# THE ROLE OF PERIODIC MOTOR VEHICLE INSPECTION IN AIR POLLUTION ABATEMENT

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In many areas of the United States, exhaust emissions from motor vehicles are a major contributor to air pollution. Consequently, governments at all levels are adopting measures designed to reduce emissions from both existing and new vehicles. Most of these measures attempt to reduce emissions per mile rather than the number of vehicles or the number of miles of operation. For these measures to be effective, the vehicles must meet appropriate emission standards throughout their useful life, which requires an effective program of continuing maintenance for each vehicle. This can be ensured by a system of periodic motor vehicle emission inspection. This paper develops the characteristics of such a system and the type of inspection process required. The relationship of inspection to maintenance is described. Issues raised by the prospect of mandatory inspection and maintenance are discussed and resolutions suggested.

•UNDER the impetus of the Clean Air Amendments of 1970, air pollution abatement programs are being developed. Such programs, particularly when applied to vehicles, are generally based on a strategy of reducing the emissions from each source rather than reducing the number of sources or the amount each source is used. Measures to reduce emissions have included retrofitting existing vehicles with emission-control devices, encouraging the use of gaseous fuels, and imposing emission standards on new vehicles. Experience has shown that where the devices used are essentially passive, as in positive crankcase ventilation devices, they are effective and remain effective. Unfortunately, that is not always the case for emission-control devices that have to do with the operation of the engine. When such a device is not effective, it is usually because the vehicle is malfunctioning. Any vehicle will emit more if it is malfunctioning or misadjusted than if it is operating properly. For present vehicles, malfunctions may cause increases in emissions from a few percent to several hundred percent. For the very low-emission vehicles to be produced in the latter part of this decade, rather common types of malfunctions are expected to produce increases of several thousand percent. The problem is to make emission-reduction measures effective by returning malfunctioning vehicles to proper operation.

## NATURE OF INSPECTION NEEDED

Periodic motor vehicle inspection is to be the first step in a process of returning malfunctioning or misadjusted vehicles to proper operating condition. (The second step is the performance of the necessary maintenance or repair to return such vehicles to proper operating condition.) The chief characteristics of a satisfactory inspection process are a capability to determine whether a vehicle is operating properly and to indicate the nature of the malfunction or misadjustment if it is not operating properly. In addition, the process should be simple, cheap, and rapid.

A vehicle engine and emission-control devices operate differently at different speeds and loads; they may operate properly under some conditions but not others. To ensure low emissions and correct operation requires that the vehicle be checked at a sufficient number of speeds and loads. Because correct operation is defined in terms of emis-

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sions, the emissions are the proper measure of correct operation. Fortunately, it has been shown that for light-duty vehicles [under 6,000 lb (2700 kg) gross weight], measurements taken under at most 4 different conditions of speed and load are adequate to determine whether a vehicle is operating properly. The Clayton Manufacturing Company, which has done much of the work in this area, terms these modes of operation KEY MODES (1). In developing its simple KEY MODE test cycle, which applies to light-duty vehicles, the company found that the measurement of carbon monoxide (CO) and hydrocarbons (HC) at idle and at 2 different speeds when the vehicle is operating under load on a dynamometer is adequate to determine whether the vehicle is operating properly. Although future vehicles may require measurements under more modes of operation and will also require the measurement of oxides of nitrogen ($NO_x$), the KEY MODE cycle is indicative of what will be required.

That the inspection process should indicate the nature of any malfunctions or misadjustments is not immediately obvious. It might seem that if a vehicle is not operating properly it should merely be necessary to take it to a mechanic to be fixed. However, the mechanic needs to know what to fix—a diagnosis. In theory at least, the mechanic should be able to diagnose malfunctions, but most garages do not have dynamometers for testing under load. Moreover, most vehicles continue to drive quite well despite even major malfunctions, particularly in the ignition and fuel metering systems. This makes diagnosing by road testing uncertain, even for experienced persons. Thus, if the inspection process also gives diagnostic information, maintenance and repair are greatly facilitated. In fact, because the inspection process under discussion requires operating the vehicle at enough different speeds and loads to check for proper operation, and because any increase in the level of 1 or more of the emissions above the proper level at a given speed and load indicates a certain kind of malfunction or misadjustment, the inspection process provides diagnostic information. The Clayton Manufacturing Company has systematized the presentation of the test data so that, by noting which levels of emissions are excessive and in which mode of operation, the mechanic may use a simple chart to tell where the trouble is likely to be. Then, if the indicated trouble spot or spots are repaired or adjusted by using standard procedures, the vehicle is very likely to operate properly. Of course the mechanic would use the standard tools and instruments normally available in any properly equipped garage.

The need for the inspection process to be simple, cheap, and rapid is obvious when one considers the number of motor vehicles in the United States. The kind of inspection being discussed here requires that the inspecting technician drive the car onto the dynamometer, insert a sampling probe into the tail pipe, and record (this may be done automatically) the emission levels from the instruments at idle (zero speed) and at 2 or 3 constant speeds. The sampling probe is then removed and the car driven off the dynamometer. The technician notes whether the emission levels indicate proper operation. If not, the card with the emission levels is given to the vehicle operator. The levels constitute the diagnostic information needed to effect repairs. The capital costs for the inspection facility, assuming yearly inspection, are about $2.00 per inspected vehicle, and the operating cost is about $1.05 per inspection. The time required to perform an inspection is less than 5 minutes (2). The procedure, cost, and time figures are for 1972 and earlier light-duty vehicles.

As the emission control system on new vehicles becomes more complex to meet increasingly stringent emission standards, the inspection process for these vehicles will also become more complex. It will probably be necessary to provide a port for sampling the exhaust upstream of any catalytic or thermal reactor as well as at the tail pipe. It will also be necessary to add an instrument to read the level of $NO_x$ emitted. Finally, it might be necessary to add a third speed at which measurements would be taken. Assuming that more instruments were added so that measurements would be made simultaneously at the sampling port ahead of any reactor and at the tail pipe, the additional capital cost per inspection lane would be less than twice as much. An additional speed, if required, would increase the time per test and the operating cost by no more than 25 percent. The increase in time would also reduce somewhat the number of cars per year that could be handled by an inspection lane and further increase the capital costs. However, not all inspection lanes would have to be so equipped or operated.

In summary then, the inspection would be done periodically to ascertain whether the vehicle is operating properly from an emissions standpoint. It would measure emissions directly under enough different loads and speeds to test the vehicle adequately. In cases where the vehicle overemits it would provide diagnostic information to aid a mechanic in making necessary repairs. It would be simple, cheap, and rapid.

## INTEGRATION OF INSPECTION AND MAINTENANCE

Of course merely inspecting an overemitting vehicle will not reduce its emissions. That can only be accomplished by appropriate repair or adjustment. It seems likely that it will be necessary to provide some compulsion to ensure that the maintenance is done. An easy to implement and effective form of compulsion is to require that the inspection be passed as a condition to continue operating the vehicle. Under this scheme, the owner of the vehicle would take it to be inspected any time during, say, a 2-week period before the registration date. If the vehicle passed, it could be registered. If not, it would have to be repaired and reinspected. It could not be registered without first passing the inspection.

## ISSUES RAISED BY MANDATORY INSPECTION AND MAINTENANCE

### Who would do the inspection?

The 2 common choices are for the state to set up inspection stations and operate them with state employees or for the state to license private organizations (probably garages) to perform the inspections. Proponents of state-run inspection stations cite the undesirability of having a garage with an interest in performing repairs make the inspection. Proponents of a system of licensed private inspectors point out that state inspection would require a huge public investment and a large addition to an already large staff of state employees. Both points of view are valid, but public confidence in an inspection scheme dealing with emissions seems to be the overriding factor. On balance, it seems necessary that the state should do the inspecting.

But a third possibility lies between the 2 opposing points of view. Inspecting could be assigned to a nonprofit organization. This approach has been used often in the past, notably by the federal government, to resolve just such conflicts as have arisen here. When used properly it permits tight governmental control without the need for a large bureaucracy. It may be a feasible alternative to state operation of the inspection system.

### How and where will the system get started?

An inspection system should have as large an effect on air pollution as possible, as soon as possible, so it should be started first in air quality control regions that have the worst air pollution problem.

An obvious way to proceed is to start with pilot programs in selected areas. Each program could start with as few as 5 to 10 inspection lanes and involve as few as 1 to 2 hundred thousand vehicles. These numbers are small enough to require not a large initial investment or number of people, but large enough to provide realistic experience.

The major problem in starting such pilot programs concerns the proper way to involve the automotive service industry. The standards set for passing the inspection are the key to its involvement. Initially the standards must not be too strict or the service industry will not be able to respond. Both the number of vehicles to be maintained and the nature of the malfunctions and misadjustments to be corrected are of concern. One way to handle the transition period would be to set initial standards at, say, 3 times the average emission level. That is, if an emission level for any kind of emission measured under any mode of operation exceeded 3 times the average level for the same measurement for similar vehicles, the vehicle would fail the test. Any such level is associated with a gross malfunction or misadjustment. Test programs indicate that about 10 percent of the vehicles would be affected. These are the worst emitters and would show the most improvement from maintenance and repair. Moreover, they would be the ones with the most obvious problems and would be the easiest for the service in-

dustry to repair. As the worst emitters are found and corrected the standards would tighten somewhat. As the service industry gains experience, the standards could be further tightened to cause the rejection of all vehicles that were overemitting. An approach such as this is needed both to make maximum initial impact and to allow the service industry the time and experience to prepare itself to maintain vehicles for low emissions. Once the pilot program shows that the inspection system is working, the system could be expanded in an orderly way to cover the entire control region.

Does a new-vehicle low-emission warranty obviate the need for inspection?

Even though a vehicle may be covered by a warranty for a certain mileage, it may require maintenance for malfunction or misadjustment. Such parts as the ignition system and the carburetor typically require repair and periodic maintenance well before 50,000 miles (80 000 km). The emission-control system is designed to reduce emissions from a properly operating engine. Usually it is not able to cope with the increased emissions from an improperly operating engine. The intent of the warranty is that, if the engine is operating correctly and if the emission-control system is properly maintained, the emissions will remain low for the stated mileage. This guards against designs that will not tolerate normal engine wear. The decision by the Environmental Protection Agency to permit 1 replacement of the catalytic reactor during the first 50,000 miles (80 000 km) for 1975-76 vehicles emphasizes the need for maintenance.

Are there other effective inspection procedures that do not require a dynamometer?

The key point in this issue is effectiveness. There are many measures of effectiveness including cost, cost per unit of emission reduction, and total emission reduction. All of these and others have been proposed, but to some extent miss the point of the reason for periodic motor vehicle inspection. Because the purpose of inspection and maintenance programs is to ensure that vehicles are operating properly, the criteria for inspection effectiveness should be how well it distinguishes proper from improper operation and how much diagnostic information it supplies. By these criteria, it is evident that an idle test or similar test is ineffective because some parts of the engine, such as the high-speed part of the carburetor, are not tested.

There is still the question of the effectiveness of inspection. Basically, such an inspection consists of the thorough examination of the various parts of an engine using diagnostic instruments. If the inspection is properly done, the vehicle that passes is operating correctly and has low emissions. The disadvantages are that it costs more, takes more time, and does not directly measure emissions (except possibly CO). And, it requires more skilled personnel because it is more specific to the particular make and model of vehicle. So, it is less suitable than the kind of inspection proposed.

Is a program of mandatory periodic maintenance as effective as a system of inspection and maintenance?

The idea here is that periodically all vehicles would have to undergo a mandatory "tune up." An approved procedure would be used, the work would be done by a licensed garage, and a certificate would be issued to show that the work had been done. The certificate would be required to register the vehicle. There are 2 problems with this scheme. The first is that the procedure would necessarily have to be a compromise between completeness and cost. It would be very expensive to do a complete maintenance on every vehicle. Anything much beyond a check of the ignition system, a replacement of points, condenser, and spark plugs, and an adjustment of the carburetor would result in much unneeded work. Yet this sort of limited procedure would not repair many vehicles that were seriously overemitting. The compromise would become even more unsatisfactory as the newer vehicles with more complex emission-control systems appeared.

The second problem is the difficulty in ensuring that the work is done properly. There would be an enormous possibility for fraud, perhaps with the collusion of vehicle owners. Any system that requires the public to periodically have work done, the results of which are difficult to perceive, would be extremely difficult to make effective. Compared to

an inspection system with built-in checks and balances, the mandatory maintenance scheme is ineffective and undesirable.

Does this approach place the burden of emission reduction on poor people who drive older cars?

The assumptions that only old cars emit and that they are driven mostly by poor people are invalid. The truly poor tend to be the old, the sick, the handicapped, and young children and their mothers. Such people are not the ones that do the bulk of the driving. But, there are no real alternatives to reducing emissions in the most effective way. And, the number of vehicles is so large that even then emissions will not be reduced sufficiently to meet the requirements of the clean air amendments. As for the truly poor, it is probable that they will continue to be subsidized, and, when necessary, the subsidy will cover the costs of a vehicle, including inspection and maintenance.

Should safety inspection be combined with emission inspection?

There is evidence that safety inspections are worthwhile and that the 2 kinds of inspection would reinforce each other (2, 3). A major obstacle to any inspection system is the inconvenience to the owner in periodically bringing a vehicle in for inspection. If there is to be both a safety inspection and an emission inspection, they should be done at the same time and the same place.

## SUMMARY

A system of mandatory motor vehicle inspection and maintenance should have the following characteristics:

1. The state (or a state-supervised nonprofit organization) should perform the inspection, but maintenance should be done by whomever the owner of the vehicle chooses.
2. Inspection should be tied to registration so that a vehicle would have to pass inspection to be driven.
3. The procedure should test the vehicles under a sufficient number of modes of operation (speed and load) to ensure that vehicles that pass are operating correctly. The procedure should provide diagnostic information to aid in the repair of vehicles that do not pass. The test procedure should be simple, cheap, and rapid.
4. The inspection system should start with pilot programs in selected areas with severe air pollution and be expanded as necessary.
5. If there is a system of safety inspections, it should be combined with the system of emission inspections to minimize inconvenience to vehicle owners.

A mandatory system of inspection and maintenance having these characteristics would complement and render more effective the program of automotive emission reduction that we now have. Without such a system the present program will probably not be fully effective.

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