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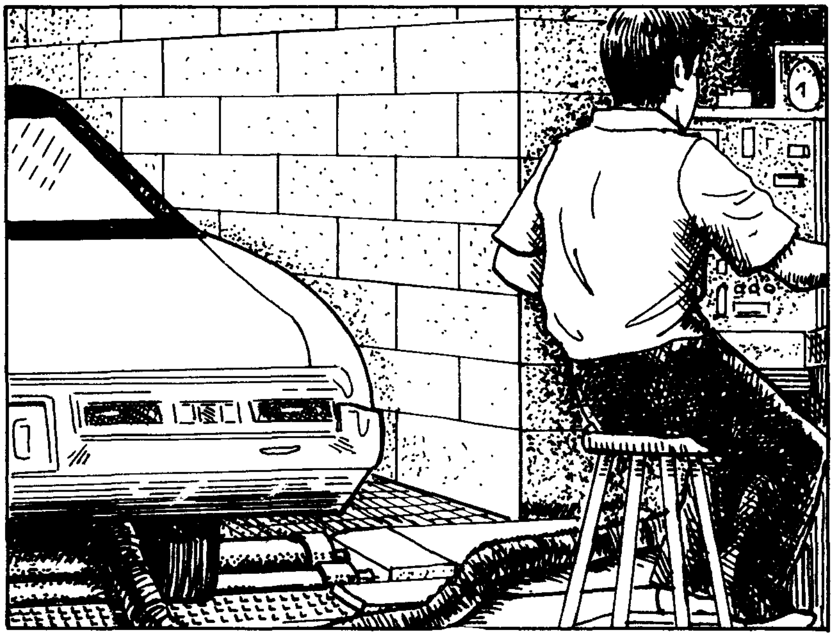
INSPECTION AND MAINTENANCE OF LIGHT-DUTY, GASOLINE-POWERED MOTOR VEHICLES: A GUIDE FOR IMPLEMENTATION



U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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by
Transportation and Land Use Planning Branch
Strategies and Air Standards Division

ENVIRONMENTAL PROTECTION AGENCY
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ABSTRACT

This document is intended to provide guidance to Federal, State, and local agencies concerned with implementing and monitoring an emissions inspection and maintenance program for motor vehicles. The guide provides a discussion of major inspection and maintenance methods, legal considerations, implementation factors, monitoring and reporting requirements, and Federal and State programs in the field.

INSPECTION AND MAINTENANCE OF LIGHT-DUTY, GASOLINE-POWERED MOTOR VEHICLES: A GUIDE FOR IMPLEMENTATION

1. INTRODUCTION

This document is intended to provide guidance to Federal, State, and local agencies concerned with implementating and monitoring an inspection and maintenance program for motor vehicles. Before beginning discussion of the various aspects of an inspection and maintenance program, however, a brief review of the evolution of the fight against air pollution, with emphasis on motor vehicle pollution abatement, might be in order.

LEGISLATIVE REVIEW

The U. S. Congress first responded to growing public concern over declining air quality in 1955 through legislation authorizing a Federal program of air pollution research and technical assistance to State and local governments (PL 84-159). This legislation established a policy, retained in all subsequent legislation, of giving State and local governments the fundamental responsibility for local air pollution control with the Federal government providing leadership and support.

The first Congressional efforts to bring vehicle emissions under control were initiated in 1961 with Public Law 86-493. This legislation authorized the Public Health Service to conduct a study of pollution caused by vehicles and to report the results to Congress. An amendment to this law (PL 87-761) authorized vehicle studies on a continuing basis. As a result of this legislation, significant progress was made toward achieving an understanding of the vehicle-related air pollution problem and developing methods for control. By 1963, however, it became apparent that the progress in scientific understanding was not being translated into improved air quality, primarily because State and local governments had neither the resources nor the authority to adequately cope with the problem.

Results of early studies authorized by Congress indicated that motor vehicles were contributing significantly to overall air pollution levels. Consequently, Congress passed an amendment to the Clean Air Act in 1965 authorizing the Department of Health, Education, and Welfare to set emission standards for motor vehicles. Initial standards pertaining to crankcase and tailpipe emissions from gasoline-powered motor vehicles became effective in the 1968 model year. The most recent Federal legislation, the Clean Air Amendments of 1970, established more stringent new motor vehicle emission standards to be effective in the 1975 model year for carbon monoxide and hydrocarbons and in the 1976 model year for oxides of nitrogen. Required compliance with these emission standards has been delayed until 1976 for carbon monoxide and hydrocarbons and until 1977 for oxides of nitrogen. Although the establishment of these new motor vehicle emission standards are a Federal responsibility, the States are responsible for controlling, regulating, or restricting the use, operation, or movement of registered or licensed motor vehicles. Consistent with this policy, the 1970 Amendments directly affect State and local transportation systems by requiring State implementation plans to include land use restrictions and transportation control where necessary.

AIR QUALITY CRITERIA, AIR QUALITY STANDARDS, AND POLLUTANT CHARACTERISTICS

Air Quality Criteria

The 1967 amendments to the Clean Air Act required the Department of Health, Education, and Welfare to publish criteria of air quality judged to be requisite for the protection of public health and welfare. Air quality criteria are an expression of the scientific knowledge of the relationship between various concentrations of pollutants in the air and their effect on man and his environment. Criteria are descriptive in that they delineate the effects that have been observed to occur when the concentration of a pollutant in the air has reached or exceeded a specific level for a specific period of time. Such criteria provide the most realistic basis that is presently available for determining to what point pollution levels must be reduced to assure the protection of public health and welfare.

As scientific knowledge grows, air quality criteria will have to be reviewed and, in all probability, revised. The Congress has made it clear, however, that we are expected, without delay, to make the most effective use of the knowledge we now have.

Air Quality Standards

The 1970 amendments to the Clean Air Act required the Environmental Protection Agency (EPA) to promulgate national air quality standards for each air pollutant for which air quality criteria had been issued. Air quality standards are prescriptive. They prescribe pollutant exposures or levels of effect that should not be exceeded in a specified geographic area.

Air quality standards for motor-vehicle-related pollutants are provided in Table 1-1.

Table 1-1. SUMMARY OF NATIONAL AIR QUALITY STANDARDS FOR MOTOR-VEHICLE-RELATED POLLUTANTS

Pollutant	Averaging time	Primary and Secondary standards
Carbon monoxide	8-hour[a]	10 mg/m^3 (9 ppm)
Nitrogen dioxide	1-hour[a]	40 mg/m^3 (35 ppm)
Nitrogen dioxide	Annual (arithmetic mean)	100 $\mu g/m^3$ (0.05 ppm)
Photochemical oxidants	1-hour[a]	160 $\mu g/m^3$ (0.08 ppm)
Hydrocarbons[b] (non-methane)	3-hour[a]	160 $\mu g/m^3$ (0.24 ppm)

[a]Not to be exceeded more than once per year.
[b]The hydrocarbon standard is a guide to developing State implementation plans to achieve the oxidant standard. The hydrocarbon standard does not have to be met if the oxidant standard is met.

Air quality standards are set at two levels, primary and secondary. Primary standards establish how clean the air must be to safeguard human health. Secondary standards establish how clean the air must be to prevent damage to clothes, buildings, metals, plants, animals, etc. As shown in Table 1-1, primary and secondary standards for motor-vehicle-related pollutants are the same, which means that the levels set for each pollutant are sufficient to protect both health and welfare.

The above standards are "national" in that they apply to all 50 States, the District of Columbia, and three U. S. territories. These political jurisdictions have until mid-1975 (1977 in some cases) to meet the standards.

Pollutant Characteristics

The four air pollutants discussed below are often called motor-vehicle-related pollutants because they are emitted by motor vehicles and because the amounts of these pollutants emitted by motor vehicles constitute a major portion of the total of such pollutants emitted by all sources.

Carbon Monoxide - Carbon monoxide is the most widely distributed and the most commonly occurring air pollutant.[1] Total emissions of carbon monoxide to the atmosphere exceed those of all other pollutants combined. Most atmospheric carbon monoxide is produced by the incomplete combustion of carbonaceous materials such as fuels for vehicles, space heaters, and industrial processes. Man's activities are, therefore, largely responsible for carbon monoxide contamination.

The introduction of the internal combustion engine for transportation and the development of a number of technological processes that produce carbon monoxide have greatly increased atmospheric concentrations. Transportation activities represent the largest source category. Concern has now broadened from the acute and often lethal effects of temporarily high concentrations of the gas to encompass as well as those effects that may occur as a result of considerably longer exposures to much lower concentrations.

Nitrogen Oxides - Among the various oxides of nitrogen, the most important as air pollutants are nitric oxide and nitrogen dioxide. The term nitrogen oxides usually refers to either or both of these two substances. Nitric oxide and a comparatively small amount of nitrogen dioxide are formed under high temperature conditions such as those that accompany the burning of fossil fuels.[2] They are emitted to the atmosphere from automobile exhausts, furnace stacks, incinerators, and vents from certain chemical processes.

These substances are also important in air pollution control because they are involved in photochemical reactions in the atmosphere.

Mobile sources are the largest single source category, contributing over 40 percent of all man-made nitrogen dioxide in the United States.[3] The next largest source is electric power generation, which is responsible for nearly 20 percent of all man-made nitrogen dioxide.

Photochemical Oxidants - As initiated by sunlight, a series of complex atmospheric reactions between hydrocarbons and nitrogen oxides lead to the formation of new substances, among which are ozone and oxidants.[4] These substances are chemical entities detrimental to biological systems and destructive to certain materials. The complexity of the atmospheric reaction has led to differences in interpretation of experimental results by researchers. These differences relate to the degree of reactivity of various hydrocarbons and the effects of reactivity over a period of time. The Chemistry and Physics Laboratory of the National Environmental Research Center, Research Triangle Park, N. C., is conducting research in these and other areas.

Hydrocarbons - Hydrocarbons are important in air pollution control, not because of their direct effects, but because of their role in photochemical reactions. Hydrocarbon emissions originate primarily from the inefficient combustion of volatile fuels and from their use in processing certain raw materials. It was estimated that the transportation source category contributed 52 percent of the nationwide hydrocarbon emissions in 1968.[5] Organic solvent use was the second largest source category, contributing about 27 percent, and industrial processes was third, contributing 14 percent.

EXTENT OF PROBLEM

By itself, the automobile appears to be a minor air pollution offender. The amount of hydrocarbons, carbon monoxide, and nitrogen oxides emitted by a single automobile is small compared with emissions from industrial sources. However, the sheer numbers of automobiles operating daily cause serious air pollution problems in many metropolitan areas. For example, approximately 4 million vehicles, including trucks, were registered in Los Angeles County in 1970,[6] or one vehicle for every two people in the county. If the present growth trend continues, there will be approximately 6 million vehicles in Los Angeles County by 1990. In the Greater Houston area, 1.5 million vehicles were driven about 13 billion miles in 1971, and over 1 billion gallons of gasoline and diesel fuel were consumed in the process.[7] These kinds of statistics make it obvious that pollution from motor vehicles must be controlled.

Transportation control measures are of two basic types. Measures such as bus/carpool lanes and parking restrictions are intended to encourage the use of more efficient modes of travel, such as buses and carpools, instead of the single-passenger motor vehicle. As a result of a shift to more efficient travel modes, vehicle miles of travel (VMT) are reduced and the pollutants emitted are reduced. Measures such as retrofits of emission control devices and inspection and maintenance prior to registration are intended to reduce the quantity of pollutants emitted by motor vehicles. The latter of these measures, inspection and maintenance, is required either by the State or EPA in most of the metropolitan areas that now require transportation controls.

An inspection and maintenance program by itself is a control measure that can bring about substantial reductions in automobile exhaust emissions.

More importantly, however, an inspection and maintenance program serves as a cornerstone in any effective mobile source control program. For example, an inspection and maintenance program is basic to any retrofit program that may be implemented. These programs will assist in assuring that the vehicle emission reductions required by the Federal Motor Vehicle Control Program are actually attained.

REFERENCES FOR CHAPTER 1

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2. INSPECTION AND MAINTENANCE PROGRAMS

The term inspection and maintenance covers a variety of strategies for reducing air pollutant emissions from light-duty motor vehicles currently in use by establishing procedures that will assure proper maintenance of control devices by the motorist. Most of the approaches have two distinct phases: an inspection phase, in which motorists are required to periodically present their vehicles for examination; and a maintenance phase, in which vehicles that fail the examination must be taken to a garage for maintenance to bring them into compliance.

PROGRAM DESCRIPTION

Three classifications cover the major alternative approaches in an inspection and maintenance program: emission inspection, engine parameter inspection, and mandatory maintenance. Emission inspection involves sampling the exhaust gases from the vehicle being examined and passing these gas samples through suitable analytical instrumentation to measure the quantities of air polluting compounds they contain. If the concentrations of these compounds all fall below the applicable emission standards, the vehicle passes the examination. If the concentrations of any pollutant are above the standard, the vehicle fails. Vehicles failing the test must then be adjusted or repaired to bring the emissions into compliance. Following the maintenance, it would normally be required that the vehicle be resubmitted for an emission test to determine that it is in compliance.

Engine parameter inspection involves the examination of critical engine components and adjustments to determine whether the engine is functioning according to the manufacturer's specifications. If the vehicle fails to fall within the tolerances set by the specifications, the vehicle must be adjusted or repaired to bring it within the tolerances. If the required maintenance is performed by a certified mechanic, there would be no necessity for returning the vehicle for reinspection.

Mandatory maintenance avoids the inspection phase entirely. In this approach, the vehicle must periodically undergo specified maintenance procedures at an authorized garage. The maintenace procedures are designed to correct or avoid the most frequent types of emission-related malfunctions of vehicles of a particular make, model, and year of manufacture.

Before discussing the various inspection and maintenance programs, it is perhaps worthwhile to discuss the alternate ways in which a State, county, or municipal agency might structure an inspection and maintenance program.

Operational Configuration

The broad configurations of inspection and maintenance programs are:

1. Publicly operated lane system.
2. Licensed garage system.

In the publicly operated lane system, the appropriate governmental agency performs the inspection in publicly owned and operated facilities set up for inspection of motor vehicles. The facilities may be exclusively devoted to emission testing or may include other types of required inspection such as vehicle safety.

In the licensed garage system, the testing is performed by existing private service or repair agencies within the repair and maintenance industry. The facility is certified, licensed, and controlled by the appropriate governmental agency.

Generally, it is assumed that any needed repair, adjustment, or maintenance would be done by private service garages and dealerships. In the case of the licensed garage system described above, the garage performing the inspection could also do the required work to bring the vehicle into compliance.

Emission Inspection

The two major considerations in performing an emission inspection are the emission measurement itself and the vehicle operating condition during the measurement.

Analysis of Vehicle Exhaust Gases - The air pollutants in automotive exhaust of concern during inspection and maintenance are hydrocarbons, carbon monoxide, and nitrogen oxides.

Hydrocarbons may be measured by either of two methods: infrared absorption or flame ionization detection. Infrared instruments measure the infrared energy absorbed by the hydrocarbons in the sample gas. Although hydrocarbon molecules with complex banding structures cannot be detected using infrared absorption, a number of simple hydrocarbons, known as paraffins, exhibit strong infrared absorption peaks. Current motor vehicle exhaust compositions exhibit a reasonably constant proportion between the paraffins and total hydrocarbons.[1] The infrared instrument is sensitized for n-Hexane, and a measure of the paraffin content is obtained which can then be related to total hydrocarbons using the proportionality constant.

The flame ionization detection method depends on the fact that hydrocarbons introduced into a sample gas generate electrons in a hydrogen flame that can be detected as an electric current by applying a voltage across the flame. Although the analysis is not affected by the presence of carbon monoxide, carbon dioxide, nitrogen oxides, or water, the procedure is extremely sensitive to the precise control of the sample flow rate through the analyzer.[1]

The presence of carbon monoxide is determined by infrared absorption. In this case the instrument is set to respond to the particular frequencies of infrared radiation absorbed by carbon monoxide. It is, therefore, not affected by the hydrocarbons present in the gas because they absorb in a different region of the infrared spectrum.

Nitrogen oxides are really two gases, nitric oxide (NO) and nitrogen dioxide (NO_2). The nitrogen oxides in exhaust gas freshly sampled from an engine are almost entirely nitric oxide. However, if the sample stands for more than a minute (as it does in some sampling methods), oxygen present in the exhaust will oxidize a portion of the nitric oxide converting it to nitrogen dioxide. This tendency for the nitric oxide to convert to nitrogen dioxide complicates the measurement of nitrogen oxides. Nitric oxide can be determined by infrared absorption. However, because water absorbs infrared radiation fairly strongly in the nitric oxide absorption region, the gas must be first passed through a dessicant to remove all water.

Nitrogen dioxide can be measured by ultraviolet light absorption, but the method lacks sensitivity. When the infrared and ultraviolet absorption instruments are used, the individual concentrations are summed to give the total concentration of nitrogen oxides.

In recent years, chemiluminescent instruments have become available for nitrogen oxide measurement. They depend upon the fact that when nitric oxide is mixed with ozone, the nitric oxide rapidly converts to nitrogen dioxide emitting light in proportion to the concentration of nitric oxide present. The emitted light is measured with a photomultiplier tube. To make the instrument measure total nitrogen oxides, the sample gas is first passed through a stainless steel or molybdenum tube at high temperature to decompose any nitrogen dioxide present back to nitric oxide. By this procedure all the nitrogen oxides are present as nitric oxide as they pass into the ozone reaction chamber.

This method requires a means of generating ozone and the careful control of pressures. There may also be interference from carbon monoxide under certain operating conditions. The chemiluminescent method is specified in the Federal motor vehicle certification regulations for measuring exhaust from gasoline-powered engines.

Exhaust gases contain about 15 percent water and varying levels of particulate matter. At room temperature the water will condense in sample lines and within the instruments. This condensation along with the entrained particulate matter will quickly cause an analytical instrument to malfunction or give erroneous readings. It is customary, therefore, to provide a water trap to condense excess water and a filter to remove the particulate matter. For the delicate research-grade instrumentation commonly used in the Federal test procedure for new vehicle certification, elaborate refrigerated condensing systems and high-efficiency glass fiber filters are used. For the simplest instrument used by garage mechanics for diagnostic tests, simple ambient temperature knockout traps and ceramic filters will do the job.

The sampling system in its simplest configuration is a hand-held metal probe attached to the instrument system with flexible tubing. A gas pump pulls gas through the probe, the clean-up system, and the analytical instrument. Typically the concentration is expressed as volume percent for carbon monoxide and parts per million by volume for hydrocarbons and nitrogen oxides.

If emission measurements that will correlate more closely with results that would be obtained by the Federal certification procedure and provide the same units in grams/mile are desired, a constant-volume sampling system would be used. This system has the effect of weighting emissions at each driving condition by the flow rate of exhaust gas at that condition. It automatically weights and averages the emissions collected over changing operating conditions. It also allows correct comparison of emissions from different engine sizes. Although this procedure would provide the most accurate results, the systems are generally large and expensive and are only feasible where a large number of vehicles are to be processed by each system.

Vehicle Preconditioning- Preconditioning of the vehicle is important in achieving repeatable and meaningful results. In the Federal test procedure, the vehicle must stand inoperative for at least 12 hours within a specified range of ambient temperatures before the engine is started and the emission measurement begun. This procedure, called a cold start, brings into play the effect of choke setting on emissions.

An alternate procedure, referred to as a hot start, is to start the test with the vehicle at or near its normal operating temperatures. For in-use vehicle emission inspection, however, both these procedures require more time than is normally available. Because it is not reasonable to require the car to stand for 12 hours until inspected, some variation of hot test preconditioning is necessary. In the case of an idle test, EPA requires that the engine be in a warmed-up condition prior to testing. This conditioning can be helpful if vehicles have been standing in an inspection line idling for some time before the start of the test. When a loaded mode test is used, there can be some short running at a higher speed under load.

Vehicle Operating Modes - The choice of the mode or modes of operation over which the sample is taken determines how closely the emissions measured by the inspection procedure correspond to or correlate with the emissions to the atmosphere from vehicles in normal use. The test modes also determine the amount of diagnostic information the test will provide in the case of a vehicle failing the inspection test.

An operating mode is a period of operation over which the vehicle is either running at a constant speed or undergoing an acceleration or deceleration. A constant speed or cruise mode would be defined by the speed and the time interval over which it was maintained. Idle is a constant speed mode of zero speed. An acceleration or deceleration mode, called transient mode, could be typified by the speed of the vehicle at the start and end of the mode and the time interval between the two speeds.

An inspection may consist of sampling exhaust gases at one or more modes. Up to a point, the greater the number of modes examined, the better the correlation with emissions to the atmosphere and the more diagnostic information available.

The idle mode is commonly referred to as a no-load mode because there is little or no resistance to the running of the engine. All other modes are considered loaded because wind resistance, rolling friction, and engine friction all put a load on the engine. A chassis dynamometer is used to simulate the action on the engine of running on the road.

A chassis dynamometer consists of a pair of parallel rollers that support the rear wheels of the vehicle under test. The car can then be placed in gear and the rear wheels driven on the rollers while the vehicle stands in place. Adjustable, heavy, inertial weights are attached to the rollers to resist changes in speed, thus simulating the weight of the vehicle. Also, a power absorption unit is usually attached to the rollers to resist their rotation and thus simulate wind and other resistances to the motion of a vehicle. With a chassis dynamometer, it is possible to fully simulate the engine behavior for a vehicle on the road while the vehicle stands in place--a great convenience for emission testing.

An idle mode inspection test is the simplest emission inspection that can be performed. It requires the simplest instrument system and needs no dynamometer. Pass or fail can be indicated by lights on the instrument set to activate at the fail points. The inspector need only indicate which pollutants were above the standard. There is no need to indicate how far above because there is little or no diagnostic content in this information. The test should be completed in approximately 2 minutes in a licensed garage inspection and in less than 1 minute in a lane inspection.

Loaded-mode emission tests with a dynamometer allow for a variety of test cycles. One of the well known test cycles is the Clayton key mode test. In this test emissions are measured under each of three successive constant speed modes, 50 mph, 30 mph, and idle. The power absorption is set proportional to the third power of the road speed giving a high loading of 30 horsepower at 50 mph. Under this condition the vehicle is at a higher load than would be experienced in level road operation. The high engine loading is said to provide better diagnostic information than a normal load. Fail limits can be set for each of the conditions or for a linear combination of them. In any event, the readings at all three conditions should be given to the vehicle owner on a card so that a mechanic can use them in performing the needed maintenance.

An example of how a mechanic might use this information is as follows: a normal hydrocarbon level at idle and a too-high level at high speed points to electrical problems. The reverse would indicate incorrect adjustment of the carburetor at idle. Alternatively, a card indicating the probably faults may be supplied.

Because only cruising speeds are used, the dynamometer for a key mode test does not require inertial weights. The result is a substantial reduction in the cost of equipment and elimination of the need to set inertial weight for each vehicle.

The driving cycle may also involve transient operating modes. An example is the so called ACID (Accelerate-Cruise-Idle-Decelerate) cycle[2] in which the emissions are measured while the vehicle is accelerated at a constant rate to 30 mph, held at 30 mph, decelerated at a constant rate to idle, and held at idle for a specified time. This cycle was designed to operate with a constant volume sampler. Because the loading is not as severe as with the key mode, it may not be as valuable a diagnostic tool. The ACID cycle requires a dynamometer with both power absorption and inertial weights so that it responds properly to the acceleration and deceleration modes. Use of inertial weights increases the costs substantially.

Engine Parameter Inspection

The second major alternate strategy for inspection and maintenance is the inspection of selected engine parameters to discover any departures from manufacturers' specifications. Only those parameters that have an impact on vehicle emissions need be inspected. Table 2-1 shows the significant parameters influencing carbon monoxide and hydrocarbon emissions for precatalytic emission control systems identified in one study.[3]

Table 2-1 ENGINE PARAMETER INSPECTION[3]

Subsystem	Engine parameter	Equipment requirements
Idle adjustments	% carbon monoxide at idle and timing	Infrared carbon monoxide analyzer; Tachometer and timing light
Secondary ignition	Plugs, wires, and distributor	Electronic engine analyzer
Induction	Air cleaner PCV valve Air injection system	Air cleaner tester Pressure gauge Air flowmeter

An infrared analyzer is used in measuring the idle adjustments. Here the instrument is being used as an air-fuel ratio meter rather than as an emission measurement device. With the adoption of devices for controlling nitrogen oxides and with the use of catalytic devices to meet 1975 and later standards, additional parameters will have to be added to those in Table 2-1.

A check of the subsystems in Table 2-1 represents an extensive and costly inspection procedure. Depending upon the extent of emission reduction expected from inspection and maintenance, a less extensive system might be substituted.

Failure limits would be established based on manufacturer's specifications, but this does not guarantee identification of all the high emitters. The engine parameter inspection strategy specifically identifies the maintenance to be done and, in effect, combines inspection and diagnosis. This also means that the car need not be reinspected if it is repaired at a certified garage.

Mandatory Maintenance

Mandatory maintenance eliminates the inspection step by simply requiring that certain replacements and adjustments be made to the engine periodically. This maintenance can include replacement of spark plugs, points and condenser, air cleaner filter, catalyst, etc. and adjusting timing, air fuel ratio, air pump belt tension, etc. In the area of adjustments, manufacturer's tolerances would still have to be followed so that mandatory maintenance does not eliminate the inspection phase but rather, makes it an integral part of the maintenance. In effect, the certified mechanic who does the maintenance is also the inspector. Although this is a simplifying step, it may result in more maintenance than is needed to achieve the desired control of emissions from the in-use vehicle population.

INSTRUMENTATION AND EQUIPMENT

The necessary technology for conducting vehicle inspections and required maintenance has reached a point where a State has a full range of alternate systems to choose from without the necessity of sponsoring an extensive development effort. The scientific instrument, computer, dynamometer, and garage service industries have participated in various inspection and maintenance programs over the last 7 years and have developed a substantial capability.

The following companies have been involved in the design and manufacture of emission test systems (not to be confused with manufacturers of individual system components) for inspection and maintenance programs and may be consulted on the overall system design:

1. Automotive Environmental Systems, Inc.
2. Beckman Instruments, Inc.

3. The Bendix Corporation, Environmental Science Division
4. Horiba Instruments, Inc.
5. Interteck Corporation
6. Olson Laboratories
7. Sun Electric Corporation
8. Scott Research Laboratories, Inc.

The need for low cost infrared analyzers for measuring carbon monoxide and hydrocarbons that would be suitable for use in idle emission inspection and by repair garages has spurred a major and successful effort by the instrument industry to develop practical devices. Consequently, a large number of good instruments are now available. For example, Table 2-2 lists the infrared instruments currently approved by New Jersey for use in repair garages. These same instruments would be suitable for inspection in a licensed garage inspection system.

PROGRAM EFFECTIVENESS

The three main inspection and maintenance programs are compared in Table 2-3 on the basis of reductions in emissions obtained immediately following required maintenance.[4] The data shown for the exhaust emissions inspection are a combination of results obtained using idle- and loaded-mode inspection tests. The data show that, for each of the three general programs, it is possible to achieve significant reduction in hydrocarbons and carbon monoxide in rejected vehicles that have been serviced, that is, vehicles on which corrective maintenance was performed. No significant improvement in nitrogen oxide emissions occurred for the pre-1972 vehicles tested. Because inspection and maintenance programs have so far shown little or no effect in reducing nitrogen oxide emissions, the emphasis in this and the remaining chapters will focus on reductions of carbon monoxide and hydrocarbons.

Table 2-2. NEW JERSEY-APPROVED MANUFACTURERS OF LOW COST INFRARED ANALYZERS SUITABLE FOR USE IN REPAIR GARAGES

Supplier	Model
Allen Electric Company	Emission Analyzer Model 23-060 series and 23-070 series
American Motors Corporation[a]	AMserv Model 23-067 series and 23-077 series
American Parts Company	Powerready Infrared HCKO Analyzer Model 370-400
Atlas	Exhaust Emission Tester Model 340
Autoscan, Incorporated	CO and HC Analyzer Model 710 and 4030
Barnes Engineering Company	Emission Analyzer Model 8335
Beckman Instrument Company	HC/CO Vehicle Emissions Analyzer Model 590
Chrysler Corporation	Technican Service Equipment Program. Model DCE-75, 23-066 series and 23-076 series
Ford Motor Corporation	Rotunda Equipment Program Rotunda Analyzer Model BRE-42-730 and BRE-42-731
Kal-Equip	HC/CO Infrared Emissions Analyzer Model 4094-C
Marquette Manufacturing Corporation	Emissions Analyzers Model 42-151 and 42-153
NAPA Balkamp	Infrared HC/CO Emissions Analyzer Model 14-4787
Horiba Instruments Limited	Engine Exhaust Analyzer Models CSM-300 and Mexa-300
Peerless	Infrared Exhaust Gas Tester Model 600
Stewart-Warner	Infrared Gas Analyzer Model 3160-A
Sun Electric Corporation	Sun EET-910, U-912, U-912-I, and EPA-75 Exhaust Emission Testers
Womaco-Yanaco	Exhaust Gas Analyzer Model EIR-101

[a] Available only in new car dealers of the company.

Table 2-3. INITIAL REDUCTIONS IN POLLUTANTS USING MAJOR INSPECTION STRATEGIES, PRE-1972 VEHICLES[1]

(percent)

Inspection and maintenance strategy	Percent vehicles serviced	Initial reduction in mean exhaust emissions					
		From serviced vehicles[a]			From total fleet		
		HC	CO	NO_x	HC	CO	NO_x
Exhaust emission inspection							
Loaded test	30	50	41	0	27	19	0
Idle test	30	45	38	0	22	16	0
Engine parameter inspection	95	11	6.5	0	10	6	0
Mandatory maintenance	100	15	11	0	15	11	0

[a]Vehicles on which corrective maintenance was performed.

Comparisons are made of initial reductions immediately following maintenance--both for the vehicles that were serviced and the total fleet (serviced and unserviced). The latter measure is a better indicator of reductions in emissions to the atmosphere.

Based on the reductions in the serviced vehicles only, the exhaust emission inspection strategy (Table 2-3) appears to be substantially more effective than either of the other two programs in the initial reductions in the serviced vehicles. However, to get a more accurate comparison of the effectiveness of the three different types of programs, the emission reduction for the total vehicle fleet should be considered. Based on this comparison, the exhaust emission inspection is still substantially more effective than the other programs. When the costs expected to be incurred by the average vehicle owner (see "Costs per Vehicle Inspected") is included in the comparison, the exhaust emission inspection clearly has a cost/effectiveness advantage.

Reductions in Atmospheric Emissions

Before data such as those shown in Table 2-3 can be translated into reductions in emissions to the atmosphere, it is necessary to account for deterioration in emission levels of a newly serviced vehicle as the vehicle detunes during subsequent use. Unfortunately, there is an absence of good experimental data in this area. The deterioration rate varies widely in character and level from one vehicle to the next and even within a given vehicle over time. Available data suggest that the simple assumption of a linear deterioration rate over a period of a year is not grossly in error, however. On this basis, Table 2-4 was developed to show the percentage reductions in emissions to the atmosphere from a vehicle population subjected to annual vehicle emission inspection.

Table 2-4. REDUCTIONS IN ATMOSPHERIC EMISSIONS FROM VEHICLES SUBJECTED TO EMISSION INSPECTION[a,4]

(percent)

Emission inspection	Initial failure rate,[b] percent				
	10	20	30	40	50
Idle inspection					
Hydrocarbons	6	8	10	11	11
Carbon monoxide	3	6	8	9	10
Loaded-mode inspection					
Hydrocarbons	8	11	13	14	15
Carbon monoxide	4	7	9	11	12

[a]No comparable information is presently available for emission parameter inspection or for mandatory maintenance.

[b]Initial failure rate is as an index of the severity of the emission standard that would be set to achieve the levels of reductions in emissions shown.

Establishment of Pass/Fail Standards

Table 2-4 can be used as a basis for establishing emission standards for an emission inspection program. First, the percentage reduction in emissions for carbon monoxide and hydrocarbons that will be needed with the inspection and maintenance program is determined. This consideration is part of the overall transportation plan. Once this figure is established and a decision made as to whether an idle inspection or loaded mode inspection will be used, Table 2-4 can be consulted to determine what initial failure rates for hydrocarbon and carbon monoxide are needed to obtain the desired reductions in emissions. It will then be necessary to run an experimental program to define the distribution of emission levels of the vehicle population. A cumulative distribution of the kind shown in Figure 2-1 is then constructed.

From the emission distribution of the vehicle population, the emission standard (normally expressed as a mass emission such as percent concentration or parts per million) that will yield the desired failure rate can be determined. For example, suppose that the cumulative distribution curve in Figure 2-1 represents the hydrocarbon emission distribution for a vehicle population. Further suppose that the divisions on the horizontal axis correspond to 200 ppm, 400 ppm, 600 ppm, and 800 ppm from left to right on the axis. The dashed vertical line intersects the horizontal axis at approximately 480 ppm for this example. Thus, about 80 percent of the vehicles in the population will have hydrocarbon emissions of 480 ppm or less. The other 20 percent of the vehicles will have emissions higher than 480 ppm, and will fail the exhaust emission test. These vehicles will require maintenance before their emissions can comply with the emission standard.

Given the needed rejection rate, the standard can then be set. Figure 2-1 illustrates the emission standard corresponding to an initial rejection rate of 20 percent.

It needs to be emphasized again that initial failure rate is not a prime consideration in setting the standard, but only an intermediary between Table 2-4 and Figure 2-1 to get from the required reductions in the atmosphere to the emission standard that will achieve that reduction.

Although this procedure can be applied to the vehicle population as a whole, it is probably fairer to distinguish between vehicles according to whether they have emission controls and according to the sophistication of the emission control. This distinction obtains because an emission inspection program is fundamentally trying to assure that a vehicle is properly maintained and is not emitting pollutants in excess of its original design intention.

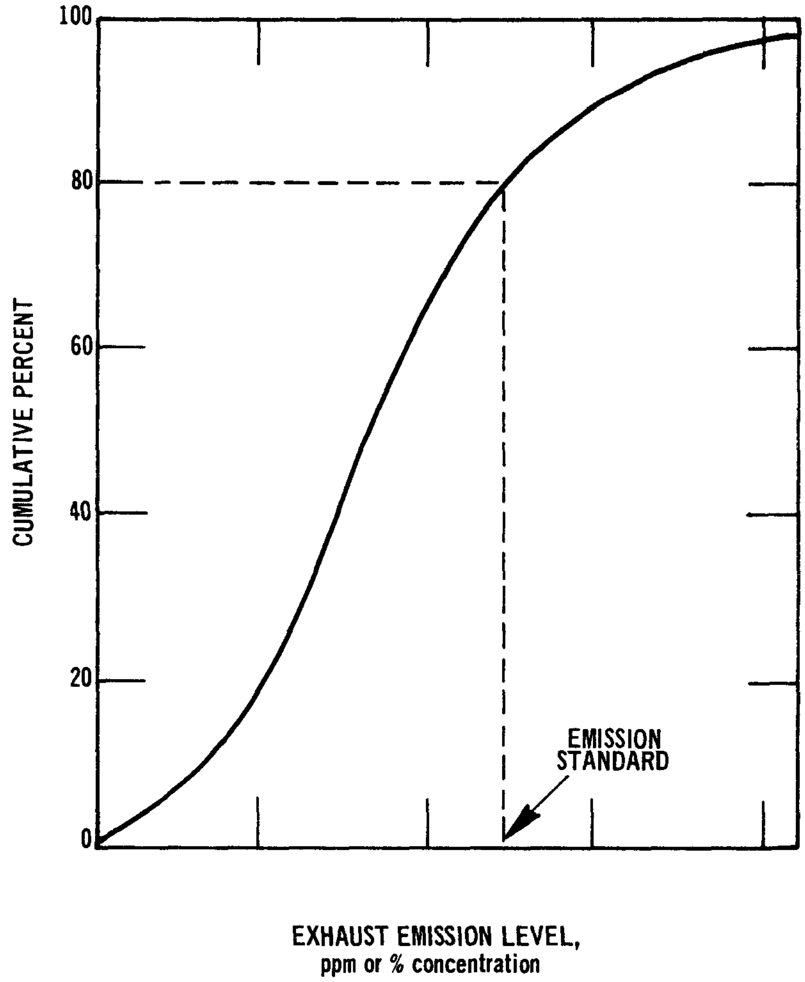

Figure 2-1. Derivation of emission standard from cumulative distribution of emissions.

New Jersey, for example, whose idle inspection program became fully operational on February 1, 1974, has segregated vehicles into three classes and developed the emission standards shown in Table 2-5.

These standards become increasingly stringent over time. An advantage of starting with less stringent standards and tightening them is that it gives both the public and the repair industry an opportunity to become accustomed to the system before the standards come into full force. Most States, however, are required to implement inspection and maintenance programs on an established schedule. This schedule, in most cases, will not allow much time for starting with a low failure rate and easing into the failure rate that is required.

Table 2-5. NEW JERSEY IDLE INSPECTION STANDARDS

Vehicle model year	Effective Feb. 1, 1974		Effective July 1, 1974		Effective July 1, 1975	
	CO, %	HC, ppm	CO, %	HC, ppm	CO, %	HC, ppm
Pre-1968	10.0	1600	8.5	1400	7.5	1200
1968 - 1969	8.0	800	7.0	700	5.0	600
1970 - 1974	6.0	600	5.0	500	4.0	400
Estimated failure rate, %	12-15		25		35	

PROGRAM COSTS

The overall costs of putting an inspection and maintenance program into operation will vary markedly from one situation to another. Some of the specific costs, however, can be pinpointed with reasonable accuracy. This section describes estimated costs on several bases to given an appreciation of the nature of costs that will be faced.

Costs Per Vehicle Inspected

A useful view of overall costs that will have wide applicability is to place them on a per-car-inspected basis. Annual emission inspection in State-operated lanes will cost about $2 per vehicle. Where the tests can be incorporated into existing State safety inspection lanes, costs can be still lower. In the case of licensed garages, costs have been estimated in the range of $3 to $6 per vehicle for an idle emission inspection. Performing an extensive engine parameter inspection in a licensed garage will cost approximately $8 per vehicle.

Repair costs for an average car failing an emission or engine parameter inspection will be $20 to $30. An extensive mandatory maintenance program could cost as much as $60 per vehicle.

Costs of Instruments and Equipment for Emission Inspection

As has been discussed, instrumentation and equipment for emission inspection can vary widely from simple visual instrumentation to fully automated systems. Table 2-6 shows the price range for systems that can be used with idle- and loaded-mode inspection programs. The specific systems shown do not cover all the possibilities. For example, on a State lane there may be a desire to add a minicomputer for some added automation. This could easily raise the price an additional $10,000.

Costs of State-operated Inspection Lane

Table 2-7 shows estimates of the investment and annual operating costs of State-operated inspection lanes using the idle and key mode inspections.[4] For both methods, it was assumed that processing of emission data was semiautomated. The equipment cost for the key mode is about double that of the idle inspection when the automated data handling is added. Without the addition of this feature, the cost is about seven times greater for the key mode than for idle inspection. The predominant operating cost is labor, which is the same for both methods. Note, however, the distinctly higher capacity of the idle inspection lane, which will lead to lower costs on a per-vehicle-tested basis.

Total Program Costs

Total costs for a State maintenance and inspection program would also include costs for training, program planning, initial qualification and certification of the inspection facilities, maintenance and depreciation of the facilities, and the overall program administration and enforcement requirements.

An analysis of cost has been performed for the State of California and can serve as a general guide.[4] The total program costs are summarized in Table 2-8. The testing capacity of the system is based on a yearly inspection of a total population of 10 million vehicles.

Table 2-6. COST OF EQUIPMENT FOR EMISSION INSPECTION

Idle emission inspection	
Infrared hydrocarbon/carbon monoxide instrument	
(Simple meter readout with pass/fail lights)	
	$ 1,800
Loaded vehicle emission inspection	
Loaded constant speed modes (Key Modes)	
Simple instrumentation for HC/CO	3,000
Dynamometer with power absorption	5,000
Ventilation and exhaust disposal unit[a]	$ 4,000
	$ 12,000
Constant speed acceleration and deceleration modes	
Simple instrumentation	3,000
Dynamometer with power absorption and inertia weights (direct drive)	21,000
Ventilation and exhaust disposal unit[a]	4,000
	$ 28,000
Fully automated system	
Instrumentation	
Automatic data treatment	
CVS system	
Dynamometer with power absorption and inertia weights	
Ventilation and exhaust disposal unit[a]	
	$ 67,000
Repair garage instruments for carbon monoxide and hydrocarbons	$600 - $1,000

[a]The ventilation and exhaust disposal unit is optional. However, because this unit also protects inspectors and/or the general public from objects that could be thrown by a dynamometer, the State may consider its use desirable.

Table 2-7. INSPECTION STATION COST ESTIMATES, 1971 VALUES[a,5]

Cost element	Idle mode 1 lane	Idle mode 2 lane	Key mode 1 lane	Key mode 2 lane
Investment Costs				
Inspection equipment[b]	$11,200	$22,400	$20,000	$40,000
Administration	1,000	1,700	1,000	1,700
Site acquisition, ($2/ft²)	14,380	20,000	21,800	33,220
Construction, ($8/ft²)	10,960	16,320	16,320	24,480
Total	$37,540	$60,420	$59,120	$99,400
Operating cost (First year)				
Personnel salaries	$22,000	$44,000	$22,000	$44,000
Supplies and maintenance	1,748	3,186	2,216	3,994
Total	$23,748	$47,186	$24,216	$47,994

[a]Annual capacities of inspection lanes: idle mode-32,000 vehicles per lane, key mode-25,000 vehicles per lane.

[b]Inspection equipment costs have been updated from the original reference to allow for higher cost of the absorption dynamometer ($6,000 increase).

STRATEGY SELECTION FACTORS

Three major alternative approaches to an inspection and maintenance program have been considered. Variations of these programs and combinations of them that have not been considered here are, of course, possible. The EPA-and industry-sponsored APRAC CAPE-13 program explored a number of programs experimentally and developed a cost/benefit analysis computer program that could be helpful in deciding which program is most suited to a given regional problem.

Table 2-8. TOTAL PROGRAM COSTS, STATE OF CALIFORNIA[a]

($ x 10^3)

Cost element	Idle mode	Key mode
Investment cost		
Site acquisition and construction	7,117	12,445
Equipment and installation	4,090	6,270
Planning and training	112	193
Qualification and certification	745	912
Total	12,064	19,820
Operating cost (First year)		
Salaries of inspection personnel	6,635	6,648
Salaries of administrative personnel	631	981
Equipment maintenance and depreciation	1,214	1,473
Facility maintenance and depreciation	256	516
Program administrative costs	1,243	1,301
Total	9,979	10,919

[a]Estimated for California vehicle population (10 million).

It is clear, however, from the material presented in this chapter that the emission inspection schemes are less costly than pure engine parameter inspection or mandatory maintenance programs and appear equally effective in reducing emissions from the vehicle population as a whole. The emission inspection approach gives the added satisfaction of identifying the high emitters and concentrating the maintenance action on them.

The chief problem with emission inspection procedures is that while they identify the high emitters, they do not specifically identify the cause of the high emission values. This throws a substantial burden on the repair mechanic who at present is not trained in identifying and correcting the malfunctions or maladjustments leading to high emissions. In fact, extensive studies have shown that mechanics are only about 50 percent effective in diagnosing and correcting emission problems. Furthermore, they often over repair and over adjust in their efforts to assure that the vehicle passes on retest. How severe this problem may be will not be known with certainty until emission inspection is fully implemented in the field. Clearly, where the emission inspection program is adopted, consideration needs to be given to proper training of mechanics and to providing them with diagnostic information where feasible.

Some States have been considering providing training for inspectors and mechanics through community colleges. The automobile and oil companies are aware of the problem and are beginning to provide training to dealer garages and service stations.

The loaded-mode emission test does provide limited diagnostic information. This benefit, however, needs to be balanced in a specific situation against the added complexity and cost over an idle inspection test. It may also be true that vehicles failing a simple idle test may be brought back into compliance more easily. Certainly the mechanic would be greatly aided by the use of low-cost carbon monoxide/hydrocarbon instruments that would allow him to directly verify the effect of his corrective actions on the idle emissions.

Operational configuration is another major consideration. Will State owned or franchised inspection lanes be used or will the inspection be done in licensed, privately owned garages? The decision in many cases has already been made if the State has set up a safety inspection program. In this case it would be a simplification if the emission inspection could be included in the sequence of safety tests. New Jersey, for example, has 38 State-owned safety inspection stations and has added its idle emission test at the beginning of the lane. Pennsylvania, on the other hand, employs licensed, privately owned garages for its safety program. Should it decide on an idle emission inspection it would appear reasonable to add the test to the safety inspection test now performed in the licensed garages. However, should the State decide on a more elaborate loaded-mode test, it would be necessary to construct State owned or franchised lane systems placed strategically around the State.

REFERENCES FOR CHAPTER 2

1. Control Strategies for In-Use Vehicles. Environmental Protection Agency, Research Triangle Park, N.C. Publication Number APTD-1469. November 1972.
2. Elston, J.C., A.J. Andreatch, and L.J. Mislosk. Reduction of Exhaust Pollutants through Automotive Inspection Requirements -- The New Jersey REPAIR Project. (Presented at International Clean Air Conference on Air Pollution. Washington, D.C. February 1971).
3. TRW Systems Group. The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions. Coordinating Research Council, 30 Rockefeller Plaza, New York, N.Y. APRAC Project Number CAPE-13. July 1972.
4. Title 40 - Protection of Environment. Part 51 - Requirements for Preparation, Adoption, and Submittal of Implementation Plans, Appendix N. Federal Register. 38 (110). June 8, 1973.
5. Mandatory Vehicle Emission Inspection and Maintenance. Vol III. Northrop Corporation. Prepared for California Air Resources Board under contract. May 1971.

3. LEGAL CONSIDERATIONS

The 1970 amendments to the Clean Air Act give EPA the necessary legal authority at the Federal level for carrying out pollution abatement efforts. EPA has direct authority to set automobile emission standards and require automobile manufacturers to meet those standards. Thus, Federal authority preempts all State and local authority with regard to "new car" emission levels. This preemptive authority, however, may be waived by the Administrator, after notice and opportunity for public hearing, for any State that has adopted emission standards (other than crankcase standards) for new motor vehicles prior to March 30, 1966, unless the State does not require emission standards more stringent than Federal standards. The Clean Air Act intended that other transportation controls be implemented, monitored, and enforced by State agencies. However, if a State fails to provide the transportation controls that are considered necessary for achieving air quality standards, EPA has the authority to require that State to provide such transportation controls. Here again, the responsibility for implementing, monitoring, and enforcing transportation controls would be placed on the State, and the State must have or obtain the necessary legal authority to conduct the programs.

For best results, the legal authority for an inspection and maintenance program should be held by the State, especially if the program encompasses a large number of vehicles spread over a wide geographical area. The training requirements, the administrative and enforcement procedures, and the financial requirements for facilities, equipment, and salaries are normally such that in most cases local agencies may hesitate to implement an inspection and maintenance program unless a substantial number of vehicles would be covered by the program. Some local agencies such as those in Chicago, New York, and Washington, D. C. are planning inspection and maintenance programs. In these cities, large numbers of vehicles in relatively small geographical areas will be subject to inspection and maintenance.

Although the State agency may have the responsibility for carrying out an inspection and maintenance program, the State may authorize local agencies to carry out certain portions of the program such as testing, compliance certification, performing maintenance, and enforcement. This, however, does not relieve the State agency of the ultimate responsibility for the program's operation. The State may also delegate authority for certain portions of a program by licensing private businesses. The State agency would, in all likelihood, want to establish certification, licensing, and bonding of private repair facilities if they are involved in the inspection and maintenance program. This would ensure that sufficient equipment, qualified personnel, and adequate facilities were available for operating the program.

Effective control of an inspection and maintenance program requires adequate legal authority under which enforcement actions can be taken. The legal authority may be divided into two major parts: the enabling legislation of the State and the rules and regulations of the individual air pollution control agencies within the State.

ENABLING LEGISLATION

Sound enabling legislation at the State level is an essential prerequisite in establishing the legal and administrative framework necessary to organize, to staff and fund, to provide procedures for the passage of rules and regulations, and to authorize enforcement actions. Imperfections in any enabling provision may cause delays and even failures in implementing a control program. Enabling legislation that identifies specific authority to be exercised by the agency responsible for the inspection and maintenance program will be more likely to withstand challenges in court. Some essential provisions include:

1. Adequate authority to adopt rules and regulations concerning:
   a. Requirements for periodic inspection (should specify the type of inspection such as emission, parameter, etc.).
   b. Establishment of fees for providing the inspection service.
   c. Withholding vehicle registration for those vehicles that do not satisfactorily complete the inspection or do not comply with an applicable variance.
   d. Prohibition of tampering with control devices.
2. Adequate funds for implementing, monitoring, and enforcing the inspection and maintenance program, if allowed by the State's constitution.
3. Adequate authority to obtain pertinent data and information and to require periodic reporting of emission information.
4. Authority to make emission reports and information available for public inspection.
5. Authority to compel compliance with rules and regulations supported by civil or criminal penalties.
6. Provisions for injunctive relief where deemed necessary.

RULES AND REGULATIONS

Regulations that specifically limit emissions of pollutants to the atmosphere are of paramount concern in an inspection and maintenance program. The nature and extent of emission control regulations are primarily determined by the air quality problem. The preparation and application of emission regulations requires knowledge of the polluting characteristics of motor vehicles and the type of program to be implemented. This is especially important for enforcement personnel in documenting violations for the purpose of legal actions. Inadequate understanding of concepts and applications can result in the loss of court decisions, thus weakening the entire enforcement operation. Rules and regulations are generally comprised of the following.

1. Test Procedures. These regulations specify the type of test to be required (that is, idle, loaded, or parameter) and how often vehicle owners must submit their vehicles for inspection. Additional test procedure requirements are also desirable.
   a. Idle procedures could include the type of measurement equipment to be used and the engine revolutions per minute (rpm) at which vehicles would be tested.
   b. Loaded procedures are more complex than idle inspection methods and thus, would require more information. An agency could include such information as the modes through which vehicles will be operated, the stabilization time for each mode if required, the appropriate equipment operation, and the emission measurement procedures.
   c. Parameter procedures could include the particular engine parameters that would require testing and the criteria for determining the need for maintenance or component replacement.
2. Emission Limitations. These regulations establish the rate of emission above which a violation or test failure occurs. There may be one emission limit applicable to all vehicles subject to the program, or several limits based on vehicle age.

3. Equipment Design Standards. These regulations specify permissible features, specifications, or standards relating to the design of testing equipment or the prescribed use of such equipment. The necessity for these type regulations is more prevalent for a program in which private businesses participate in the inspection and/or maintenance operation.
4. Prohibition of Use or Operation. This type of regulation prohibits the use of operation of motor vehicles that exhibit emission rates in excess of the standards. Upon failure of a vehicle to meet the standard, the owner or operator of the vehicle is usually allowed some period of time in which to bring the vehicle into compliance. There is usually a requirment for a retest of failed vehicles or a certification to be produced by the owner/operator that proper corrective maintenance has been performed.
5. Vehicle Registration. This type of regulation prohibits the registration of vehicles that fail to comply with applicable emission limits or with a variance.
6. Inspection Fees. A State would normally desire to establish an inspection fee that would cover the cost of performing inspections, whether the inspections are performed by the State or by licensed private businesses.
7. Variance. Because of engine design or operating characteristics, some motor vehicles may not be able to comply with emission standards. In these cases, the air pollution control agency may wish to exempt such vehicles from the compliance requirement. An automatic exemption may be included for antique and/or classic vehicles, for example.

8. Tampering. To be effective, emission control devices must be in good working order. A regulation to prevent intentional tampering with or adjustment of devices or components required by Federal or State law may be desirable. Appropriate penalties should be included in the regulation for discouraging such tampering.

9. Powers. These supporting regulations are enacted to establish right of entry, police powers, and requirements for submission of information on pollutant emissions.

REFERENCES FOR CHAPTER 3

1. National Emission Standards Act. Part A-Motor Vehicle Emission and Fuel Standards. Section 209 - State Standards. The Clean Air Act. 42 U.S.C 1857 et seq. December 1970.

4. PROGRAM IMPLEMENTATION

AGENCIES INVOLVED

The purpose of this section is to discuss the interagency relationships in the implementation of an inspection and maintenance program. Several types of agency relationships that already exist or are likely to exist are presented and the benefits and problems of each type discussed.

Interagency relations are important because the development and implementation of an inspection and maintenance program includes a broad range of activities such as development of program procedures, procurement of equipment, inspection of vehicles, enforcement of rules and regulations, training of inspectors and mechanics, monitoring results, and handling consumer complaints or problems. Usually one agency does not have the resources or authority to carry out all these tasks without the cooperation or assistance of other agencies. Therefore, it is important to have good working relations among all the agencies involved.

The legislation authorizing the inspection and maintenance program is an important factor in determining which agencies are involved. In some cases, one agency is given total responsibility. That agency must then obtain cooperation and assistance from other agencies as necessary during development, implementation, and monitoring of the inspection and maintenance program. In other cases, several agencies are charged with a particular area of responsibility. The particular agencies specified in the legislation are determined by factors such as the existence of a

State vehicle safety inspection program, the current structure of governmental agencies, and the legislator's ideas of the most workable arrangement.

Several examples of existing inspection and maintenance programs are available to illustrate which agencies can be involved and how these agencies are interrelated. For example, the program in New Jersey involves four agencies:

The Department of Environmental Protection

The Division of Motor Vehicles

The Department of Education

The Office of Consumer Affairs

New Jersey had an existing State vehicle safety inspection program administered by the Division of Motor Vehicles to which the emission inspection program could easily be added. Therefore, the legislation authorizing the inspection and maintenance program called for the Division of Motor Vehicles to work with the Department of Environmental Protection. The Department of Environmental Protection was responsible for developing the inspection and maintenance program, providing the necessary technical assistance, and monitoring the results. The Department of Motor Vehicles performs the actual inspection and handles enforcement through the vehicle registration procedure. Two other State agencies are becoming involved in certain aspects of the inspection and maintenance program. The Department of Environmental Protection is working with the Department of Education to investigate ways to train auto service industry mechanics in the repair of vehicles that have failed the emission inspection. The Office of Consumer Affairs has become involved in investigating cases where consumers have problems getting their vehicles repaired properly.

This type of interaction can present both problems and benefits. One advantage is that the resources and experience of several agencies can be brought to bear on the new program. This should allow the various parts of the program to be carried out in an expeditious manner because each part is being handled by the most experienced agency. On the other hand, more coordination and cooperation is required by the primary agency to see that all parts of the program are properly carried out.

Many of the States that will require inspection and maintenance programs have existing vehicle safety inspection programs. In most cases the agency currently responsible for the safety inspection will also be involved to some extent with the inspection and maintenance program. The particular agency responsible for the safety inspection varies considerably between States. Some examples include the Registrar of Motor Vehicles in Massachusetts, the Secretary of Revenue in Pennsylvania, the Administrator of the Vehicle Inspection Department in Indiana, and the Superintendent of the State Highway Patrol in Ohio.

An example of a local inspection and maintenance program, in an area which requires a safety inspection of commercial vehicles only, is the City of Chicago. A City ordinance authorizes the Department of Environmental Control to carry out the inspection and maintenance program. The Department of Environmental Control handles the entire program including technical development and vehicle inspection. In the future the Department of Environmental Control may also become involved in garage certification.

In California the Bureau of Automotive Repair in the Department of Consumer Affairs has the responsibility for regulating all auto repair garages. Beginning in January 1974, the Bureau of Automotive Repair was given the responsibility for developing an inspection and maintenance program for southern California including technical development, inspection, and certification of repair garages. An idle-mode test was incorporated into the random spot safety inspection conducted by the highway patrol.

The primary advantage of having all responsibility in one agency is that the overall program can be controlled by one agency. Presumably, this would allow for tighter managerial control of the program. However, one disadvantage is that expertise must be developed in several areas that are somewhat unrelated to the primary objective of reducing emissions from vehicles.

In all cases the agency with primary responsibility for the inspection and maintenance program must see that all aspects of the program including technical development, inspection, enforcement, monitoring, vehicle maintenance, inspector and mechanic training, public relations, and consumer protection are developed. In addition, contact should be maintained with the Environmental Protection Agency through the appropriate Regional Office (see Appendix A).

IMPLEMENTATION SCHEDULE

In this section the factors leading to implementation and their timing will be discussed. Generalized implementation schedules will be presented as models and the assumptions explained. The models illustrate the required steps and their time dependence. The variables affecting the implementation schedule and how these variables may differ between States will be discussed. Examples from State agency experience will be used to illustrate certain points.

The bar charts (Figures 4-1 and 4-2) show the estimated time period for implementation of inspection and maintenance programs. Figure 4-1

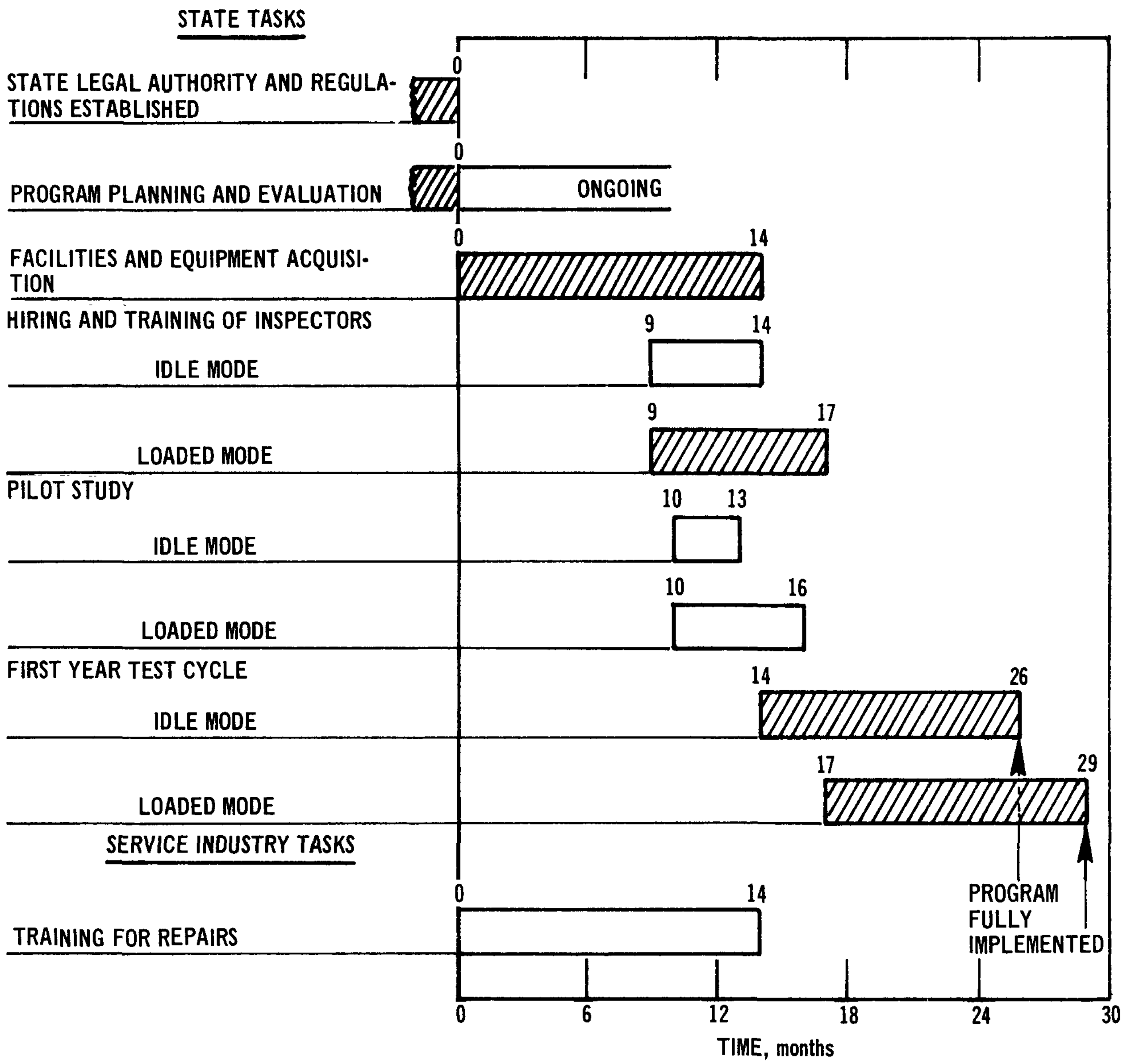

Figure 4-1. Estimated time required for implementation of state-owned inspection lanes using idle- or loaded-mode tests. (Shaded bars represent critical path of tasks leading to full implementation.)

shows a State-owned program with either an idle test or a loaded-mode inspection. Figure 4-2 shows a time schedule for an idle inspection program at licensed garages. The estimated time required for implementing a State-owned program is 26 months for an idle test and 29 months for a loaded-mode test. For a State-licensed idle test program the time required is about 26 months. These time estimates include the first year cycle necessary to phase-in the program to cover the vehicle population.

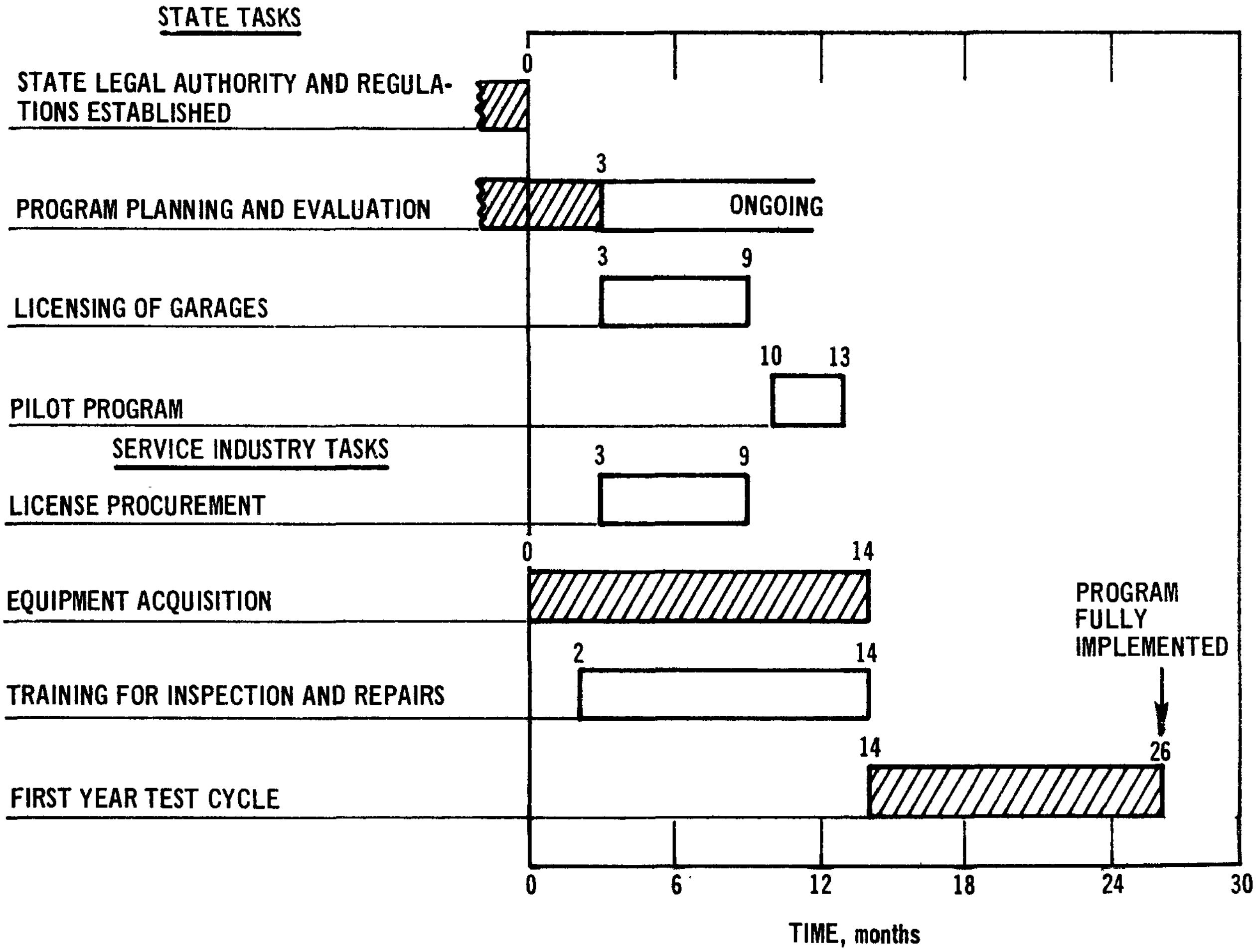

Figure 4-2. Estimated time required for implementation of idle inspection at licensed garages. (Shaded bars represent critical path of tasks leading to full implementation.)

Some of the assumptions made in constructing these model implementation schedules should be pointed out. The first assumption, which can be seen from the charts, is that the lead time begins at the point in time when both legal authority and funding arrangements exist. The time required to obtain legal authority and to make the necessary funding arrangements can be a critical factor in the total time required for implementation. In some cases, it may be possible to begin the planning, the pilot program, and parts of the training program before legal authority has been granted. (Legal authority and funding problems will be discussed later in this chapter.)

A second assumption is that no facilities or pilot programs are available to build on. In some cases, however, inspection and maintenance programs may be incorporated into procedures at existing safety inspection stations, thus reducing the time required for the facilities acquisition step. An existing pilot plant program could reduce the time required to evaluate and select test equipment and procedures. In addition, the staff would have some experience that would speed development of the program.

Another assumption made in developing the model implementation schedules is that only an idle test program would be considered for States with State-licensed garages. It is unlikely that an adequate number of private garages would invest in the more expensive testing equipment necessary for a loaded-mode emission inspection under a State-licensed program. If such a loaded-mode program is used, the time required for implementation would be longer than that shown in the model.

The current status of a State safety program can also affect the time required to implement an inspection and maintenance program. For example, a planned State-owned inspection program could be implemented faster in a State with an existing State-owned safety program because the existing stations could be expanded to incorporate emission testing. Likewise a State-licensed inspection and maintenance program could be implemented faster in a State with an existing State-licensed safety program.

The experience of State or local agencies that are operating inspection and maintenance programs supports the time estimates shown in Figures 4-1 and 4-2, although the exact timing of the various parts of the program differ. Experienced agencies also observed that:

1. Obtaining legal authority can be a long drawn out process and thus a major time delay.
2. Locating sites for State-owned facilities can cause time delays because of land procurement procedures.
3. In order to assure smooth implementation, considerable effort must be made to maintain interagency cooperation in cases where more than one agency has responsibility for parts of the inspection and maintenance program.

FEDERAL ASSISTANCE

The EPA is committed to assisting air pollution control agencies in various ways. Technical assistance in developing implementation plans has been provided to many States in the past several years and will continue through EPA's Regional Offices. States have also received financial assistance through the grants program. Technical and financial assistance relating specifically to inspection and maintenance programs are discussed in more detail in the following pages.

Technical Assistance

Federal technical assistance for inspection and maintenance programs through the EPA Regional Offices will be available in several forms:

1. A periodic newsletter will be published to report on inspection and maintenance developments in State or local agency experience, EPA demonstration contracts, and other studies. Only the main points of information will be discussed in the newsletter, but references will be provided for those interested in a more detailed discussion on the subject. The newsletter will serve as an outlet for information on other vehicle-related subjects such as retrofit devices, engine tampering, and fuel economy.

2. The Emission Control Technology Division is evaluating objectives for an inspection and maintenance evaluation program. By requiring mandatory maintenance for those vehicles that have higher than allowable emissions, inspection and maintenance effectiveness can be determined, the service industry's capability to handle the required maintenance can be evaluated, maintenance costs can be determined, and public reaction to inspection and maintenance can be sampled. Although these data are important, the success of the evaluation program will depend on the willingness of State agencies to operate an inspection and maintenance program according to the program requirements.
3. Planning is underway for a seminar sponsored by EPA for State and local officials on the subject of inspection and maintenance programs. The seminar will provide a forum for EPA to dispense recent information and for State and local officials to share their experience and information.
4. The document Control Strategies for In-Use Vehicles (APTD-1469)[1] will be reissued with more emphasis on aspects of implementation and with recently developed information not contained in the first edition. The new information will include a discussion of an evaluation procedure for retrofit devices, a discussion of high altitude emission inspection, and an examination of State agency experience with specific problems encountered in implementing inspection and maintenance programs.
5. EPA is considering establishing a team of experts that would be available to handle requests for information or assistance on technical matters relating to inspection and maintenance. The

kind of assistance that this group could provide would include technical review of State inspection and maintenance plans, recommendations on instrumentation and other testing equipment, assistance in mechanic training programs, testimony on technical questions at public hearings, and on-site visits to evaluate technical problems with the inspection and maintenance program.

6. Several specific reports and studies related to inspection and maintenance are discussed in Chapter 6.

Funding Assistance

Acquiring adequate funding is an important factor in the development of an inspection and maintenance program. Funding an inspection and maintenance program is basically the responsibility of the State and/or local agencies.

In general, funds are required for two purposes: (1) to provide capital to start up the program and (2) to operate and maintain the program once it has been started. The amount of capital investment will depend on three factors: (1) the type of program (State-owned lanes or State-licensed garages), (2) the type of emissions test (idle or loaded-mode), and (3) whether the emissions test is added to an existing safety inspection or set up independently. The initial capital can be acquired through several mechanisms, such as issuing bonds or borrowing from the State's general fund. In any case, an inspection fee can be charged to cover both the operating and maintenance costs and to pay off the initial investment. Oregon's system is an example of this method of financing, that is, borrowing the initial capital from the State's general fund and setting the inspection fee at a level to cover the operating costs and to pay back the initial capital.

The additional cost an air pollution control agency will incur when setting up an inspection and maintenance program may be included in the agency's operating budget. As part of the agency budget, the inspection and maintenance program costs would be eligible for matching funds through EPA's grant program to support air pollution control agencies. However, because EPA's agency grant funds are not expected to increase, this funding mechanism will not be able to provide substantial support. Further information concerning program grants can be obtained from an EPA Regional Office.

As mentioned in the following section on training, Federal funds can be obtained for inspector and/or mechanic training. The EPA Regional Offices have available some Manpower Development and Training Act (MDTA) funds for training of technician-level people. Several State and local agencies in Colorado, Oregon, and Texas have already used or propose to use this mechanism to obtain funds for training of inspectors and/or mechanics necessary to carry out the inspection and maintenance programs. Interested agencies should contact the manpower development officer in their EPA Regional Office.

TRAINING

An adequate supply of trained inspectors and maintenance mechanics is necessary in order to successfully implement an inspection and maintenance program. This section will examine the importance of inspector and mechanic training, the steps that the primary inspection and maintenance agency should take to assure a supply of trained personnel, and some examples of what is being done in the area of inspector and mechanic training.

Trained inspectors must be available before the program can become operational, and trained mechanics are required to properly repair the rejected vehicles. The kind of training and magnitude of the training program required would depend on whether the inspection and maintenance system is State-owned or State-licensed, and whether an idle test or a loaded-mode inspection is used. In State-owned systems the inspection function is separate from the maintenance function, which allows separate training programs to be developed. Generally the professional staff together with the instrument vendors can put together the necessary training program for inspectors. The training program for a loaded-mode test would be more extensive than the training program for an idle test, but both of the training programs for inspectors are relatively simple. The main objective is to train the inspectors to operate and maintain the instruments, perform the test, and make the proper record of the test results.

The main factor determining the magnitude of the inspector training program will be the size of the inspection and maintenance program. For example, New Jersey has about 69 inspection lanes with one emission inspector per lane. Other States with a larger number of lanes will require a substantial number of inspectors. For example, Arizona's proposed plan calls for 511 employees most of whom will be inspectors.

In a State-licensed system, the personnel at each station should be trained and capable of performing both the inspection and the maintenance functions. The degree to which the inspection and maintenance agency can become involved in training of mechanics under either type of inspection and maintenance system will depend on several factors including legal authority, personnel and funding capabilities, and the level of expertise and initiative of the local auto service industry.

Early in the planning process, the agency responsible for the inspection and maintenance program should determine the role it will have in the training program. In some States, an agency such as the Department of

Education may be better equipped to handle inspector and mechanic training. The particular legislation under which the agency operates, however, may specify the agency's role in the training process. Another factor to consider is the level of expertise in the local auto service industry and the existence of private education programs. Several oil companies have training courses for their dealers. Garage owners may decide to prepare themselves for future inspection and maintenance business by obtaining the necessary training for their employees. In any case, the primary inspection and maintenance agency should assess the need for mechanic training and take whatever measures are necessary to prepare the auto service industry for handling emission repairs.

EPA is involved in two aspects of the mechanic training area that can be useful to the State or local agencies responsible for inspection and maintenance programs. One is in providing Manpower Development and Training Act funds for inspector and for mechanic training. Several States are using or plan to use these funds to set up training programs. The Denver, Colorado, program is an example of this type of program. A contract was awarded to Colorado State University to develop a training program and to train 60 persons. This program is directed at training auto mechanic instructors and teachers who will then go back to their technical institutes, junior colleges, or other place of employment to teach the working level mechanics. The multiplier effect of this method will help spread the knowledge faster than would training the working level mechanics directly. A similar training grant for certified auto teachers has been awarded to Colorado State University to expand the training program started under the first contract. EPA expects to gain training materials and methods from the work carried out under these contracts. These materials and methods can then be made available to others as training packages. Agencies interested in using Manpower Development and Training Act funds for mechanic training programs should contact the manpower officer in their EPA Regional Office.

The Control Programs Development Division of EPA in Durham, N. C., is currently working on projects to develop training programs for inspectors and mechanics. One program that includes training materials has been developed and will be tested in the Denver mechanics training program mentioned above. Once the materials and methods are tested and approved, the training package will be available for others. Further study is being given to the need for developing other training packages for people involved with inspection and maintenance at other levels, such as supervisors.

Because of the importance of having well-trained inspectors and mechanics in the outcome of any inspection and maintenance program, the primary agency should assess the training needs for its program and make sure that the necessary training is provided. Who runs the training program and how extensive it is will depend on the factors discussed above. The primary agency will ultimately be responsible for the success of the inspection and maintenance program, and therefore should make a special effort to develop adequate training for inspectors and mechanics.

POTENTIAL PROBLEMS

A variety of approaches can be followed in implementing an inspection/maintenance program. The program can be State owned and operated or licensed to private garages; the inspection can be made while the vehicle is at idle or under simulated driving conditions; annual or semiannual inspections can be required, etc. With all of these approaches, implementing an automobile inspection/maintenance program may result in a number of problems that should be considered early in the planning process of such a program. These problems fall into the following general areas:

1. Legislative or statutory requirements.
2. Organizational impediments.
3. Funding or budgetary restrictions.
4. Labor supply or skill shortages.
5. Lack of public support.
6. Lack of data.
7. Equipment and facility procurement.
8. Determination of rejection rate.
9. Certification of mechanics.

Legislative or Statutory Requirements

The implementation of an inspection/maintenance program requires statutory authority for its development and operation. Acquiring this authority necessitates formal approval by the State legislature for a State-operated program. This is not necessarily true for a program established by a local agency. In many instances this approval is given in two phases--the first being a pilot or demonstration project, the second the actual program to be implemented. As an example, in Colorado the legal authority for a pilot program was already included as a part of the Colorado Clean Air Act; once the results of the pilot are available, the necessary legal authority for the implementation of mandatory inspection and maintenance will be acquired. In Arizona, the State legislature approved the construction and operation of a prototype inspection facility in 1972; a report containing emission test data, inspection station network studies, and specific recommendations regarding how a statewide mandatory inspection system should be implemented has been completed and will go to the State legislature in 1974. In many cases the State legislative body has only minimal technical knowledge and little understanding of the actual requirements necessary for attaining the air quality standards. The purpose of the transportation plan in helping attain these standards and the necessity for implementing an inspection and maintenance program must be appropriately presented to the legislators so that their approval will be forthcoming. Adequate agency preparation may require many months of work to construct a logical, understandable proposal.

Getting the necessary statutory authority can be a time consuming task in implementing an inspection and maintenance program. This situation necessitates early action on legislative approval. However, States may be able to use an EPA-promulgated inspection and maintenance requirement as the authority to act in implementing a program and thus, avoid time delays.

Organizational Impediments

As was discussed earlier, the implementation of an inspection and maintenance program may involve several State or local agencies. Cooperation between these agencies is essential if the program is to operate successfully. Having specific agency responsibilities delineated in the legislative authority will aid in avoiding controversy over assignment of duties and enforcement of the program.

Funding or Budgetary Restraints

Once the legal authority for establishing a mandatory inspection and maintenance program is acquired, adequate funding to operate the program must be obtained. In many States, convincing the legislature to fund such a program requires more effort and time than getting the legal authority. State legislators may be reluctant to fund such a program in one area of the State, or the legislator may not believe adequate funds are available for such a program. Time delays of a year or more may be experienced in getting necessary appropriations, which obviously would extend the start-up date of the program. If funding provisions are included in the enabling legislation, as is suggested in Chapter 3, significant delays can be avoided.

Location of Federal sources of funding (discussed earlier) may ease this problem somewhat. Although some Federal funding may be available, it is the responsibility of the State to provide the funds necessary to implement an inspection and maintenance program.

Labor Supply or Skill Shortages

The successful implementation of an inspection and maintenance program requires sufficient qualified staff to operate all phases of the program. Because of the hiring procedures used by many State and local government agencies, the hiring of competent staff to aid in implementing an inspection and maintenance program may pose problems. In many cases, finding the qualified personnel is simple, but getting them on the job may take 3 to 12 months because of local government hiring mechanisms. In a State-operated inspection program, both inspectors to actually perform the inspection and qualified staff to calibrate the equipment and verify the accuracy of the inspection results must be employed. For example, approximately 500 people must be employed to operate the State inspection and maintenance program being considered by Arizona.

In State-operated inspection programs, individuals with general skills may be hired as inspectors and trained to perform the inspections. Also under a State-operated inspection and maintenance program, the mechanics in the individual garages who perform the required maintenance will require some training in repairing or tuning engines to achieve emission reductions; the development of diagnostic skills in correcting emission deficiencies is also essential for accurate, cost effective repairs. Development of training programs for these mechanics and for the inspectors should be considered an integral part of the inspection and maintenance planning process and should be included as a necessary step in implementation of the program.

In a State-licensed inspection and maintenance program, the training of mechanics and inspectors to administer the inspection and perform necessary maintenance is equally as important as in a State-operated system. This training of mechanics may lead to a certification program for mechanics who complete a specific amount of study in the correction of automotive emission problems. Currently in Colorado, where a State-licensed system is being considered, the EPA is funding a pilot program for the training of mechanics in both diagnosing emission problems and making corrective adjustments.

In some instances, getting legislative approval and funding for training mechanics and inspectors has posed problems. It becomes apparent, however, that the lack of a trained staff could bring an inspection and maintenance program to a standstill or lead to adverse public reaction. The overall effectiveness of such a program hinges on the ability of those operating the system to complete the inspections accurately and to perform the maintenance adequately and efficiently. Therefore, training of mechanics and inspectors and timely hiring of personnel are essential in getting the inspection program underway.

Lack of Public Support Problem

Gaining public support may be one of the more difficult problems associated with implementing a motor vehicle inspection and maintenance program. In areas where the public is in favor of such a program, legislative approval is much easier to acquire. For example, the Speaker of the Arizona House of Representatives has been strongly in favor of the inspection and maintenance program for Phoenix-Tucson; he has ellicited great public support for this measure. As a result, the measure will in all likelihood gain legislative approval this year.

One of the prime reasons for the public concern stems from the fact that individuals fear being overcharged for mandatory maintenance or paying excessive fees for simple tuneup functions. To prevent these events from occurring, some States are attempting to develop detailed diagnostic techniques for use by mechanics in detecting deficiencies. For example, in Arizona an innovative diagnostic tool may be employed. If an auto fails the motor vehicle inspection, the driver may take the car to another lane where an electronic device will identify where his problem lies; the driver then goes to his garage and has the specific deficiency corrected. Other States are setting up a detailed checklist of items that may cause specific deficiencies so that diagnosis of problems can be handled more efficiently. Proper training of mechanics will also aid in avoiding unnecessary maintenance work.

As an added preventive measure, the public should have some simple means to make complaints regarding the inspection or maintenance performed at a garage. A "hot line" for making complaints or suggestions or a return card to report problems would provide the individual with a readily available means of making known to the proper agency officials his specific grievance. The New Jersey Department of Environmental Protection is considering a similar means of monitoring complaints.

Data Collection Problem

Another area of concern in establishing an inspection and maintenance program is the gathering of adequate data upon which to base a decision relative to the type of program to implement and the emission reduction to be achieved. All of the data currently available on pilot projects or research studies in this area were obtained from tests on automobiles. These data are not directly applicable to medium-duty vehicles, heavy-duty vehicles, diesels, turbines or light-duty trucks. Furthermore, most of the vehicles used in the completed studies have been pre-1970 vehicles and none have been equipped with the advanced control systems that will be a major determinant in the total mobile source pollution levels at the time that the inspection and maintenance programs are expected to be implemented.

Some areas are undertaking pilot or demonstration inspection and maintenance programs on a small scale to provide actual data for decision making relative to the type of inspection to utilize, the operation and enforcement of the program, the kind of results to expect, and the costs. Some States may be hesitant to undertake an inspection and maintenance program without much more background information than is now available. Nevertheless, States must gather what information is available and proceed with implementation in order to meet compliance dates.

One specific area where lack of data is posing a problem is in determining the rate of deterioration of the vehicle to before-maintenance emission levels. The emission reductions attributed to inspection and maintenance are those recorded immediately after the vehicle maintenance phase of such a program. If the vehicles are allowed to deteriorate to their pretuned emissions level before they are reinspected and retuned, the time-averaged emission reduction will be considerably less than those measured initially. Because definitive data on the shape and period of the deterioration curve is not available, a straight line deterioration to the pretuned condition in 1 year has been used for estimating purposes. This approach was used in Appendix N of the Requirements for Preparation, Adoption and Submittal of Implementation Plans.[1] The result of this assumption is that the time-averaged emissions reductions are half the initial reductions achieved. Actual test data will be necessary to determine what actual average deterioration rates will be.

Equipment and Facility Procurement

Procurement of emission inspection equipment may pose some problem in implementing an inspection and maintenance program because of the purchasing procedures and the lengthy procurement process employed in State and local government agencies. For example, the State of Arizona estimates it will require 12 months to procure the necessary equipment for the inspection phase of the State-owned program. Much of this time is required to process the orders for the equipment. At present, there appears to be no problem regarding the availability of an adequate supply of the necessary testing equipment from the various manufacturers.

In the case of testing facilities, a franchise inspection and maintenance system presents no problem because individual garages will be inspected and approved before being permitted to administer the inspection. No serious facility problems are anticipated in States where the emission inspection is to be completed in parallel with a State-operated inspection program. If new facilities must be purchased and constructed for the inspection and maintenance program, considerable time for acquiring sites, designing inspection stations, construction of stations, etc. must be allowed in the State's plan. This may pose a serious time delay.

Vehicle Rejection Rate

The potential for initial emission reductions as a result of an inspection and maintenance program will depend upon the accuracy of the inspection procedure and the level at which emission standards are set. The level of the emission standards determines what the inspection rejection rate will be. This rejection rate may pose problems if it is so high that a large number of vehicles fail the test. This may lead to adverse public reaction. Of course, the more stringent the emission standards and the higher the rejection rate, the greater the emission reduction allowed for this strategy will be.

One means of initially avoiding the problems of an extremely high rejection rate is to set emission standards at a fairly high level for the initial year and reduce the allowable emissions each year. In this way, the more restrictive standards would be achieved over a period of several years, but people would gradually become accustomed to the corresponding higher rejection rates.

Certification of Mechanics

If training of mechanics to correct emission deficiencies is provided by a State or local agency as part of an inspection and maintenance program, some consideration may also be given to their certification or licensing. This would provide consumers with some assurance that the mechanic has had adequate training to perform the maintenance required to pass the vehicle inspection. In a State-operated program, the mechanics doing the necessary maintenance might receive a certification or license if they either complete the training being provided or pass a qualifying test.

In a State-licensed inspection and maintenance program, State certification of the garage as having the necessary facilities and equipment to perform emission inspections and required maintenance is essential. In addition, assurance that the garage has the qualified staff to complete the inspections and perform the maintenance must be provided. Certification of the individual mechanics as being capable of performing emission repairs may be part of this assurance.

The certification or licensing of mechanics participating in inspection and maintenance programs may pose potential problems with regard to implementation and monitoring of the certification program. This would require additional work on the part of the agency operating the inspection and maintenance program. The certification might create an adverse reaction among mechanics unless training could be provided on an equal basis to all. The certification does, however, serve as a consumer protection measure and provide the operating agency with a lever to ensure that if quality maintenance work is not done, certification will be revoked. The type of certification or licensing procedure to be followed depends on the specific inspection and maintenance program under consideration.

REFERENCES FOR CHAPTER 4

1. National Emission Standards Act. Part A-Motor Vehicle Emission and Fuel Standards. Section 209-State Standards. The Clean Air Act. 42 U.S.C. 1857 et seq. December 1970.

5. MONITORING AND REPORTING REQUIREMENTS

MONITORING

Once an inspection and maintenance program has been implemented, it is essential that the program be monitored and the information reported to Federal, State, and local agencies, as appropriate. As noted in Chapter 2, emission reductions achieved through an inspection and maintenance program can range up to 15 percent for hydrocarbons and up to 12 percent for carbon monoxide, depending on the initial rejection rate and the type of program selected. It will not be possible to detect these reductions through measurements in air quality. Therefore, to determine the effectiveness of a program and the adequacy of operating and maintenance procedures, data must be collected at the inspection station. The data collected should be sufficient, at a minimum, to allow determination of the actual pass/reject rate and the amount by which emissions from the vehicle population are being reduced.

Rejection Rate

The rejection rate can be easily determined. All that is required is that the inspector be given a signal as to whether a vehicle's emissions are above or below the established emission limitation. Such a signal is normally designed into testing equipment, either through a dial indicator that shows the actual pollutant concentration measured or through a simple lighting system that is triggered when the measured concentration is either above or below the standard. Usually both such signal methods are available on testing equipment. It will be necessary to record pass/fail information for future analysis and reporting. This can easily be done at the time the inspection takes place by having the inspector (or other appropriate person) record the desired information. Figures 5-1 and 5-2 provide an example of a format for recording pertinent vehicle information. Of course, data collection forms can be designed for recording the type and amount of data desired. In Figure 5-1, the third column under the heading "Open Throttle" allows an additional emission measurement to be recorded for an engine speed higher than normal idle. This measurement provides additional data that can be used for diagnosing the cause for high emissions and requires only a small amount of time for completion.

The rejection rate can provide very useful information. It can indicate whether operating procedures at all inspection stations are consistent. Too high or too low a rejection rate can mean that a station is not following proper testing procedures, equipment is not functioning properly, vehicles tested at a particular station are above or below average emitters, or a combination of these causes. The first two causes can be corrected through proper program management; the third cause is an additional indicator itself.

If proper procedures are being followed and if the equipment is functioning as it should, then a high or low rejection rate may reflect the quality of maintenance being performed on the vehicles. This is especially true when vehicles are retested after being rejected. The adequacy of maintenance can also be determined in other ways.

If rejected vehicles are required to undergo a retest before being allowed to operate, the number of times a vehicle returns for retest will indicate that corrective maintenance is either good or poor. A vehicle owner who is required to have repeated maintenance on his vehicle will not undergo the cost and inconvenience long before complaining to the

VEHICLE EMISSION INSPECTION - IDLE TEST

VEHICLE INFORMATION

Year:______ Make:____________________ Model:____________________

No. of cylinders:______ Engine displacement: ______ cubic inches

Serial No.:___________________________

Carburetor:______-barrel or other_________________ (F. I. etc.)

Transmission: Automatic______ Manual ______ No. of shifts________

Date:_________________________ Odometer reading:__________________

EMISSION INFORMATION

Vehicle year	Subject	Idle	Open throttle
All	Engine speed, rpm	Max. Mfrs. Specs + 100	2400 ± 100
1967 and earlier	Carbon monoxide	Max. 9.0%	Max. 9.0%
	Hydrocarbons	Max. 1200 ppm	Max. 1200 ppm
1968 and later	Carbon monoxide	Max. 7.0%	Max. 7.0%
	Hydrocarbons	Max. 600 ppm	Max. 600 ppm

Figure 5-1. Example of format for recording vehicle emission information for idle test.

VEHICLE EMISSION INSPECTION - LOADED TEST

VEHICLE INFORMATION

Year:_____Make:____________________ Model:______________________

No. of cylinders:_____ Engine displacement:________cubic inches

Serial No.:_______________________

Carburetor:_____-barrel or other__________________(F.I. etc.)

Transmission: Automatic_______ Manual_______ No. of shifts__________

Date:_______________________ Odometer reading:___________________

EMISSION INFORMATION

Vehicle year	Pollutant	Idle	Low cruise	High cruise
1967 and earlier	Carbon monoxide	Max. 9.0%	Max. 5.5%	Max. 4.5%
	Hydrocarbons	Max. 1200 ppm	Max. 900 ppm	Max. 900 ppm
1968 and later	Carbon monoxide	Max. 7.0%	Max. 4.25 %	Max. 3.75%
	Hydrocarbons	Max. 600 ppm	Max. 450 ppm	Max. 450 ppm

Figure 5-2. Example of format for recording vehicle emission information for loaded-mode test.

testing officials. If a high percentage of rejected vehicles pass on the first retest, then this is an indication that corrective maintenance is being properly diagnosed and performed. Regardless of whether the indication is that maintenance is good or poor, the agency should investigate to determine the cause. If maintenance is good, the diagnosis and treatment methods used can be passed on to other maintenance facilities, incorporated into a certification program, and/or used in mechanic training programs. If the maintenance is poor, the agency will want to correct the situation, for the maintenance function is critical to the success of the inspection and maintenance program.

Emission Reduction

The emission reduction from a vehicle population is the key indicator that an inspection and maintenance program is achieving the desired result (see Figures 5-1 and 5-2 for an example method of data collection). The most accurate method of quantifying emission reductions is through surveillance using the Federal test procedure. However, adequate estimates of emission reductions can be obtained by measuring pollutant concentrations in exhaust gases using an idle-mode or loaded-mode test. An agency may wish to record, summarize, and analyze pollutant concentrations from each vehicle test. This procedure would provide the most accurate results. However, if an agency lacks sufficient manpower or data processing facilities, a portion of the vehicle population can be sampled at various intervals to provide sufficiently accurate estimates of emission reductions. Of course, the accuracy of these data will be affected by the size of the sample, by how well the sample represents the vehicle population, and by the type of emission test conducted (idle mode tests provide the least accurate results). Proper statistical procedures should be used to determine the sample size and vehicle mix (age and weight class) of the sample. New Jersey is instituting such a monitoring system for its idle inspection and maintenance program.

A surveillance team is maintained in the field to visit each inspection station once a month. During these visits, testing equipment is calibrated, and for a period of 2 hours, concentrations of carbon monoxide and hydrocarbons from a sample of from 50 to 60 vehicles are recorded. The vehicle year, make, and model, any test problems encountered, and whether a vehicle is being retested are also recorded. Data on about 2,500 vehicles are obtained for each quarter of the year. A computer program provides a distribution of pollutant concentration by vehicle age, by weight class, and by make and model. Rejection rates are also computed. Through study of these data, trends can be observed and the overall effectiveness of the program determined.

State-Operated Versus State-Licensed Programs

The above discussion of the surveillance team concept applies most appropriately to a State-operated program in which a limited number of inspection stations are located over a relatively small geographical area and in which a large volume of vehicles are tested at each station. The surveillance team concept would not be practical for a State-licensed inspection and maintenance program because there would be a low rate of inspection at a large number of stations spread over a wide geographical area. Licensed stations must be required to report rejection rates and emissions data either to the licensing agency or another appropriate agency. This requirement could be part of the licensing agreement.

Licensed facilities would normally perform maintenance as well as vehicle testing. Thus, it would be relatively easy for the "before" and "after" emission data to be collected on rejected vehicles. Some problems may be encountered in collecting these data if a majority of owners of rejected vehicles elect to have maintenance and retesting done at facilities other than where the initial test was conducted. This may occur if it becomes common knowledge that maintenance at a particular licensed station is poor.

An additional step in the monitoring system can be included to survey the testing and maintenance functions of licensed stations. This can be accomplished through direct calibration of testing equipment at the station by agency personnel at periodic intervals and through the testing of calibrated vehicles with known maladjustments as a quality check.

REPORTING

Operation of an inspection and maintenance program will involve reporting information to various levels of State and local agencies and to EPA. Development of data collection and analysis procedures and design of the information reporting mechanism should be carried out early in the program development phase to ensure that information flow both vertically and horizontally through the managing and/or participating agencies is smooth.

State and Local Agency Reporting Requirements

The State and local agency reporting requirements will vary in detail and content between States and according to the type of inspection and maintenance program implemented. As suggested by the discussion on monitoring, reporting requirements for a State-owned and -operated program would be somewhat more simplified than for a program operated through State-licensed inspection and maintenance facilities. This primarily results from the requirement to report information "internally" between and through State and local agencies who, in all probability, already have established lines of communication. In addition, there would probably be more control over agency personnel as regards collecting and analyzing data and submitting reports in a timely manner.

For licensed facilities, reporting requirements must be levied on private businesses. Thus, control over the accuracy of data collection and timely submittal would be limited. Of course, the owner of a facility whose success depended primarily on operating under a license in good standing would probably be prudent in fulfilling reporting requirements. Data reporting for inspection and maintenance programs that are incorporated with existing safety inspection programs should be less complicated if some form of reporting exists by which owners and operators are already in the habit of collecting and submitting information.

Federal Reporting Requirements

There are two separate cases in which a State and/or local agency may be required to submit data to EPA. If a State has an approved implementation plan that contains an inspection and maintenance program, emission data generated by the program, along with other emission and air quality data, must be submitted to EPA through the appropriate Regional Office (see Appendix A) in the semiannual report required by EPA regulations.[1]

If a State is required to implement, operate, and enforce an inspection and maintenance program, the State must submit vehicle emission data resulting from the program on a quarterly or semiannual basis in accordance with the promulgated reporting requirements. These data must be submitted in the format prescribed by EPA regulations,[2] which is shown here as Table 5-1. The time periods in the first column represent the quarter or semiannual period for which the data are being reported. The subregion can represent an inspection station at which data are collected, a county in which data are collected, or any other geographical area that is specifically defined. The choice of subregion selection belongs to the State or local agency. Emission data collected through operation of the inspection and

Table 5-1. INSPECTION AND MAINTENANCE EMISSION DATA

	(Specify pollutant here)	
	With control measure	Without control measure
Time period 1		
Subregion 1		
Subregion 2		
Subregion 3		
Time period 2		
Subregion 1		
Subregion 2		
Subregion 3		

maintenance program are entered in the second column opposite the appropriate time period and subregion. Vehicle emissions that would have occurred had the program not been in operation are entered in a similar manner in the third column.

States required to implement an inspection and maintenance program must submit actual per-vehicle emission data to EPA. Analysis of these data will indicate the effectiveness of the inspection and maintenance program and will also assist EPA in handling the warranty and recall provisions of the Clean Air Act.

Emission data are submitted quarterly or semiannually for that period only. At the end of a calendar year, data are summarized for all quarters or semiannual periods during which data were collected, and this summary is also submitted to EPA. Thus, at the end of a calendar year, the reporting agency will submit two reports, one covering the last quarter or semiannual period for the year, and one summary for the year.

PUBLIC ACCEPTANCE

In addition to the official reporting requirements to Federal, State and local agencies, the implementing agency should seriously consider reporting to and obtaining information from the general public. Public acceptance directly affects the degree of emission reduction that can be achieved from an inspection and maintenance program by a willingness of the public to tolerate a certain stringency in vehicle emission limitations. In addition, the life expectancy of the overall program depends on public acceptance, or the lack of it. An agency would thus be wise to devote considerable time and effort to public relations both prior to implementation of a program and throughout its operation.

Prior to implementation of an inspection and maintenance program, the news media can be used effectively to smooth the way for public participation. Points to emphasize include an explanation of why the program is needed, what the benefits will be, how the program will operate, and how much the cost to the average motorist is expected to be. Time permitting, public participation in the program during the first year should be voluntary, or at least the maintenance portion of the program should be voluntary. In this approach, public reaction, both good and bad, could be tested, and motorists prepared to some extent for mandatory participation. This preparation is especially important if there is no existing safety inspection program that has gotten the motorist in the habit of taking his vehicle in periodically to have it checked.

As mentioned previously, dissatisfaction with poor maintenance and high costs can be expected to surface through motorists' complaints. An effective procedure for soliciting and receiving such complaints, and following up with solutions to legitimate problems can greatly enhance the effectiveness of the entire program.

REFERENCES FOR CHAPTER 5

1. Title 40-Protection of Environment. Part 51-Requirements for Preparation, Adoption, and Submittal of Implementation Plans. Section 51.7. Federal Register.

2. Title 40-Protection of Environment. Part 51-Requirements for Preparation, Adoption, and Submittal of Implementation Plans, Appendix N. Federal Register. 38(110). June 8, 1973.

6. FEDERAL AND STATE PROGRAMS RELATED TO INSPECTION AND MAINTENANCE

Over the past 7 years, a variety of programs on inspection and maintenance have been sponsored by Federal and State governments, and a number of new programs have been started recently. This chapter will summarize pertinent programs, past and present.

PROGRAMS SPONSORED BY FEDERAL GOVERNMENT

In order to collect information for use by the States in establishing inspection and maintenance programs, several experimental studies have been conducted over the past 4 years. The results of these studies have been made available to the States and other interested agencies through the Federal Register, a Control Strategies document[1], the reports of the Coordinating Research Council APRAC CAPE 13-68 committee, and various contacts between EPA personnel and State and local pollution control agencies.

Task 52 Program: The purpose of this program conducted at EPA in Ypsilanti, Michigan, and Los Angeles, California, was to determine the degree of correlation between the emissions during several of the common inspection cycles and those during the 1975 Federal Test Procedure, which is considered to be the only test that is capable of predicting air quality effects from vehicle emissions. In addition, the study provided data on the cost and effectiveness of mandatory programs.

Short Cycle Study: The purpose of the Short Cycle Study was to evaluate the costs and effectiveness of idle tests and the Clayton key mode procedure. A full report of the study including a comparison of the key mode test, the idle test, and Federal Short Cycle test and the 7-mode test will be available from EPA, Air Pollution Technical Information Center, Research Triangle Park, N.C. 27711.

High Altitude Study: This study, sponsored by the EPA Region VIII Office, compares the costs and effectiveness of idle and key mode testing at high altitudes. The results of the testing, which was conducted in Denver, Colorado, are in general agreement with those obtained in other studies at low altitudes.

CAPE 13-68 Study: The primary purpose of this Coordinating Research Council Inc. study was to develop a computer model that could be used to predict the air quality effects of various inspection and maintenance procedures. In support of the computer model, experimental studies were conducted to quantify typical values of many of the parameters involved in the computation. Among the parameters studied were:

1. Effect of parameter adjustment on emissions.
2. Inspection station costs.
3. Demographic data on Los Angeles and Detroit.
4. Emission baseline data on Los Angeles and Detroit.
5. Engine parameter data on Los Angeles and Detroit.
6. Typical repair costs.
7. Parameter and emission deterioration rates.
8. Service industry diagnostic and repair effectiveness.
9. Emission measuring instruments comparison.

The results of this 3-year study are now available in a multi-volume report from CRC at Thirty Rockefeller Plaza, New York, New York 10020.

Evaluation of Post 1974 Prototypes: The purpose of this task is to obtain information on the applicability of present short cycle (e.g. steady state, idle, and key mode) test to post-1974 light-duty vehicles. Prototype versions of post-1974 light-duty vehicles will be subjected to the 1975 Federal test procedure and additional short cycle tests. Particular attention will be paid to the applicability of the cycles, instruments, and procedures to these vehicles.

PROGRAMS SPONSORED BY STATE AND MUNICIPAL GOVERNMENTS

Arizona

Two pilot emission inspection stations capable of running loaded-mode tests are being set up. One station will be in Phoenix and the other in Tucson. The State is also experimenting with an instrument for diagnosing malfunctions leading to high emissions. A State-wide inspection and maintenance program is planned.

California

The State Bureau of Automotive Repair is presently running an intensive program to certify hydrocarbon-carbon monoxide instruments for repair garages. These instruments were required for all Class A garages. The California Highway Patrol presently spot-checks vehicles, using an idle test, as part of their random sample safety inspection program. Vehicles that fail are sent to Class A garages for correction. A new State law requires a loaded-mode test and will result in an intensive development program.

The Bureau of Automotive Repair is planning to establish a pilot inspection station in Riverside County to run loaded-mode emission tests. Vehicles would be tested once a year. If a vehicle fails the test, it will be referred to a certified and licensed Class A garage for needed repair. A vehicle will not have to return for a second inspection after the repair has been made. Idle emission tests will be performed randomly by the highway patrol as part of its on-the-road safety inspection program. If a vehicle fails this test at any time, it must go back to a Class A garage for repair. California plans to first spread the program to the counties of southern California after the completion of the pilot program and then to the entire State.

Colorado

The state has conducted a program to determine the effect of altitude on emissions and at what operating conditions vehicles should be set to minimize emissions.

Illinois

The city of Chicago has set up low budget emission inspection stations and is phasing in a complete inspection and maintenance program. Little is being done as regards maintenance and repair. There is some interest in spreading the program to all of Cook County.

New Jersey

All safety inspection facilities have been performing an idle test for carbon monoxide and hydrocarbons since July 1973. Repair and retesting of rejected vehicles was voluntary. Beginning in February 1974, rejected vehicles must be repaired and retested until they pass inspection. The State has a continuing program to certify instruments for measuring hydrocarbons and carbon monoxide for use by garages and dealers. The present standards fail about 10 percent of the tested vehicles. More stringent standards will be adopted within a year. The State is developing a loaded-mode CVS test for mass emission measurement to eventually replace the idle test currently used. In the past, the State conducted extensive programs on emissions from used vehicles, studying effectiveness of short cycles and effectiveness of repair in reducing emissions.

New York

The State is operating a pilot program for upstate cities employing mobile inspection units. They collect emission data primarily in shopping centers. Several thousand vehicles have been tested so far. New York City has an active development program for trucks and buses. This is the only research program now being run on inspection and maintenance of heavy-duty vehicles.

Oregon

The State legislature appropriated $1 million for an inspection and maintenance program that will be used to set up and operate prototype inspection stations.

Washington, D.C.

The District has inspection lanes with dynamometers and analyzers for conducting loaded-mode tests. No maintenance program has as yet been established.

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APPENDIX A
ENVIRONMENTAL PROTECTION & AGENCY REGIONAL OFFICES

EPA REGION	STATES AND TERRITORIES
Region I John F. Kennedy Federal Building Boston, Massachusetts 02203	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont
Region II 26 Federal Plaza New York, New York 10007	New Jersey, New York, Puerto Rico, and Virgin Islands
Region III 6th and Walnut Streets Philadelphia, Pennsylvania 19106	Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and District of Columbia
Region IV 1421 Peachtree Street Atlanta, Georgia 30304	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee
Region V 1 North Wacker Drive Chicago, Illinois 60606	Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin
Region VI 1600 Patterson Street Dallas, Texas 75201	Arkansas, Louisiana, New Mexico Oklahoma, and Texas
Region VII 1735 Baltimore Street Kansas City, Missouri 64108	Iowa, Kansas, Missouri, and Nebraska
Region VIII 1860 Lincoln Street Denver, Colorado 80203	Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming
Region IX 100 California Street San Francisco, California 94111	American Samoa, Arizona, California, Guam, Hawaii, and Nevada
Region X 1200 Sixth Avenue Seattle, Washington 98108	Alaska, Idaho, Oregon, and Washington

APPENDIX B
GLOSSARY

1. Chassis Dynamometer - A machine equipped with two parallel rollers that 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 deceleration.

2. 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 has failed and must be adjusted or repaired to bring its emissions into compliance with the standard.

3. Heavy-Duty Vehicle - Any motor vehicle designed for highway use that has a gross vehicle weight of more than 10,000 pounds.

4. Idle Test - An emission inspection program that 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.

5. Initial Failure Rate - The percentage of vehicles rejected because of excessive emissions of a single pollutant during the first inspection cycle of an inspection and maintenance program. (If inspection is conducted on more than one pollutant, the total failure rate may be higher than the failure rates of any single pollutant).

6. Inspection and Maintenance Program - A program to reduce emissions from in-use vehicles through identifying vehicles that needs emission-control-related maintenance and requiring that such maintenance be performed.

7. 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.

8. Light-Duty Vehicle - A motor vehicle of less than 6,000 pounds gross vehicle weight designed for highway use. Further distinctions are sometimes made between light-duty automobiles and light-duty trucks such as pickup trucks.

9. Loaded-Mode Test - An emission inspection program that measures the exhaust emissions from a motor vehicle operating under simulated road load on a chassis dynamometer.

10. Mandatory Maintenance Program - A special case of an inspection and maintenance program that requires each vehicle, regardless of its emission level or mechanical condition, to have specific maintenance operations performed at specified intervals. There is no inspection phase to determine what maintenance is necessary. The appropriate maintenance is explicitly specified for each type of vehicle.

11. Medium-Duty Vehicle - Any motor vehicle designed for highway use that has a gross vehicle weight of more than 6,000 pounds and less than 10,000 pounds.

12. Parameter Inspection Program - An inspection and maintenance program in which each vehicle is subjected to a sequence of diagnostic tests that

evaluate the mechanical condition of various emission related systems or components and determine if malfunctions or maladjustments are present. Vehicles showing measurements outside acceptable tolerance ranges have failed and are required to have corrective maintenance performed.

13. Positive Crankcase Ventilation - A system designed to return blow-by gases from the crankcase of the engine to the intake manifold so that the gases are burned in the engine. Blow-by gas is an unburned fuel/air mixture that 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.

14. Rejection Rate - 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.

15. Transportation Control Measure - Any measure that is directed toward reducing emissions of air pollutants from transportation sources. Examples of measures include reducing vehicle use, changing traffic flow patterns, decreasing emissions from individual vehicles through inspection and maintenance or retrofit, and altering existing modal split patterns (e.g. getting people to use buses or carpools instead of individual cars)..

16. Transportation Control Strategy - The sum total of all transportation control measures used in an area to reduce emissions of air pollutants from transportation sources.

17. 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).

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

This document is intended to provide guidance to Federal, State, and local agencies concerned with implementing and monitoring an emissions inspection and maintenance program for motor vehicles. The guide provides a discussion of major inspection and maintenance methods, legal considerations,implementation factors, monitoring and reporting requirements, and Federal and State programs in the field.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Motor vehicles Emissions Inspection and maintenance		

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