for inspecting the components, and an indication of the time and level of expertise required to perform the inspections.

The technical aspects of the four programs vary only as a function of whether the high or low option is being considered. The discussion that follows, therefore, does not involve issues relative to the centralized approach versus the decentralized approach.

Inspection Elements

The basic premise in any parameter inspection concept is that if specific vehicle components and systems are maintained to design specifications, emissions characteristics, driveability, and performance will be optimized in terms of achieving the best balance of these attributes. The parameter inspection concept is maintenance-intensive since the focus is directly on checking, repairing, and adjusting specific components and systems that affect the emissions characteristics of the vehicle. On the other hand, tailpipe measurement programs may be considered less maintenance-intensive since these programs focus more directly on vehicle inspections even though the primary objective is to ensure that maintenance practices are adequate.

The inspection items for the high option were defined by a consultant[8] working under contract to the EPA on a program to assist the State of Michigan with the development of the initial I/M planning effort. The use of the proposed inspection scenario in this effort does not necessarily reflect an endorsement by either the State of Michigan or GCA/Technology Division.

The general inspection scenario for this option requires that all light-duty vehicles (with some yet-to-be-defined exemptions) undergo the parameter inspections and adjustments on an annual basis as outlined in Table 1. The requirement is for all affected vehicles to undergo the complete maintenance cycle; there is no screening performed to identify only those vehicles that actually may need maintenance work performed.

The inspection process proposed for this option involves very detailed inspection and adjustment of the carburetor and ignition system as well as both visual and functional inspections of specific emissions control devices. It is of interest to consider the individual inspection elements.

Carburetor System--

The proposed inspection requires that the choke and metering rods be adjusted, and that various visual inspections be made of the power valve, float, and vacuum break valve. Idle speed and the air-to-fuel ratio (A/F) are to be adjusted. In order to determine the time, equipment, and level of expertise required, discussions were held with service managers at various auto repair facilities, and with manufacturers' service representatives. Also, repair manuals for different types of carburetors were reviewed in detail.

In general, the procedure proposed for this inspection element constitutes a major carburetor tune-up. The exact procedures vary as a function of manufacturer and by model. Some models require major disassembly of the carburetor and related equipment in order to perform the adjustments required under this proposed inspection format. All models require the removal of the air cleaner. The sequences depicted in Appendix A provide a general indication of both the nature of the carburetor inspection and the degree of variability in the techniques used to inspect and adjust three models manufactured by the Rochester Division of General Motors.

In addition to the adjustments outlined above, the A/F must be reset. It is not entirely clear that this step will be necessary (or, for that matter, practical) on vehicles manufactured subsequent to 1981 since generally the carburetors on these vehicles are equipped with limiter caps or plugs that prevent any adjustments to the A/F unless these devices are removed. Once the caps are removed, they cannot be replaced. One important function that these caps perform beyond preventing readjustment (actually tampering) is that their presence indicates that the A/F has not been altered and therefore it can be assumed that it does not require adjustment. In fact, the following note appears in a service manual[9] published by Rochester Products Division of General Motors:

NOTE

> Idle mixture screws have been preset at the factory and capped. Do not remove the caps during normal engine maintenance. Idle mixture should be adjusted only in the case of major carburetor overhaul, throttle body replacement, or high idle

CO as determined by state or local inspections. Adjusting mixture by other than the following method may violate Federal and/or California or other state or provincial laws.

For vehicles that require the adjustment, one of three techniques is used.

The first A/F adjustment technique is referred to as the "lean drop" method. This method is used on many 1975 through 1978 vehicles. It involves the adjustment of the idle mixture until the highest idle engine speed is achieved (as determined through the use of a tachometer). When this maximum idle speed is obtained, the mixture is leaned (the A/F is increased) to the point where a specified RPM drop occurs. This is the point where the optimum A/F occurs for emissions, fuel economy and driveability.

The second technique is used primarily on pre-1977 Chrysler Corporation cars. This process involves adjusting the A/F based on idle carbon monoxide levels in the exhaust stream measured by an appropriate emissions analyzer.

The third technique is referred to as propane enrichment. On vehicles that utilize carburetors having a limited range of idle mixture adjustment on the rich side, the use of propane introduced into the fuel mixture provides an artificial means of enrichment. The lean drop characteristics described above are achieved in this manner. A recommended[10] procedure for performing idle mixture adjustment using propane enrichment is:

1. Set parking brake and block drive wheels. On cars equipped with vacuum parking brake release, disconnect and plug hose at brake.

2. Disconnect and plug hoses as directed on the emission control information label under the hood.

3. Engine must be at normal operating temperature, choke open and air conditioning off.

4. Connect an accurate tachometer to engine.

5. Disconnect vacuum advance and set timing to specification shown on the emission control information label. Reconnect vacuum advance.

NOTE

On cars equipped with electronic spark timing, check timing as directed on the emission label.

6. Disconnect crankcase ventilation tube from air cleaner.

6A. On L-4 151 CID engines - disconnect crankcase ventilation hose at vapor storage canister.

7. Insert hose with rubber stopper from propane valve into the crankcase ventilation tube opening in the air cleaner (see Figure 1).

7A. On L-4 151 CID engines - insert hose with rubber stopper from propane valve into the positive crankcase ventilation hose at the charcoal canister end of the hose.

8. Propane cartridge must be in a vertical position.

9. Slowly open propane control valve until maximum engine speed is reached with the transmission in Drive (Neutral for manual shift).

NOTE

Too much propane will cause engine speed to drop.

10. Observe propane flow meter to ensure propane cartridge is adequately full.

11. With propane flowing, adjust idle speed screw or solenoid to the enriched RPM (starting point for lean drop setting - see specifications).

NOTE

On some applications, it is necessary to remove the air cleaner and tile to one side to gain access to the idle speed screw. Install flexible shaft tool over idle speed screw, re-install air cleaner and proceed with adjustment.

12. Turn off propane. Place transmission in Neutral and run engine at approximately 2,000 rpm for 30 seconds. Return to idle and put transmission in Drive (Neutral for manual shift).

13. Check idle speed. If it is as shown on the emission control information label, the idle mixture is correct. In this case, proceed with Step 18.

14. If the speed is too low, carefully remove caps from mixture screws and back out (richen) 1/8 turn at a time until speed on emissions label is reached. If the speed is too high, carefully remove caps from mixture screws and turn screws equally in (leaner) 1/8 turn at a time until speed is reached.

NOTE

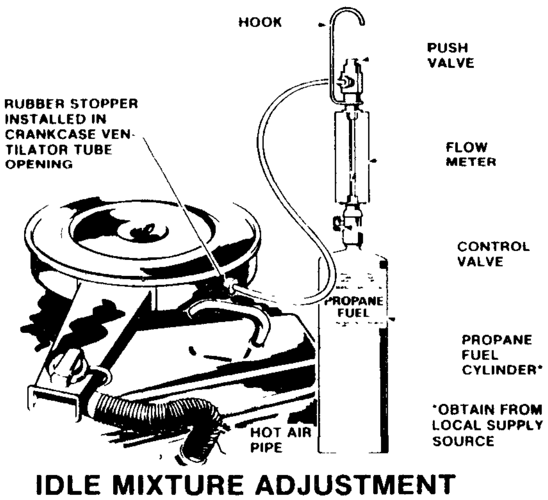
If necessary, remove air cleaner and tilt to one side to gain access to the idle mixture screws. Install flexible shaft tool over idle mixture screws(s), re-install air cleaner and proceed with adjustment.

15. Turn propane on again to check maximum engine idle speed. If speed is different from specification (enriched RPM - starting point for lean drop setting), readjust idle speed screw on solenoid to enriched RPM with propane flowing.

16. Turn off propane again, clean out engine at 2,000 rpm for 30 seconds in Neutral. Recheck idle speed with transmission in Drive (Neutral for manual shift). It should be as shown on the emission control information label. If not, repeat the adjustment procedure as in Step 14.

17. If rough idle persists, turn mixture screws in until lightly seated. Back these out equally to the average previous position and re-run propane idle test starting with Step 9.

18. Turn off engine and remove propane tool. Connect crankcase ventilation tube to air cleaner. On L-4 151 CID engines - connect crankcase ventilation hose at vapor canister.



Source: Reference 10

Figure 1. Propane enrichment device.

It is obvious that the carburetor inspection and adjustment proposed under the high option is a very demanding process in terms of both time and skill. Discussions with service personnel indicate that only a highly competent mechanic should attempt to perform the adjustments required by this option. The required skill level is increased if the mechanic is expected to perform the adjustments on all types and makes of vehicles, which would be expected in an I/M program.

Special equipment requirements are more or less limited to small tools and special gauges, a propane enrichment device, and an emissions analyzer. Also, a complete set of service manuals for all carburetor and vehicle configurations is essential.

The time required to perform the complete carburetor inspection and adjustment routine is highly variable from vehicle to vehicle. Generally, estimates provided by service representatives range from 1 to 2½ hours per carburetor depending on the type of vehicle, the carburetor type and model, what accessories (such as air conditioning) are on the vehicle, and the mechanic's familiarity with the particular vehicle configuration.

Ignition System--

The proposed inspection scenario calls for the examination of seven components of the ignition system, including:

- spark plugs;
- wires;
- distributor cap;
- rotor;
- vacuum advance;
- magnetic trigger; and
- timing.

The individual inspection procedures are outlined in Table 3.

The skill level required for this portion of the inspection is not as great as for the carburetor phase. Generally, a mechanic experienced in engine tune-up work should be able to perform the required inspections adequately. The amount of time required to perform the inspections is quite variable. Estimates provided by several automotive service managers indicated that the time range is from 30 minutes to over 2 hours, again depending on the particular vehicle being inspected.

There are no highly specialized equipment items required, although an oscilloscope could be used to assess the condition of ignition wires. Use of an osilloscope would likely be optional, based on its availability.

Thermal Air Inlet--

The following is a typical procedure used to check the thermostatically controlled valve in the air cleaner.

TABLE 3. PROCEDURE FOR IGNITION SYSTEM INSPECTION

Element	Procedure
Spark plugs	• Remove from engine and examine for excess deposits or signs of unusual oil deposits or fouling that might indicate a more serious problem. Check for proper plug type and gap.
Wires	• Clean exterior of wires. Remove any evidence of corrosion on terminals. Inspect for evidence of checking, burning, or cracking of insulation. Check for tight fit at distributor cap and plugs. An engine analyzer (oscilloscope) may be used to check resistance.
Distributor cap	• Visually check interior and exterior of distributor cap for cracks, carbon tracking, and terminal corrosion.
Rotor	• Visually check for cracks, carbon tracking, and terminal corrosion.
Vacuum advance	• For transmission controlled vacuum advance: - First method: 1. Set parking brake and block drive wheels. 2. Run engine at fast idle. 3. Shift 3-speed transmission into third, 4-speed transmission into fourth, or 5-speed transmission into fourth and fifth. Do not release clutch. 4. Engine speed should increase noticeably as vacuum is applied to the distributor. - Alternate method: 1. Set parking brake and block drive wheels. 2. Connect a vacuum gauge to vacuum line at distributor. 3. With transmission in neutral, run engine at 1,000 rpm. There should be no vacuum reading on gauge. 4. Shift 3-speed transmission into third, 4-speed transmission into fourth, or 5-speed transmission into fourth or fifth.

(continued)

TABLE 3 (continued)

Element	Procedure
Vacuum advance (continued)	5. There should now be vacuum at the gauge. - If vacuum is not present in these tests: 1. Connect a test light (1893 bulb or smaller) between the two connector terminals on the solenoid. 2. Start engine. Test light should be on. 3. If light is not on, check for open circuit. If there is no open circuit, replace transmission switch. 4. Place 3-speed transmission into third, 4-speed transmission into fourth, or 5-speed transmission into fourth or fifth. 5. Light should go out. 6. If light does not go out, check for grounded wire between solenoid connector and transmission. If wire is not grounded, replace transmission switch. ● All others: - Set parking brake and block drive wheels. Place transmission in Park or Neutral. - Disconnect and plug vacuum hose at distributor. - Apply at least 15" Hg of vacuum to the distributor from an external vacuum source. - Engine speed should increase. Also, diaphragm should hold vacuum for at least one minute. - If either part of Step 4 fails to occur, replace vacuum advance diaphragm.
Magnetic trigger	● No specific test identified.
Timing	● Using tachometer and timing light, set timing as per instructions on Emissions Control Information Label, or service manual.

1. Inspect air cleaner to ensure that all hoses and ducts are connected and correctly installed. Inspect valve in snorkel for proper operation. If engine is warm (above room temperature) remove top of air cleaner. Cool the temperature sensor with a cool wet rag.

2. If air cleaner has cold air intake hose, it must be disconnected.

3. Start engine. Watch damper valve in air cleaner snorkel. It may be necessary to use a mirror to see inside the snorkel.

4. When engine is first started, valve should close. As air cleaner warms up, valve should slowly open.

5. If valve doesn't close when the engine is started, check for vacuum at the vacuum motor.

6. If vacuum is present, check for binding on the damper valve and operating link. If damper moves freely, replace vacuum motor. (Failure of the valve to close is more likely to result from mechanical bind due to a damaged or corroded snorkel assembly than from a failed motor. This should be checked first, before replacing vacuum motor).

7. If no vacuum is present, check hoses for disconnects, cracks or pinches.

8. If there are none, replace temperature sensor in the air cleaner.

This task is not particularily difficult nor does it require specialized tools or other equipment. The time required to perform the inspection can be expected to range from 10 to 20 minutes.

Heat Riser--

The inspection procedure involves manually checking the heat riser valve to ensure that it operates freely and that the operating mechanism (generally a bimetalic sensor) is connected. The purpose is easily accomplished by a mechanic who has a basic familiarity with the inspection requirements, in less than one minute.

PCV Components--

The following procedure is used to inspect the PCV system:

1. Remove PCV valve from engine.

2. Shake valve, listen for rattle.

3. If valve does not rattle, replace valve.

4. Start engine. Check for vacuum through valve by placing thumb over end of valve.

5. If no vacuum is felt, check for plugged hoses or valve. Replace valve or hoses if plugged.

6. Check PCV filter; clean or replace as necessary.

Exhaust Gas Recirculation (EGR) System--

Ordinarily, this system does not usually require routine maintenance, however it is possible to ensure that the system is functioning properly by performing one of the following test routines:

1. Set parking brack and block drive wheels. Place transmission in Neutral or Park.

2. With the engine at normal operating temperature, open the throttle while feeling the bottom side of the valve diaphragm.

CAUTION

Valve is hot. It may be necessary to wear gloves to avoid burning fingers.

3. Valve diaphragm should move upward (open) as the engine accelerates.

4. Valve diaphragm should move downward (close) as the engine returns to idle.

NOTE

A slight vibration of the diaphragm plate may be noticed on backpressure models. This is due to the control valve modulating under light load and does not indicate an undesirable condition nor one requiring correction.

5. If valve diaphragm does not move, check for vacuum at hose with engine at 2,000 rpm.

6. If vacuum is present, replace valve.

7. If there is no vacuum, check vacuum hose for restriction.

8. If there is no restriction in the hose and the engine is thoroughly warmed-up, replace EGR temperature control valve.

If the EGR is suspected of causing a problem or when there is a possibility the EGR passages are plugged, a more detailed test may be performed.

1. Connect accurate tachometer to engine.

2. With engine at normal operating temperature, run engine at 2,000 rpm in neutral.

3. Disconnect vacuum hose from EGR valve.

4. Engine speed should increase. If it does, the EGR valve is operating and the passages are clear.

5. If the speed does not increase, check under the valve diaphragm for movement as the hose is connected. If there is no movement and there is vacuum at the hose, replace the valve.

CAUTION

Valve is hot. It may be necessary to wear gloves to avoid burning fingers.

6. If the valve moves, but the speed does not increase, remove and clean valve. Also clean passages in manifold.

7. To test the EGR vacuum temperature control, the engine must be allowed to cool or the temperature sensor cooled to at least 60°F. It should then block vacuum to the EGR valve. If it does not, replace temperature sensor.

The inspection requires only a basic familiarity with the EGR system and can be accomplished easily by an inspector with minimal training. The time required for this inspection is approximately 2 minutes.

Evaporation Control System--

This system is inspected as follows:

1. Check all fuel and vapor lines and hoses for proper connections and correct routing as well as condition. Remove canister and check for cracks or damage. Replace damaged or deteriorated parts as necessary. Replace filter in lower section of canister at designated intervals.

2. Inspect the fuel tank, lines and cap for damage that could cause leaks.

3. Remove fuel cap.

4. On threaded caps inspect rubber O-ring for cuts, breaks, swelling, or misposition. Inspect threads for wear or damage.

5. Install cap. Check for proper ratcheting as cap is tightened. On cap with locking tabs, inspect gasket for an even imprint from the filler neck.

6. Replace any damaged or deteriorated parts.

The inspection process is relatively simple, requiring basic familiarity with the system and no special tools. The entire inspection, including required maintenance, should take no more than 15 minutes.

Air Injection Reaction (AIR) System--

This system does not require routine periodic maintenance other than inspecting the pump drive belt every 15,000 miles for tension, cracks, fraying, or other signs of wear. The belt should be adjusted or replaced as necessary. The air pump should never be oiled. The air pump cannot be disassembled. If it becomes noisy or otherwise inoperative, it must be replaced.

To inspect AIR system, the following procedure is followed:

1. Set parking brake and block drive wheels.

2. Start engine. Place transmission in neutral or park.

3. Feel for air exhausting from ports in diverter valve silencer or from the muffler on the air by-pass valve. There should be none. Momentarily accelerate engine.

4. As engine returns to idle, air should exhaust from diverter valve silencer or from the muffler on the by-pass valve. In most cases, the air can be heard. If in doubt, feel diverter valve exhaust ports for air. It should exhaust for several seconds.

5. If system does not perform properly, refer to the manufacturer's service manual for complete diagnostic and service information.

This inspection task requires a basic familiarity with the AIR system. No special tools or equipment are required. The test procedure, excluding any maintenance or adjustment, should not require more than one to two minutes.

Spark Delay Valves--

See Ignition System.

Three-way Catalyst, Reduction Catalyst, Oxidation Catalyst--

The exhaust catalysts are visually inspected to determine that they are present and not damaged. The inspection process requires a lift, a pit, or a lighted mirror device since the catalyst is located under the vehicle. Inspection time is approximately one minute.

Discussion of the High Option

The obvious intent of the high option is to ensure that all systems and components that affect carbon monoxide or hydrocarbon emissions are maintained to manufacturer's specifications. From the standpoint of comprehensiveness only, this option approaches the ideal in that it focuses on most of the items and systems that can adversely affect emissions characteristics. Realistically, however, the complete definition of the "ideal" program must be developed in terms of practicality, cost effectiveness, public acceptance, etc., in addition to the thoroughness of the inspection. In this overall context, then, the high option becomes somewhat less than ideal. In fact, even without quantifying the cost and other associated impacts, there is a tendency to question whether the approach is at all reasonable. This uncertainty is based primarily on the time requirements and level of expertise needed to perform the inspections. The overall inspection time has been estimated to have a range of from <u>1½ to almost 5 hours per vehicle</u>. This is clearly beyond the desired scope of most inspection programs.

An important consideration in parameter inspection programs in general is whether the intent should be only to identify specific defects and maladjustments and require the motorist to go elsewhere for repairs, or whether the inspection should include necessary adjustments and minor repairs. On one hand there is a question of consumer protection. Generally, it is considered desirable to separate the inspection and repair process in the interest of consumer protection. On the other hand, however, the issue of consumer convenience argues for a combined inspection/repair approach. This is particularly relevant to the high option since separating the inspection and repair phases imposes severe time and cost requirements on the motorist. Essentially, any failure requires repair <u>and</u> retesting, since EPA's current policies require "... maintenance and retesting of failed vehicles ..." as stated previously. This results in extremely high costs for motorists whose vehicles fail any of several inspection elements, particularly those involving the carburetor.

A related issue concerns whether or not the state or an agent of the state can legally become directly involved in the repair of motor vehicles. This type of issue surfaces with a centralized approach where the state or an agency contracted by the state operates the inspection facilities. If it is determined that it is either not legal or not desirable for the state to be involved in repairs, then the program must be limited to the performance of inspections only. It appears that a parameter program of this type would be extremely unpopular and difficult to manage.

Notwithstanding these preliminary observations, a more thorough assessment of the costs, benefits, effectiveness, and indirect impacts associated with the high option parameter inspection program is in order. In the context of this report, the specific programs being evaluated reflect the extremes in the range of possibilities.

TECHNICAL ASPECTS OF THE LOW OPTION

General

Although there are many different systems and individual components that affect the emissions characteristics of a motor vehicle, it is reasonable to expect that only certain ones are likely to deteriorate in a manner that would warrant periodic inspection. Moreover, it can be expected that some components that are out of adjustment or that need repair will have a more significant impact on emissions compared to other deficient components. These factors provide the basis for the low option concept.

Essentially, the difference between the high and low options is that the low option focuses on a limited number of parameters — specifically, those that both warrant periodic inspection and have a relatively significant impact on emissions. A limited analysis of the causal aspects of high-emitting in-use vehicles indicates that an annual inspection and adjustment of the parameters listed in Table 2 would provide a reduction in the overall emissions rate from the in-use vehicle fleet (this is discussed in detail in Section 3).

Inspection Elements

In contrast to the high option, the low option only considers five elements. Of these five, three involve visual inspections while the other two require a functional check. Each inspection element is discussed in the following paragraphs.

Visual Inspection--

The intent here is to identify any obvious tampering with or damage to the emissions control system and accessories. The exact nature of the visual inspection will vary from vehicle to vehicle although several specific elements will generally be common to all vehicles. The types of items to be examined include lines and hoses, air cleaner, carburetor preheat duct, wires and electrical connections, and drive belts. Also, the inspector must check to see that all appropriate components are present.

The basic intent is to ensure that the emissions control system is intact and that the system's operation is not impaired. Inspection criteria are based primarily on the condition of the components to the extent that a visual inspection permits.

The skill level associated with this task is not exceptionally high. Essentially, the inspector should be familiar with the general types of emission control devices used on different vehicles, and how to assess the condition of hardware (hoses, etc.). The actual inspection time is estimated to range from 1 to 2 minutes.

Fuel Filler--

The primary concern is that the fuel neck restrictor is in place on all vehicles that require the use of unleaded fuel. This can be checked by merely removing the filler cap and visually inspecting for the presence of the restrictors. A go/no-go gauge can also be used to ensure that the restrictor has not been enlarged to accept a leaded fuel nozzle. It is also suggested that the filler cap be inspected to ensure that the O-ring is not damaged or deteriorated, that the proper racheting action occurs when the cap is replaced, and that the threads on the cap and filler neck are not damaged.

The inspection requires only a basic familiarity with the fuel filler components; the actual inspection time range is 30 seconds to 1 minute.

Catalytic Converter--

The intent of this inspection is to ensure that the converter has not been removed and that there is no obvious physical damage to the converter housing. This constitutes a reasonable inspection of the device since obvious damage to the housing generally means that there is a strong possibility that internal damage has also occurred. On the other hand, it is obvious that this type of inspection would identify problems such as catalyst poisoning, which could occur without the fuel filler neck having been modified.

The inspection procedure involves visually checking the converter for holes, dents, or signs of overheating or burning. The inspection can be accomplished without tools or special equipment, although a lighted mirror or similar device could be incorporated. The inspection time requirement is less than 1 minute.

EGR Check--

The process for inspecting the EGR system is the same for both options and was described in detail previously.

Idle Air/Fuel Mixture--

This procedure is the same as for the idle mixture inspection task discussed previously as part of the high option. The time requirement for this task is estimated to be 20 to 30 minutes.

Discussion of the Low Option

The obvious difference between the high and low options is the level of intensity involved. Whereas the inspection time requirement for the high option is discussed in terms of hours, the low option can be accomplished in about 35 minutes. The question of the relative effectiveness of the two options is of importance and will be considered in detail in a subsequent section.

From the standpoint of inspection time, expertise, and special equipment required, the low is much more reasonable than the high option. However, compared to the tailpipe inspection approach, the low parameter inspection requires a significantly greater amount of time to perform — generally 5 to 10 minutes for a tailpipe measurement inspection compared to approximately 35 minutes for the low parameter inspection. The additional time required is directly reflected in the cost of the inspection. As stated previously, however, a major factor that can contribute to the attractiveness of a parameter inspection program, particularly one on the scale of the low option, is the ability to incorporate some of the more minor repair and adjustment work into the inspection process. For the low option, the most likely repair and adjustment work would involve the carburetor adjustment and replacing minor components such as vacuum hoses and lines found to be damaged.

In an overall sense, the low option appears to be much more practical than the high option owing primarily to the fact that the inspection time and undoubtedly the costs are more in line with what would be considered reasonable for any type of mandatory inspection. Although it is shown here that the low parameter inspection procedure requires more time than a tailpipe measurement inspection, the actual difference is not so significant that a more detailed assessment would not be warranted. This more detailed analysis would be appropriate if specific program alternatives were being compared and if comparisons were made of the total inspection-maintenance-reinspection cycles. These types of analyses cannot be conducted at this point since only general concepts are being considered.

SECTION 3

POTENTIAL EFFECTIVENESS IN REDUCING MOTOR VEHICLE EMISSIONS

INTRODUCTION

Given the context in which most I/M programs are implemented, a primary measure of effectiveness is the overall reduction in emissions that is achieved. The expected emissions reductions result from maintenance performed in response to the program that would not have otherwise been undertaken. The parameter inspection programs being considered here are exceptionally maintenance-intensive, therefore it is necessary to assess the expected effectiveness very carefully to determine, at least in a basic sense, whether the expected reductions in emissions warrant such a high level of vehicle maintenance. This section discusses the potential effectiveness of applying various levels of inspection and maintenance to the general vehicle fleet in terms of the relative levels of emissions reductions that can be expected. The intent is not to develop a detailed quantitative assessment of the emissions reductions expected with each program, but rather to provide a discussion of the relative effectiveness of each type of program in terms of emissions reduction potential.

It is emphasized that the overall effectiveness of any I/M program is determined by many other factors besides emissions reduction. In fact, an even more important measure of effectiveness is the relative cost effectiveness of each program alternative. Several additional factors, such as consumer impacts, program flexibility, impact on the repair industry, etc, must also be considered in evaluating the overall effectiveness of alternative I/M approaches. The discussion provided in this section therefore provides only a partial indication of the potential effectiveness of the four parameter inspection approaches under consideration.

POTENTIAL FOR REDUCING EMISSIONS

The effectiveness of any I/M program reflects the change in maintenance practices that result. The most thorough inspection program is of little value unless deficiencies in the various emissions-related systems and parameters are corrected. The underlying premise in parameter inspection is that if all emissions-related components and systems are functioning in accordance with the manufacturer's specification, the emissions characteristics, driveability, and fuel economy should be optimized. Parameter inspection programs require that all affected vehicles be inspected periodically to verify that the appropriate parameters are set according to the manufacturer's specifications. As one would expect, there are many individual parameters, systems, and components in today's motor vehicles that either directly or indirectly affect emissions characteristics. A fundamental concern in designing a parameter inspection program is to include as inspectable parameters, only those items that have a significant impact on emissions, and that have at least a moderate potential for actually requiring some form of maintenance. The intent of the discussion presented in the following paragraphs is to indicate which specific vehicle systems, components, and parameters have both a potentially significant impact on emissions and a moderate likelihood of requiring maintenance on a periodic basis.

Factors That Affect Vehicular Emissions

If all possible I/M concepts could be expected to achieve the same result with regard to maintenance, then only the relative differences in costs, convenience, political and public acceptability, and similar issues would have to be assessed. The types of programs being considered here, however, are not expected to be at all similar in terms of maintenance, therefore differences in effectiveness can also be expected. An overview of issues related to emissions generation, emissions-related maintenance experience, and various characteristics of the programs under consideration provides a basis for understanding the nature of these differences.

The control of pollutants from spark ignition, gasoline engines is a well understood science as is evidenced by the degree of control that is currently achieved in the latest production vehicles. Essentially, control is achieved through closely regulating various engine parameters and systems, such as air/fuel ratio and timing, and by treating exhaust gases to ensure complete combustion and convert certain pollutants to less noxious compounds. In discussing these control concepts, separate consideration can be given to basic engine components and systems that affect emissions, and emissions control systems and devices that are used exclusively for controlling specific pollutants.

The primary engine systems that are of importance include the induction and the ignition systems. The induction system consists of those components that introduce a charge of fuel and air into the combustion chamber such that the composition of the charge is appropriate with respect to both the engine output demand and the prevailing environmental conditions in which the engine is operated. The primary components include the carburetor, intake manifold, warm-up system, and related items. These components directly affect the composition of the charge (that is, the air/fuel ratio) and hence the stoichiometric balance, which essentially determines the composition of the exhaust gases. Components such as the carburetor and warmup system are comprised of a number of individual elements that function either independently or as a complete system. Isolated malfunctions of many of these individual elements can affect the emissions rate of HC, CO, or NO_x. A summary of the most critical elements of each components, and an indication of how either a malfunction or maladjustment of each element affects emissions are presented in Table 4.

TABLE 4. IMPACT OF MALADJUSTMENT OR MALFUNCTION OF VARIOUS ENGINE COMPONENTS ON EMISSIONS OF CO, HC, AND NO_x

System	Component	Element	Impact of maladjustment or malfunction		
			CO	HC	NO_x
Induction	Carburetor	Metering rods	High	Moderate	Low
		Power valves	High	Moderate	Low
		Float and valve	Moderate	Moderate	
		Idle setting	Moderate-high	Moderate	
		Choke	High	High	Low
		Vacuum break	Moderate	Low	Low
	Warm-up components	Heat riser	Moderate	Moderate	
		Thermal air inlet	Moderate	Moderate	Low
		Choke	— see carburetor —		
	Other	Air filter element	Low	Moderate	
		Intake manifold	Low	Moderate	
		Vacuum lines/hoses	Moderate	Moderate	Low
		Exhaust valves	Moderate	High	
		Compression	Low	Moderate	
Ignition	Timing related	Basic timing	Low	High	Moderate
		Spark advances/ delay mechanisms	Low	High	Moderate
	Quality related	Spark plugs/wires		High	Low
		Coil		High	Low
		Distributor, points, condenser		High	Low
		Electronic components		High	Low

Once the air and fuel charge has been induced and compressed, a source of ignition must be provided in order to initiate combustion. For Otto-cycle engines, the ignition source is a spark generated by the ignition system. Both the timing and quality of the spark are critical to emissions as well as to fuel economy and performance since both directly affect the quality of the combustion process. A general representation of the relationship between ignition timing, and fuel economy and emissions is provided in Figure 2. As can be seen from Figure 2, ignition timing has a fairly important impact on HC emissions and fuel economy. Proper ignition timing is a function of several parameters including engine speed and load, and operating mode (e.g., cold starting, accelerating, etc.). The general control of ignition timing occurs in the distributor. Precise control as a function of engine speed and power demand is accomplished through two spark advance mechanisms - the centrifugal advance mechanism, which adjusts as a function of engine speed, and the vacuum advance, which responds to varying power demands.

The quality of the ignition spark depends largely on the physical condition of the breaker points, condenser, rotor, distributor cap, ignition wires, and spark plugs. Poor spark produces misfiring and inadequate charge combustion, resulting in high HC emissions and poor fuel economy. The general impact of maladjusted or malperforming ignition system components on emissions is also illustrated in Table 4.

Several systems are employed only for the control of pollutants, therefore, if these are maladjusted or malperform, the resulting impact on emissions is obvious. Included are systems that control tailpipe emissions, crankcase emissions, and evaporative emissions in addition to those that influence the combustion process to the extent that the production of undesirable exhaust compounds is minimized. Specific emissions control devides and systems, and the types of emissions that they affect are listed in Table 5.

The previous discussion provides a very basic summary of the types of special systems and parameter controls used to reduce HC, CO, and NO_x emissions from the existing vehicle fleet. It can be expected that the maintenance aspects of any I/M program tend to focus on the specific devices and systems that have the largest potential impact on emissions. There are several additional factors that must be considered. One of the more important of these is the relative frequency of maladjustment of malfunction of each component or system. This is discussed in the following paragraphs.

Frequency of Parameter Defects and Their Impacts on Emissions

Whereas the previous discussion identified specific systems and components that contribute to excess emissions if not properly maintained, the discussion here considers how often the various systems are found to actually require repair or adjustment, and the relative impact that various parameters have on emissions from in-use vehicles.

Several sources of information exist that provide a good indication of the expected frequency of malperformance of various emissions-related systems. One such source is data developed by the U.S. Environmental Protection Agency's

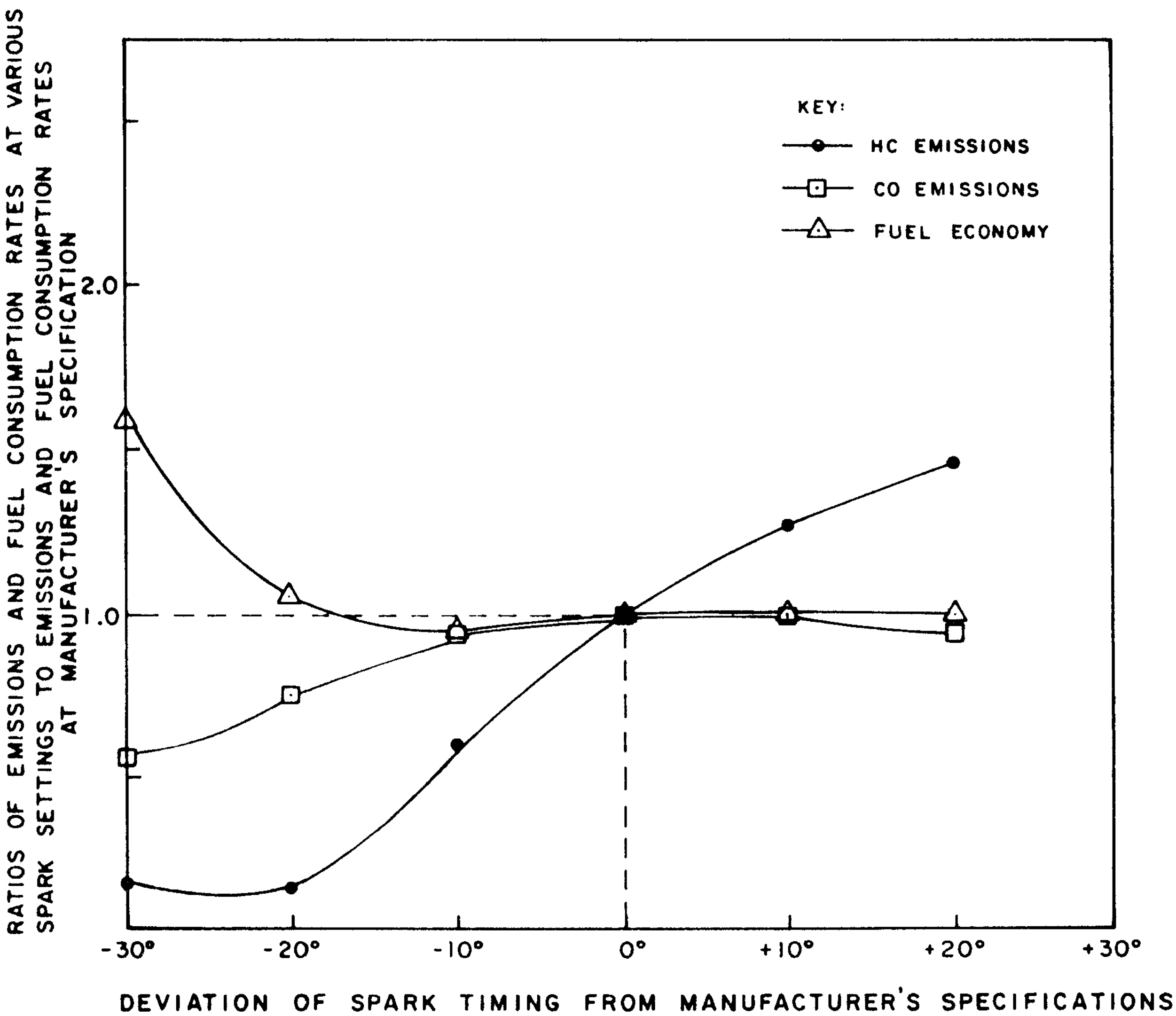


Figure 2. General representation of the impact of spark timing on fuel economy and emissions.

TABLE 5. IMPACT OF MALADJUSTMENT OR MALPERFORMANCE OF EMISSIONS CONTROL COMPONENTS ON HC, CO, AND NO_x EMISSIONS

System	Component	Impact of maladjustment or malfunction		
		CO	HC	NO_x
Crankcase emissions control	PCV	Moderate	Moderate	—
Combustion control	EGR valve	—	—	High
	Temperature sensor	—	—	High
Exhaust treatment	AIR pump	High	High	—
	AIR pump drive and plumbing	Moderate-high	Moderate-high	
	Oxidation catalyst	High	High	—
	Reduction catalyst	—	—	High

Office of Mobile Source Air Pollution Control concerning the state of repair of in-use 1975-76 model year vehicles. These data were developed as part of a program referred to as the Restorative Maintenance (RM) program, which was initiated specifically to investigate the causes for and possible resolutions to the problem of much higher than expected emissions rates from the 1975-76 in-use vehicles.

The RM program involved analyzing engine parameters and systems that directly affect the emissions characteristics of the so-called Technology II (catalyst equipped) vehicle fleet. Many of these systems and parameters are the same ones discussed in the previous paragraphs; the specific systems and individual components considered are listed in Table 6. A sample (albeit an admittedly small one) of the 1975 and 1976 model-year vehicles was analyzed in detail by automotive technicians to assess the condition of the systems listed in Table 6. This sample included a total of 300 vehicles — 102 manufactured by General Motors, and 99 manufactured by each of Ford and Chrysler. The observed rate for failures (either malperformance or maladjustment of the major systems, by manufacturer, is shown in Table 7.

As is shown in Table 7, the most frequent failures are found in the ignition and carburetor systems. More specifically, the analysis indicates that the most common failures are associated with:

- Improper idle mixture setting;
- Improper idle speed setting; and
- Improper timing adjustment.

The emissions impact of these three types of deficiencies was anlayzed using the Federal Test Procedure (FTP) and correlating the observed deficiencies to the resulting emissions measurements. Table 8 summarizes the results of a further analysis that identified which deficiencies resulted in a statistically significant difference in FTP emissions as compared to a no-deficiency case. This table shows, for instance, that when comparing the emissions from General Motors vehicles that have maladjusted idle CO (idle mixture), with General Motors vehicles that have idle CO adjusted within specifications* without regard as to whether other parameters are in or out of specification, statistically significant differences occur in each of the three FTP phases (cold start, hot start, and stabilized) as well as in the composite FTP emissions rate, for both CO and HC. The "At Least One" category compares vehicles that had at least one of the three parameters within specification to similar vehicles where all three parameters were within manufacturer's specification simultaneously. This table is quite interesting in that it illustrates that idle CO is a fairly important indicator of whether the vehicle is emitting CO and HC at a rate that is higher than the mean for that particular type of vehicle. Further, additional analysis of the actual emissions data for each vehicle suggests that idle CO levels may in fact correlate acceptably well

---

*Since most vehicles do not have idle CO specifications, an idle CO value was selected to define the difference between adjusted and maladjusted idle CO. A value of 0.5 percent was selected for the idle CO specification, where values greater than 0.5 percent are considered outside of tolerances.

TABLE 6. ENGINE PARAMETERS AND EMISSIONS CONTROL SYSTEMS CONSIDERED IN THE EPA RESTORATIVE MAINTENANCE PROGRAM

Major system	Subsystem	Elements considered
Induction system	—	Heated air inlet door Heated air inlet diaphragm Temperature sensors, switches, modulators Delay valve Air filter element Hoses, tubes, lines, wires
Carburetor system	Fuel delivery	Carburetor assembly Limiter caps Tailpipe idle CO Idle speed External idle enrichment Idle stop solenoid Dashpot and other throttle modulators Fuel filter element Hoses, lines, wires
	Choke	Choke adjustment Vacuum diaphragm Electrical controls Hoses, lines, wires
	Preheating control	Exhaust heat control valve assembly Actuating diaphragm Coolant temperature sensing switches Check valve Hoses, lines, wires
Ignition system	—	Distributor assembly Initial timing Spark plugs and their wires Vacuum advance diaphragm Spark delay devices Coolant temperature sensing switches Hoses, lines, wires Dwell
Emissions control system	EGR	EGR valve assembly EGR valve backpressure transducer EGR time delay solenoid Venturi vacuum amplifier High speed modulator Vacuum reservoir Coolant temperature sensing switches Hoses, lines, wires

(continued)

TABLE 6 (continued)

Major system	Subsystem	Elements considered
	Air injection	Air pump assembly Bypass and/or dump valves Check valve Electrical PVS Solenoid vacuum valve Floor pan switch Vacuum differential control Drive belt, attaching hardware Hoses, lines, wires
	Crankcase emissions subsystem	PCV valve assembly Filters Hoses, lines, wires
	Exhaust system	Exhaust manifold, tailpipe, Muffler catalyst
	Evaporative emissions subsystem	Evaporative canister Canister filter Hoses, lines, wires
Miscellaneous		Engine assembly Engine oil and filter Cooling system Mechanical valve adjustment Carburetor and intake manifold mounting bolts Belt tensions Hoses, lines, wires

TABLE 7. OBSERVED FAILURE RATE FOR MAJOR SYSTEMS AND PARAMETERS BY MANUFACTURER

Manufacturer (No. of vehicles)	Percent of vehicles failing									Percent of vehicles with at least one failure
	Induction	Carburetor	Ignition	EGR	AIR	PCV	Exhaust	Evaporative	Miscellaneous	
General Motors (102)	2	49	22	9	0	0	0	1	0	59
Ford (99)	9	55	25	18	2	1	0	1	2	69
Chrysler (99)	3	94	32	19	0	1	0	2	1	96
Total (300)	6	66	26	15	1	1	0	1	1	74

TABLE 8. EFFECTS OF CERTAIN ENGINE PARAMETER MALADJUSTMENTS ON FTP EMISSIONS

Manufacturer	Deficiency	Statistically significant impact resulting from deficiency											
		Hydrocarbons				Carbon monoxide				Oxides of nitrogen			
		FTP	Cold start	Hot start	Stabilized	FTP	Cold start	Hot start	Stabilized	FTP	Cold start	Hot start	Stabilized
General Motors	Timing												
	Idle CO	X	X	X	X	X	X	X	X				
	Idle speed									X	X	X	
	At least one												
Ford	Timing												
	Idle CO					X	X	X	X				
	Idle speed	X	X										
	At least one	X			X	X		X	X				
Chrysler	Timing			X	X	X			X	X			
	Idle CO	X	X	X	X	X	X		X				
	Idle speed	X		X	X	X	X	X	X				
	At least one	X	X		X	X	X	X	X				
All vehicles	Timing	X		X	X	X		X	X				
	Idle CO	X	X	X	X	X	X	X	X				
	Idle speed												
	At least one	X	X	X	X	X	X	X	X				

with the ability to pass the FTP for CO and HC. This is indicated by considering the pass/fail rates for vehicles undergoing the FTP as a function of whether or not the idle CO parameter is within (assumed) specification; Table 9 shows these rates for FTP CO and HC by manufacturer.

TABLE 9. PERCENTAGES OF VEHICLES PASSING AND FAILING FTP FOR CO AND HC WITH IDLE CO PARAMETER IN AND OUT OF ASSUMED SPECIFICATIONS

Manufacturer	No. of vehicles outside CO specification	Percent of vehicles outside idle CO specification that failed FTP for CO, (HC), and [NO_x]			No. of vehicles in idle CO specification	Percent of vehicles in idle CO specification that failed FTP for CO, (HC), and [NO_x]		
General Motors	28	96	(71)	[18]	74	7	(0)	[27]
Ford	15	53	(27)	[20]	84	10	(7)	[31]
Chrysler	75	87	(73)	[31]	24	13	(13)	[38]
All	118	85	(67)	[26]	182	9	(5)	[30]

Table 9 shows that there is a reasonable degree of agreement between idle CO and the ability to pass the FTP for either CO or HC, while there is no apparent agreement for NO_x. It appears that the idle CO parameter would be valuable to consider in both the inspection and maintenance phases. This conclusion is supported by numerous other EPA test programs, as well.

In addition to analyzing the impacts of ignition timing, idle CO, and idle speed on emissions characteristics, the RM study also considered the impact of each component and system listed in Table 6 on emissions. As a first step, each vehicle in the sample was inspected in detail to identify the frequency of maladjustment, defects, disablements, or other impairments to each element. The results for the "as received" sample are shown in Table 10. This rather detailed look at the types of components found to be in need of repair or adjustment is of importance here because it provides an indication of which specific elements might be appropriate to consider in a parameter inspection program from the standpoint of maximizing the potential for identifying needed repairs. This particular sample is relevant in connection with I/M programs because the vehicles represented were generally about 1 year old when inspected (all had accumulated fewer than 15,000 miles) and, assuming that no deficiencies existed when each vehicle was new, in this sense can be assumed to reflect annual deterioration for certain (although, obviously, not all) parameters.

TABLE 10. PERCENTAGE OF VEHICLES IN A 300-CAR SAMPLE WITH VARIOUS DEFICIENCIES RELATED TO EMISSIONS-CRITICAL COMPONENTS AND SYSTEMS

Major system	Component/element	Percentage of vehicles		
		Not applicable	No deficiency	Maladjusted, disabled, defective, or otherwise deficient
Induction	Heated air inlet door	0.3	99.4	0.3
	Heated air inlet diaphragm	0.3	99.0	0.7
	Temperature sensors	0.6	98.4	1.0
	Delay valve	99.7	0.3	0.0
	Air filter element	0.0	100.0	0.0
	Hoses, tubes, wires, etc.	0.0	96.0	4.0
Carburetor	Carburetor assembly	0.0	98.7	1.3
	Limiter caps	0.0	54.7	45.3
	Idle mixture	0.0	62.3	37.7
	Idle speed	0.0	75.3	24.7
	External idle enrich	80.7	18.3	1.0
	Idle stop assembly	88.0	12.0	0.0
	Dashpot and throttle	99.4	0.3	0.3
	Fuel filter	0.3	99.7	0.0
	Fuel hoses and lines	0.0	99.3	0.7
	Other fuel	0.0	100.0	0.0
	Choke adjustment	0.3	88.7	10.0
	Vacuum diaphragm	7.3	90.7	2.0
	Electrical controls	32.0	66.0	2.0
	Choke lines and wires	0.3	98.0	1.6
	Exhaust heat control	68.3	31.7	0.0
	Actuating diaphragm	78.7	21.0	0.3
	Coolant temperature switches	79.7	20.0	0.3
	Check valve	97.0	39.0	0.0
	Hoses, lines and wires	60.7	39.0	0.3
	Other choke-related	100.0	0.0	0.0
Ignition	Distributor	0.0	98.4	1.6
	Initial timing	0.0	81.0	19.0
	Spark plug and wires	0.0	98.3	1.7
	Vacuum advance	1.0	98.3	0.7
	Spark delay devices	78.0	20.7	1.3
	Coolant temp. switches	76.0	23.7	0.3
	Other hoses and wires	0.0	96.7	3.3

(continued)

TABLE 10. (continued)

Major system	Component/element	Percentage of vehicles: Not applicable	No deficiency	Maladjusted, disabled, defective, or otherwise deficient
EGR	EGR valve	0.7	96.0	3.3
	EGR valve transducer	77.3	18.0	4.7
	EGR time delay	86.7	12.6	0.7
	Venturi vacuum amplifier	73.0	27.0	0.0
	High speed modulator	99.3	0.7	0.0
	Vacuum reservoir	94.3	5.7	0.0
	Coolant temp. switches	22.0	77.4	0.6
	Hoses, wires, lines	2.3	90.7	7.0
AIR	Air pump	65.7	34.3	0.0
	Bypass valve, pump valve	65.7	34.3	0.0
	Check valve	65.7	34.3	0.0
	Electric PVS	97.7	2.3	0.0
	Solenoid vacuum valve	96.3	3.7	0.0
	Floor pan switch	99.0	1.0	0.0
	Vacuum differential control	87.0	13.0	0.0
	Drive belt and hardware	65.7	34.3	0.0
	Hoses, lines, wires	65.3	34.0	0.3
PCV	PCV valve	0.3	99.7	0.0
	Filters	0.3	99.7	0.0
	Hoses, lines	0.3	99.0	0.7
Exhaust	Exhaust, manifold, and muffler	0.0	100.0	0.0
	Catalytic converter	2.0	98.0	0.0
Evaporative	Canister	0.0	100.0	0.0
	Canister filter	0.0	99.7	0.3
	Hoses, lines	0.0	99.0	1.0

The question of which deficient parameters contribute most to high emissions must also be considered. The initial FTP emissions testing performed on the 300-vehicle sample resulted in 175 vehicles failing. A detailed analysis of the individual engine parameters and emissions control systems for these 175 vehicles was then performed as part of the RM program. As a result, the failure rate for each emissions-related element of the 175-vehicle group was identified. These are summarized in Table 11, which shows the percentage of vehicles with deficiencies by major system. Again, it is shown that the carburetor system is prone to a much higher deficiency rate than all other systems, although the ignition and EGR systems also appear to have a significant deficiency rate. A closer analysis of these three systems shows that deficiencies are most likely to occur in eight specific elements or parameters. These are listed along with their respective deficiency rates for both the 175-vehicle group that failed and the 125 vehicle group that passed the initial FTP test, in Table 12.

TABLE 11. MAJOR SYSTEM FAILURE RATE FOR VEHICLES THAT DID NOT PASS THE INITIAL FTP EMISSIONS TEST

Major system	Percentage of the 175-vehicle sample with deficiencies in the major system
Induction	6.3
Carburetor	84.0
Ignition	36.0
EGR	23.4
AIR	1.1
PCV	0.6
Exhaust	0.0
Evaporative	2.3
Engine assembly and miscellaneous	1.7
At least one deficiency	91.4

TABLE 12. FREQUENCY OF DEFICIENCIES IN SPECIFIC ENGINE PARAMETERS AND COMPONENTS FOR VEHICLES TAKING THE INITIAL FTP EMISSIONS

Major system	Component/parameter	Number and (percentage) of vehicles with deficiencies			
		For vehicle group failing		For vehicle group passing	
Carburetor	Disabled limiter cap	112	(64)	24	(19)
	Maladjusted idle mixture	102	(58)	11	(9)
	Maladjusted idle speed	52	(30)	22	(18)
	Maladjusted choke	21	(12)	9	(7)
Ignition	Maladjusted timing	45	(26)	12	(10)
EGR	Defective or disabled EGR valve	10	(6)	0	(0)
	Defective EGR transducer	10	(30)*		—
	Disabled hoses or lines				—

*Only 33 of the 175 vehicles were equipped with this component.

Also as part of the RM program, maintenance was performed on certain emissions-related systems to determine its impact on the ability to pass the FTP emissions test. This was accomplished by comparing the FTP pass/fail rate for the initial test, which was performed on all vehicles in the "as received" state, with pass/fail rates for subsequent FTP tests after various maintenance scenarios were performed. Of the 300 vehicles that received the first test, 113 were retested after correction of all observed maladjustments other than idle speed and idle mixture. This retest included 19 vehicles that passed and 94 vehicles that failed the first test. Of those 113 vehicles taking the second test, 74 failed at least one standard (CO, HC, or NO_x); two of these 74 had previously passed the first test. The emissions control components of all 300 vehicles were then inspected. The FTP emissions levels was made accordingly. At this point, a total of 148 vehicles had passed the FTP (either test 1 or test 2). The 152 vehicles that had failed were inspected to determine whether the idle speed and idle mixture parameters were within specification and adjustments were made as required (for those vehicles without an idle CO specification, the manufacturer's recommended procedure for resetting idle parameters was followd). Of the 152 vehicles inspected, nine were found to be within specifications. The remaining 143 vehicles were retested, and 60 of these were able to pass. The 74 vehicles that failed the third RTP emissions test, and the nine vehicles that were found to be within specifications for idle speed and idle CO then received major tuneups, which included correction of defective emissions control components. These 83 vehicles were then tested, and a total of 56 vehicles passed. The pass/fail rate for each of the four tests by pollutant are shown in Table 13 as a function of the number of vehicles tested, and in Table 14 as a function of the entire 300-vehicle sample.

A more quantitative indication of the impacts of the maintenance performed in conjunction with the RM tests can be provided by considering the mean emissions rates for vehicles before and after undergoing the maintenance. Comparisons of these mean emissions rates for individual maintenance procedures and combinations of maintenance are provided in Table 15. This table shows that the most dramatic decrease in mean FTP emissions occurs as a result of maintenance performed prior to Test 3. This maintenance involves correcting maladjusted idle parameters (mixture and speed).

The RM study provides a significant amount of data that is directly useful in assessing the proposed parameter inspection concepts. Even at this point it becomes obvious that an I/M program need not require that all systems, components, and parameters that influence emissions be inspected on a periodic basis. This is particularly relevant to the "high" option discussed previously, which called for both annual inspection and adjustment of numerous components that, based on the RM data as well as on conversations with service personnel, would not be expected to contribute significantly to reducing emissions rates from in-use vehicles. In fact, if failures developed for many of the components suggested in the high option — particularly in connection with the carburetor — the result would be driveability related problems, which most motorists would be likely to have repaired regardless of whether an I/M program exists. The RM data tend to support the general experiences of states

TABLE 13. PASS/FAIL RATES FOR THE FOUR FTP TESTS BY POLLUTANT FOR INDIVIDUAL TESTS

Test No.	No. of vehicles	Number and (percent) of vehicles failing							
		CO		HC		NO_x		At least one	
1	300	116	(38.7)	88	(29.3)	86	(28.7)	175	(58.3)
2	113	51	(45.1)	40	(35.4)	27	(23.9)	74	(65.5)
3	143	23	(16.1)	25	(17.5)	46	(32.2)	74	(51.7)
4	83	15	(18.1)	15	(18.1)	37	(44.6)	56	(67.5)

TABLE 14. PASS/FAIL RATES FOR THE FOUR FTP TESTS BY POLLUTANT FOR THE 300-VEHICLE SAMPLE

Test No.	No. of vehicles	Number and (percent) of 300-vehicle sample failing							
		CO		HC		NO_x		At least one	
1	300	116	(38.7)	88	(29.3)	86	(28.7)	175	(58.3)
2	300	51	(17.0)	40	(13.3)	27	(9.0)	74	(24.7)
3	300	23	(7.7)	25	(8.3)	46	(15.3)	74	(24.7)
4	300	15	(5.0)	15	(5.0)	37	(12.3)	56	(18.7)

TABLE 15. COMPARISON OF MEAN FTP EMISSIONS RATES BEFORE AND AFTER MAINTENANCE ROUTINES

Tests involved	Conditions compared	No. of Vehicles	Mean FTP emissions rate in gm/mi and (percent change)					
			CO		HC		NO_x	
Test 1 only	All vehicles as received	300	20.26		1.32		2.89	
Tests 1 and 2 only	After test 1	113	28.01		1.66		3.20	
	After test 2	113	23.20	(-17.2)	1.48	(-10.8)	2.72	(-15.3)
Tests 1 and 3 only	After test 1	75	29.13		1.68		2.96	
	After test 3	75	10.56	(-63.7)	1.10	(-34.5)	3.10	(+4.7)
Tests 1, 2, and 3	After test 2	68	34.12		1.89		2.76	
	After test 3	68	9.93	(-70.9)	1.01	(-46.6)	2.84	(+2.9)
Tests 1, 3, and 4	After test 3	72	13.55		1.36		3.45	
	After test 4	72	11.98	(-11.6)	1.22	(-13.2)	2.95	(-14.5)
Tests 1, 2, and 4	After test 2	36	26.82		1.69		3.30	
	After test 4	36	10.88	(-59.4)	1.13	(-33.1)	3.09	(-6.4)

currently operating I/M programs with regard to the types of repairs that failed vehicles require in order to pass the emissions tests. As an example, the Portland I/M program, which is currently undergoing extensive analysis by the U.S. EPA, has developed data concerning the types and costs of repairs required to bring vehicles that failed the emissions test into compliance with the standards. Table 16 summarizes the types of repairs made on a sample of 201 vehicles that had failed the idle mode emissions test used by the Portland program. This table indicates that the primary maintenance procedures included carburetor adjustments, timing adjustments, and routine tuneups. Many of the individual items, such as air filters, oil, dwell, points and condenser, and others are part of the tuneup and do not necessarily reflect required maintenance. The estimated emissions reductions for the failed vehicles (model years 1975-77 only) that subsequently underwent maintenance are shown in Table 17. Although data are not available concerning the impact of individual maintenance procedures, the overall impact depicted by Table 17 is quite similar to that shown in Table 15.

TABLE 16. REPAIRS REQUIRED FOR 201 VEHICLES FAILING THE PORTLAND I/M STANDARDS

Repair item	Number (and percentage) of vehicles requiring maintenance
Spark plugs	68 (34)
Spark plug wires	41 (20)
Points and condenser	40 (20)
Distributor and rotor	27 (13)
Spark timing controls	33 (16)
Carburetor	170 (85)
Choke	81 (40)
Intake system	12 (6)
Air filter	68 (34)
Engine oil	37 (18)
Idle speed	116 (58)
Timing	111 (55)
Dwell	48 (24)
AIR	11 (5)
EGR	11 (5)
PCV	10 (5)
Valves	9 (4)

TABLE 17. FTP EMISSIONS REDUCTIONS FROM FAILED VEHICLES UNDERGOING MAINTENANCE FOR THE PORTLAND I/M — 1975 THROUGH 1977 VEHICLES ONLY

Condition	FTP emissions rate in gm/mi and (percent reduction)		
	CO	HC	NO_x
Before maintenance	40.9	2.87	2.32
After maintenance	19.4 (-53)	1.60 (-44)	2.37 (+2)

The cost data for the Portland study support the general premise that most of the maintenace required to bring a vehicle into compliance is fairly minor in nature. The Portland statistics indicate that average repair cost for the 1975-77 vehicles that failed the test was $23.35; it certainly is not necessary here to substantiate the fact that $23.35 does not purchase a significant amount of automobile repair work. A more detailed summary of repair costs for the Portland program is provided in Table 18.

TABLE 18. REPAIR COSTS EXPERIENCED IN THE PORTLAND I/M PROGRAM

Model year category	Repair costs ($)				
	Sample mean ($)	Percentiles			
		25	50	75	90
1972-74	34.97	5	11	41	78
1975-77	24.46	7	14	37	59
1972-77	29.47	6	14	38	70

Whether or not the same types of repairs would result from a parameter inspection program depends largely on the inspection items included. It is likely that a very rigorous inspection program, such as the high option, would result in additional repair work, hence higher total repair costs. Considering only those vehicles that failed the emissions measurement inspection, it could be argued that a parameter inspection might have isolated the specific deficiency more readily, and therefore reduced the incidence of unnecessary repair. This is not to say that the total inspection plus maintenance costs would be less for the parameter inspection approach.

If the assumption is made that the proposed parameter inspection program and the RM program are approximately equal in terms of identifying and correcting emissions-related deficiencies, then it might be valid to conclude that the effectiveness (in terms of emissions-reduction only) of parameter inspection programs is likely to be at least equal to a tailpipe inspection program such as Portlands. The basic assumption that the parameter inspection program and the RM program are equal, however, is undoubtedly not valid, owing primarily to the fact that RM inspections and maintenance were performed by highly skilled automotive technicians working without the time constraints that would be imposed in an I/M program, and utilizing diagnostic equipment that probably would not be available in most private repair shops and garages. The RM program may be considered as providing an indication of the upper limit of effectiveness for a parameter inspection program. In theory, the parameter inspection approach is potentially as effective in reducing emissions as the tailpipe measurement approach provided that the inspection routine includes those parameters and components that are most often found to be in need of repair, replacement, or adjustment in order to pass a tailpipe measurement inspection. This assumes, of course, that the quality of both the inspection and maintenance performed is comparable.

Issues Related to the Quality of Inspections and Maintenance Performed

The ability of those individuals involved in performing the inspections and subsequent maintenance to adequately identify and resolve emissions-related deficiencies is crucial to the success or failure of any I/M program, regardless of approach. Several factors can be identified that directly affect the quality of either inspections or maintenance. Several factors apparently have a very dramatic impact on the quality of inspections and repairs, as are indicated in the following discussion of a study performed in California.

Two separate I/M program approaches are currently being used in California. The first program, which began in 1964, involves the use of licensed private garages to perform idle-mode emissions testing and limited parameter inspections of all light-duty vehicles. This program is referred to as the "Blue Shield" program. A summary of the inspection procedures is provided in Table 19.

TABLE 19. CALIFORNIA BLUE SHIELD EMISSIONS INSPECTION PROCEDURES

1. Inspection of external emission control devices (e.g., air pumps, exhaust gas recirculation valves) to ensure that they are installed and operating properly.

2. Correction of any ignition defects which are causing engine misfiring.

3. Check and adjustment (if necessary) of ignition timing, idle air/fuel mixture, and idle speed.

Source: Reference 12

The second program, which began in March 1979, involves a centralized approach and is operated for the State by a private contractor. The actual inspection procedures used are different from those used in the decentralized program in that only emissions measurements are preformed — no repairs or adjustments are included.

The relative effectiveness of the centralized and decentralized approaches was studied during the early summer months by the California Air Resources Board (CARB). The intent was to:

- Compare the effectiveness of the two programs

- Identify methods for improving the effectiveness of each program, and

- Estimate the relative effectiveness of the two programs in future years.

To assess the private garage program, the following evaluation criteria were defined.

- Determine the extent to which emissions related defects are identified

- Determine the change in idle emissions as a result of repairs or adjustments made at the station

- Determine costs

- Determine the extent of intentional and unintentional failure to perform inspections properly, and

- Determine impacts of different levels of quality control and surveillance on inspection effectiveness.

To evaluate the performance of both the centralized and private garage systems, CARB used vehicles that were specially prepared so that each one had one or more well-defined, emissions related defect, such as improper air/fuel ratio, maladjusted ignition timing, or disconnected EGR valve. First, these vehicles were taken to the inspection stations by a CARB employee who did not identify himself as such, but merely posed as a motorist who required an emissions test; this is referred to as the "blind phase." The second phase, or "open phase," used the same vehicles with the same defects; however, upon entering the test facility the CARB employee identified himself to the inspector and explained the actual purpose of the visit. Although not coached by the CARB employee, the inspectors were aware that they were being monitored closely. Some basic results of the evaluation are summarized in Table 20.

From Table 20, it can be seen that even under 100 percent monitored conditions when mechanics knew their performance was being evaluated, only 55 percent of the emissions measurements were properly recorded. It is intuitively obvious

TABLE 20. SUMMARY OF INSPECTION AND REPAIR ACTIVITIES OF PRIVATE GARAGES

	Private Garage		
	Phase I Blind Phase	Phase II Open Phase	Centralized
Percentage of time emissions analyzers were used	82%	94%	100%
Percentage of time emissions data recorded on the Certificate matched the levels measured*	46%	55%	100%
Percentage of time ignition analyzers were used	43%	80%	--
Percentage of time spark timing and rpm were measured	31%	83%	100% (rpm only)
Percentage of time misadjusted carburetors were detected and properly adjusted	6%	48%	--
Percentage of time EGR tampering was detected and corrected	7%	37%	28%
Percentage of time other defects were detected and corrected	36%	48%	28%
Percentage of time unnecessary repairs were performed	2%	13%	--
Average time to obtain a Certificate, including waiting time	28 min	58 min	19 min
Average waiting time before inspection began	13 min	19 min	15 min
Average cost of inspection and adjustments	$14	$14	$11 (inspection only)
Average cost of additional repairs (per Certificate)	$1.15	$0.40	$30†

*Data available from Northern California survey only.

†Preliminary data.

Source: See Table

that they were being evaluated. Why, then, this large discrepancy? The inspectors, it would seem, are either inadequately or improperly trained on emissions measurements.

It can be assumed that the "blind phase" of the program represents the typical performance by private garages, while the "open phase" represents the best the mechanic could do within the time constraints (it should be noted that, on average, an extra 24 minutes were spent on the inspection when the mechanic knew he was being watched). From Table 20, it can be seen that under "normal" circumstances, maladjusted carburetors and malfunctioning EGR devices were detected and repaired only 6 percent and 7 percent of the time, respectively. Even when the inspectors were aware of being evaluated these items were correctly identified and repaired only 48 percent and 37 percent of the time, respectively.

Even under complete surveillance, the garages mechanics detected and corrected carburetor maladjustments only 48 percent of the time. Data from the Portland (Oregon) Study* identifies the carburetor as the single most repaired/adjusted item on vehicles failing the State Inspection Test. One could conclude, then, that the effectiveness of an I/M program may be severely affected by the inability of the mechanics to identify carburetor maladjustments.

The frequency of unnecessary repairs increased from 2 percent to 13 percent when inspectors were aware that they were being monitored. This appears to indicate that the tendency is for mechanics to "try too hard" to correct problems and that there is a basic inability to determine what repairs actually should be.

Perhaps the most important measure of the effectiveness of the two types of I/M programs is the actual reduction in emissions achieved. CARB developed estimates of the actual emissions reductions resulting from the two program types currently in operation, and from a private garage option utilizing 100 percent enforcement. These estimates are shown in Table 21.

TABLE 21. ESTIMATES OF EMISSIONS REDUCTIONS FOR VARIOUS I/M PROGRAMS IN CALIFORNIA

Program	Percent of emissions-related problems identified			Estimated initial reduction in emissions (percent)		
	CO	HC	NO_x	CO	HC	NO_x
Current centralized	90	90	25	32	25	4
Current private garage	6	6	7	2	2	1
Private garage with 100 percent enforcement	48	48	37	17	13	6

*Portland Study Interim Analysis: Observations on 6-Months of Vehicle Operation. U.S. Environmental Protection Agency. Emissions Control Technology Division. January 1979.

The results of the California study are interesting in terms of a general comparison of centralized and decentralized inspection programs, as well as in terms of the impact that the quality and motivation of inspectors can have on a program, regardless of whether it involves parameter inspection or tailpipe measurement. In terms of effectiveness, it would be extremely difficult to argue that a decentralized program, be it parameter inspection or tailpipe measurement, would be nearly as effective as a centralized program, primarily because of the much larger problem assicated with ensuring inspection quality. The problem of ensuring adequate quality control increases as a function of inspection intensity, therefore one could very easily speculate regarding the types of problems that would likely be associated with maintaining quality control for a decentralized, high option, parameter inspection program. Also important is the apparent difficulty that was encountered in detecting and correcting various deficiencies. This rather poor showing argues for the use of an emissions test as the final determinant of whether or not a vehicle has been satisfactorly inspected or repaired. As mentioned previously, EPA may require emissions measurement as part of any decentralized I/M program to ensure that inspections and repairs are performed adequately.

Other issues have a potential affect on the quality of either the inspection or maintenance. One rather significant one is whether or not repairs to vehicles failing the inspection are allowed to be made at the inspection facility, and if they are, whether or not any of the repair costs are included in the basic inspection fee. The ideal program scenario would permit appropriate repairs or adjustments to be made as part of the inspection process, thereby eliminating the need for the motorist to spend additional time obtaining repairs elsewhere and returning for a second inspection. If the program involves the decentralized approach where inspections are performed in private garages, the primary problem concerns protecting the public from "over-repair" by the inspector where the inspection fee is based on the amount of time required to perform the inspection, and repairs or adjustments are performed at extra cost. Further, if the inspection fee is set and certain repairs and adjustments are included in the fee, then the problem becomes one of ensuring that "under-repair" or "under-inspection" does not occur. For programs utilizing the centralized approach, the problems mentioned above may of ensuring that "under-repair" or "under-inspection" does not occur. For programs utilizing the centralized approach, the problems mentioned above may not be as significant if the program operator neither benefits nor incurs additional costs as a result of vehicles passing the inspection with or without repairs or adjustments.

Estimating Emissions Benefits

An important aspect in planning I/M programs is the development of estimates of the reductions in vehicular emissions that can be expected as a result of the program. For tailpipe measurement programs, EPA has developed emissions credits for estimating the reduction in CO and HC as a function of program stringency, the number of years that the program has been in effect, the calendar year being considered, and whether a formal mechanics training program is utilized. These credits can be applied directly to mobile source emissions inventories developed using EPA's MOBILE1 emissions model. Of significance here is that the emission credits are not applicable to programs other than those utilizing tailpipe measurements. There is a requirement, then, for developing an alternative method for estimating emissions reductions from parameter inspection programs.

There appear to be two possibilities for satisfying the requirement for estimating the emissions reductions achievable from a specific parameter inspection format. First, it may be possible to derive specific estimates based on existing data regarding the impact of various maintenance procedures on emissions levels. The discussion of the RM and Portland I/M studies certainly indicates that there may be adequate data available on which preliminary estimates of the effectiveness of a particular program could be based. The second possibility, which is perhaps less desirable, is that the state could conduct a demonstration program designed to evaluate the emissions reduction potential of a particular program. It is noted that such a study is being conducted in the State of Texas by the Texas Air Board. Also, the State of Colorado has been operating a pilot study of a parameter inspection program, which may serve to adequately demonstrate that program's effectiveness.

It is noted that EPA is providing support to the Texas study owing to the interest in parameter inspections shown by Texas and other states. The format of the Texas program is such that the evaluation of its effectiveness would not provide a sufficient basis for assessing the emissions impacts of the parameter inspection proposals considered in this report. With regard to obtaining similar support for other proposed program alternatives, EPA has indicated that: "If another state proposed a parameter inspection approach, or some third approach to I/M altogether, which was (1) so significantly different that previously gathered field data could not be used to evaluate it, (2) on its face potentially workable and effective, (3) seriously being considered as an I/M alternative because it had substantial attractive features not shared by other alternatives, and (4) implementable on schedule, EPA might support another field evaluation. EPA's decision would be influenced in part by the availability of funds and the number of states showing interest."* In the same letter, it was indicated that a parameter inspection program proposed by the Motor Vehicle Manufacturers Association, and which is almost identical to the low option considered in this report, "... does not, in EPA's opinion, satisfy the second of these four conditions." If the State of Michigan decides to implement a parameter inspection program similar to low option, it is likely that it must accept the entire burden of deriving and substantiating emissions reductions estimates.

SUMMARY

In terms of the emissions reduction potential of any I/M program alternative, two primary factors must be considered. The first factor is the ability to detect deficiencies that contribute to high emissions. The parameter inspection approach to I/M is based on a premise that these types of deficiencies can be detected directly by examining the particular components, and parameters that affect emissions. There are many individual components, systems, and parameters that offset emissions although several studies

---

*Letter to Mr. Harry Weaver, Motor Vehicle Manufacturers Association, from Charles L. Gray, Director Emissions Control Technology Division, U.S. Environmental Protection Agency. 15 November 1979.

indicate that only a few specific ones that have a significant impact can be expected to require periodic maintenance. In terms of the four programs considered here, the two involving the high options do not appear to be viable. Notwithstanding the fact that the inspection and adjustment process is estimated to require approximately two and one-half hours to complete, the minimal reductions in emissions that can be achieved as a result of performing many of the more complicated tasks, such as carburetor metering rod adjustments, make this option extremely unattractive. In fact, based only on the time requirements, it is expected that the high option as it is currently defined can be eliminated from serious consideration as a viable approach to I/M.

On the other hand, the low option concept appears to focus on the maintenance areas that have the greatest impact on emissions, and which are in fact the areas that are genrally of primary concern in connection with maintenance performed as a result of failing a tailpipe measurement test. The question, then, is what are the real differences in the tailpipe measurement and parameter inspection approaches to I/M with regard to the types of maintenance expected to result?

The answer to this question lies in the second factor that must be considered in evaluating emissions reduction potential of an I/M program. This factor concerns the ability of the repair industry to adequately correct emissions-related problems once they have been identified. Experience gained in California indicates that there are many problems associated with both the identification and correction of emissions-related deficiencies, particularly those involving the carburetor. While this does not guarantee that an equivalent problem would occur in Michigan given the same I/M program, it does provide a meausre of uncertainty concerning the quality of both inspection and repair likely. This, in turn, indicates a need for ensuring that both inspections and repairs are performed properly as part of the overall I/M program. The most convenient and readily available method for ensuring this quality is to require emissions measurement as part of the inspection and reinspection procedures. Undoubtedly, if an emissions test is required, some will argue that the results should be used to screen vehicles to determine which ones really need maintenance. This will diminish one of the advantages that a parameter program may have over a tailpipe measurement program since not all vehicles would receive maintenance. Also, if an emissions test is used (it will likely be an idle test) to either screen vehicles or determine pass/fail, standards will have to be established that must be construed as being representative of a vehicle's ability to pass the FTP emissions test. Whether or not any short test correlates well enough to the FTP to adequately portray the FTP emissions characteristics is a point that is hotly contested by the automotive and regulatory sectors; in fact, the motivation for suggesting alternative inspection and maintenance concepts, e.g., parameter inspection, lies primarily in the controversy regarding the appropriateness of short tests, especially the idle test. The use of a tailpipe measurement step as the pass/fail determinant transforms the parameter inspection program to a tailpipe measurement program that utilizes a fixed maintenance routine.

SECTION 4

CONSUMER ISSUES

INTRODUCTION

Effective consumer protection is a critical element for the success of any I/M program regardless of the specific inspection option selected. In order to determine the specific consumer protection mechanisms that must be employed, it is first necessary to examine the consumer issues associated with I/M, and to determine if and how the selection of a particular inspection type will affect the impact of the program on the motorists of Michigan.

PROGRAM COST

The first and perhaps most important issue involves program cost. How much will Michigan motorists be required to pay for inspection? How many motorists will be required to seek repairs? How much will they be obligated to spend on repairs? An analysis of the likely fee requirements is presented in Section 7. As is discussed in Section 7, the potential inspection fees are quite variable depending on the actual inspection option selected. There is also substantial variability within any given option. For example, a parameter inspection that does not include adjustment of parameters found to be outside of manufacturers' specifications will have a lower inspection fee than a parameter inspection that includes these adjustments. However, a program including minor adjustments may reduce some duplication of effort and yield a lower average repair cost than a program that keeps the inspection and repair sequences separate. This introduces a few additional issues. Should Michigan implement an I/M program which results in the lowest inspection fee or the lowest combined inspection and repair fee? By selecting a program that will yield the lowest inspection fee, those who fail may be required to pay more than they would under a program which minimizes the combined inspection and repair cost. Yet, selection of a program that minimizes the repair cost (i.e., combined parameter inspection and adjustment) could mean a higher fee for those whose vehicles did not need any repairs.

Cost of the inspection process is extremely variable between options. The most influential variable on the cost of the parameter inspection options evaluated in Section 7 is the intensity of the inspection. The high option could cost the consumer more than four times as much as the low option. This could effectively eliminate the high option, as defined in this report, from consideration.

Where the inspections are conducted will also affect the impact of the program on consumers. Although the inspection costs of program options differing only in the inspection location (centralized, decentralized) are roughly equivalent, other consumer issues, discussed below, are quite dependent on this variable.

CONSUMER CONVENIENCE

Convenience of the program to the public is in a very real sense a cost issue. In addition to the inspection fee and program related repair bills, I/M will also "cost" each motorist in terms of vehicle operating expenses (to get to and from the inspection station), and in personal time, whatever value each individual places on his or her time. The costs being somewhat unquantifiable due to wide variations in expected travel distances, vehicle operating costs, and the value of personal time, the issue of convenience of the program is best handled in a more relative sense.

Decentralized programs can be more convenient than centralized programs if sufficient facilities are licensed to adequately handle the inspection demand. Since in a decentralized program there are considerably more inspection facilities, it is quite certain that the average travel distance to an inspection facility will be less than in a centralized program. Once a motorist reaches the inspection facility, he or she may still have to wait for an inspection. The duration of this waiting time is dependent on:

- the inspection demand,
- the number of inspection facilities licensed,
- the duration of the inspection, and
- the manner in which the inspections are staggered.

Selection of a decentralized option does not necessarily ensure a more convenient program than a centralized option. If an adequate number of facilities are licensed, however, the decentralized approach can be more convenient to more motorists than a similar program utilizing a centralized approach. It should be noted that certain economic factors, discussed in detail in Section 7, also influence the number of inspection facilities that can participate in the program.

The duration of the inspection is also an important convenience issue. The high option parameter inspection, for example, may take from 1½ to 5 hours to perform. For many motorists, this would mean having to leave the vehicle at the inspection facility. Regardless of how much value each motorist places on his or her personal time, an inspection of this length would certainly be viewed as an inconvenience. A summary of the inspection times, excluding waiting time is provided in Table 22.

TABLE 22. INSPECTION TIME REQUIREMENTS[a]

Test mode	Total performance time (minutes)	Locale
Tailpipe measurement (idle centralized)	4-5	Oregon
Tailpipe measurement (loaded centralized)	6-8	Arizona, California
Safety and idle test (centralized)	4-6	Cincinnati, Ohio; New Jersey
Idle test and parameter adjustments (decentralized)	20-25	Nevada
Low option parameter inspection	30	Estimate
High option parameter inspection	90-300	Estimate

[a]Does not include waiting time.

Source: Kincannon, B.F. et al. Viable Alternative Types of Inspection and Maintenance Programs for St. Louis prepared for U.S. EPA, GCA-TR-77-03-G, GCA Corporation, GCA/Technology Division, Bedford, Massachusetts. June 1977.

From Table 21, it appears that either the idle or loaded mode tailpipe tests can be performed in less time than a parameter inspection. It should be noted, however, that the parameter inspection process could also include minor adjustments. The same concept applies to a decentralized tailpipe measurement program as well. A centralized parameter inspection that includes adjustments can also reduce the I/M process to one stop, however, allowing minor adjustments to be performed by a single public or private entity may adversely affect the repair industry. This is discussed in greater detail in Section 5.

This brings to light an additional consumer convenience issue. For whom should the convenience of I/M be maximized — those whose vehicles will need repairs to meet the requirements or those whose vehicles have been properly maintained? An I/M option that enables inspection and maintenance at one stop can be much more convenient for the motorist whose vehicle requires repairs, even if the inspection time is longer than in a two-stop approach. Alternatively, the motorist whose vehicle will pass the inspection, will find as most convenient the option which will have the shortest total inspection time (including travel time, waiting time and inspection time). Permitting inspection and maintenance at the same stop may maximize convenience for many motorists, particularly those who will fail the inspection. However, if the inspector stands to benefit from one particular inspection result, a conflict of interest may occur.

CONFLICT OF INTEREST

Any of the centralized options enable a one-stop approach to I/M. Similarly, a centralized parameter inspection option is capable of providing the same convenience if adjustments are included in the inspection. Regardless of whether the price of adjustments/repairs is included in the inspection fee or a separate charge is made, a conflict of interest will exist. In the case of one price covering inspection and repair, the inspector will benefit (saved time) from minimizing repair time or by determining that the vehicle "passes" without adjustments or repairs. Conversely, spending a significant amount of time on a vehicle will result in a financial loss if more effort was spent on the vehicle than compensated for in the inspection fee. On the other hand, if costs for inspection and repair are kept separate, the inspector could stand to benefit from failing a vehicle and offering repairs the vehicle may not need. In either of these two examples a potential conflict of interest exists – the inspector (or his/her employer) stands to benefit more from one test result than another. This can act to make the inspector biased and, if unchecked, could lead to a consumer ripoff.

CONSUMER PROTECTION

Regardless of the I/M option selected, there will likely be some adverse impact for certain motorists at least on consumer issues. Through an effective consumer protection program, these impacts can be reduced and the potential for consumer ripoffs diminished. One important consumer protection measure is a sound quality assurance program. Since quality assurance is also a repair industry impact, it is discussed in detail in Section 5.

Consumer protection measures can be divided into two general categories. First, there are specific procedures that can be employed to deal with consumer complaints as they occur. These include consumer "hotlines" and complaints investigation. Neither the need for, nor the format of these types of programs will vary significantly from a tailpipe emissions measurement program to a parameter inspection.

The second type of consumer protection involves certain features built into the program that directly or indirectly protect consumers from potential inequities or abuses. These include state motor vehicle repair regulations, repair cost ceilings, waivers and exemptions, repair (or inspection) facility and/or mechanic licensing or certification, and basic warranty protection offered under the Clean Air Act. The applicability, nature, and scope of these particular measures are more dependent on the type of I/M program implemented.

The discussion presented here focuses on the specific consumer protection issues that can be expected to vary with the type of I/M program implemented. This being the case, then, only the issues that fall into the second of the two categories are considered.

Inspection/Repair Cost Limits

To prevent I/M from becoming an excessive financial burden, particularly on vehicle owners in lower and fixed income brackets, a minimum cost ceiling is often placed on the amount of money a vehicle owner is obligated to spend on the repair process. Although this concept applies to both tailpipe and parameter inspection approaches, the specific provisions may vary depending on the test type selected. In either case, however, it should be clearly stated that vehicle owners should in no way be compelled or encouraged to limit their maintenance expenditures. For those who can afford the extra costs, or who simply desire to minimize their contribution to the pollution problem, there should be strong encouragement to do so.

In either the case of a tailpipe test or a parameter inspection, a consumer-conscious I/M program will incorporate one of two types of repair (or adjustment) cost limits — an absolute dollar limit, or a sliding scale limit based on the value of the vehicle, along with a preset, standard inspection cost. The first approach involves setting a fixed upper limit that applies to all vehicles, regardless of age, condition, or resale value. Programs with this type of limit generally require maximum expenditures of from $50 to $100 depending on local repair shop rates. The second type of limit, which in theory is more equitable than the first, involves a maximum required expenditure based on the vehicle's value as determined by a standard, accepted reference such as the used car "Blue Book" of average retail prices. Parameter inspection programs might also limit required repairs to only a specified set of parameters. Again, however, the program should <u>not</u> discourage detection and correction of other emission-related problems; rather, motorists should be informed of both the <u>required</u> corrective actions as well as other <u>optional</u> measures that could improve the overall vehicle operation.

Other related consumer protection measures for the parameter inspection approach include the development of specific repair and adjustment procedures that would represent the maximum requirement, and provide the motorist a list of "reasonable rates" for various adjustments or repairs that may be required.

In a combined parameter inspection and adjustment program, a standard, uniform fee may be developed for all inspection facilities to cover the inspection and adjustment costs. The advantage of this approach is that the motorists will know exactly what the inspection/adjustment will cost. One disadvantage of combined parameter inspection and adjustment is that motorists who have properly maintained their vehicles such that they are within specifications, would be required to pay the same amount for the inspection as the motorist who has not maintained his vehicle. As an incentive, the State could offer waivers to motorists who present proof of having recently had their vehicles undergo a complete tuneup (e.g., itemized repair bill within so many days prior to the test).

<u>Licensing and Certification Programs</u>

Licensing or certification of repair shops and mechanics are mechanisms for ensuring that repairs are performed adequately and at a reasonable cost to the consumer. As such, they are also important in the context of consumer protection. The type and degree of regulation over private industry, such as repair shops, by state government is a sensitive issue, but given the need to ensure protection of the consumer and the adequacy of repair, some type of interaction or influence on the repair industry practices is crucial. A prerequisite for certification of a repair facility could be employing one or more mechanics who have attended a training program in emission control. An active mechanic training program in emission-related tuneup and emission repairs has been shown to have a very beneficial impact on upgrading mechanic skills and fostering a possitive attitude toward emission control. The selection of a separated parameter inspection and repair approach necessitates that inspectors are trained as mechanics; in a combined approach, of course, the inspectors are mechanics. This issue is discussed in greater detail in Section 5, Impacts on the Automobile Repair Industry.

Clean Air Act 207 (a) and (b) Warranty Provisions

The ability of in-use vehicles to maintain the emission levels for which they were designed depends largely on the integrity of the emission control components with which they are equipped. Federal requirements related to emissions control from new motor vehicles also considers the issue of durability and long-term effectiveness of emission control devices used. In fact, the Clean Air Act Amendments of 1977 include provisions for warranty protection of various emissions-related components; these provisions are discussed in the following paragraphs.

The U.S. Environmental Protection Agency considers the emission performance warranty, along with inspection/maintenance, as primary strategies for ensuring the in-use motor vehicles continue to meet the emission standards for which they were designed.[13] The 207(a) warranty provision requires all vehicle manufacturers to warrant their vehicles to be free from defects in materials and workmanship that will cause the vehicle to fail to meet applicable emission-related regulations. The 207(b) warranty regulations require vehicle manufacturers to warrant the emission control devices and systems for each new vehicle such that if the vehicle, although maintained and used in accordance with manufacturer's instructions, fails an approved short emission test, the cost of repairing the emission control devices or systems would be borne by the vehicle manufacturer.

Section 207(a) is in two parts, as shown below.

> "(1) Effective with respect to vehicles and engines manufactured. In model years beginning more than 60 days after the date of enactment of the Clean Air Amendments of 1970, the manufacturer of each new vehicle and new motor vehicle engine shall warrant to the ultimate purchaser and each subsequent purchaser that such vehicle or engine is (a) designed, built, and equipped so as to conform at the time of sale with applicable regulations under section 202, and (b) free from defects in materials and workmanship which cause such vehicle or engine to fail to conform with applicable regulations for its useful life (as determined under section 202(d))."
>
> "(2) In the case of a motor vehicle part or motor vehicle engine part, the manufacturer or rebuilder of such part may certify that use of such part will not result in a failure of the vehicle or engine to comply with emission standards promulgated under section 202. Such certification shall be made only under such regulations as may be promulgated by the administrator to carry out the purposes

of subsection (b). The administrator shall promulgate such regulations no later than two years following the date of the enactment of this paragraph."

According to Section 207(a) (1), a vehicle owner may initiate a warranty claim under which the motor vehicle manufacturer is obligated to replace any defective part or component of a new motor vehicle or engine which causes it to fail to conform with application regulations for its useful life. Its useful life under Section 202(d) is 50,000 miles or 5 years, whichever comes first.

Unlike Section 207(b), there is no distinction, with regard to 207(a), among the various emission control components. Of significant concern is use of the term "defective." According to the U.S. EPA,[14] the term "defective" refers to any part or component, which affects emissions, that has failed during the useful life of the vehicle, provided that (1) the vehicle has been maintained according to the manufacturer's written instructions, and (2) the vehicle has been used in a normal manner.

Section 207(a) (1) and Paramater Inspection--

The important question concerning Section 207(a) (1) is whether or not a motor vehicle would have to fail an approved emissions test or participate in an I/M program in order for the vehicle owner to establish a valid claim under the warranty. EPA officials have indicated that there is no relationship between I/M or an emissions test and 207(a)(1).[15] It is only necessary to establish that a part is defective, given of course that proper maintenance has been performed and the vehicle received normal use. If the defective part is discovered in the course of a parameter inspection, then the claim is valid. The same situation holds if the defective part is discovered independently of any emissions test. In other words, the vehicle owner may file a claim for any defective emission related part, component, or system, whether or not the vehicle fails an I/M test, or is even subject to I/M.

Emission Control System Components Covered by Section 207(b) Warranty--

During the initial period of 24,000 miles or 24 months the 207(b) warranty covers any system, assembly or device, or component thereof which affects emissions. From this period until the warranty expires at 50,000 miles or 5 years, the coverage is somewhat more limited. It includes "a catalytic converter, thermal reactor or other component installed in or on a vehicle for the sole or primary purpose of reducing emissions, which was not in general use prior to the model year 1968." This more limited coverage does include modification to parts (other than calibration changes) made for the sole or primary purpose of reducing motor vehicle emissions. Many components have been on a vehicle prior to 1968 or may have an additional purpose other than control of emissions but to exclude these components would defeat the purpose of the warranty since these components, as modified, may be an integral part of the emission system. Examples of such dual purpose components covered for the entire 50,000 or 5-year period would be a dual diaphragm vacuum advance unit on a distributor, or a quick release electric assist choke on a carburetor. However, a general failure of a distributor or a carburetor would not be covered after the 24,000 mile or 24-month period because these components were in general use prior to 1968 and are not devices used solely or primarily for the purposes of controlling emissions.

Full implementation of 207(b) requires a number of determinations by the EPA Administrator, with regard to 207(b) (1), and 207(b) (2). The Administrator has made all of the determinations, including the existence of "identifiable short tests, reasonably capable of being correlated with the Federal Test Procedure," as specified by 40 CFR Part 86, Subpart B. EPA anticipates final promulgation of regulations establishing at least three of the short tests listed below, as well as promulgation of the 207(b) warranty, prior to 1981.

- Idle test
- Federal three-mode test
- Clayton key-mode test
- Federal short cycle
- New York/New Jersey short cycle

Vehicles Covered by 207(b)--

207(b) will be applicable only to vehicles manufactured in model years subsequent to final EPA promulgation of the regulations establishing the warranty and short test correlation. It is expected that 1981 and later light-duty vehicles will be covered by these regulations. EPA also anticipates that appropriate short tests will eventually be developed for other types of vehicles, so that the warranty provisions will eventually extend to include all vehicle types.[7]

207(b) and Parameter Testing--

Unlike the 207(a) warranty, 207(b) establishes a close relationship between the I/M program and the warranty claim itself. Specifically, 207(b) requires as a prerequisite to a valid claim, that the vehicle must have failed an approved short test, which would set into motion a procedure bringing about a sanction or action, such as the withholding of vehicle registration.

Currently, parameter inspection is not being considered in the process of identifying short tests that correlate with the FTP. However, future inclusion of parameter test(s) has not been ruled out. As discussed in more detail elsewhere in this study, EPA plans to investigate various parameter inspection options in a demonstration project scheduled to begin January 1, 1980. Unfortunately, it is not expected that the Texas Program will generate sufficient data to make an assessment of the degrees of correlation between parameter inspection and the FTP emissions, prior to the end of calendar year 1980. Depending on the outcome of the "Texas Study," an investigation of the applicability of 207(b) will be made at that time.

In the low option, except for a functional check of the EGR valve, the remaining portions of the inspection apply primarily to misadjusted, improperly maintained, or tampered with components. If the inspection process is limited to these types of checks, warantee claims under 207(b) could be restricted to covering only EGR valves. However, if the process is such that, if while setting air/fuel ratio, for example, a defective carburetor component was detected and the motorist required to have it repaired, 207(b) would apply provided, of course, all of the other previously discussed criterion were met.

The high option, being more rigorous and involving actually examining the functionability of carburetor and ignition system components, would likely result in a greater frequency of 207(b) claims; provided defects detected are not tampering related.

Presumably, neither parameter test would enable warranty replacement of catalytic converters, perhaps the single most important emission control device, although valid claims for replacement of defective converters could be made under 207(a). It is unlikely, however, that in the absence of a loaded-mode emissions measurement test, or a parameter test that included a catalytic converter "functional" test, a nonfunctioning converter would ever be detected.

Whether or not the parameter inspection concept would enable warranty claims under 207(b) is not entirely clear at this time. Generally, in order to be acceptable in terms of indicating the need for 207(b) related warranty repairs, the method must prove to the satisfaction of EPA that it is able to indicate that the emissions from the vehicle are outside the FTP standard and that the actual estimate of emissions established by the method correlate well with FTP emissions.

SECTION 5

IMPACTS ON THE AUTOMOTIVE REPAIR INDUSTRY

INTRODUCTION

Regardless of the specific program format implemented, I/M will have a significant impact on all facets of the automotive repair industry. Implementation of the I/M will result in an increased demand for replacement parts, repairs, and qualified mechanics. Since the magnitude of the program in terms of geographic coverage, vehicle types, and model years affected, etc., remain undefined at this time, a quantitative assessment of the impact of I/M on the automotive repair industry cannot be presented. Alternatively, the impacts of I/M in general and the relative impacts of parameter inspections versus tailpipe inspections can be addressed in a qualitative sense.

DEMAND FOR MECHANICS

Perhaps the most significant impact on the automotive repair industry involves the necessary increase in the supply of qualified mechanics to meet the I/M created demand. The national mechanic-to-vehicle ratio has been declining significantly in the past few decades. In 1950 there was one mechanic for every 73 vehicles, nationwide. By 1975 that ratio decreased to only one mechanic for every 146 vehicles. In addition to increases in the number of vehicles that will require repairs, increasingly complex emission control systems may extend repair times on vehicles as well.

While all of the I/M options will increase the demand for mechanics, the extent of this increase is dependent, to a certain extent, on the specific program option selected and will affect not only the demand for mechanics but the skill level of mechanics (or inspectors) as well. The discussion here will be limited to the demand requirements. A discussion of the skill level and, thus, training requirements is presented in a separate subsection.

Of the options under consideration, the centralized tailpipe measurement approach will result in the lowest increase in demand for mechanics. The inspection and repair sequences are separated in this option, and the inspectors need not be mechanics. The repair industry will be involved only in the repair process and only for those vehicles that fail (probably 20 to 30 percent). For a hypothetical 1 million vehicle population, this equates to approximately 250,600 vehicles. Based on the average repair costs experienced in other states an average repair time of 20 minutes can be assumed. This equates to approximately 83,000 mechanic hours.

In a decentralized tailpipe approach, the demand for mechanics will be greater than in the centralized approach. The inspection and repair sequences will likely be combined in this approach, therefore the inspection requirements will be filled by mechanics. Again using a hypothetical million vehicles the requirement would be for the same 83,000 mechanic hours for repairs plus 1 million inspections at about 10 minutes per inspection (approximately 157,000 hours); a total of about 250,000 mechanic hours or about three times the demand for the centralized option.

The inspection and repair components are assumed combined in a parameter inspection approach. Since inspectors would essentially have to be mechanics in a parameter approach, regardless of whether the program is conducted in centralized or decentralized locations, the demand for mechanics will be approximately equivalent. For the low option, a 30 minute inspection/adjustment time is assumed. Again using the hypothetical 1 million vehicle population, this equates to 500,000 mechanic hours or, in relative sense, about twice the demand as for a decentralized tailpipe inspection.

For the high option, an average of 2½ hours per vehicle must be expended. For a 1 million vehicle population, this equates to 2,500,000 mechanic hours; 10 times the demand for the low option and 30 times the demand under a centralized tailpipe option.

DISTRIBUTION OF I/M CREATED WORKLOAD

While all of the I/M options evaluated will create business for the repair industry, the distribution of this workload is dependent on the specific program format implemented. A discussion of the relative impacts on the distribution of the I/M created workload associated with each potential program configuration is presented in the following paragraphs.

Tailpipe Inspections

In a centralized tailpipe measurement approach, the repair industry is effectively kept separate from the inspection process and engages only in the repair business generated by the program. Since no repair establishment is connected with the inspection process, all entities will compete for repair business. The experienced repair work distribution for the Portland, Oregon program is presented in Table 23.

TABLE 23. DISTRIBUTION OF I/M-RELATED REPAIR WORK – PORTLAND, OREGON

Establishment type	Distribution of repairs (percent of vehicles)		
	1972 - 1974 Model years	1975 - 1977 Model years	Composite
Auto dealer service department	18	48	34
Independent repair garage	41	21	31
Service station	17	18	18
Owner	21	12	16
Other	1	0	<1
No maintenance	1	0	<1

Implementation of a decentralized tailpipe measurement program could mean that selected repair industry entities would be performing both inspections as well as most repairs. Despite allowing motorists whose vehicles fail the inspection to seek repairs anywhere, many such motorists will seek those repairs at the same facility where the inspection was performed for convenience ("one-stop"). Under this scenario, State-selected facilities will be realizing most of the program created business. This introduces another issue. Will the State allow all qualified facilities to perform the inspections or limit the number of stations? Allowing all stations to participate will ensure a more equal distribution of the additional workload, however, as discussed in the cost analysis in Section 7, increasing the participation rate beyond a certain point will increase the fee to an unacceptable level. Additionally, a much more intensive quality assurance and consumer protection effort would be required. By limiting the participation in the program, the created workload will be disproportionately allotted to certain entities.

Parameter Inspections

The selection of a centralized parameter approach (State- or contractor-run) could have a serious economic impact on the repair industry. Since some repairs (adjustments) will likely be included in a parameter inspection scenario, many motorists could actually substitute the inspection for annual minor tuneups. This could seriously reduce tuneup business in the repair industry. This also raises an important legal issue. In the case of a State-run centralized program, are there legal obstacles to allowing State inspectors to adjust vehicles? The State would likely encounter serious adverse reaction from repair industry groups regardless of the choice of a contract- or State-operated program. A State-operated program could shift a lot of business from the private to the public sector. A contractor-operated program would likely be viewed by the industry as the State allowing a single entity to monopolize the minor tuneup business. To allow a single entity, either private or public, to control this entire market will not likely be viewed favorably by the private garage industry in Michigan. Most likely the industry will view this as an infringement on its business. Selecting this type of program could jeopardize I/M in Michigan since it provides the most disproportionate allotment of I/M created business of all of the options evaluated.

The problem of disproportionate allotment of business could be more acute with a decentralized parameter inspection approach than with a decentralized tailpipe approach since, logically, adjustments would be included with the inspection. In essence, this would allot all of the inspections and nearly all of the repairs to the selected repair shops. Since parameter adjustments may be substituted for regular minor tuneups by some motorists, stations not selected to participate in the program could actually lose existing work in addition to not receiving any of the created business.

MECHANICS TRAINING REQUIREMENTS

The subject orientation of mechanic training programs and certification tests should not vary considerably between a parameter inspection program and one that incorporates tailpipe testing. Except, under a parameter inspection approach, inspectors will essentially have to be trained as mechanics; whereas in a tailpipe approach, the inspectors only need to be proficient at measuring emission levels properly since the inspection would not require determination of the reason(s) why a vehicle is failing, rather a straightforward determination of pass/fail will be made based on emission levels alone. One advantage of a parameter inspection, in this regard, is that to a certain degree the problem diagnosis responsibility occurs at the inspection facility. This will become more important as emission control technology advances since on future vehicles diagnosing causes for problems will be more difficult than actually solving the problem once it is identified.

By inspecting parameters and functionally testing emission control components, the problems are attacked directly; tailpipe testing on the other hand leaves detection of the problem up to the mechanic who may be separate from the inspection phase of I/M.

In a relative sense that "high" option will demand more comprehensive mechanics training. While mechanics should be proficient at repairing all of the additional items in the high option anyway, investigations into such components as interfaced carburetor system parts, for example, would occur in the low option as repairs (i.e., if air/fuel ratio cannot be properly adjusted, then the repair mechanic will investigate float levels, metering rod, etc.). Since these components are not part of the routine "low" option investigations the mechanic can generally take more time to check diagrams and specifications in repairing these items; where in the "high" option, these investigations are part of the inspection and the inspector should be very familiar with most configurations and will not have much time to look up information.

There are 29 Community Colleges and an approximately equal number of Career Centers in Michigan which currently offer some form of mechanic training. Michigan also has the good fortune of being the home location of the major auto producers. As a result, mechanics can benefit from expertise available through these sources as well. One potential consumer protection benefit of any I/M scenario is that it ensures increased interfacing of the manufacturers, the repair industry, and the State by necessity; without this close cooperation, serious problems may surface which could endanger the existence of the program.

The increased demand for mechanics may serve as a mechanism to drive up wage rates for those who are qualified. The extent of this supply/demand problem will depend on the ability of the industry to fill positions created by the increased demand. No matter how responsive the supply of mechanics is to this increase in demand, some lag is inevitable. Because of this, windfall profits may accrue to existing shops for some initial lag period, particularly in the case of a program that separates the inspection and repair components. The tight supply situation, if unchecked, could lead to more frequent overcharging until the increased demand is met with additional mechanics.

In addition to recruiting and training new mechanics, existing mechanics should undergo at least a limited retraining phase to orient them to the purposes and goals of I/M and emissions control. In some cases the needs of I/M are in conflict with maintenance standards now existing that emphasize high engine performance. It is important that the repair industry be aware of the different criteria demanded by I/M so that it may act accordingly. The amount of mechanics' training that must be made available is directly dependent on the increase in the demand for mechanics, which was discussed previously.

LICENSING OR CERTIFICATION OF REPAIR SHOPS AND MECHANICS

Licensing or certification of repair shops and mechanics are mechanisms for ensuring that repairs are performed adequately and at a reasonable cost to the consumer. As such, they may be important as consumer protection elements. The type and degree of regulation of private industries such as repair shops by state government is a sensitive issue, but given the need to ensure protection of the consumer and the adequacy of repair, some type of interaction or influence on repair industry practices is crucial. An active mechanic training program in emission-related tuneup and emission repairs has been shown to have a very beneficial impact on upgrading mechanic skills and fostering a positive attitude toward emission control. The selection of a separated parameter inspection and adjustment approach necessitates that inspectors are trained as mechanics. (In a combined approach, of course, the inspectors are mechanics.)

Most repair industry groups do not look favorably at formal licensing of repair shops and mechanics; rather, they view it as expensive interference in private industry. Of course, when the repair facilities are designated as official inspection stations then some sort of official licensing and closer supervision is very important for both consumer protection and quality assurance considerations.

Since January 1978, all repair facilities in Michigan have been required to employ at least one mechanic who has received certification in each area of automotive repair the facility deals in (brakes, tuneup, transmission, etc.). Beginning January 1, 1981, all mechanics must be certified in the specific area he performs repairs in. Mechanics who do not pass the State certification test, may work as a mechanic trainee for a maximum of 2 years, but only under supervision of a certified mechanic. Additionally, the mechanic's signature and certification number must appear on every work order. These stringent regulations are enforced through constant surveillance by State authorities, who also investigate for overcharging, unnecessary repairs, etc.

The existence of this State Certification system will be a significant asset for any I/M program Michigan implements. It can also serve as the basic framework for other adjunctive programs such as quality assurance, mechanics training, complaints investigation, etc.

Currently, there is no special classification for emission control systems, however, there is a general "tuneup" category which covers much of this material. As emission control technology development continues, the content of the certification test for tuneups can, or course, be continuously updated. The very rapid advancement of this technology may make frequent reexamination a necessary requirement.

QUALITY ASSURANCE

One of the most important elements crucial to the success of any I/M program is a sound, effective quality assurance program. Quality assurance is, in effect, a consumer protection measure. For any of the options evaluated here, motorists will benefit if the inspections are conducted in a uniform manner with properly calibrated and maintained equipment. Quality assurance differs from consumer protection measures in that the latter refers to features and rules built into the program for the purpose of protecting consumers from potential abuses, while quality assurance refers to measures taken to ensure that inspections are properly conducted, data collected is reliable, test results are repeatable, etc. Accurate, reliable information must be generated to correctly analyze the impact of the program, in terms of meeting the objectives of I/M (reduced vehicular emissions, fuel usage, etc.) and maintaining public interest in the program. Enforcement of the program will be more difficult, if not impossible, if the public perceives the program as haphazard or arbitrary. The format Michigan selects for its program will, to a large extent, determine what types of quality assurance practices will be required to ensure the success of I/M. As discussed in the following paragraphs, the concept of a parameter inspection introduces some difficult, though not insurmountable, quality assurance problems. For comparison, a discussion of currently utilized quality assurance measures is in order.

Quality Assurance Techniques for Tailpipe Measurement I/M Programs

Centralized Programs--

The repeatability of the actual test results is central to the issue of quality assurance. The test must be carried out correctly and with a high degree of uniformity on all vehicles included in the program. A program utilizing a network of centralized inspection stations will facilitate the standardization and repeatibility of tests. Such a system contains a relatively small number of high quality exhaust gas emission analyzers that can be closely monitored. It is technically feasible and desirable to automate the testing sequence in this situation, tieing all operatings associated with the test into a central computer system.

An automated test sequence interfaces control of the emission analyzer and dynamometer (in the case of a loaded-mode test) with a computer routine, thus removing perhaps the largest cause of test result variability, human error. This approach enables the limitation of human involvement to: (1) identifying the vehicle to the computer by means of entering the vehicle identification number (VIN) and registration information into an input/output device (such as a "CRT" or T.V. screen type computer terminal), (2) manually inserting the analyzer probe(s) into the tailpipe(s) of the vehicle, and (3) operating the vehicle on the dynamometer (in the case of a loaded-mode test). The computer routine can monitor the "load" being applied by the dynamometer and automatically take and evaluate exhaust gas samples at the appropriate times. The sample results can then be integrated by the computer and compared with previously established test standards stored in the computer and pass/fail decisions can be automatically determined.

Once such a system has been installed and its software has been found to be accurate and reliable, a series of relatively simple checks can be made to ensure continued proper, reliable operation. For example, analyzers must be calibrated periodically. This procedure is straightforward; by analyzing a set of precisely-blended "calibration gases" and comparing the analyzers readings with the actual known concentrations, the analyzer's accuracy can be easily determined and, if necessary, adjustments can automatically be made. With an automated system, analyzers can be calibrated regularly as requently as desired (usually hourly) to minimize the possibility of inaccuracies resulting from equipment malfunction.

The data from each inspection station can be stored on computer tapes that can subsequently be analyzed to determine if correct cut-off points are being used; also, failure rates can be analyzed to detect patterns indicative of incorrect procedures at a particular lane, by a particular inspector or to uncover unintentional biases or improperly determined cutpoints with respect to a particular year/class/make of vehicle.

One practice which falls into both the quality assurance and consumer protection categories, involves the retesting of vehicles which failed inspection and received repairs. Data on repair costs, types of repairs performed, and the name or identification number of the repair facility can be recorded. From this data, facilities overcharging motorists or performing excessive, inappropriate, or insufficient repairs can easily be identified. Also, the reduction in emission levels can be quantified by comparing the results with those of the previous test.

Periodic inspections can be made by the State to verify the accuracy of data generated at the centralized facilities. This is particularly true in the case of a contractor-operated program. In addition to regular checks on equipment condition and accuracy, the State may perform unannounced checks to verify that proper procedures are being followed.

Experience to date shows that the operation of automated centralized systems is relatively trouble-free, and that downtime resulting from equipment malfunction is minimal. The important point to note here, is that a computerized, automated data handling system is most suited to a centralized, tailpipe measurement program and allows for easy access of important information which is crucial for quality assurance checks.

Not all centralized programs in operation today utilize automated computerized data handling procedures, but do provide for quality assurance checking. Notably, the State of New Jersey and the City of Cincinnati both have centralized tailpipe measurement programs, but emission levels and pass/fail decisions are recorded manually. Quality assurance studies can still be made, but involve extra costs including keypunching time, etc. Also the quality of the data is assumed somewhat lower than with an automated system as human errors can occur when: (1) the inspector reads the emission levels, (2) determines the pass/fail status, (3) records the information, and also, (4) when the keypuncher codes the information.

Decentralized Tailpipe Programs--

Currently, decentralized I/M programs which employ tailpipe testing do not easily lend themselves to computerized, automated data recording due to prohibitively high costs of such equipment. Discussions with representatives of garage-type emission analyzer manufacturers, however, indicate that in the very near future, garage level analyzers will be capable of producing a hard copy record of the emission level readings in the form of a punched computer (IBM) card. This will contribute a great deal to the minimization of human error in a decentralized approach, but this option will likely add almost 50 percent to the cost of the analyzer.

By the nature of the decentralized approach, quality assurance practices such as equipment calibration and inspection procedure checks will be more costly. The reasons for this are two-fold. First, if a decentralized system is selected, there will be considerably more facilities to keep track of than in the case of a centralized program. Additionally, since the decentralized approach utilizes repair shops as the inspection facilities, the State must ensure against the possibility of intentional errors or biases in pass/fail determinations and data recording due to the conflict of interests associated with having the same facilities conducting both inspections and repairs. It is also less likely that stations overcharging motorists or performing unnecessary repairs could be easily identified as the data will be supplied by these stations, enabling those who abuse the system to "cover their own tracks." As a result of this abuse potential, undercover visits will likely be a requirement if the State is to ensure that the desired emission reductions are being achieved, and that consumers are protected from unscrupulous mechanics. In the case of a contractor-operated centralized program, the conflict of interest problem can be addressed in the I/M legislation through provision of a clause that prohibits the contractor from engaging in any other type of business that leads to a conflict of interest. This will ensure that the contractor will not be in a position to profit from one test result but not another.

Quality Assurance Techniques for Parameter Inspections

As previously discussed, combining parameter inspections with adjustments dictates, for all practical purposes, that the inspection process be conducted in a network of private repair establishments. Since either the "high" or "low" option parameter approaches involve checking engine parameter adjustments, it is doubtful that "hard copy" data, in the form of a punched computer card, could be provided, rather it is most likely that data would be manually recorded. The same limitations and consequences that applied to the tailpipe measurement inspection in private garages apply here. The data processing will be more costly, and the quality of the data will likely be less than in an automatic recording approach. As in the previously discussed private garage tailpipe approach, considerable surveillance by the State will be required to ensure a high quality program.

Unlike a tailpipe measurement approach, a parameter inspection involves a mechanic's determination of whether or not particular parameters are set to specification. While tailpipe measurement involves an objective determination of whether or not the concentrations of emissions are below a certain level, the parameters inspection involves a subjective judgment on the part of the mechanic. To assure quality, reliable, and most important, repeatable results some uniformity must be assured. Perhaps the most effective method to assure that proper inspection procedures are being carried out involves state surveillance. Undercover inspectors with vehicles known to have or not have maladjustments, defective components, etc., can seek inspections and monitor the inspection process and determine if a particular repair establishment (or inspector) is doing an adequate job.

One problem that is common to all parameter inspection approaches is that measuring program effectiveness in terms of emission reductions will be extremely difficult if not altogether impossible. Without actually measuring emission levels, there will be no assurance that the I/M program is actually meeting its objective of reducing vehicular emissions. To ensure that the program is in fact bringing about a significant emission reduction, either "before and after" emission measurements would have to made on all vehicles, as in Nevada, or a random sample of vehicles would have to be checked.

SECTION 6

PROGRAM ADMINISTRATION REQUIREMENTS

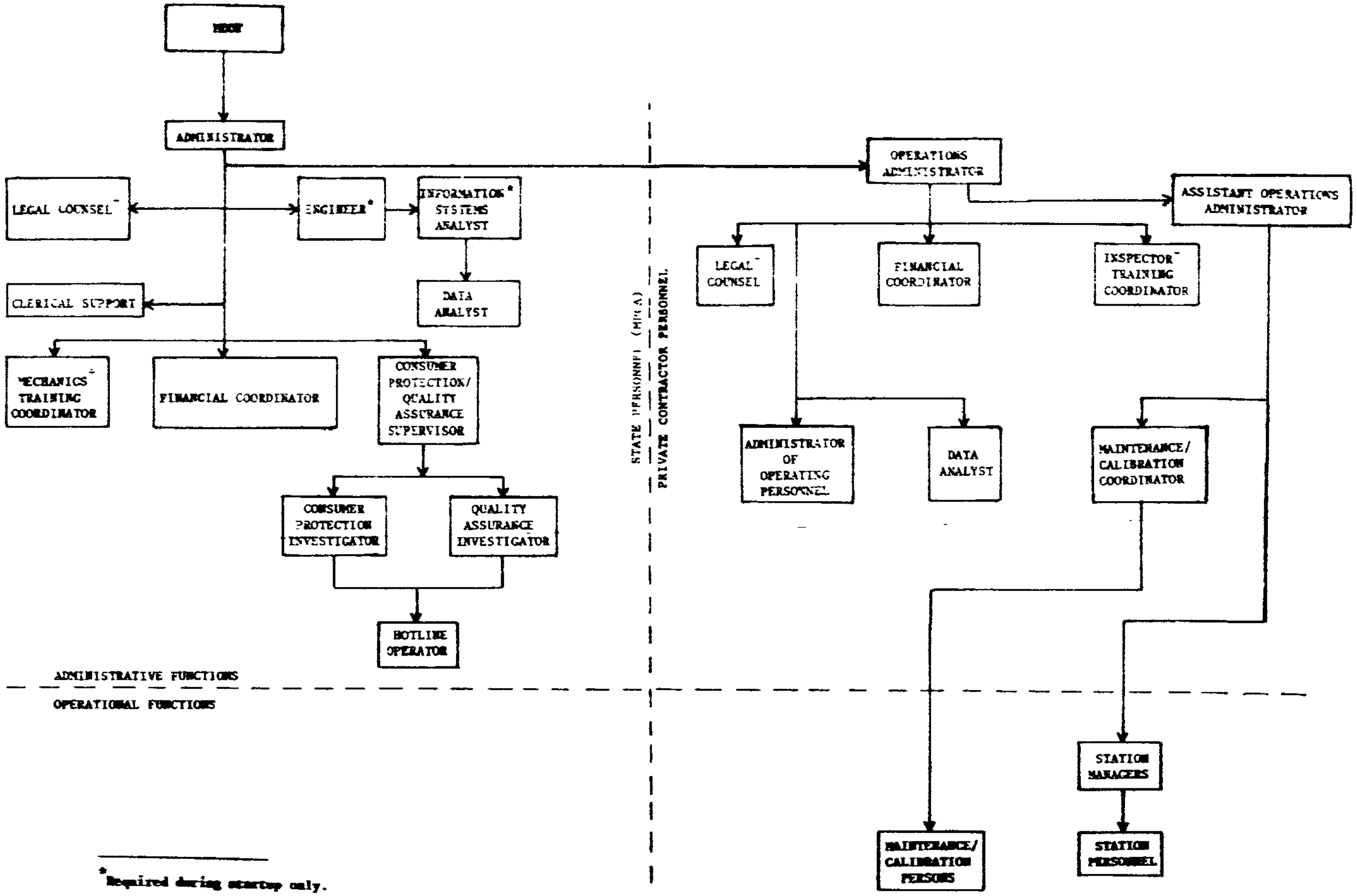
INTRODUCTION

Program administration refers to the organizational and personnel structure necessary to implement, support, and maintain the I/M program. The administrative requirements, in terms of the specific tasks and responsibilities involved, will not vary significantly between an I/M program incorporating tailpipe testing and one involving parameter inspections. However, there are differences in the number of individuals required to perform specific tasks. The choice of a decentralized rather than a centralized program, for example, will necessitate more consumer protection/quality assurance investigators since in decentralized approaches, the State will have far more inspection facilities to monitor than in a centralized approach. Selection of the high option parameter inspection instead of the low option will result in similar increases in the administrative staff.

A suggested administrative structure is presented in the following paragraphs. Since the nature of Michigan's I/M program, in terms of geographic coverage and specific vehicles included in the program is still undefined, the exact number of individuals required cannot be specified here. Alternatively, the administrative positions required were identified and where option-specific differences occur, they are discussed in a relative sense. While most of the personnel described here would likely be employed directly by the State or contractor (if applicable), it is not likely that all positions would require new personnel; rather, it is quite probable that existing State personnel could assume many of the responsibilities. The positions discussed here are divided into State and contractor personnel for centralized approaches; all positions fit into the State category for decentralized or State-run programs. Those positions not applicable for certain options are identified as such in the position descriptions.

STATE PERSONNEL

The system administrative structure, shown in Figure 3, is assumed to be organized under the Michigan Department of Transportation (MDOT). Reporting directly to MDOT would be an Administrator, who would be responsible for operating the program in accordance with regulations established by MDOT. MDOT staff would provide input to the Administrator regarding policy decisions and would monitor the effectiveness of the program.



*Required during startup only.

†Not a full-time position.

Figure 3. Typical administrative structure.

The Administrator would be supported by Legal Counsel, as necessary. The function of Legal Counsel would be to advise the Administrator and MDOT on all matters concerning the legal aspects of the program. In all likelihood, this position would be filled as needed by existing staff lawyers within the State government structure.

An Engineer(s), who would be required primarily during the startup phase of the program, would be responsible for overseeing design and construction of inspection facilities, the selection of test equipment, and the development of data handling software.

The Mechanics Training Coordinator would be responsible for establishing and implementing training programs for the repair industry. After startup, this position would probably not require full-time effort; rather an occasional effort would be required periodically during the actual operation of the program.

Responsibility for the program finances with respect to the State, would be held by the Financial Coordinator. This would likely not be a full-time position, and could perhaps be handled by existing State staff.

An Information Systems Analyst would be responsible for developing the software to be used in the overall data collection system. A Data Analyst, working in conjunction with his contractor counterpart (discussed later) would be responsible for providing MDOT with periodic summaries concerning program operation (e.g., percent failures, second failures, emission characteristics of the inspectable fleet, etc.).

A Consumer Protection/Quality Assurance Supervisor would be required to administer the quality control and consumer protection aspects of the program. Subordinate to the coordinator would be the consumer protection and quality assurance Investigators. The number of investigators would be dependent on the format of the program. The fewest investigators would be associated with the centralized-tailpipe or low-option parameter inspection approach. The centralized, high option would require about five times as many investigators as the low option, since, as shown in the Section 7 Cost Analysis, approximately five times as many facilities would be required under the high option. The high option facilities are also likely to be almost twice as large, in terms of the number of bays, as the low option facilities.

The decentralized approaches would involve a much greater effort. For the high option, for instance, more than 2,600 private facilities would likely be required to match the capacity of one hundred 38-bay facilities. Although a single-bay repair shop inspection facility would require significantly less investigation time than a large centralized facility, the large number of decentralized facilities and additional travel time between facilities will necessitate a substantial increase in the number of investigators required. The low option, on the other hand, will require fewer decentralized facilities and, thus, fewer investigators than the high option, but more than in a centralized low option approach.

CONTRACTOR PERSONNEL

If a centralized, contractor-operated approach is used, several administrative positions would be filled that are similar to State positions. The contractor personnel would be headed by an Operations Administrator who would be responsible for management of the operational aspects of the program and for planning of future program operations. In a State-run or decentralized program, the functions of this administrator would be handled by an Assistant Administrator for Support Services.

The Operations Administrator would be supported by an Assistant Operations Administrator who would oversee station managers and the Maintenance/Calibration coordinators, as well as holding responsibility for day-to-day operation of the program. This position would remain relatively unchanged in a State-run or decentralized program.

Also subordinate to the Operations Administrator would be a Financial Coordinator and Legal Counsel having duties similar to their respective State counterparts.

In a State-run or in a decentralized program the functions of the two positions would be absorbed by the State personnel of the same titles.

The Inspector Training Coordinator would be responsible for all the formulation and establishment of a comprehensive training program for all inspection station personnel employed by the contractor (or the State).

Inspector training could, in any centralized approach, be conducted by the individual facility managers and assistant managers. In a decentralized approach incorporating tailpipe testing a number of instructors may be required on a one-time basis and a smaller number continuously throughout the life of the program. In any of the parameter inspection approaches, inspector training could be incorporated with mechanic's training.

The Personnel Administrator would handle all matters directly involving any of the contractor's personnel. This administrator would also serve as liaison between station personnel and contractor management personnel, and would represent the employees in any labor disputes which might arise. This position would be handled by existing State staff in a State-run program, and would be unnecessary in a decentralized program.

The Data Analyst would work in conjunction with the State in preparation of periodic reports on the program, and would be responsible for the daily data processing effort.

The Maintenance/Calibration Coordinator would oversee maintenance/calibration persons and would hold ultimate responsibility for the repair and overall condition of all contractor equipment.

In a State-run or decentralized approach, these positions would be filled by MDOT personnel. The number of persons required would vary as a function of the specific option selected in a manner similar to that discussed for consumer protection/quality assurance investigators.

The above described administrative structure is a suggested approach and should be viewed as such. The actual structure established by the State should reflect the particular option selected, existing personnel available within the State government, and the available funding. The primary point in this Section, however, is administrative requirements are fairly constant with regard to whether parameter inspection or the tailpipe measurement approach is utilized.

SECTION 7

COST ANALYSIS

INTRODUCTION

The primary interest at this point is to consider parameter inspection programs in terms of general concepts — more specifically, in terms of the four concepts described in the previous paragraphs. In that specific program scenarios are not being considered, detailed cost analyses have not been developed, nor would it be possible to develop these at this time. Of more concern are the relative costs associated with each parameter inspection concept, and, again in a general sense, how these costs compare with tailpipe measurement program costs. The analyses presented here consider the relative costs associated with parameter inspection alternatives only. Reference 1 should be used in conjunction with the data presented in this document to compare parameter inspection costs with tailpipe inspection costs. Since these two analyses were developed independently, the costs derived should be compared in general terms.

In analyzing costs, the methodology used for decentralized programs is significantly different from that used for the centralized programs, regardless of whether the high or low option is being considered. For convenience the analyses are presented separately for the decentralized approach — high and low options — and the centralized approach — high and low options.

DECENTRALIZED APPROACH

General Methodology

There are a number of variables that will affect the cost of an inspection at a decentralized repair shop, several of which cannot be addressed quantitatively within the scope of this project. One such variable involves the competitive nature of the service station industry. Since each station competes with all others for customers, prices will be set at levels that attract enough business to meet costs plus realize an acceptable margin of profit. The basic premise underlying the behavior of a single station is that total revenue must be at least equal to total station costs:

$$\text{Total Station Revenues} \geq \text{Total Station Costs}$$

This applies generally to individual services performed by the station, as well. One slight deviation, however, is that a particular service does not necessarily have to provide a profit (or, for that matter, produce sufficient revenue to offset its cost) if it creates a demand for some other service that will produce profit.

With regard to inspection and maintenance, the gross revenue produced is equal to the sum of the inspection fees and repair work performed as a direct result of the inspections. The costs associated with providing the inspection service depend on several factors such as the equipment required, licensing fees, salaries and overhead, etc. Gross revenue and costs are directly related and are both affected by many common factors. One such factor is the expected number of inspections performed annually by a facility; this factor can be discussed in terms of market behavior.

Market Behavior--

Within a given geographic area, the average annual throughput per inspection station, N, can be calculated from:

$$N = \frac{I}{S}$$

where I = the total number of inspections and reinspections required in the given geographic area.

S = the number of inspection stations within the given geographical area.

Thus, the number of inspection stations and the annual throughput are inversely related; as the number of such stations increases within a given geographical area, the throughput for each will decline, and vice versa.

The market participation rate, R, is a useful term in discussing the market behavior. It is calculated using the following formula:

$$R = \frac{S}{G}$$

where S = the number of inspection stations within a given geographic area

G = the total number of service stations within that area.

As indicated above, service stations are motivated to provide inspection services by the potential profits to be made. Unless otherwise constrained, service stations will continue to enter the inspection business as long as these profits can be realized. There is a point, however, beyond which increasing the participation rate will mean throughputs so small that inspection revenues will not equal costs. Figure 4, below, provides a generalized indication of the functional relationship between the participation rate, R, and both the costs incurred and revenue derived from the inspection program, for each inspection facility.

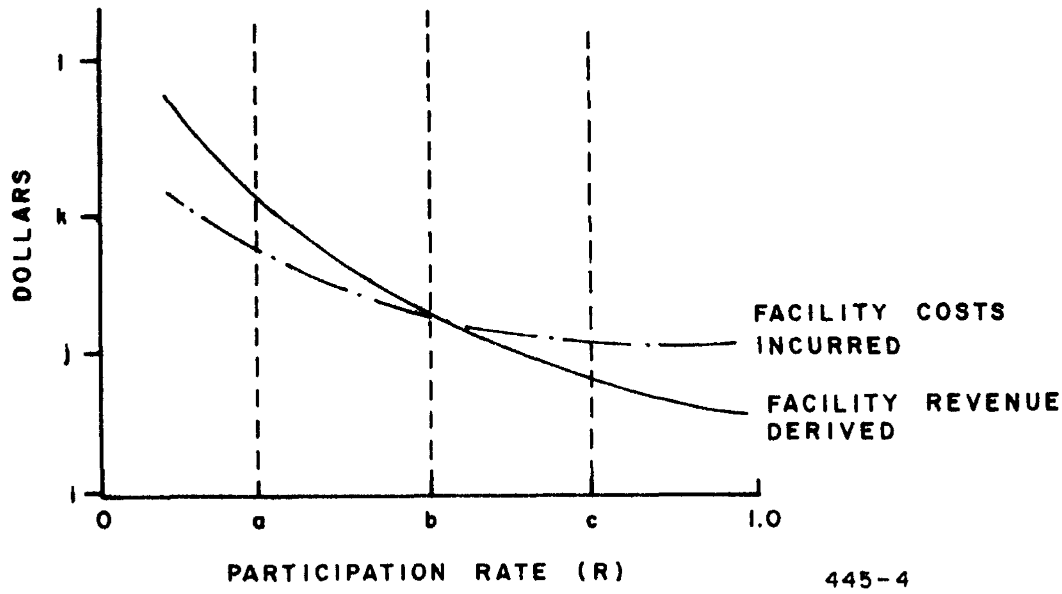


Figure 4. Generalized relationship between participation rate, R, and costs and revenue associated with providing inspection service.

If the participation rate in a network is close to "a" in Figure 4, all stations will, on the average, be making a profit on the inspections, therefore, the program will tend to attract additional stations. As the participation rate increases to around point c, some stations will begin to experience a loss since costs will be higher than revenues. If the participation rate is in the vicinity of point b, the average station will just break even on its investment. Some stations will operate at this seemingly irrational point because repair business on failed vehicles is likely to generate some new revenue that would otherwise not occur.

From the standpoint of costs, then, it is desirable to keep the participation rate low. On the other hand, if the rate is too low, the inspection capacity will not be able to accommodate demand in a satisfactory manner. This would be evidenced by long waiting lines at the inspection sites, and would likely result in many consumer complaints. The actual participation rate in a given area might be controlled to some extent through:

- establishing a certain fixed number of station licenses to be granted within a given geographic area in a given year;

- establishing uniform maximum or minimum fees to be charged by inspection stations for performing inspections; and

- varying the licensing fee paid by inspection stations to the state.

For the purposes here, it is not essential that the number of inspection stations be derived. In fact, this number cannot be derived at this point since the geographic coverage — hence, the size of the affected vehicle population — has not been projected. Instead, the cost computations for the decentralized option were based on three factors that can be dimensioned fairly accurately at this point, and which will provide a realistic estimate of the actual fee that would be charged for an inspection. The three factors include:

- time required to perform the inspection;
- current hourly shop rate (1979 dollars) for service facilities in Michigan; and
- estimated costs for administering the program.

Very simply, the estimated inspection fee, f, is computed as:

$$f = (T)(H) + (Ca/I)$$

where T = time required to perform the inspection;

H = the 1979 average hourly shop rate for service facilities in Michigan;

Ca = the annual administrative cost incurred by the State for operating the program; and

I = the total number of inspections (excluding reinspections) to be performed by the program.

The inspection fee reflects two separate components — the actual inspection represented by the product of T and H, and an administrative fee, which is a function of several factors but essentially reflects the total administrative costs divided by the annual number of paid inspections.

Several assumptions are implicit in this approach. The most crucial of these, however, is that the existing shop rate, H, provides a relative indication of the true costs of operating a service facility, (including the costs associated with purchasing, maintaining, and replacing common tools and equipment, and general administrative, labor, and overhead costs), and that an inspection service justifies the same hourly rate as other work performed at the facility. Also, since the administrative cost element cannot be estimated specifically for the Michigan I/M program, it is assumed that the average administrative cost associated with programs in other states will provide a reasonable estimate of the administrative costs that will be incurred in the State of Michigan.

Cost Analysis

A close inspection of the high and low options reveals that the primary difference between the two is the level of intensity involved; actually very little difference occurs in the equipment and shop space required. An important conclusion, then, is that the relative cost of the two options will be primarily a direct function of the amount of time spent performing the inspection. The derivation of a fee estimate is discussed separately for the high and low options in the following paragraphs.

High Options--

Section 2 of this document provided an outline of the individual inspection tasks proposed for the high option. Included were estimates of the time requirements to perform each task, and a subjective assessment of the level of skill and special equipment (in this context, special equipment includes items that would not ordinarily be found in a general repair facility and their use would be more or less limited to performing the inspections) required.

The individual time requirements for performing each task are summarized below in Table 24. As can be seen from this table, the individual time requirements are generally specified as ranges owing to the variability in the effort as a function of vehicle manufacturer and model. The total time range is approximately 1-1/2 to 5 hours. Based on discussions with representatives of the automobile service industry, an estimated "average" inspection time of 2-1/2 hours is reasonable.

TABLE 24. SUMMARY OF INSPECTION TASK TIME – HIGH OPTION

Inspection element	Estimated time required
Carburetor-all items	1 to 2-1/2 hours per carburetor
Ignition system	30 minutes to 2 hours
Thermal air inlet	10 to 20 minutes
Heat Riser	Approximately 1 minute
PCV	2 to 5 minutes
EGR system	2 minutes
AIR system	1 to 2 minutes
Spark delay valve	(included in ignition system check)
Catalytic converter	1 minute

The shop rates for automotive repairs are also variable, primarily as a function of geographic location. Rates are generally higher in the more urban areas. The actual rate may vary by the type of work performed, as well. A sample of repair facilities in and around the metropolitan Detroit area indicated that the rates range from around $16 per hour to over $30 per hour for tune-up work; again, the range within the Detroit metropolitan area is higher – generally $25 to $35 per hour. For purposes here, an hourly rate of $30 per hour is assumed. The result, then, is an estimated cost range of $45 to $150, and an average cost of $75 to perform the inspection.

Also, the administration costs will be absorbed by the consumer. This covers the cost of support programs concerned with public information, quality assurance, mechanics training, and for the overall administrative effort required. Based on programs planned for other states, cost estimates for the overall administrative function range from $0.20 to $2.00 per inspection, depending largely on the scope of the support programs involved. For the high option of a parameter inspection program, it can be assumed that a significant effort will be required in areas such as consumer protection, public information, and quality assurance. It appears reasonable, then, to expect that the attendant costs will reflect the higher end of the previously-stated range; the assumed administrative cost is $2.00 per inspection.

Some motorists will also incur additional costs in spite of the fact that their vehicle may pass the inspection. As indicated in Section 2, some carburetors must be partially disassembled in order to perform the required adjustments or inspections. In order to reassemble the carburetors, new gaskets are required, which cost approximately $5.00 to $8.00 per set.

The total inspection cost for the high option performed in a private garage or repair facility, then, can be expected to range from about $47.00 to around $160.00; an average cost of approximately $80.00 appears likely. This cost is exclusive of any repairs or adjustments that cannot be performed as part of the inspection. Also, new parts that may be required, even though they may be installed as part of the inspection, are not included, either. At this point the likely costs of repair parts and repairs or adjustments required that are not made as part of the inspection process have not been investigated; it is acknowledged here that these costs constitute an extremely significant aspect of the proposed program and, therefore, must be considered in subsequent phases of the planning effort. In fact, reinspections under this option must also be considered from the standpoint of cost impact since reinspections could certainly be significant.

Low Option--

Estimating the costs associated with the low option essentially involves the same considerations as were applicable to the high option. Again, the primary difference is that the low option inspection process is much less demanding in terms of both time and expertise. The inspection routine along with the individual time requirements for each task are summarized in Table 25.

TABLE 25. SUMMARY OF INSPECTION TASK TIME — LOW OPTION

Inspection element	Estimated time requirement
Visual inspection	1 to 2 minutes
Fuel filler	30 seconds to 1 minute
Catalytic converter	1 minute
EGR system	2 minutes
Idle air-to-fuel ratio	15 to 20 minutes (if adjustment is required)

The total time requirement, including processing paper work and counselling, it estimated to be approximately 30 minutes.

To derive an estimate of the inspection cost, the previously-defined hourly rate of $30.00 per hour was applied to the inspection time estimate resulting in a cost of $15.00. It is likely that the overall administration costs would be less for the low option since the scope of certain of the support programs, primarily the quality assurance program and the consumer protection program, would not be as great for this option. It is estimated that a reasonable administration cost would be on the order of $1.50 per inspection. The total inspection cost, exclusive of repairs or adjustments performed separately, is estimated to be approximately $16.50.

CENTRALIZED APPROACH

General Methodology

For the centralized approach, an assessment was made of the various costs associated with implementing and operating an inspection station, from which the per inspection cost was calculated as a function of the annualized costs and the expected throughput. The general cost categories and subcategories considered in this analysis are presented in Table 26. Cost data were derived from several sources including equipment manufacturers, land assessors, building contractors, various reports concerning I/M programs in other states, and original estimates derived by GCA staff members. All cost data presented here are in constant 1979 dollars unless otherwise noted.

TABLE 26. COST CATEGORIES CONSIDERED IN THE ANALYSIS OF CENTRALIZED PARAMETER INSPECTION PROGRAM

Primary category	Subcategories
I. Initial capital costs	1. Building investment
	2. Land investment
	3. Equipment costs
II. One-time start-up costs	1. Land acquisition
	2. Facilities planning
	3. Program design
	4. Develop data handling systems software
	5. Personnel training
	6. Personnel salaries and overhead prior to start-up
	7. Initial public information program
III. Annual operating costs	1. Facility personnel
	2. Maintenance
	3. Utilities/services/supplies
IV. Annual administrative costs	1. Program administrative personnel
	2. Enforcement
	3. Consumer protection/quality assurance
	4. Public information
	5. Training, licensing, certification

The basic comparisons made in this section consider centralized parameter inspection programs utilizing either the high option or the low option; one additional possibility exists, however, which is not treated here. This additional possibility concerns whether the program is operated by the State or by a private contractor, either of which is a realistic approach. Generally, differences can be expected depending on which approach is selected because certain cost savings can be realized by a contractor since he generally has more flexibility in selecting contractors, purchasing equipment, hiring personnel, and in his overall administrative process. Previous studies of tailpipe inspection programs indicate that the cost differential may be as much as 10 percent.

The following paragraphs provide a detailed description of the cost elements analyzed and also indicates data sources and assumptions used.

Initial Capital Costs

These costs reflect the initial expenditures required for tangible items such as purchasing and improving land, constructing the test facility, and purchasing and installing all items of equipment, land, buildings, and equipment are the three major elements considered under the category of capital costs.

Building Investments--

Building costs are dependent on specific designs and features utilized; unit costs, therefore, vary substantially as a function of the particular design selected. For I/M applications, the primary concerns are functional adequacy of the building, and cost economy. A type of structure that ostensibly satisfies these criteria is a standard clear span, metal structure. These are essentially pre-engineered, modular structures that can be adapted to a wide variety of applications.

At this point, some basic specifications for a "standard" structure must be developed. The primary specification concerns the number of bays that the facility should have. Consider, for the moment, the metropolitan Detroit area. The total light-duty vehicle population to be served in this area, projected to 1987, is estimated to be 3.1 million. Assuming a conservative retest rate of 10 percent, then, means that about 3.4 million vehicles must be serviced during 1987. Based on the technical discussion in Section 2, it is seen that the inspection time for the high option is estimated at 2-1/2 hours. If the inspection facilities are open say 280 days per year, on an average of 10 hours per day, and operate with an efficiency factor of 0.80, then annually there are essentially 2,240 inspection-hours available per bay, per year. Since each inspection requires 2-1/2 hours, each bay has an annual capacity of approximately 900 inspections. The total number of inspection bays required to accommodate the 3.4 million vehicles is:

$$3.4 \times 10^6/900 \approx 3,800 \text{ bays}$$

With this factor defined, one could suggest that the size criteria be established so that no more than 100 facilities would be required; this would mean that each facility would require approximately 38 bays. Although this constitutes a rather large facility, it certainly is within the practical range;

the discussion will assume, then, that the standard facility for the high option contains 38 inspection bays.

The space requirements for this type of facility were analyzed resulting in a design concept that provides an overall size of 26,000 square feet (150' x 174'). This is comprised of approximately 14,000 square feet of inspection bays, 5,000 square feet of isle space, 5,000 square feet of administrative area, and 2,000 square feet of waiting area. A conceptual floor plan is provided in Figure 5.

For the low option these same 3.4 million vehicles would require only about 760 bays owing to the much faster inspection time (30 minutes as opposed to 2-1/2 hours). Rather than utilizing 20 38-bay facilities, it might be more reasonable to use 38 20-bay facilities; it is assumed, then, that the standard low option centralized facility will include 20 bays.

Again, the basic space requirements were analyzed and a design concept derived. This design provides 16,800 square feet in total (140' x 120'). For this facility, the individual bay sizes and waiting areas were held constant (with respect to the 38-bay facility) while the administrative areas and isle space were scaled down. A conceptual floor plan is shown in Figure 6.

The cost for constructing the facility described above was derived from conversations with manufacturers' representatives; the unit cosc was estimated to be approximately $30.00 per square foot for a total cost of $780,000 for the 38-bay facility and $504,000 for the 20-bay facility.

Land Investment--

The costs associated with land investment consists of two elements – the basic cost of the land, and necessary improvements such as landscaping and paving. The cost of a particular parcel of land depends on the size of the parcel and the unit price. Unit costs for land are extremely lot-specific; the unit cost for parcels within a given block may vary by a factor of 3, while, within a given municipality, the unit cost could easily vary by a factor of 10 or more. Available parcels may be somewhat larger than the size actually required necessitating the purchase of land that exceeds the general requirements. Obviously, then, it is not possible at this point to develop a precise cost estimate for the land required for an inspection facility. In a recent study performed for the Michigan Department of Transportation, estimates ranging from $0.50 to almost $6.00 per square foot were presented for land in the larger metropolitan areas of the State; an assumed unit cost of $4.00 per square foot appears to be reasonable.

The total area required is primarily a function of the building size. For both types of facilities, the land requirement is estimated to be four times the floor area of the building. This would provide parking areas for both customers and employees, and room to maneuver through the area. The estimated land area required, then, is 104,000 square feet (2.4 acres) for the 38-bay facility, and 67,200 square feet (1.6 acres) for the 20-bay facility. Costs of $400,000 and $270,000 are indicated for the two facilities.

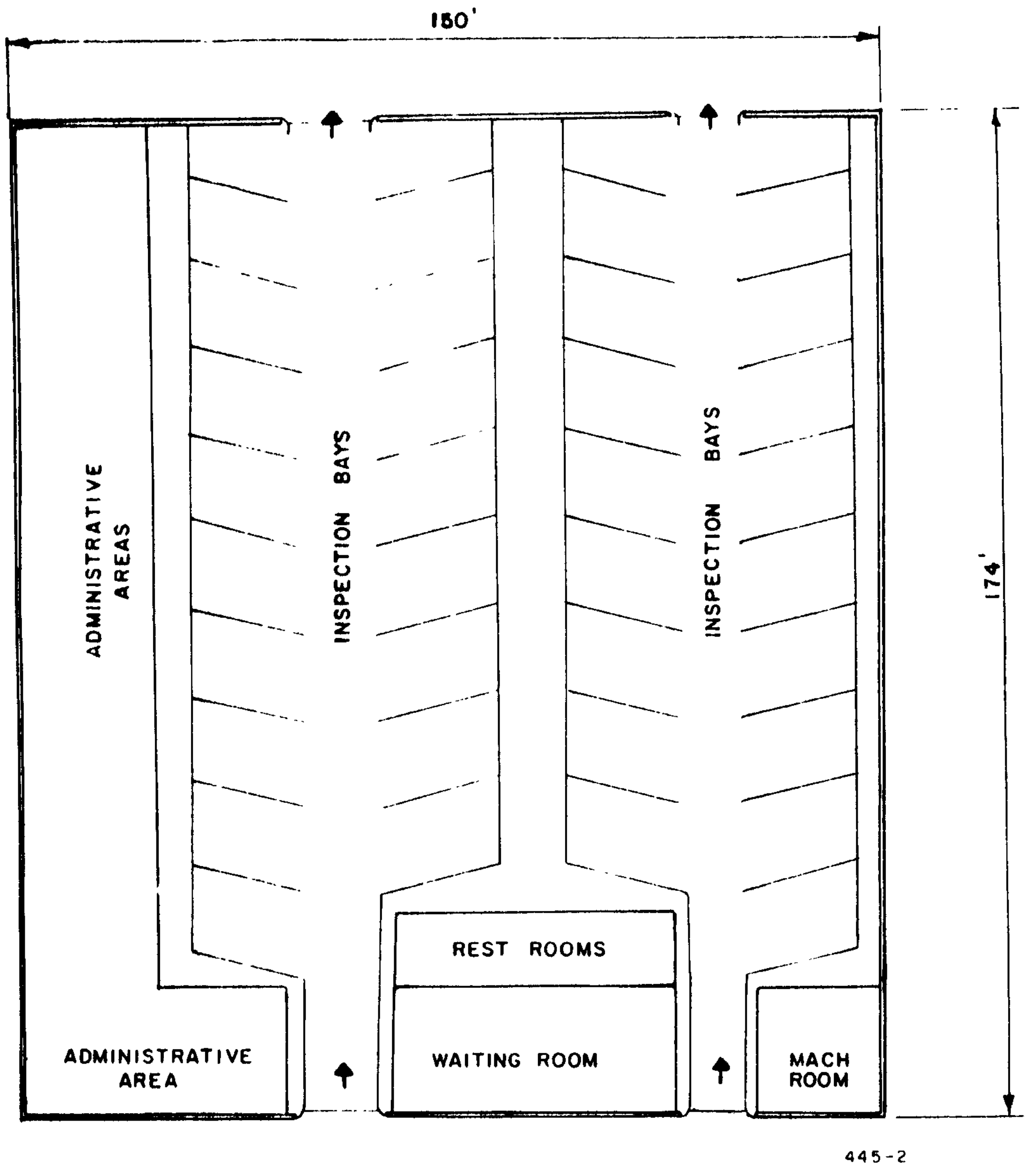


Figure 5. Conceptual floor plan — centralized facility for high option parameter inspection program.

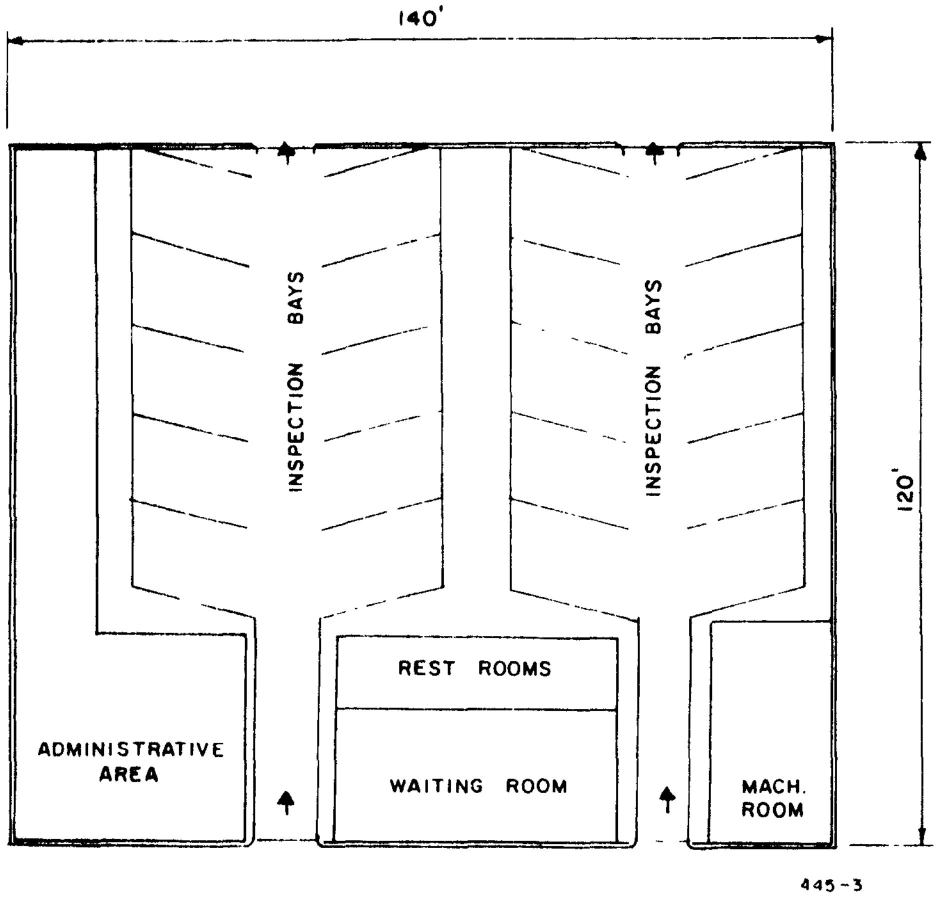


Figure 6. Conceptual floor plan — centralized facility for the low option parameter inspection program.

Added to this cost is the cost of paving and landscaping. The unit cost for this element is $1.30 per square foot, $135,000 and $87,000. The total land investment is equal to the sum of the purchase price and the improvements, or $535,000 for the 38-bay facility, and $357,000 for the 20-bay facility.

Equipment Requirements--

In concept, the parameter inspection technique can be applied without a large array of specialized equipment. In a more practical sense, however, the use of certain specialized items should be considered primarily as a method for assuring that quality control is maintained and to assist in the process of routine records keeping and program assessment.

As was previously indicated, there is some uncertainty regarding the types of tests and test equipment that will be required for vehicles that will be produced beyond the next few years. It is fairly certain that vehicles produced by Ford Motor Company will require a "black box" diagnostic device for its EEC-1 computerized engine control system. Also, for some current vehicles, emissions analyzers are required to perform certain adjustments on the carburetor (primarily, A/F adjustment). It can be concluded, then, that there is a requirement for equipment other than basic hand tools and commonly used devices such as timing lights, dwell meters, etc.

With regard to equipment available, there is a wide variety of equipment representing a wide range in sophistication, capability, utility, and cost. The extremes in this range are, at the low end, various hand held devices, such as tachometers, that perform one specific function; at the high end are computer controlled engine analyzers that are capable of performing a wide variety of specialized tasks. Figure 7 illustrates the range in equipment available, while the costs associated with these types of equipment are shown in Figure 8.

Although the cost differential among the various types of equipment mentioned above might appear to be significant, the actual impact on the inspection cost of choosing the least expensive over the most expensive (or vice versa is quite small; this will be illustrated at the end of this Section. Further, the incremental cost would likely be offset directly by the gain in efficiency and quality of the inspection process using a computer controlled system. For these reasons, the analysis presented here assumes that a highly advanced engine analyzer system will be provided in each inspection bay. It is also assumed that an online computer file will be maintained and that each bay will be equipped with a cathode ray tube (CRT) display unit so that all relevant specification for any vehicle under inspection can be obtained quickly and accurately by the inspector. The analyzer and CRT unit is assumed to be appropriate for both the high and low options since the types of adjustments that the systems would be useful for are common to both options. Further, it is assumed that the overall administrative recordkeepin- functions will utilize a computerized system.

In addition to the equipment required to perform the inspections and process records, general office equipment, furnishings for the waiting area, and special exhaust fume handling systems are required. The entire equipment requirement along with an itemized cost estimate is provided in Table 27.

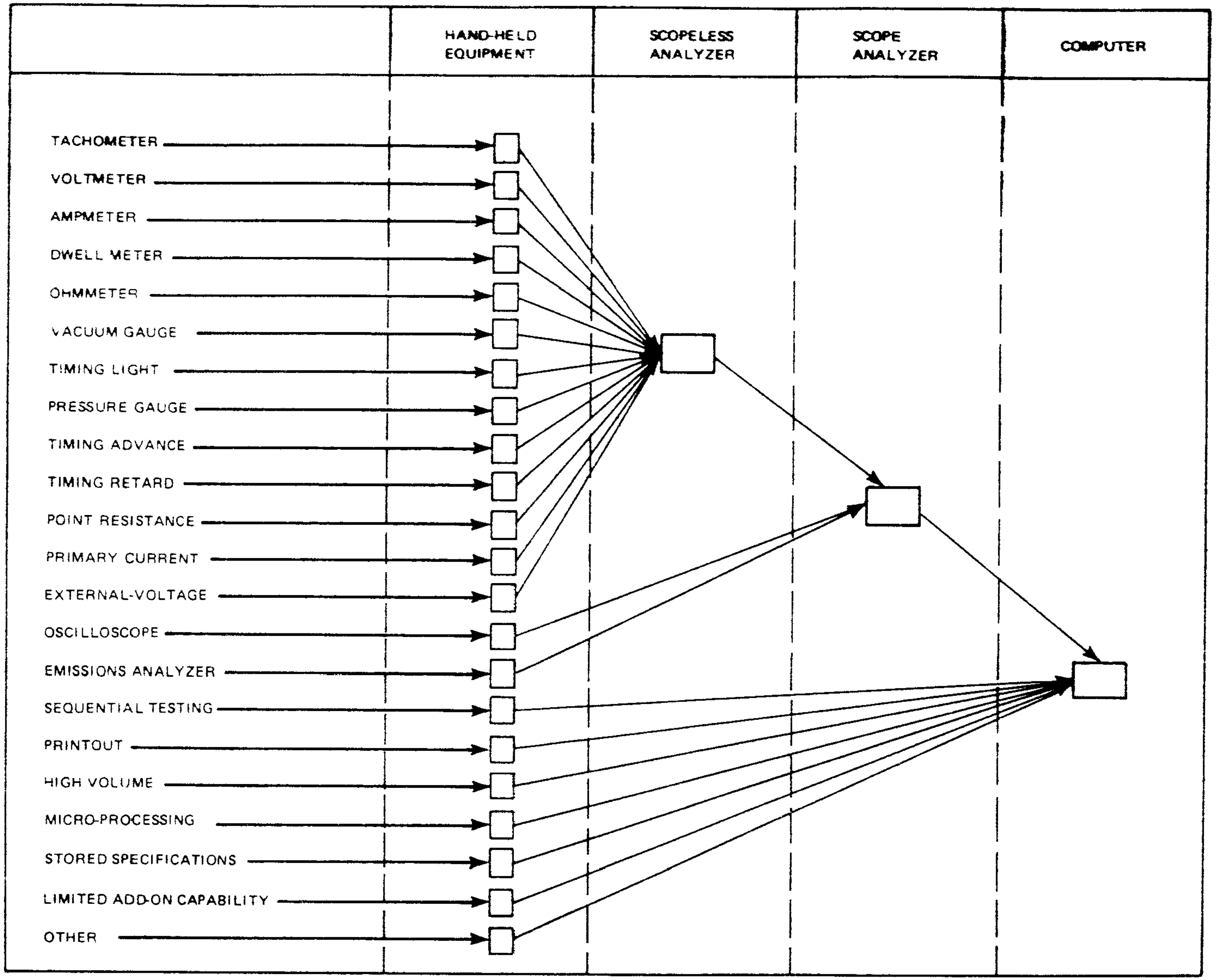


Figure 7. Functional comparison of engine testing equipment.

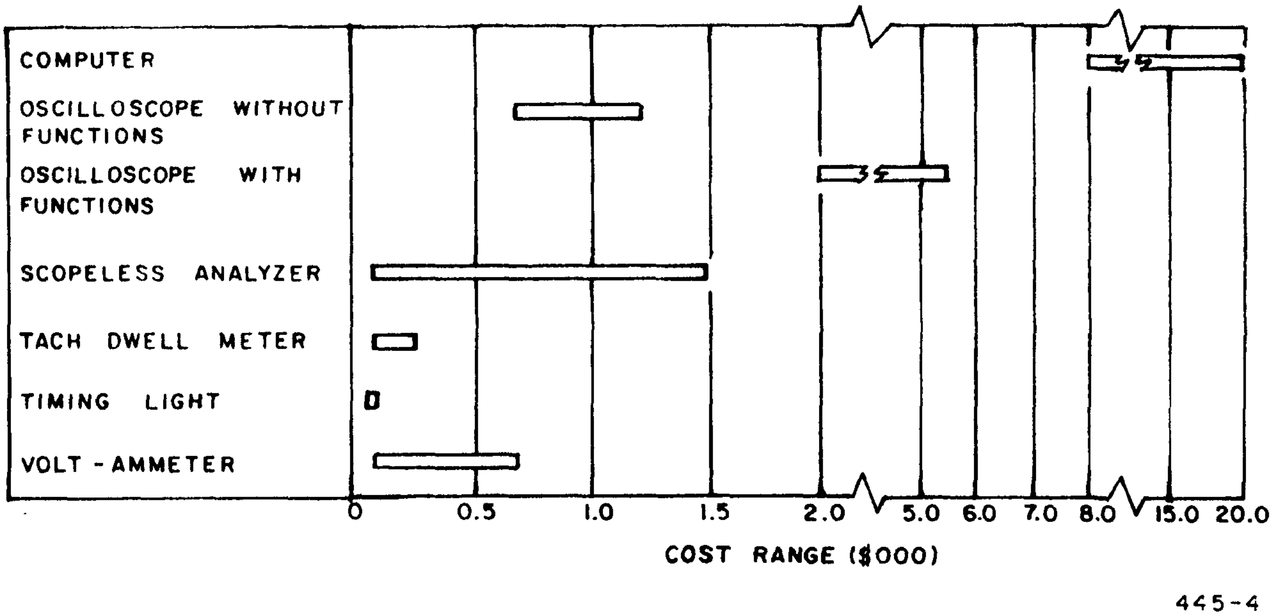


Figure 8. Cost comparison of engine/electrical test equipment.

TABLE 27. EQUIPMENT REQUIREMENTS FOR TWO TYPES OF CENTRALIZED PARAMETER INSPECTION FACILITIES

Facility type	Item	No. required	Estimated unit cost ($)	Total cost ($)
38-Bay	Engine analyzer	38	20,000	760,000
	CRT units	38	2,500	95,000
	Mini computer	1	50,000	50,000
	Tool sets	38	2,000	76,000
	Facility furnishings	—	—	50,000
Total				$1,031,000
20-Bay	Engine analyzer	20	20,000	400,000
	CRT units	20	2,500	50,000
	Mini computer	1	50,000	50,000
	Tool sets	20	2,000	40,000
	Facility furnishings	—	—	40,000
Total				$ 580,000

Summary--

The capital costs associated with a 38-bay and a 20-bay facility are summarized in Table 28.

TABLE 28. SUMMARY OF CAPITAL COSTS FOR AN INSPECTION FACILITY

Cost element	Estimated cost ($)	
	38-bay facility	20-bay facility
Building investment	$ 780,000	$ 504,000
Land investment	535,000	357,000
Equipment	1,031,000	580,000
Total	$2,346,000	$1,441,000

It is noted here that some equipment items are not included at this point; these are primarily associated with the administration of the program and will be included as part of the administrative costs.

One-Time Start-Up Costs

Implementation of any I/M program will require the expenditure of monies for noncapital items and services on a one-time basis prior to the actual start-up. Costs associated with this category are perhaps the most difficult to define at this point primarily because the elements involve services (program planning, design, development, etc.), which are inherently much more variable in cost than, for instance, equipment or building costs. Considerations used in developing cost estimates for each element are discussed with the presentation of the individual estimates as follows.

Land Acquisition--

Included in this element are the costs for identifying and locating candidate sites, negotiating purchase price, and completing title transfers. Site location and price negotiation would involve approximately 200 man-hours of professional technical time, plus 40 man-hours of professional legal time for each site. To translate man-hours to actual cost figures, a $20 per hour and $50 per hour value were assigned to technical and legal hours, respectively; this represents a total cost of $6,000 per site to cover location and negotiation. Title transfer involves physical surveys, title searches, site plan preparation, and miscellaneous support functions required to execute the purchase. The cost associated with this component is estimated to be approximately 10 percent of the unimproved land value.

For the two facilities being considered here, this cost is:

$6,000 + (0.10)($400,000) = $46,000; and

$6,000 + (0.10)($272,000) = $33,000.

Facilities Planning--

This element reflects the costs associated with engineering and design for the test facilities, bid review and construction monitoring. This element will be defined as 10 percent of the construction cost, or:

(0.10)($780,000) = $78,000 for the 38-bay facility, and

(0.10)($504,000) = $50,000 for the 20-bay facility.

Computer Software Design--

The costs associated with the development of computer software must be allocated over the entire program rather than to each facility. Based on the experience of other states, the cost of developing the required computer software for I/M programs has been estimated at around $200,000 regardless of the program size. This figure will be assumed to apply to the Michigan program as well. The problem of allocating the cost can be handled by, again, assuming that the entire program will consist of about 100 inspection stations for the high option and 38 stations for the low option; the cost per station, then, can be assumed to be 1 percent and 3 percent of the total cost for this element, or $2,000 for the high option and $6,000 for the low option. Obviously, this is a rather imprecise method, however, it does not affect the final inspection cost estimate significantly yet the fact that there is a cost associated with this element is accounted for.

Personnel Training--

Owing to the nature of the parameter inspection process, it is assumed that most inspectors would be required to have significant experience as mechanics prior to being hired. The additional training requirement would, therefore, be minimal. Given the assumptions used previously regarding the operating hours for the facility, it will be necessary to hire two inspectors per bay; one would be full-time while the other would work part-time. This requires training 76 individuals for the 38-bay facility and 40 for the 20-bay; the likely turnover rate for personnel must be considered also. This is assumed to be 10 percent annually. The requirement is to train a total of 85 and 45 individuals for the 38-bay and 20-bay facility, respectively, during the initial stages of operation.

The cost of providing training was estimated based on the experiences of other states in developing I/M programs. It is estimated that the cost per individual is $50. The inspector training would cost a total of $4,300, and $2,200 for the two options. It is noted that training is an ongoing activity and, therefore, training costs are reflected both here and as recurring.

In addition to training the inspectors, the facility manager and assistant manager must be trained in both the inspection techniques and in the administration of the facility. The cost associated with providing this training is estimated at $100 for each person, or a total of $200, which applies to both options. The total training costs for the 38-bay facility is $4,500, while the cost for the 20-bay facility is $2,400.

Personnel Salaries--

Prior to beginning actual inspections, most of the facility personnel would be hired and would participate in training and preparing the inspection station for operation. It is assumed that the manager and assistant manager would be hired and begin working 2 months prior to start-up, while the inspectors would be hired 2 weeks prior to start-up, on the average.

The pay scale for the managers, assistant managers, and inspectors is:

- managers - $2,000 per month
- assistant managers - $1,670 per month
- inspectors - $1,500 per month

The start-up costs associated with the operational personnel are summarized in Table 29.

TABLE 29. OPERATIONAL PERSONNEL SALARIES DURING PROGRAM START-UP

Position	Monthly salary ($)	Time required during start-up	No. of positions		Salary during start-up	
			High option	Low option	High option ($)	Low option ($)
Manager	2,000	2 months	1	1	4,000	4,000
Assistant Manager	1,670	2 months	1	1	3,340	3,340
Inspectors	1,500 (346/week)	2 weeks	85	45	58,820	31,140
Total					$66,160	$38,480

Added to the total shown in Table 28 would be the overhead costs, assumed here to be 25 percent of the wage rate. The total costs, then, are $82,700 and $48,000 for the high and low options, respectively.

Also during the start-up phase a number of administrative personnel will be employed. The costs associated with the administrative effort must be allocated over the entire program. Since the basic administrative structure is likely to be very similar to the administrative structure used in other states for tailpipe inspection programs, the total start-up costs associated with administrative activities can be estimated from these other programs. Several programs indicate that the administrative effort during start-up costs approximately $250,000. Assuming that the allocated administrative cost per facility is approximately 1 percent and 3 percent respectively for the high option and low option, the administrative personnel costs for the two facilities under consideration here are about $2,500 and $7,500; the total operating and administrative personnel salaries are $82,700 + $2,500 = $85,200 for the high option, and $48,000 + $7,500 = $55,000 for the low option.

Support Programs--

During the start-up phase the public information program and a mechanics training program will likely be initiated. Generally, the costs associated with public information programs are based directly on the size of the vehicle population affected by the program. For purposes here, it can be assumed that this cost will be approximately $0.15 per vehicle, which is slightly higher than the cost used for tailpipe inspection programs. This would mean that the costs allocated to the 38-bay facility and 20-bay facility under consideration are approximately $5,000 and $25,000, respectively.

At this point it is nearly impossible to estimate the requirement for mechanics training. It is not likely that the total amount spent would exceed $100,000 based on the mechanics training programs proposed for other states. Again, the allocated cost will not significantly affect the final inspection cost, although for completeness, it will be assumed that the allocated cost will be $1,000 for the 38-bay facility and $5,000 for the 20-bay facility.

Summary--

A summary of the estimated start-up costs associated with implementing operations at a 38-bay centralized inspection station for the high option and a 20-bay facility for the low option are provided in Table 30.

TABLE 30. SUMMARY OF INITIAL START-UP COSTS FOR A 38-BAY INSPECTION FACILITY, AND A 20-BAY INSPECTION FACILITY

Item	Estimated cost	
	High option ($)	Low option ($)
Land acquisition	46,000	33,000
Facility planning	78,000	50,000
Computer software	2,000	6,000
Personnel training	4,500	2,400
Personnel salaries	85,200	55,000
Support programs	6,000	30,000
Total	$221,700	$176,400

Annual Operating Costs

Annual operating costs include all costs associated with the actual operation of the program. For the purposes here, the costs of adjunctive programs (e.g., public information, inspection/mechanic training, etc.) are included under "Annual Administrative Costs," which are discussed later.

Facility Personnel--

The annual costs associated with this category are a function of the number of personnel involved in the operation of the facility and their relative level of responsibility, and the prevailing wage scale for the employment categories involved.

TABLE 31. ANNUAL PERSONNEL COSTS — OPERATIONAL PERSONNEL

Job title	Annual participation	Pay rate ($)	Number of positions		Annual salary ($)	
			High option	Low option	High option	Low option
Manager	Full-time	$24,000/yr	1	1	24,000	24,000
Assistant Manager	Full-time	20,000/yr	1	1	20,000	20,000
Inspectors — Full Time	Full-time	18,000/yr	38	20	684,000	360,000
Inspectors — Part Time	700 hr/yr	8.57/hr	38	20	228,000	120,000
Subtotal					956,000	524,000
Overhead at 25% of Wages					239,000	131,000
Total					$1,195,000	$655,000

Both the operating personnel requirements and corresponding wage rates were specified in the previous paragraphs. Applying these to the annual operation of the two types of facilities results in the costs shown in Table 31.

Maintenance--

Included in this category are repair and preventive maintenance costs for facility equipment, estimated at 20 percent of the original equipment cost per year. This equals to:

(0.20)($1,031,000) = $206,200, and

(0.20)($580,000) = $115,000.

Utilities/Services/Supplies--

Items in this category include electricity, heat, water, insurance, inspection forms, building services, office supplies, etc. Based on the size of the facilities, the type of equipment required, hours of operation, and general location, estimates of $200,000 and $150,000 per year were derived.

Summary--

A summary of the annual operating costs associated with the 38-bay and 20-bay inspection facilities are provided in Table 32.

TABLE 32. SUMMARY OF ANNUAL OPERATING COSTS FOR A 38-BAY INSPECTION FACILITY AND A 20-BAY INSPECTION FACILITY

Cost element	Estimated costs ($)	
	High option	Low option
Personnel	$1,195,000	$655,000
Maintenance	206,200	116,000
Utilities/services/supplies	200,000	150,000
Total	$1,601,200	$921,000

Annual Administration Costs

Costs involved in this category reflect the overall program administrative effort. Specifically, the salaries of personnel involved in areas such as enforcement, consumer protection, public information, training, and certification are included. Also, the operating costs for quality assurance and consumer protection vehicles fall into this category.

Administrative Personnel Costs--

The suggested administrative structure discussed in Section 6 was used to develop an estimate of the total cost for personnel salaries and overhead. Table 33 provides a summary of the personnel cost estimate. Again, these costs have to be allocated over the entire program; as before, it is assumed that

TABLE 33. ANNUAL ADMINISTRATIVE PERSONNEL COSTS — HIGH AND LOW OPTIONS

Position	Salary Annual ($)	Salary Monthly ($)	Participation annually (months)	Total salary for participation annually ($)
State Personnel				
Administrator	30,000	2,500	12	30,000
Legal Counsel	20,000	1,670	3	5,000
Clerical Support (2)	12,000	1,000	12 (each)	24,000
Mechanics Training Coordinator	20,000	1,670	6	10,000
Financial Coordinator	24,000	2,000	12	24,000
Consumer Protection/Quality Assurance Supervisor	18,000	1,500	12	18,000
Data Analyst	18,000	1,500	12	18,000
Consumer Protection Investigator	18,000	1,500	12	18,000
Quality Assurance Investigator	15,000	1,250	12	15,000
Total State Personnel Salaries				162,000
Overhead @ 25%				41,000
Total State Cost				203,000
Constractor Personnel				
Operations Administration	30,000	2,500	12	30,000
Assistant Operations Administrator	20,000	1,670	12	20,000
Legal Counsel	30,000	2,500	3	7,500
Clerical Support (2)	12,000	1,000	12 (each)	24,000
Financial Coordinator	20,000	1,670	12	20,000
Personnel Administrator	24,000	2,000	12	24,000
Data Analyst	18,000	1,500	12	18,000
Maintenance/Calibration Coordinator	15,000	1,250	12	15,000
Total Contractor Personnel Salaries				158,500
Overhead @ 25%				39,500
Total Contractor Cost				$198,000
Total Cost				$401,000

1 percent of the cost can be allocated to the 38-bay facility and 3 percent to the 20-bay facility. The resulting cost allocations for the two types of facilities are $4,000 and $12,000, respectively.

Support Programs--

The public information programs and the training programs for inspectors and mechanics will be conducted on an ongoing basis. Again, the cost of the public information program is assumed to be based on a fixed rate per inspected vehicle. The assumed rate is $0.15 per vehicle; since the 38-bay facility can accommodate approximately 34,000 vehicles annually, the allocated public information cost is approximately $5,000; the 20-bay facility can accomodate approximately 83,500 vehicles therefore an allocated cost of $12,500 is indicated.

It is assumed that the training activity will continue at the same level as during the start-up phase, therefore the allocated costs are approximately $4,500 and $2,400 annually.

Cost Summary

The individual cost categories are summarized in Table 34.

Fee Computation

In order to derive a "break-even fee," all costs found in Table 34 are converted into annual figures. The steps involved in calculating these annual costs are summarized below.

Initial Capital Costs--

The capital investment in equipment is assumed to yield equal benefits for each of 5 years and be fully depreciated thereafter. The interest rate, i, is the marginal return on capital in the absence of inflation. For the program being assessed here, i is assigned a value of 0.06.

In annualizing equipment costs, the following formulae are employed. The net present value (NPV) of an investment that yields $1 of services for each of n years at a capital growth rate of i is:

$$NPV = \sum_{k=i}^{n} \frac{1}{(1+i)^k} = 1 - \left[(1+i)^{-n}\right] \Big/ i$$

Therefore, an investment of $1 will yield annual benefits of: $\frac{1}{NPV} = \frac{1}{1-(1+i)^{-r}}$ for each of n years. Therefore, the amortized costs in constant dollars, is represented by $\frac{1}{NPV}$. The amortization factor for equipment, then, is: $\frac{0.06}{1-(1+0.06)^{-5}}$ or 0.2374.

TABLE 34. COST SUMMARY FOR A 38-BAY AND A 20-BAY INSPECTION FACILITY

Cost category	Cost element	Estimated cost ($)	
		High option	Low option
Initial Capital Costs	Buildings	780,000	504,000
	Land	535,000	357,000
	Equipment	1,031,000	580,000
	Subtotal	2,346,000	1,441,000
Startup Costs	Land Acquisition	46,000	33,000
	Facility Planning	78,000	50,000
	Computer Software	2,000	6,000
	Personnel Training	4,500	2,400
	Personnel Salaries	85,200	55,000
	Support Programs	6,000	30,000
	Subtotal	221,700	176,400
Annual Operating Costs	Personnel Salaries	1,195,000	655,000
	Maintenance	206,200	116,000
	Utilities/services/ supplies	200,000	150,000
	Subtotal	1,601,200	921,000
Annual Administrative Costs	Personnel Salaries	4,000	12,000
	Training Programs	4,500	2,400
	Public Information Program	5,000	12,500
	Subtotal	13,500	16,900

For buildings, the initial investment is assumed to yield a constant flow of capital services for 20 years and be fully depreciated thereafter.

Applying n = 20 to the above formula:

$$\frac{0.06}{1-(1+0.06)^{-20}} = 0.87$$

If structures are liquidated before 20 years, the sale price is assumed to be the capitalized flow of the remaining services. Therefore, a structure sold after j years will sell for:

$$\sum_{k=1}^{20-j} \left(\frac{i}{NPV\ (1+i)} \right)^k$$

for each dollar of initial investment. This assumption enables the use of the above amortization factor, $\frac{1}{NPV}$, without making further adjustments.

Land is assumed to yield a constant level of services in perpetuity ($n = \infty$ in the above formulae). Therefore, \$1 of investment yields i dollars of service per year. That is to say, without inflation, the resale value of land is unchanged from year to year, and the annual benefit (cost of capital services) is i times the original value of the land regardless of when liquidation occurs.

One-Time Startup Costs--

One-time startup costs, like capital costs, occur at the beginning of the project. However, these expenditures do not yield a flow of services or have a resale value, as do capital investments. Startup costs can, however, be recovered over time. Since the ideal contract length for the program being assessed here is 5 years, a 5-year period of equal annual payments in constant dollars is assumed. Therefore, the annual cost of each dollar of startup cost is:

$$\frac{0.06}{1-(1+0.06)^{-5}} = 0.2374$$

Annual Operating and Administrative Costs--

These costs are presented as annual figures. To obtain total annual cost in constant 1979 dollars, the operating and administrative costs are added directly to the annualized startup and capital costs.

Fee Calculation, f_c--

A break-even fee, reflecting constant 1979 dollars, is calculated by dividing the total annualized costs by the number of paid inspections per year. This fee is designed to recoup all of the costs presented in Table 34. The annualized costs are provided in Tables 35 and 36, for the high and low options, respectively.

TABLE 35. ANNUALIZED COSTS IN CONSTANT 1979 DOLLARS FOR A 38-BAY CENTRALIZED PARAMETER INSPECTION STATION FOR THE HIGH OPTION

	Cost category	Cost ($)	Amortization factor (i=0.06)	Annualized cost ($)
I.	Capital Costs			
	1. Land	535,000	0.06	32,100
	2. Buildings	780,000	0.087	67,860
	3. Equipment	1,031,000	0.2374	244,760
II.	Start-up Costs	221,700	0.2374	52,630
III.	Operating Costs	1,601,200	1.0	1,601,200
IV.	Administrative Costs	13,500	1.0	13,500
	Total Annualized Costs			2,012,050

TABLE 36. ANNUALIZED COSTS IN CONSTANT 1979 DOLLARS FOR A 20-BAY CENTRALIZED PARAMETER INSPECTION STATION FOR THE LOW OPTION

	Cost category	Cost ($)	Amortization factor (i=0.06)	Annualized cost ($)
I.	Capital Costs			
	1. Land	357,000	0.06	21,420
	2. Buildings	504,000	0.087	43,850
	3. Equipment	580,000	0.2374	137,690
II.	Start-up Costs	176,400	0.2379	42,336
III.	Operating Costs	921,000	1.0	921,000
IV.	Administrative Costs	16,900	1.0	16,900
	Total Annualized Costs			1,183,196

The actual inspection fee in constant 1979 dollars can be computed at this point by dividing the annualized cost shown in Tables 35 and 36 by the average number of vehicles inspected annually during the program life cycle (assumed to be from 1982 through 1987).

High Option--

Figures presented earlier indicated that the 1987 inspection demand would be approximately 34,000 vehicles for a single 38-bay facility; assuming that the average demand during the life cycle is 90 percent of the 1987 demand results in an estimated average annual demand of 30,600 vehicles. The breakeven fee, then, is computed to be approximately $65.60 per inspection.

Low Option--

As previously calculated, the 1987 inspection demand will be approximately 83,500 for a 20-bay facility. Assuming that the average demand during the life cycle would be approximately 90 percent of the 1987 demand, a 75,150 vehicle average demand would be expected. The breakeven fee, then, is computed to be approximately $15.75 per inspection.

COST SENSITIVITY ANALYSIS

One of the most crucial cost variables is the time required to perform the inspection. The more time efficient the inspection procedure, the larger the per-bay volume and thus the lower the per motorist cost. An analysis of the cost sensitivity was performed for several test time variations to determine the resultant effect on the inspection fee.

Decentralized Programs

The inspection fee for decentralized programs was previously defined as a function of the time required to perform the test plus an administrative fee to cover the annual administrative and adjunctive program costs. It was previously reported that a decentralized approach to the high option would cost, on average, about $80 per inspection. This fee was derived based on a $30/hour shop rate and 2.5 hours per inspection. If the high option was modified such that only 1.5 hours were required per test, the cost of an inspection would be reduced to about $47 per test. Say further modifications to the procedure enabled inspections to be performed in only 1 hour. This would reduce the inspection cost to about $32 per test.

Similar effects would occur on the inspection fee for the low option with test time reductions. A previous estimate of $16.50 was derived for the low option inspection fee, based on a test time of 30 minutes and a $1.50 administrative charge. Were it possible to conduct the inspection in 15 minutes, the cost to the motorist would be $9.00, again assuming a $1.50 administrative fee.

Centralized Programs

If the high option inspection time were reduced to 1.5 hours, a 38-bay facility annual throughput could increase to 57,000 inspections per year. Calculation of the change in inspection fees for the centralized programs is not quite as straightforward as for the decentralized options, as some of the administrative and startup costs were previously calculated based on the percent of the vehicle population covered at a single facility (1 percent for a 38-bay facility under the high option and 5 percent for a 20-bay facility under the low option). Using the same assumptions as before, a 38-bay facility inspecting 57,000 vehicles annually would be responsible for 1.6 percent of the total administrative related annual and startup costs. These changes are itemized in Table 37. Elements not reported in Table 37 are unchanged.

TABLE 37. COST CHANGES FOR A 38-BAY CENTRALIZED INSPECTION FACILITY ASSOCIATED WITH A 1-HOUR REDUCTION IN THE TEST TIME FOR THE HIGH OPTION

Cost category	Cost element	Previous cost ($)	New cost ($)
Startup Costs	Software	2,000	3,200
	Salaries	85,200	86,700
	Support Programs	6,000	10,000
Annual Administrative Costs	Salaries	4,000	6,400
	Mechanic's Training	1,000	1,600
	Public Information	5,000	8,000

The increases in cost were amortized in the same manner as done previously. The total annualized cost for this approach would be $2,016,150. The inspection fee can be calculated by dividing the total annualized cost by the average inspection demand (90 percent of the 1987 demand) or (57,000)(0.9) = 51,300. This translates to an inspection fee of approximately $40.00.

A similar analysis was performed for the low option, assuming a reduction in test time to 15 minutes. With these reduced time requirements, only 20 20-bay facilities would be needed. Each facility would be required to perform approximately 261,000 inspections per year by 1987. Each facility would then be responsible for 5 percent of the total administrative related startup and annual costs, as opposed to 3 percent in the original assessment. These changes are itemized in Table 38.

Again, the increases in cost were amortized in the same manner as done previously. The total annualized cost for the approach would be $1,218,000. The inspection fee can be calculated by dividing the total annualized cost by the average inspection demand (90 percent of the 1987 demand) or (167,000)(0.9) = 150,300. This translates to an inspection fee of approximately $8.10.

Additional related sensitivity analyses were performed for these options. The previous analyses were performed on the impact of time saving modifications to the inspection procedures. The following sensitivity analyses assume that the same time savings are achieved, except instead of modifications to the inspection procedures the savings are assumed due to increased automation achieved by doubling the equipment costs. The equipment maintenance costs will also increase proportionately.

TABLE 38. COST CHANGES FOR A 20-BAY CENTRALIZED INSPECTION FACILITY ASSOCIATED WITH A 15-MINUTE REDUCTION IN THE TEST TIME FOR THE LOW OPTION

Cost category	Cost element	Previous cost ($)	New cost ($)
Startup costs	Software	6,000	10,000
	Salaries	55,000	61,000
	Support Programs	30,000	30,000
Annual administrative costs	Salaries	12,000	20,000
	Mechanic's Training	2,400	5,000
	Public Information	12,500	25,000

For the high option, the cost changes are as follows:

Equipment $1,031,000 x 2 = $2,062,000

Maintenance 206,200 x 2 = $412,400

The equipment costs must be amortized as before. The total annualized cost would be $2,016,150 + $901,900 = $2,918,050. This translates to an inspection fee of approximately $56.90 for the high option.

For the low option, the cost changes would be:

Equipment $580,000 x 2 = $1,160,000

Maintenance $116,000 x 2 = $232,000

Again, amortizing the equipment costs as before, the total annualized cost would be: $1,296,800 + $507,400 = $1,804,200 this translates to an inspection fee of about $12.00.

A summary of all of the fees calculated is presented in Table 39.

From Table 39, it should be noted that in all instances, the centralized approaches are cheaper than comparable decentralized approaches. The centralized inspection fees, however, were calculated on a "breakeven" basis. That is, no contractor fee was added. A contractor would, of course, receive some return for its investment and risk. Generally, these fees are on the order of 10 to 15 percent, reducing considerably the differences in fees between these two approaches.

TABLE 39. SUMMARY OF INSPECTION FEE ESTIMATES

Assumptions used	Inspection fee ($)			
	Centralized		Decentralized	
	High option	Low option	High option	Low option
Base Case	$65.60	$15.75	$80.00	$16.50
Test time reduced to 1½ hours for high option, and to 15 minutes for low option.	40.00	8.10	47.00	9.00
Test time reduced to 1 hour for high option.	-	-	32.00	-
Test time reduced to 1½ hours for high option, and to 10 minutes for low option; all equipment costs doubled.	56.90	7.70	-	-

SECTION 8

RESPONDING TO FUTURE EMISSIONS CONTROL TECHNOLOGY

INTRODUCTION

Alternative I/M approaches must be considered in terms of being able to accommodate new technological developments in emissions control and, for that matter, in power plant design in general. Also, any program considered should be sufficiently flexible to accommodate testing of other pollutants such as NO_x. In this connection a review of the evolving emissions control technology and possible new requirements for pollutants considered and what these mean in terms of inspection and maintenance is in order.

IMPLICATIONS OF FUTURE TECHNOLOGY

In January 1979, EPA promulgated regulations that will require all light-duty cars and trucks manufactured subsequent to model-year 1980 to meet emissions standards ..."with their engines adjusted to any combination of settings within the physically adjustable ranges of their adjustable parameters..." For model-year 1981 vehicles, these requirements will apply to the air/fuel mixture and the choke parameters only; for model-years subsequent to 1981, these requirements will be extended to include idle speed and initial ignition timing, as well. As another example of future emissions control, vehicles manufactured beginning in model-year 1981 will be equipped with three-way catalysts as a primary method of controlling CO, HC and NO_x emissions. The use of these devices requires very precise control of the air/fuel ratio as a function of engine speed and output. This level of control will be achieved through the use of on-board microprocessors that will provide real-time control over the air/fuel ratio and possibly other parameters as well, such as idle speed, EGR flow rate, AIR system, ignition timing, and others.

The new technological approaches to emissions control will impose new requirements on all emissions inspections programs. It might be argued that a tailpipe measurement program will be less affected since the basic inspection procedure will not change, while a parameter inspection program will require new, individual inspection tasks and criteria. Such an argument ignores the fact that, while the inspection requirements may not change, the repair requirements do regardless of which type of I/M program is utilized. In essence, the burden of responding appropriately to new technological requirements may be placed more directly on the repair industry at large with tailpipe measurement approach since the program focus is primarily to assure compliance with established standards as determined by measuring exhaust pollutant concentrations, and notwithstanding the particular maintenance practices used to bring the vehicles into compliance. From a totally pragmatic point of view, the burden of maintaining up-to-date knowledge of repair requirements belongs entirely with the repair industry. Unfortunately, however, it has been demonstrated that the repair industry does not always respond adequately to this requirement (particularly with regard to maintaining current awareness of emissions control systems), therefore many I/M programs have established (or will establish) special mechanics training courses to prepare the repair industry for its rather critical role in the overall I/M effort. It can be concluded, then, that within the I/M program administration there must be concern for ensuring that the repair industry maintains a current awareness of emissions systems and emissions systems maintenance, regardless of whether the tailpipe measurement or parameter inspection approach to the program is utilized.

It is likely that there will be some differences between centralized parameter and decentralized parameter inspection programs in terms of the level of effort required from within the I/M program to ensure that inspectors and mechanics received adequate, periodic training. These differences are attributed to the requirement for many more inspectors for the decentralized program compared to the centralized program. It must be assumed that inspector training is a program function. The actual impact of this expanded training requirement will not add significantly to the cost of the I/M program.

New vehicles will be less susceptible to tampering and maladjustment since parameters such as air/fuel mixture and timing will be adjustable only within a very limited range. Further, the use of electronics in parameter control will also incorporate diagnostics capabilities to warn of system or component failures. It could be argued that these changes will result in vehicles that do not need I/M. In spite of these improvements, I/M will still be warranted since components are still subject to deterioration and wear, which means that periodic maintenance will be required.

CONTROL REQUIREMENTS FOR ADDITIONAL POLLUTANTS

Currently, the only pollutants of interest in I/M programs are CO and HC. There is a rather high probability that for certain regions NO_x emissions from automobiles will require the same type of control as CO and HC. In this connection, then, it is of interest to consider the ability of various I/M program types to accommodate NO_x testing or inspection.

The primary NO_x control system used on current generation vehicles is the EGR system. In terms of parameter inspection programs, the EGR system can be inspected fairly easily as described previously. For tailpile measurement programs, however, NO_x emissions must be measured when the vehicle is operating in various modes on a chassis dynamometer since the actual formation of these compounds occurs primarily during conditions of relatively high engine speed and load. As indicated previously, future control technology for NO_x will involve the use of reduction catalysts. The only method available for ensuring that these devices are functioning properly is to actually measure the exhaust concentrations, which, again, requires the use of a loaded-mode test. It has been suggested that a visual inspection of the exterior of a catalytic converter may provide an adequate indication of whether the device is functioning; this is based on the premise that a converter that has no signs of physical damage is likely to be functional. Given the rather precise control necessary of the air/fuel ratio to ensure proper functioning of the reduction catalyst, and the fact that poisoning of the catalytic bed can occur without any external indication of it having happened, it is more likely that the only reliable indication that either type of catalytic converter (oxidation or reduction) is functioning is to measure the exhaust CO, HC, and NO_x concentrations while the vehicle is operated on a dynamometer.

Another possibility that exists for future emissions control requirements concerns smoke and particulates from diesel-powered vehicles. Where there are currently no in-use standards for either smoke or particulates, it is conceivable that such standards could be promulgated, and that testing would be required as part of an I/M program. The basic tests include measuring opacity and particulate emissions in the exhaust stream while the vehicle is operating under a load (again, using a dynamometer). For these particular tests, there are no relevant parameter inspection procedures.

The central issue in the two possibilities for future test requirements discussed above is the requirement for a dynamometer; otherwise from either a technical or administrative standpoint both types of tests could quite easily be integrated into any of the parameter inspection program concepts under consideration here. Specifically, the requirement for loaded-mode emissions testing generally eliminates the decentralized inspection option from further consideration because it is very likely that small, independent garages could neither afford the cost of a dynamometer and still provide the inspection service for an acceptable cost, nor devote the shop space required for the dynamometer.

SECTION 9

SUMMARY

INTRODUCTION

The previous sections have considered several issues related to parameter inspection in a general sense, and with specific emphasis on the four programs defined in Section 1. Presented here is a summary of the key aspects of the four types of programs considered, and an indication as to how these aspects differ from those for a tailpipe inspection approach. Separate discussions are provided for each primary area considered, and for each program in its entirety.

In an overall sense, motor vehicle emissions inspection and maintenance (I/M) involves a process whereby motorists are required to have their vehicles undergo an annual inspection to ensure that the emissions performance of the vehicle is acceptable; acceptable implies that the emissions characteristics are within some range that is specified by an emission standard, which considers the vehicle model year, type and size of the engine, and other related factors. Two general I/M concepts are under consideration for implementation in the State of Michigan. These include parameter inspection, and tailpipe measurement.

The intent here is to consider four parameter inspection concepts from the standpoint of their relative effectiveness, advantages, and disadvantages.* Also, the relative advantages and disadvantages of selecting parameter inspection over the tailpipe measurement approach are considered. The parameter inspection concepts that are of interest at this point do not reflect specific program choices that may be considered for implementation in the State of Michigan; rather, they merely reflect concepts on which specific program definitions may be developed later.

OVERVIEW OF PROGRAM CONCEPTS CONSIDERED

The parameter inspection program concpets considered in this report include:

- Centralized, high option;
- Centralized, low option;

*The reader should refer to Reference 1 for a detailed review of tailpipe measurement programs, and a more complete discussion of the appplication of I/M in the State of Michigan.

- Decentralized, high option; and
- Decentralized, low option.

Obviously, the primary variables among programs are where the inspections are performed, and what items are considered. The choices regarding where inspections are performed were mentioned previously – existing private garages and repair facilities for the decentralized approach, and special network of inspection facilities where only inspection-related activity occurs. The components that require inspection under the high and low options are discussed in Section 2.

A complete definition of any I/M program also includes identifying the affected vehicle types, the geographic area coverage, stringency, repair cost limits, and provisions for waivers and exemptions. Of these, the specific vehicle types, geographic coverage, and provisions for exemptions or waivers are generally not affected by the type of inspection approach selected. Stringency refers to the expected number of vehicles that will require maintenance because of failing the inspection. In the case of parameter inspection, there will be no predetermined failure rate; rather, any vehicle that is found to have malfunctioning emissions-related components will require appropriate maintenance. Repair cost limits for parameter inspection programs may be specified separately for individual components subject to inspection. Further, repair rates for various common maintenance items, such as adjusting the air-to-fuel ratio, may be controlled to some degree.

Several support programs are required for I/M regardless of the particular inspection approach selected. These include public information, mechanics training, inspector training, quality assurance, and enforcement. These support programs are not particularly sensitive to the inspection approach in an overall sense, although the specific focus of any of these may be influenced greatly by the inspection type. This also applies to the administrative structure used for overall program control. The general composition of the administration structure depends more on the particular wishes and desires of those responsible for implementing and operating the program than on any overriding factor related to the inspection approach.

The four parameter inspection concepts can be compared with the tailpipe measurement approach in terms of general format. Like the parameter inspection concept, the tailpipe measurement approach can operate as a centralized or decentralized program using essentially a high or low option. The facility considerations are identical for the parameter and tailpipe measurement approaches. Generally, if the decentralized approach is used, the inspection stations are required to be certified or licensed by and responsible to the state agency administering the program. With regard to the inspection technique, the high option can be considered as the use of a loaded mode test, while the low option can be considered an idle test. In either case, however, the only inspection item is the exhaust emissions levels measured by an exhaust analyzer.

Whereas with the parameter inspection concept any combination of high or low option and test facility type is appropriate, the possibilities are somewhat limited for the tailpipe measurement approach. Essentially, the decentralized approach to tailpipe measurement must use an idle test rather than loaded mode owing to the rather expensive and space consuming equipment required to perform loaded mode testing.

As with parameter inspection, the vehicle types affected, geographic coverage, and exemptions and waivers all involve policy considerations and are not specifically influenced by the type of inspection used. Generally, tailpipe measurement programs establish emissions standards that reflect a point somewhere between the 70th and 90th percentile emissions rate for various categories of vehicles, so that the expected failure rate is between 10 and 30 percent.

Resource requirements describe the equipment, time, and expertise required to perform the inspections. For the parameter inspection approach these requirements vary only as a function of the inspection items included; large differences can be expected, therefore, in the requirements for the high and low options.

The high option requires a significant amount of time to perform. It is estimated that the time range is between 1-1/2 and 5 hours, with an average that is close to 2-1/2 hours. Although equipment requirements are not significant, essentially only common hand tools with a few speciality items are required, the level of expertise required is quite high. It is envisioned that only an experienced, highly trained mechanic or technician could properly perform many of the inspections and adjustments related to the carburetor. On the other hand, the low option requires a modest amount of time — estimated to be approximately 30 minutes — and only common tools and equipment. The level of expertise required is not nearly as demanding as that for the high option, yet it is assumed that the inspection would be performed by an experienced tune-up mechanic.

The tailpipe measurement approach requires an emissions analyzer as a minimum, which is a fairly expensive item. For centralized operations, the emissions analyzer must be designed to accomodate high throughput efficiently and accurately. Usually, this means adding the capability of interfacing with a computer for both data recording and standards determination. For the loaded mode inspection process, a chassis dynamometer is required, which is also expensive. Again, if the loaded mode is used, it is usually desirable to interface a data handling system as well as the emissions measurement function so that the entire operation becomes highly systematized. The level of expertise re-required to perform the inspections is not as high as that for either of the parameter inspection concepts. The inspection procedures are relatively straightforward, although there is generally a requirement for the inspector to be able to interpret the results for those vehicles that fail the test. Tailpipe measurement in centralized facilities using automated data handling systems requires approximately 2 to 5 minutes. For the decentralized approach, it can be expected that inspections will require approximately 10 to 15 minutes to perform.

Although it would appear that both approaches are actually based on achieving the same end — assuring that in-use vehicles are properly maintained in order to minimize emissions — arguments against each approach have been voiced by those apparently in favor of the opposite approach. Those favoring the tailpipe measurement approach generally consider parameter inspection as being akin to mandatory maintenance, which is politically undesirable. On the other hand, those favoring parameter inspection tend to disagree with the premise that a short emissions test can provide an acceptable indication of a vehicle's emissions characteristics during actual use.

To discuss the relative merits of various approaches to I/M, a number of questions regarding the potential effectiveness in reducing emissions, costs, and other impacts of each program type must be answered. Also, questions must be asked regarding whether the approaches under consideration are likely to meet special requirements that might exist, and whether adverse public, institutional, or political reactions might occur that would effectively block implementation.

RELATIVE EFFECTIVENESS IN REDUCING EMISSIONS

The underlying premise in the parameter inspection approach to I/M is that if all emissions-critical components and systems are functioning in accordance with manufacturer's specifications, then the optimum level of emissions control will be achieved. The high option represents an attempt to ensure that all possible systems and individual parameters are within specifications, regardless of the probability that they are out of adjustment or not functioning, and without concern as to the magnitude of the actual impact that each component has on emissions. Limited studies have indicated that there are a relatively few specific components that can be expected to require routine, periodic maintenance of the type that would be appropriate for an I/M program. Primarily, these components include the idle speed setting, the idle mixture, initial timing, and the EGR system. An extremely important objective in selecting parameters to be included in the program is to select those that are most likely to result in a direct emissions benefit, and at the same time, are appropriate in terms of the resources required to perform the inspection. That this objective is not achieved in the proposed high option is evident upon considering the time requirement and procedures that are used to perform some of the inspection tasks.

At present there are no specific data that provide a clear definition of the actual impact that a parameter inspection program would have on emissions. Based on the Restorative Maintenance (RM) study referred to in Section 3, it is possible to assume that a parameter inspection program designed around the low option concept would have a positive impact on emissions. Many questions remain, however, regarding the actual level of reduction that could be expected. The RM program was limited in scope to model-year 1975 and 1976 vehicles that had accrued fewer than 15,000 miles of use; a basic question at this point is whether the test results from this limited sample can be extrapolated to older vehicles, or to the same model-year vehicles after several additional years of use. A major requirement for any state contemplating the implementation of an alternative I/M program, such as parameter inspection, is to develop and substantiate estimates of emissions reductions achievable.

The effectiveness of any I/M program will be affected by the choice of the centralized or the decentralized approach. The primary difference in the two approaches is the level of control that can be exercised over both the inspection and maintenance phases. By their nature, decentralized programs involve many more inspectors and inspection facilities serving a wider range of interests compared to a centralized program. Quality control and surveillance are much more difficult with the decentralized approach, therefore, the potential reduction in emissions with this approach is likely to be lower than that of a centralized program. Issues concerning consumer skepticism and consumer protection are more crucial with a decentralized program, as well. In terms of reducing consumer costs and inconvenience, it would be highly desirable to incorporate some repairs into the inspection phase with parameter inspection programs. If the centralized approach is used, a serious problem may be encountered concerning whether or not the state (or whatever governmental entity is responsible for the program) or an agent of the state can, in fact, become involved directly in the repair of motor vehicles. It would appear that a contractor-operated inspection program would present fewer problems in terms of state involvement in a sector of private industry; this would be particularly true if there were more than just one or two contractors involved in the program.

The impact of tailpipe measurement programs on emissions from in-use vehicles has received, and is continuing to receive, substantial study by EPA. The basic conclusion that these programs are effective in reducing emissions has been documented. In essence, this implies that the various short tests, including the basic idle test, adequately reflects a vehicle's emissions characteristics in actual use. Whether or not the short test adequately portrays this ability is a point that has been debated between the auto industry and EPA. Data concerning the types of repairs most frequently required to bring vehicles into compliance with short test standards, and data from the RM study as well as the focus of the inspection items in the parameter inspection concept (low option) suggested by the manufacturers, indicate that the various opinions as to which approach is more effective may not be as diverse as they might appear to be on the surface.

An additional issue regarding the effectiveness concerns the ability for the programs to accomodate vehicles using future technology emissions control systems. Many of the control concepts for the future will involve electronic control of parameter settings, as well as advanced exhaust treatment concepts such as reduction catalysts in conjunction with strict parameter control. Based on current information, there does not appear to be a large difference between the abilities of a parameter inspection program and a tailpipe measurement program using the idle mode test to accomodate new technology vehicles. On the other hand, if control of NO_x emissions becomes a requirement, then both of these test types may prove to be inadequate. Currently, the primary NO_x control system is the EGR system, which can be inspected visually. Future control will require a reduction catalyst, the effectiveness of which cannot be determined visually. Further, NO_x emissions can only be characterized by a measurement procedure when the vehicle is operating in a loaded mode (e.g., accelerating, high cruise, etc.), therefore, the idle mode emissions measurement technique is not applicable. The only acceptable test for NO_x will likely be loaded mode tailpipe measurement.

Several conclusions can be presented at this point regarding the potential effectiveness of the parameter inspection concept in reducing emissions. First, the rationale for parameter inspections — that is, if all emissions-sensitive systems and parameters are properly adjusted and repaired, emissions will be minimized — is sound. In fact, this is essentially the same premise on which any I/M program is based. However, given the rather poor performance record of the repair industry, it is doubtful that a parameter inspection program would guaranty that all deficiencies would be identified and corrected. While the same argument applies to the tailpipe measurement approach, emissions testing does provide a reasonable indication of whether or not various emissions-sensitive systems, components, and parameters are functioning properly. Further, the parameter approach requires that all vehicles undergo a rigorous inspection without regard to the actual emissions performance. Numerous studies have indicated that relatively few (certainly less than 20 percent) vehicles are gross emitters, which are really the focus of I/M. The reasonableness of requiring all vehicles to be subjected to this relatively rigorous inspection must be considered carefully in terms of cost effectiveness. On the other hand, tailpipe measurement has been demonstrated to be a relatively simple and reasonably accurate method for identifying gross emitters, although errors of commission and omission do occur with this method (and with the parameter approach as well).

The second conclusion concerns the ability to adapt to new inspection requirements imposed by future emissions control technology. Generally, there will be differences between the ability of a parameter program and a tailpipe measurement program, but these will not be extremely significant. If NO_x testing is required in the future, neither parameter inspection or idle-mode emissions testing may be adequate since some form of loaded-mode emissions testing may be essential.

Third, regardless of which inspection approach is selected, the choice of using centralized or decentralized facilities may have a significant impact on the actual emissions reductions achieved. In general, it can be expected that quality control will be much more difficult with a decentralized program for several reasons, not the least of which is the much larger number of inspectors involved, and the fact that there may be significant motivation to either over inspect or under inspect, depending on the inspection fee rate structure. These factors can seriously jeopardize the effectiveness as well as the credibility of the program.

Finally, the last major conclusion regarding the effectiveness of the parameter inspection concepts considered here is that the high option does not reflect a viable approach to I/M owing primarily to both the excessive time required to perform the inspections and the lack of any evidence that many of the more time consuming inspection tasks would provide a measurable increase in the emissions benefits received.

PROGRAM COSTS

The relative costs of the four parameter inspection concepts vary directly with the intensity of the inspection process. The cost calculated for the four programs range from about \$16.00 for a low option inspection performed in a centralized facility, to approximately \$80.00 for a high option inspection performed at a private garage. Within this range is the low option decentralized inspection, estimated to cost about \$16.50, and the high option centralized inspection costing approximately \$65.00.

These costs can be compared directly with those associated with tailpipe inspection programs. Generally, tailpipe inspection programs have been shown to have break-even fees of approximately $5.00 to $8.00; for any given program, the cost of the loaded mode test is generally about the same as that for the idle mode.

The relative costs of I/M program alternatives must consider repair costs and costs for traveling and personel time associated with obtaining repairs and reinspections, in addition to the basic inspection cost. If the assumptions are made that (1) parameter inspection eliminates the need to travel elsewhere for repair, (2) repairs, adjustments, and parts replacement is significantly less costly if performed as part of the inspection process, and (3) the quality of diagnosis and repair if performed as part of the inspection is the same as that expected elsewhere, then the overall cost differential between tailpipe inspection and parameter inspection becomes much less significant. On the other hand, without the capability of consolidating the inspection and repair/adjustment routines, the parameter inspection approach may prove to be totally impractical from the cost standpoint.

OTHER RELATED IMPACTS

Consumer Issues

Many of the essential consumer protection elements that apply to tailpipe testing will apply to an I/M program involving parameter testing as well. The applicability, nature, and scope of some measures are dependent on the type of I/M program implemented. For example, although the concept of repair cost limits applies to both tailpipe and parameter inspection approaches, the specific provisions may vary depending on the test type selected. For parameter inspections, one related consumer protection measure would be the development of specific repair and adjustment procedures that would represent the maximum requirement, and provide motorists with a list of reasonable rates for typically required repairs.

Another important consumer protection consideration involves the applicability of the 207(b) warranty provisions under a parameter inspection approach to I/M. 207(b) establishes a close relationship between the I/M program and the warranty claim itself. Specifically, 207(b) requires as a prerequisite to a valid claim, that the vehicle must have failed an approved short test, which would set into motion a procedure bringing about a sanction or action, such as the withholding of vehicle registration.

Parameter inspections are not currently being considered in this regard. However, future inclusion has not been ruled out.

Assuming the parameter approach will gain approval, the applicability of 207(b) will still depend on the nature of the parameter inspection. If the inspection process is limited to misadjusted, improperly maintained, or tampered with components warranty claims would be severely limited. If the process is such that repair of any defective components uncovered while setting parameters is required, then 207(b) would apply (provided all other criteria were met).

Repair Industry Impacts

One other consumer protection measure that has serious impacts on the repair industry is the question of combining or separating the repair and inspection process. Combining parameter inspection with adjustment and repair could create a conflict of interest, particularly if additional charges are made for adjustments or repairs. This would, for all practical purposes, eliminate a centralized, contractor- or state-operated parameter inspection approach. If repairs and adjustments are included in the parameter inspection scenario, many motorists could actually substitute the inspections for annual minor tuneups. Therefore, a state-operated program could shift a lot of business from the private to the public sector. A contractor-operated program would likely be viewed by the industry as the state allowing a single entity to monopolize the minor tuneup business. To allow a single entity, either private or public, to control this entire market will not likely be viewed favorably by the private garage industry in Michigan.

Alternatively, separating parameter inspection and adjustment would involve considerable duplication of effort. These issues make a decentralized parameter inspection approach much more feasible. This introduces the problem of allocation of inspection and repair work. Allowing all stations to participate will ensure a more equal distribution of the additional workload. Additionally, a much more intensive quality assurance and consumer protection effort would be required. By limiting the participation in the program, the created workload will be disproportionately alloted to certain entities.

Demand for Trained Mechanics--

Any of the I/M options evaluated here will increase the demand for mechanics and mechanics training. The increased demand for mechanics may serve as a mechanism to drive up wage rates for those who are qualified. The extent of this supply/demand problem will depend on the ability of the industry to fill positions created by the increased demand, some lag is inevitable. Because of this, windfall profits may accrue to existing shops for some initial lag period, particularly in the case of a program that separates the inspection and repair components. The tight supply situation, if unchecked, could lead to more frequent overcharging until the increased demand is met with additional mechanics.

The subject content of mechanic training programs and certification tests should not vary considerably between a parameter inspection program and one that incorporates tailpipe testing. Under a parameter inspection approach, inspectors will essentially be trained as mechanics, whereas in a tailpipe approach, the inspectors only need to be proficient at measuring emission levels properly.

Quality Assurance--

One problem that is common to all parameter inspection approaches is that measuring program effectiveness will be extremely difficult if not altogether impossible. Without actually measuring emission levels, there will be no assurance that the I/M program is actually meeting its objective of reducing vehicular emissions. To ensure that the program is in fact bringing about a significant emission reduction, either a "before or after" emission measurement would have to be made on all vehicles, as in Nevada, or a random sample of vehicles would have to be checked.

Administrative Requirements

The administrative requirements, in terms of the specific tasks and responsibilities involved, will not vary significantly between an I/M program incorporating tailpipe testing and one involving parameter inspections. There are differences in the number of individuals required to perform specific tasks. The choice of a decentralized rather than a centralized program, for example, will necessitate more consumer protection/quality assurance investigators since the state will have far more inspection facilities to monitor. Selection of the high option parameter inspection instead of the low option will result in similar increases in the administrative staff. The overall administrative requirements are fairly constant regardless of whether a parameter inspection or tailpipe measurement approach is utilized.

Issues Requiring Special Consideration

Throughout the discussion it has been mentioned that the parameter inspection approach should include both inspection and repair or adjustment as part of the inspection process. An important issue in this connection is the legal implications of the state becoming involved in the repair of motor vehicles. This potential problem surfaces only with the centralized approach. The use of contractor-operated, centralized facilities may deminish the problem particularly if several different contractors are involved.

Another issue concerns the expected duration of the program. A basic question here concerns whether or not the program would continue if it were demonstrated that it wasn't required to maintain air quality objectives. If there is a possibility that the program would not be operated past, say, 1987, then this fact should be considered in selecting a particular option since a heavy capital expenditure for equipment and buildings may not be desirable for a relatively short-term program.

Ability to Satisfy Minimum EPA Policy

Consideration must be given to the ability of the program to meet various statutory requirements imposed by EPA. The primary requirements concern the minimum reduction in emissions achievable, and basic program elements used. Regarding the issue of minimum emissions reductions, EPA requires that exhaust emissions from light-duty vehicles be reduced by 25 percent by 1987, compared to what they would have been without I/M. The problem here is that there is currently no available method or data base that can be used to easily develop an estimate of the emissions reductions expected over time with a parameter inspection program. Further, EPA requires that the State proposing an alternative approach to tailpipe measurement (e.g., parameter inspection) demonstrate adequately that the required emissions reductions will be achieved. In this connection, if the State of Michigan proposes to adopt the parameter inspection approach, it may be faced with a rather significant task of developing and substantiating estimates of the programs effectiveness in reducing emissions.

A second issue that must be considered is the requirement (although one that must be considered tentative at this point) that all decentralized I/M programs include measurement of exhaust emissions. The parameter inspection routines considered here do not include such a provision, although it could be easily incorporated. The more critical issue concerns how the tailpipe measurement is to be used in the parameter inspection approach. It is not clear that there is any specific requirement that the measurements be used for anything more than emissions data collection (obviously, where NO_x is of concern, a tailpipe measurement procedure is required). Including emissions measurement, however, raises questions as to whether or not the measurements should provide a screening function to determine which vehicles actually require the parameter inspection. This means that the pass/fail criteria would be based on a short emissions test, which is perhaps not acceptable to those who favor the parameter inspection concept.

REFERENCES

1. Bhatia, V., et al. Pacific Environmental Services. Santa Monica, California. Evaluation of Motor Vehicle Emissions Inspection and Maintenance Programs for the State of Michigan. Volume II. Prepared for U.S. Environmental Protection Agency, Region V Office. Chicago, Illinois. EPA Report No. EPA-905/2-79-003b. October 1979.

2. Ibid.

3. Lucas, Albert G., and Robert L. VanCura. A Parameter Inspection and Adjustment Approach to Vehicle Emissions Inspection and Maintenance. General Motors Corporation. Environmental Activities Staff. June 1979.

4. Bernard, Jefferey C., and Jane F. Pratt. An Evaluation of Restorative Maintenance on Exhaust Emissions of 1975 Through 1976 Model Year In-Use Vehicles. Calspan Corporation, Buffalo, New York. Prepared for U.S. Environmental Protection Agency, Office of Mobile Source Air Pollution Control. Ann Arbor, Michigan. EPA-460/3-77-021. December 1977.

5. U.S. Environmental Protection Agency. Office of Air and Water Programs. Memorandum from David G. Hawkins. Inspection/Maintenance Policy. 17 July 1978.

6. 40 CFR 51.328. Appendix N. Emissions Reductions Achievable Through Inspection, Maintenance and Retrofit of Light-Duty Vehicles. Environment Reporter. Bureau of National Affairs, Inc. Washington, D.C. 24 August 1979. pp. 125:0143 through 125:0146.

7. User's Guide to MOBILE1: MOBILE SOURCE EMISSIONS MODEL. U.S. Environmental Protection Agency. Office of Air, Noise, and Radiation. Washington, D.C. 20460. August 1978.

8. Bhatia, V., et al., op. cit.

9. Rochester Products Division, General Motors Corporation. Rochester Carburetor Diagnosis, Adjustments, and 1978 Specifications. November 1977.

10. 1977 General Motors Emission Control Systems Maintenance Manual. Service Section, General Motors Corporation. Detroit, Michigan. 1977.

11. An Evaluation of Restorative Maintenance on Exhaust Emissions of 1975 Through 1976 Model Year In-Use Automobiles. U.S. Environmental Protection Agency. Office of Air and Waste Management. Mobile Source Air Pollution Control, Emission Control Technology Division. Ann Arbor, Michigan 48105. EPA-460/3-77-021. December 1977.

12. Austin, T.C., and G. Roberstein. A Comparison of Private Garage and Centralized I/M Programs. Society of Automotive Engineers. Paper No. 790785. August 1979.

13. Federal Register. Wednesday, August 9, 1979. Voluntary Aftermarket Part Self Certification Regulations; Proposed Rule EPA.

14. Feldman, David. U.S. EPA Attorney. Mobile Source Enforcement Division, Washington, D.C. Conversations August 21 and September 11, 1979.

15. Nash, R.W. Letter to GCA/Technology Division. Dated 17 September 1979. U.S. EPA, Ann Arbor.

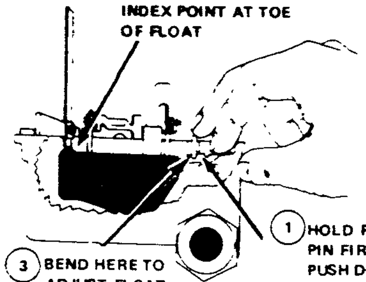
APPENDIX A

DIAGRAMS SHOWING VARIOUS CARBURETOR INSPECTION AND ADJUSTMENT PROCEDURES FOR THE HIGH OPTION

123

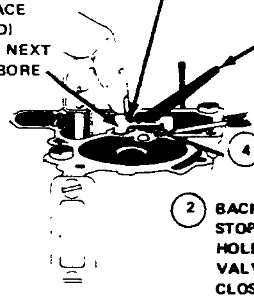
MODEL 1M & 1ME CARBURETOR ADJUSTMENTS

1



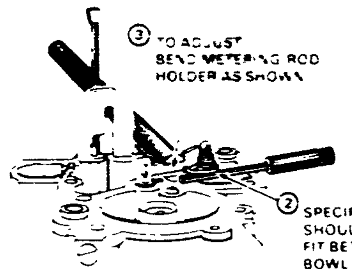
FLOAT LEVEL ADJUSTMENT – ALL

2



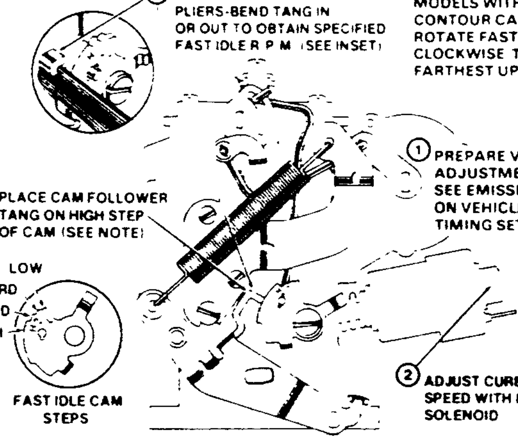
METERING ROD ADJUSTMENT – 6 CYL. – ALL

3



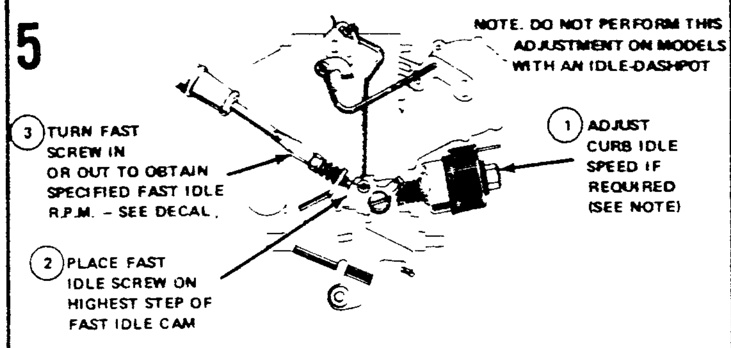
METERING ROD ADJUSTMENT - 4 CYL. - 1ME

4



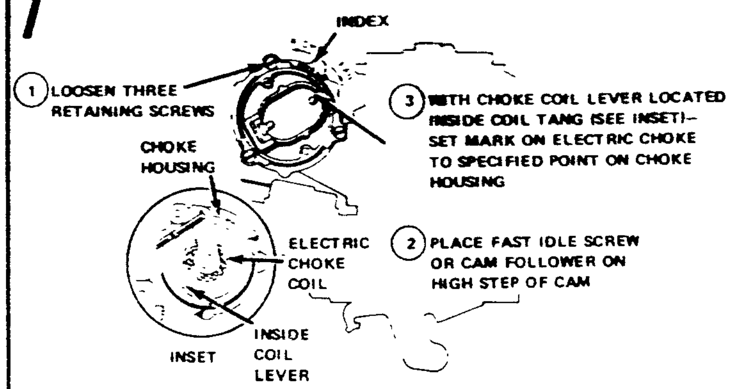
FAST IDLE ADJUSTMENT – 6 CYL. – ALL

5



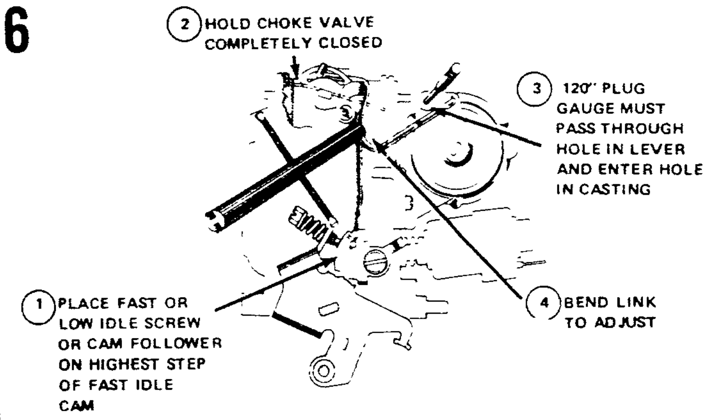
FAST IDLE ADJUSTMENT – 4 CYL. – 1 ME

7



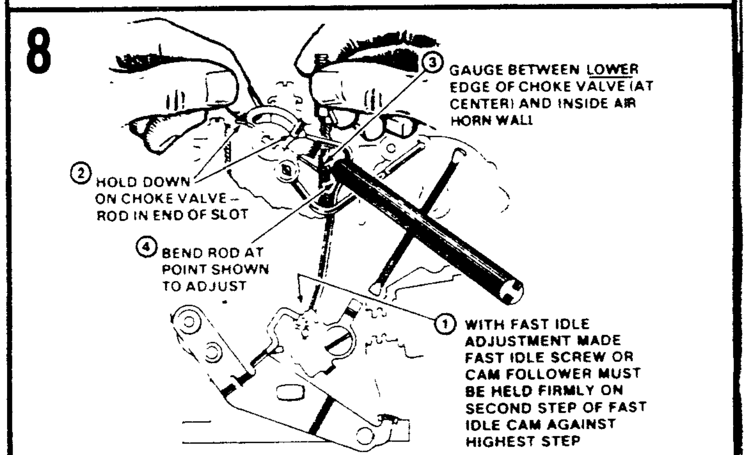
AUTOMATIC CHOKE ADJUSTMENT – 1 ME

6

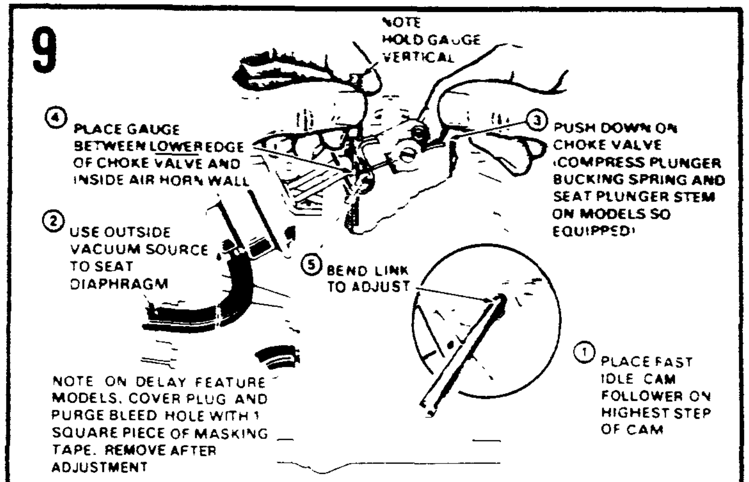


CHOKE COIL LEVER ADJUSTMENT 4 & 6 CYL. – 1 ME

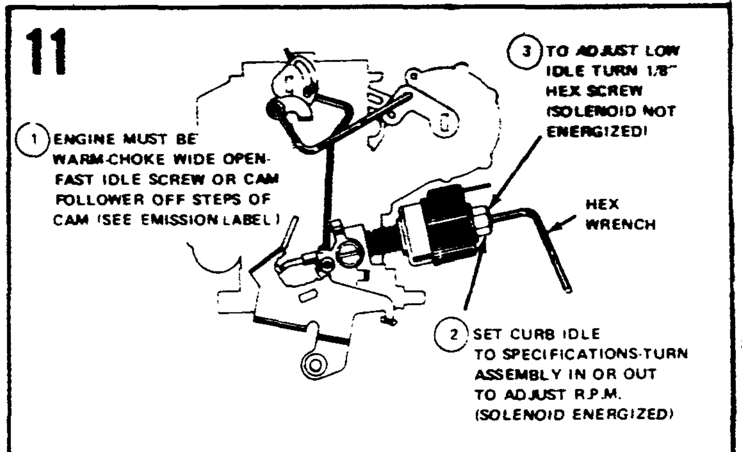
8



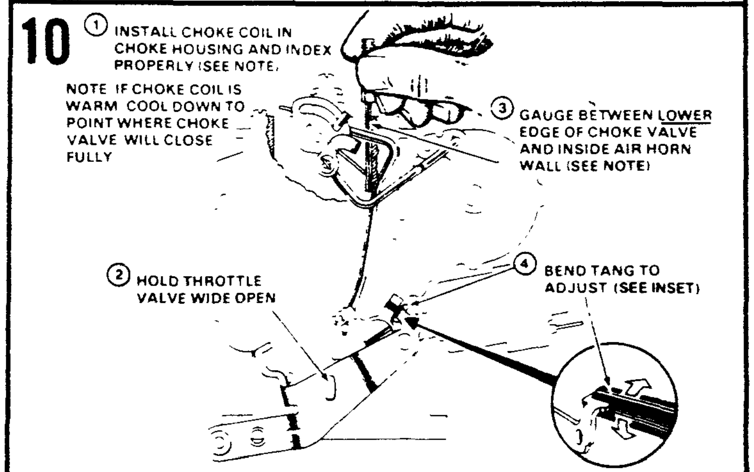
FAST IDLE CAM (CHOKE ROD) ADJUSTMENT



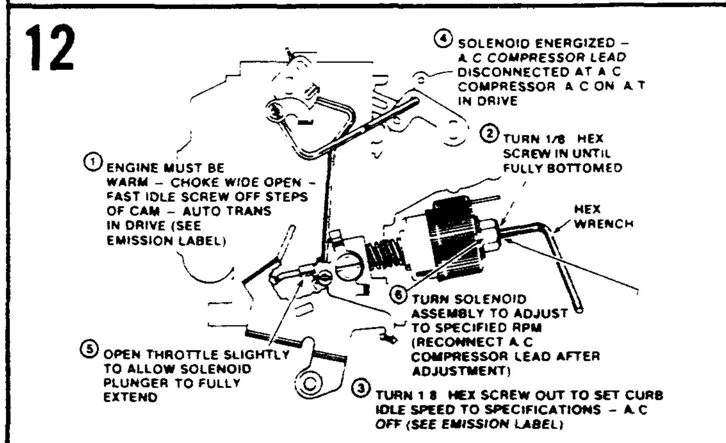
VACUUM BREAK ADJUSTMENT - 1ME (BOWL SIDE)



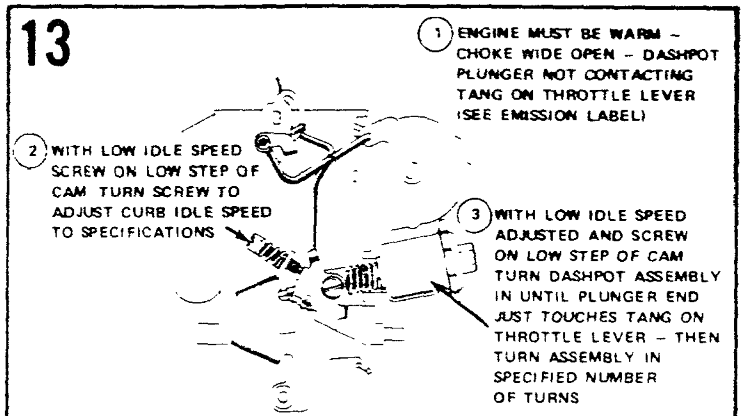
IDLE STOP SOLENOID ADJUSTMENT — ALL



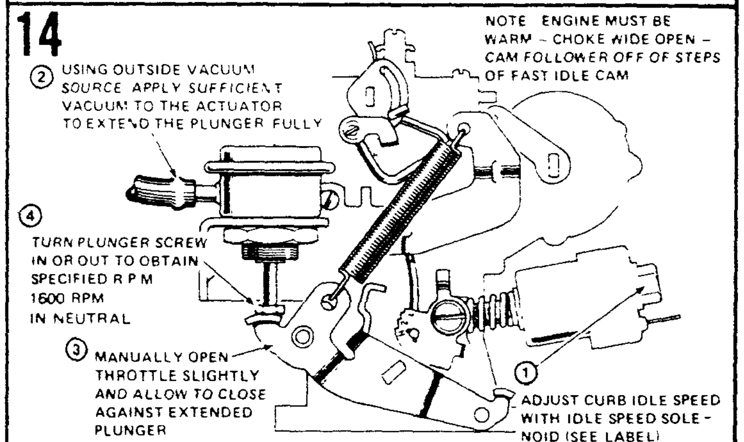
UNLOADER ADJUSTMENT - 1ME



IDLE SPEED ADJUSTMENT



IDLE-DASHPOT ADJUSTMENT – 4 CYL. M/T ALTITUDE & CALIF. (CHEVETTE)

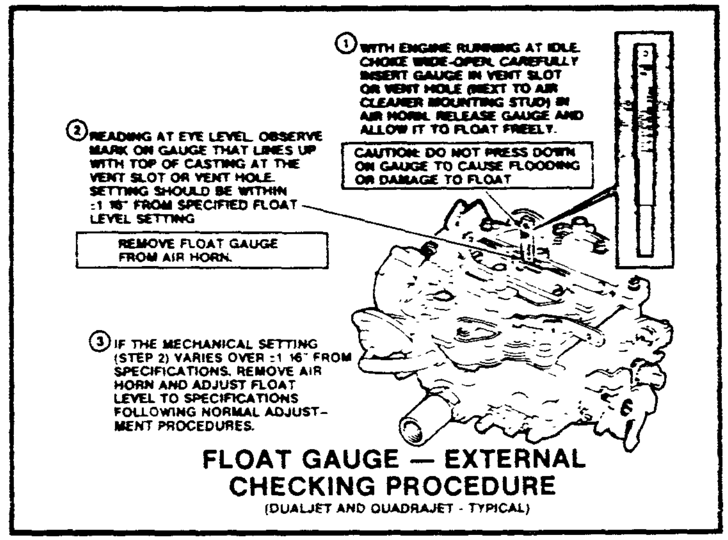


THROTTLE LEVER ACTUATOR ADJUSTMENT

FLOAT GAUGE - EXTERNAL CHECKING PROCEDURE

On 1978 and past model Dualjet and Quadrajet carburetors (except those using a screen over the vent slot in the air horn), it is now possible to externally check the float level using a new float gauge J-9789-130* or BT-7720** This gauge is designed for field use in quickly and accurately measuring externally the float level on Dualjet and Quadrajet carburetors to eliminate the need to remove the carburetor air horn to check float levels Using the gauge, the float level may be checked "on-the-car" with the engine running

*Currently available from Kent-Moore Tool Division
**Currently available from Burroughs Tool & Equipment Corp



FLOAT GAUGE — EXTERNAL CHECKING PROCEDURE
(DUALJET AND QUADRAJET - TYPICAL)

FLOAT GAUGE - EXTERNAL CHECKING PROCEDURE

1 With the engine running at idle, choke wide-open, carefully insert gauge in vent slot or vent hole (next to air cleaner mounting stud) in air horn. Release gauge and allow it to float freely.

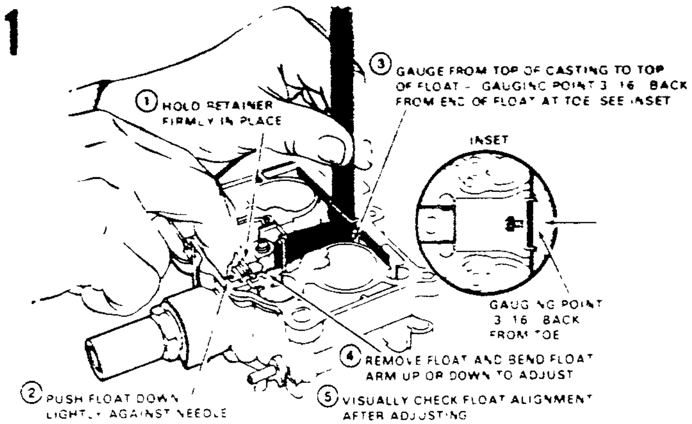
2 Reading at eye level, observe mark on gauge that lines up with top of casting at the vent slot or vent hole. Setting should be within ± 1/16" from specified float level setting

3 If the mechanical setting (Step 2) varies over ± 1/16" from specifications, remove air horn and adjust float level to specifications following normal adjustment procedures

CAUTION: *Do not press down on gauge to cause flooding or damage to float.*

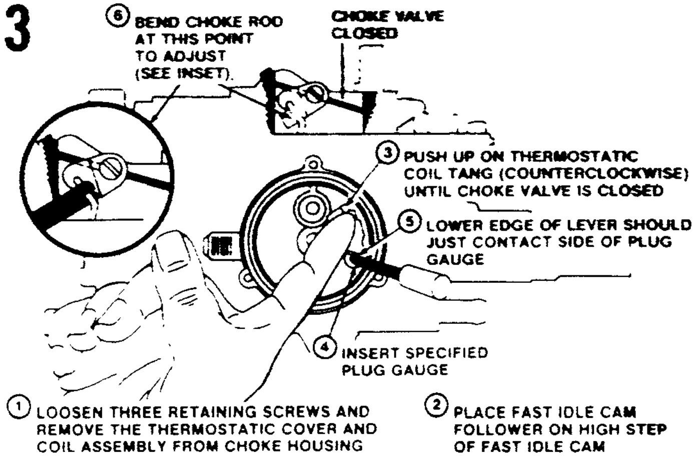
M2MC-M2ME DUALJET CARB. 210 ADJUSTMENTS

1



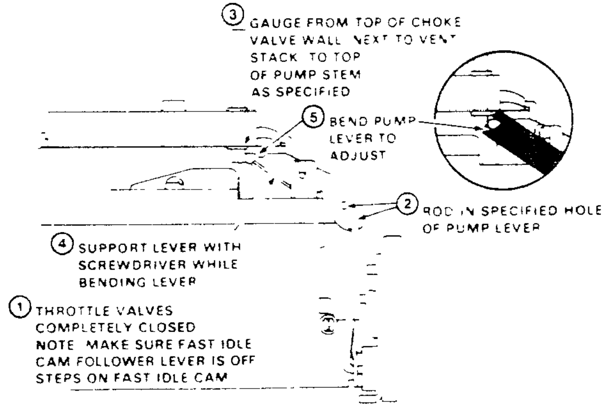
FLOAT ADJUSTMENT

3



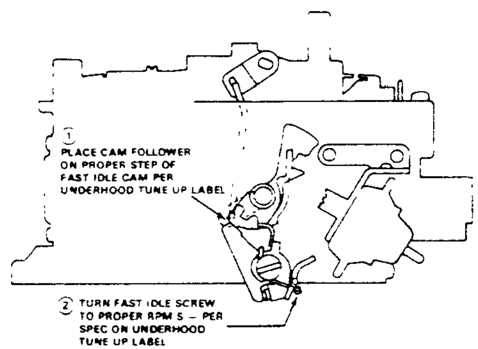
CHOKE COIL LEVER ADJUSTMENT

2



PUMP ADJUSTMENT

4



FAST IDLE ADJUSTMENT (ON CAR)

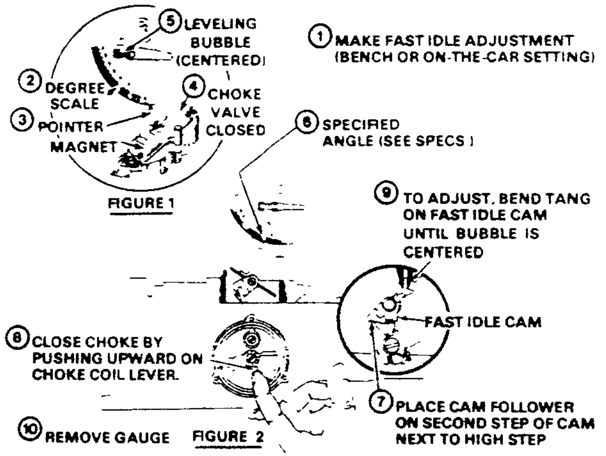
5

FIGURE 1

1. MAKE FAST IDLE ADJUSTMENT (BENCH OR ON-THE-CAR SETTING)
2. USE CHOKE VALVE MEASURING GAUGE J-26701 OR BT-7704. TOOL MAY BE USED WITH CARBURETOR ON OR OFF ENGINE. IF OFF ENGINE, PLACE CARBURETOR ON HOLDING FIXTURE SO THAT IT WILL REMAIN IN SAME POSITION WHEN GAUGE IS IN PLACE
3. ROTATE DEGREE SCALE UNTIL ZERO (0) IS OPPOSITE POINTER
4. WITH CHOKE VALVE COMPLETELY CLOSED, PLACE MAGNET SQUARELY ON TOP OF CHOKE VALVE
5. ROTATE BUBBLE UNTIL IT IS CENTERED

FIGURE 2

6. ROTATE SCALE SO THAT DEGREE SPECIFIED FOR ADJUSTMENT IS OPPOSITE POINTER
7. PLACE CAM FOLLOWER ON SECOND STEP OF CAM NEXT TO HIGH STEP
8. CLOSE CHOKE BY PUSHING UPWARD ON CHOKE COIL LEVER
9. TO ADJUST BEND TANG ON FAST IDLE CAM UNTIL BUBBLE IS CENTERED
10. REMOVE GAUGE



CHOKE ROD (FAST IDLE CAM) ADJUSTMENT - ANGLE GAUGE METHOD

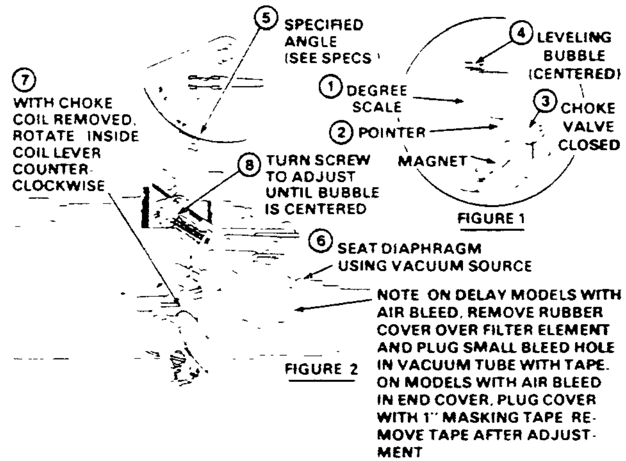
6

FIGURE 1

1. USE CHOKE VALVE MEASURING GAUGE J-26701 OR BT-7704. TOOL MAY BE USED WITH CARBURETOR ON OR OFF ENGINE. IF OFF ENGINE, PLACE CARBURETOR ON HOLDING FIXTURE SO THAT IT WILL REMAIN IN SAME POSITION WHEN GAUGE IS IN PLACE.
2. ROTATE DEGREE SCALE UNTIL ZERO (0) IS OPPOSITE POINTER
3. WITH CHOKE VALVE COMPLETELY CLOSED PLACE MAGNET SQUARELY ON TOP OF CHOKE VALVE
4. ROTATE BUBBLE UNTIL IT IS CENTERED

FIGURE 2

5. ROTATE SCALE SO THAT DEGREE SPECIFIED FOR ADJUSTMENT IS OPPOSITE POINTER
6. SEAT CHOKE VACUUM DIAPHRAGM USING VACUUM SOURCE
7. HOLD CHOKE VALVE TOWARDS CLOSED POSITION, PUSHING COUNTER-CLOCKWISE ON INSIDE COIL LEVER
8. TO ADJUST, TURN SCREW IN OR OUT UNTIL BUBBLE IS CENTERED
9. REMOVE GAUGE



FRONT VACUUM BREAK ADJUSTMENT - ANGLE GAUGE METHOD

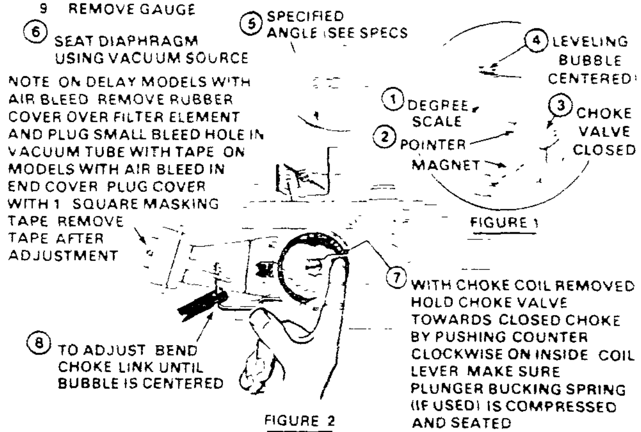
7

FIGURE 1

1. USE CHOKE VALVE MEASURING GAUGE J-26701 OR BT 7704. TOOL MAY BE USED WITH CARBURETOR ON OR OFF ENGINE. IF OFF ENGINE PLACE CARBURETOR ON HOLDING FIXTURE SO THAT IT WILL REMAIN IN SAME POSITION WHEN GAUGE IS IN PLACE
2. ROTATE DEGREE SCALE UNTIL ZERO (0) IS OPPOSITE POINTER
3. WITH CHOKE VALVE COMPLETELY CLOSED, PLACE MAGNET SQUARELY ON TOP OF CHOKE VALVE
4. ROTATE BUBBLE UNTIL IT IS CENTERED

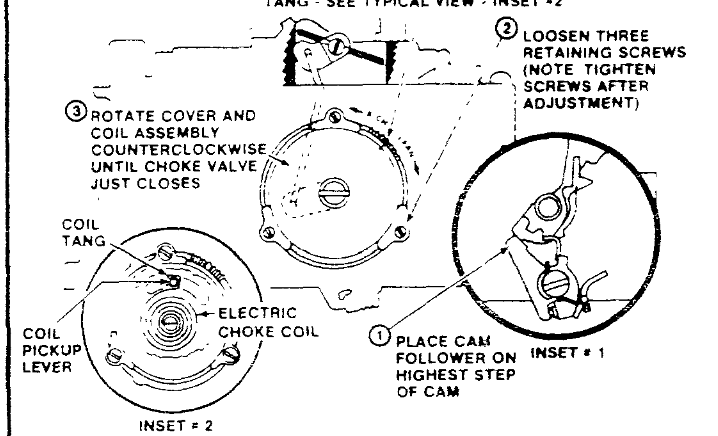
FIGURE 2

5. ROTATE SCALE SO THAT DEGREE SPECIFIED FOR ADJUSTMENT IS OPPOSITE POINTER
6. SEAT CHOKE VACUUM DIAPHRAGM USING VACUUM SOURCE
7. HOLD CHOKE VALVE TOWARDS CLOSED POSITION. PUSHING COUNTER CLOCKWISE ON INSIDE COIL LEVER
8. TO ADJUST, BEND LINK UNTIL BUBBLE IS CENTERED
9. REMOVE GAUGE



REAR VACUUM BREAK ADJUSTMENT - ANGLE GAUGE METHOD

8



AUTOMATIC CHOKE COIL ADJUSTMENT - (M2MC-M2ME)

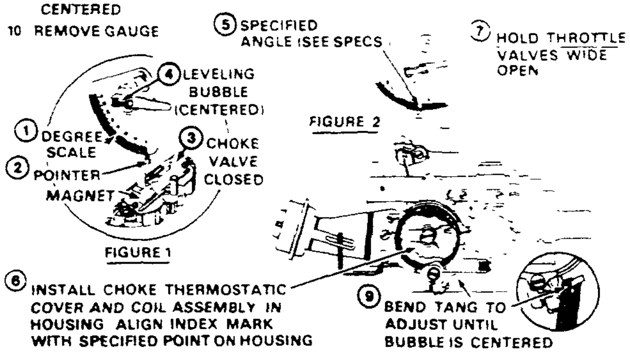
9

FIGURE 1

1. USE CHOKE VALVE MEASURING GAUGE J-26701 OR BT-7704. TOOL MAY BE USED WITH CARBURETOR ON OR OFF ENGINE. IF OFF ENGINE, PLACE CARBURETOR ON HOLDING FIXTURE SO THAT IT WILL REMAIN IN SAME POSITION WHEN GAUGE IS IN PLACE.
2. ROTATE DEGREE SCALE UNTIL ZERO (0) IS OPPOSITE POINTER.
3. WITH CHOKE VALVE COMPLETELY CLOSED, PLACE MAGNET SQUARELY ON TOP OF CHOKE VALVE.
4. ROTATE BUBBLE UNTIL IT IS CENTERED.

FIGURE 2

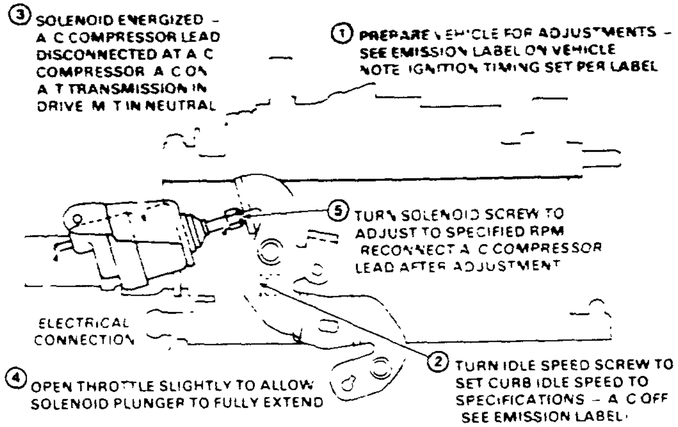
5. ROTATE SCALE SO THAT DEGREE SPECIFIED FOR ADJUSTMENT IS OPPOSITE POINTER.
6. INSTALL CHOKE THERMOSTATIC COVER AND COIL ASSEMBLY IN HOUSING. ALIGN INDEX MARK WITH SPECIFIED POINT ON HOUSING.
7. HOLD THROTTLE VALVES WIDE OPEN.
8. ON WARM ENGINE, CLOSE CHOKE VALVE BY PUSHING UP ON TANG ON VACUUM BREAK LEVER (HOLD IN POSITION WITH RUBBER BAND).
9. TO ADJUST, BEND TANG ON FAST IDLE LEVER UNTIL BUBBLE IS CENTERED.
10. REMOVE GAUGE.



⑧ ON WARM ENGINE, CLOSE CHOKE VALVE BY PUSHING UP ON TANG ON VACUUM BREAK LEVER (HOLD IN POSITION WITH RUBBER BAND)

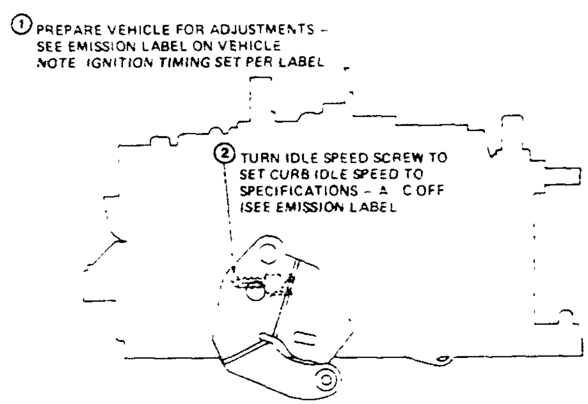
UNLOADER ADJUSTMENT - ANGLE GAUGE METHOD (TYPICAL)

10



A/C IDLE SPEED ADJUSTMENT (ON CAR)

11

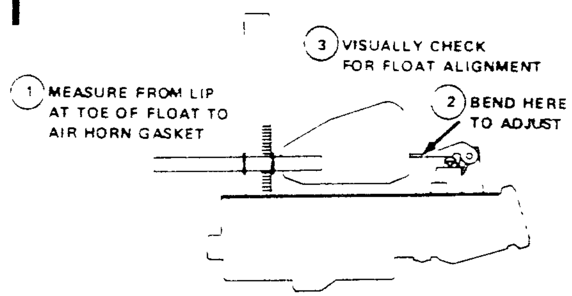


IDLE SPEED ADJUSTMENT

MODEL 2GC, 2GE CARB.

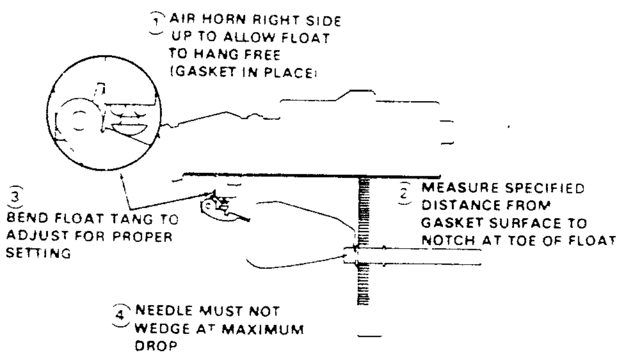
ADJUSTMENTS

1



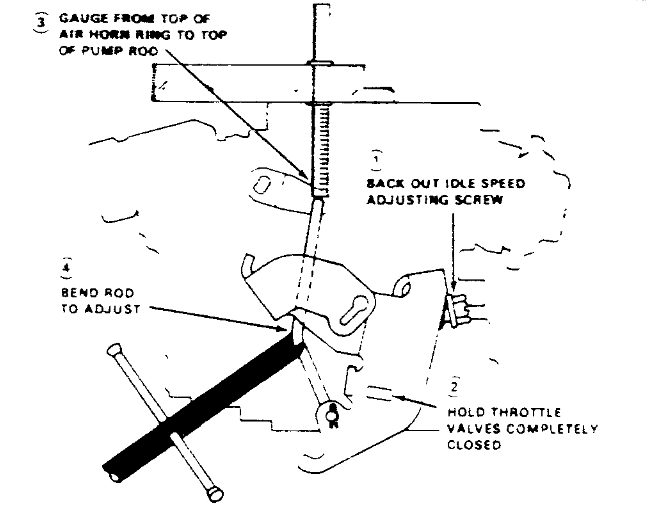
FLOAT LEVEL ADJUSTMENT

2



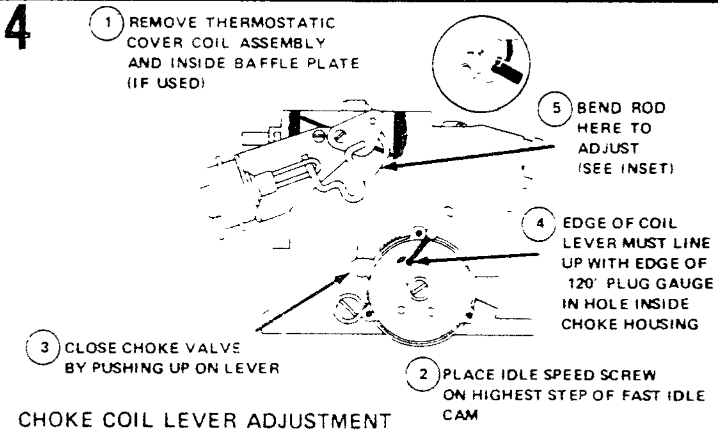
FLOAT DROP ADJUSTMENT

3



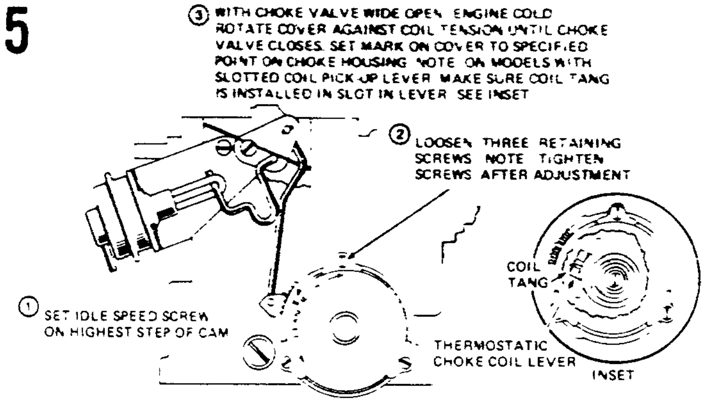
PUMP ROD ADJUSTMENT

4



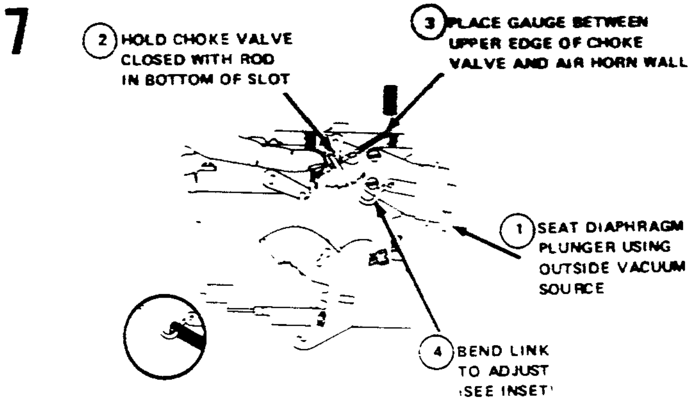
CHOKE COIL LEVER ADJUSTMENT

5



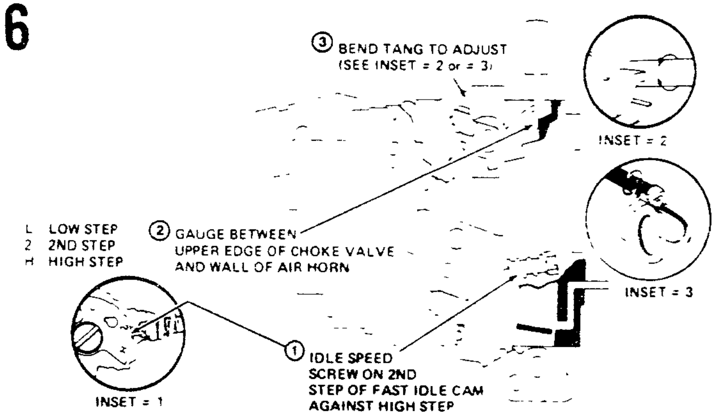
AUTOMATIC CHOKE COIL ADJUSTMENT

7



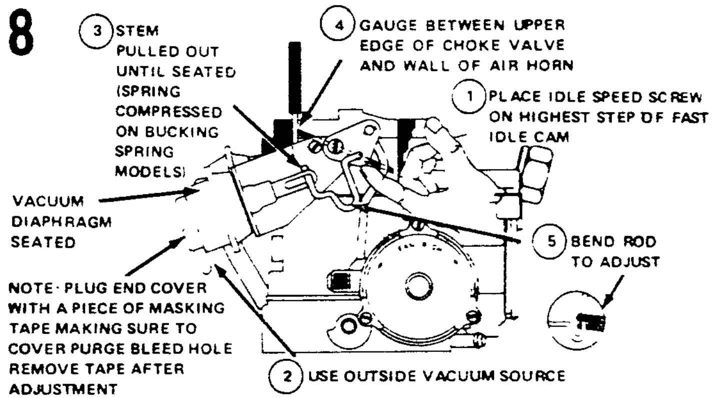
VACUUM BREAK ADJUSTMENT (THROTTLE LEVER SIDE)

6



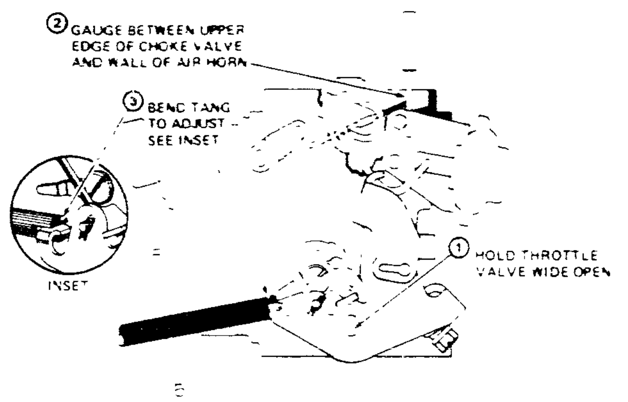
CHOKE ROD (FAST IDLE CAM) ADJUSTMENT

8



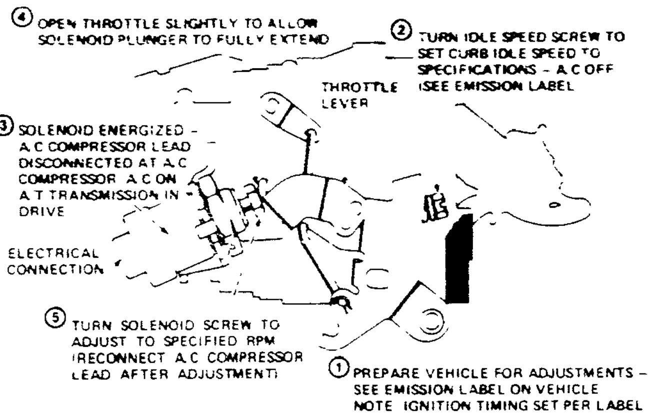
VACUUM BREAK ADJUSTMENT (CHOKE SIDE)

9



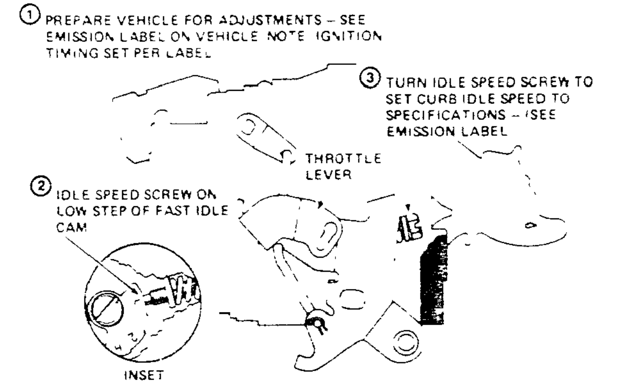
CHOKE UNLOADER ADJUSTMENT

11



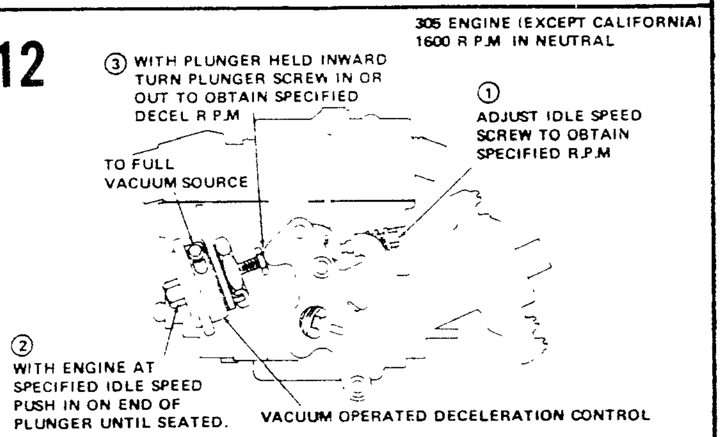
A/C IDLE SPEED ADJUSTMENT

10



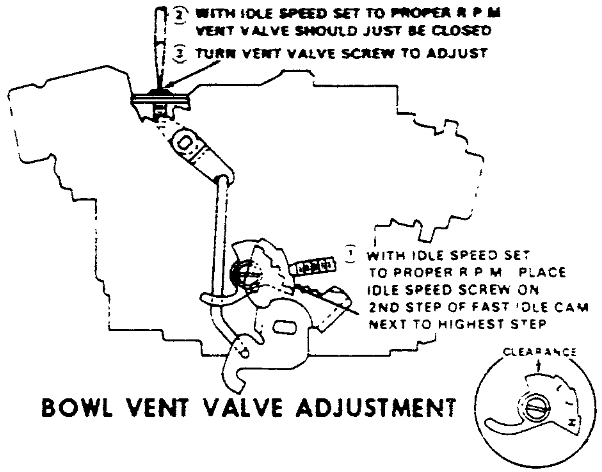
IDLE SPEED ADJUSTMENT

12



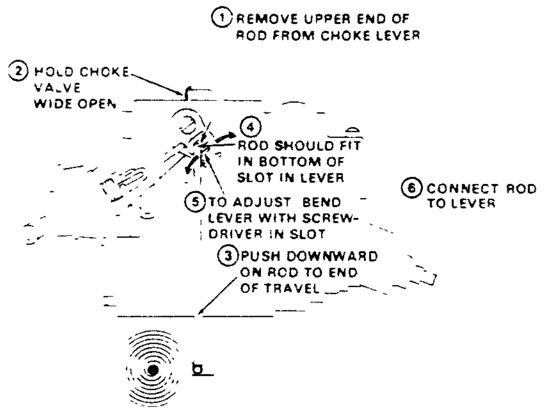
THROTTLE LEVER ACTUATOR ADJUSTMENT

13



BOWL VENT VALVE ADJUSTMENT

14



CHOKE COIL ROD ADJUSTMENT

GLOSSARY

accuracy: The degree by which an instrument is able to determine the true concentration of a pollutant in the exhaust gas sampled.

air contaminants: Any fumes, smoke, particulate matter, vapor gas, or any combination, but excluding water vapor or stream condensate.

air-fuel ratio: The expression of the proportional mixture of air and gasoline created by the carburetor. Usually expressed as a numerical relationship such as 14:1, 13:1, etc.

ambient air: The surrounding or outside air.

calibration gases: A blend of HC and CO gases using nitrogen as a carrier gas.

carbon monoxide: A nonirritating, colorless, odorless gas at standard conditions which has the molecular form of CO.

catalytic emission control system: Device to reduce automobile emissions by converting CO and HC emissions to harmless carbon dioxide and water.

certificate of compliance: A document which is issued upon completion of the inspection which records the results of the inspection and serves as proof of said inspection for vehicle owner.

certified mechanic: An individual licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.

certified station: A private facility licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.

chassis dynamometer: A machine equipped with two parallel rollers which support the rear wheels of a motor vehicle. When positioned on the dynamometer the vehicle may be "driven" to simulate the loadings the engine would experience when the vehicle is operated on the road. A power absorption unit is connected to the rollers to simulate the loading from the various sources of fluid and mechanical friction present during road operation. Weights can also be coupled to the rollers to simulate the inertial effects of vehicle mass during acceleration and deceileration.

Crankcase emissions: The products of combustion emitted into the ambient air from portions of the engine crankcase ventilation or lubrication system.

degradation: The decreased effect of I/M on emission reduction due to normal wear of engine system.

deterioration: A synonym for degradation indicating an increase in emission levels due to wear.

drift: The amount of meter reading change over a period of time. Zero drift refers to change of zero reading. Span drift refers to a change in reading of a calibration point on the upper half of the scale. The calibration point is established by reading a calibration gas of known concentration.

emission inspection program: An inspection and maintenance program in which each vehicle is subjected at specified intervals to a test of its emissions under specified conditions. The emission levels are compared with a standard established for the vehicle class. If the emissions are higher than the standard, the vehicle is failed and must be adjusted or repaired to bring its emissions into compliance with the standards.

exhaust gas analyzer: An instrument for sensing the amount of air contaminants in the exhaust emissions of a motor vehicle.

exhaust emissions: The products of combustion emitted into the ambient air from any opening downstream of the exhaust ports of a motor vehicle engine.

fleet owner authorized stations: A permit issued to a qualified fleet owner to perform vehicle emissions inspection limited to his fleet only.

fleet operator: The owner of a fleet of a designated number of vehicles.

hang-up: HC which clings to the surface of the sampling and analyzer system in contact with the gas sample stream which causes an erroneous indication of HC in the measured value.

heavy-duty vehicle: Any motor vehicle designed for highway use which has a gross vehicle weight of more than 8,500 pounds.

hydrocarbons: A compound whose molecular composition consists of atoms of hydrogen and carbon only.

idle test: An emission inspection program which measures the exhaust emission from a motor vehicle operating at idle. (No motion of the rear wheels.) A vehicle with an automatic transmission may be in drive gear with brakes applied or in neutral gear.

independent contractor: Any person, business firm, partnership or corporation with whom the state may enter into an agreement providing for the construction, equipment, maintenance, personnel, management and operation of official inspection stations.

inspection and maintenance program: A program to reduce emissions from in-use vehicles through identifying vehicles that need emissions control related maintenance and requiring that maintenance be performed.

inspection station: A centralized facility for inspecting motor vehicles and pollution control devices for compliance with applicable regulations.

inspector: An individual who inspects motor vehicles and pollution control devices for compliance with applicable regulations.

instrument: The system which samples and determines the concentration of the pollutant gas.

key mode test: A loaded mode test in which exhaust emissions are measured at high and low cruise speeds and at idle. The cruise speeds and dynamometer power absorption settings vary with the weight class of the vehicle. The dynamometer loading in the high cruise range is higher than normal load in order to more effectively expose malfunctions leading to high emissions.

light-duty vehicle: A motor vehicle designed for highway use of less than 8,501 pounds gross vehicle weight. Further distinctions are sometimes mad made between light-duty automobiles and light-duty trucks such as pickup trucks.

loaded mode test: An emission inspection program which measures the exhaust emissions from a motor vehicle operating under simulated road load on a chassis dynamometer.

model year of vehicle: The production period of new vehicle or new vehicle engines designated by the calendar year in which such period ends.

motorcycle: A motor vehicle having a seat or saddle for use of the rider and designed to travel on not more than three wheels in contact with the ground, but excluding a tractor.

motor vehicle: Any self-propelled vehicle which is designed primarily for travel on public right of ways and which is used to transport persons and property.

positive crankcase ventilation: A system designed to return blowby gases from the crankcase of the engine to the intake manifold so that the gases are burned in the engine. Blowby gas is unburned fuel/air mixture which leaks past the piston rings into the crankcase during the compression and ignition cycles of the engine. Without positive crankcase ventilation these gases, which are rich in hydrocarbons, escape to the atmosphere.

prescribed inspection procedure: Approved procedure for identifying vehicles that need emissions control related maintenance.

registered owner: An individual, firm, corporation or association whose name appears in the files of the motor vehicle registration division of the department of motor vehicles as the person to whom the vehicle is registered.

repeatability: The instrument's capability to provide the same value for successive measures of the same sample.

response time: The period of time required by an instrument to provide meaningful results after a step change in gas concentration level initiated at the tailpipe sample probe.

smoke: small gasborne and airborne particles, exclusive of water vapor, arising from a process of combustion in sufficient number to be observable.

stringency factor: The percentage of total vehicles tested in an inspection/maintenance program in a given time period that fail inspection and are required to have maintenance performed.

tampering: The illegal alteration, modification, or disconnection of emission control device or adjustments or manufacturer tuning specifications on motor vehicles for the purpose of controlling vehicle emissions.

vehicle dealer: An individual, firm, corporation or association who is licensed to sell motor vehicles.

vehicle emissions standard: A specific emission limit allowed for a class of vehicles. The standard is normally expressed in terms of maximum allowable concentrations of pollutants (e.g., parts per million). However, a standard could also be expressed in terms of mass emissions per unit of time or distance traveled (e.g., grams per mile).

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-905/2-79-005	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Comparison of Parameter and Exhaust Testing Approaches for a Vehicle Emissions Inspection and Maintenance Program in Michigan		5. REPORT DATE December 1979
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Midurski, Theodore P., and Sellars, Frederick		8. PERFORMING ORGANIZATION REPORT NO. GCA-TR-79-70-G
9. PERFORMING ORGANIZATION NAME AND ADDRESS GCA Corporation, GCA/Technology Division, Burlington Road, Bedford, Massachusetts 01730		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-02-2887, WO# 7
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency, Region V Office, Chicago, Illinois		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Michigan Department of State Highways and Transportation is in the process of developing a motor vehicle emissions inspection and maintenance (I/M) program for implementation in various nonattainment areas of the State. To date, the effort has focused on identifying and assessing the various program alternatives available that satisfy the objectives of I/M. A primary issue at this point concerns whether the program should use the emissions measurement concept, or a concept involving parameter inspection.

Assessments of the specific requirements related to implementing I/M in Michigan, including a first level assessment of alternative program approaches, have been developed as part of this initial planning. Based on these initial assessments, the need for a more detailed assessment of the parameter inspection concept was identified.

These detailed analyses of issues related to the parameter inspection concept were performed by GCA/Technology Division, under a contract with the U.S. Environmental Protection Agency. These analyses considered the emissions reduction potential, costs, consumer and repair industry impacts, and administration requirements of four parameter inspection concepts. The results of these analyses are reported here.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Automobile engines Exhaust detection Exhaust emissions	Automobile emissions Inspection and maintenance Mobile source emissions control	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 152
	20. SECURITY CLASS *(This page)*	22. PRICE

EPA Form 2220-1 (9-73)