Paper Number

Motor Vehicle Inspection and Maintenance: The Worldwide Experience

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ABSTRACT

The goal of a motor vehicle pollution control program is to reduce emissions from motor vehicles in-use to the degree reasonably necessary to achieve healthy air quality as rapidly as possible. A comprehensive strategy to achieve this goal includes four key components: increasingly stringent emissions standards for new vehicles, specifications for clean fuels, programs to assure proper maintenance of in-use vehicles, and transportation planning and demand management. These emission reduction goals should be achieved in the most cost effective manner available.

Although significant measures have been carried out in recent years to control mobile source emissions in India, there is still much to accomplish to reach acceptable levels of ambient air quality. Some of the steps carried out in recent years in Delhi, for example, include tightening of new vehicle emission standards, lowering sulphur in diesel fuel to 500 ppm, lowering benzene in gasoline to 1 percent, and shifting public transport vehicles from diesel to compressed natural gas (CNG). These have lowered particulate and other toxic emissions from vehicles and improved air quality. However, air quality levels remain well above healthy levels and additional control measures are needed. One of the most important of the remaining potential measures that could bring about significant additional emissions reductions is to upgrade the existing I/M program.

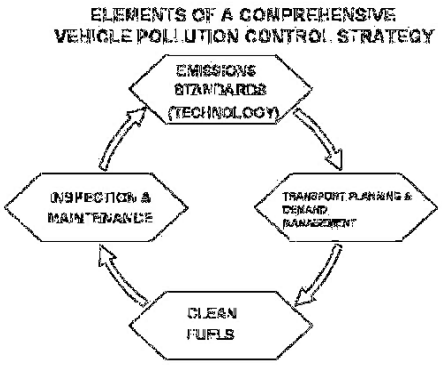
The remainder of this paper will review the role of I/M in a comprehensive motor vehicle pollution control strategy, summarize experience with a good I/M program using a couple of case studies, review and critique the current PUC program in Delhi and the steps currently underway to improve it.

INTRODUCTION

Reducing the pollution that comes from vehicles will usually require a comprehensive strategy. Generally, the goal of a motor vehicle pollution control program is to reduce emissions from motor vehicles in-use to the degree reasonably necessary to achieve healthy air quality as rapidly as possible or, failing that for reasons of impracticality, to the practical limits of effective technological, economic, and social feasibility. As illustrated below, a comprehensive strategy to achieve this goal includes four key components: increasingly stringent emissions standards for new vehicles, specifications for clean fuels, programs to assure proper maintenance of in-use vehicles, and transportation planning and demand management. These emission reduction goals should be achieved in the most cost effective manner available.

Air quality problems in developing countries are often caused or exacerbated by the emissions from the growing number of poorly maintained motor vehicles. A well designed and operated Inspection and Maintenance (I/M) program is an important element of an overall strategy to reduce vehicle emissions and air pollution.[1]

[1] Asian Development Bank, Vehicle Emission Standards and Inspection and Maintenance, 2003.



Modern vehicles remain absolutely dependent on properly functioning components to keep pollution levels low. Minor malfunctions in the air/fuel or spark management systems can increase emissions significantly. Major malfunctions can cause emissions to skyrocket. A relatively small number of vehicles with serious malfunctions frequently cause the majority of the vehicle-related pollution problem. Unfortunately, it is rarely obvious which vehicles fall into this category, as the emissions themselves may not be noticeable and emission control malfunctions do not necessarily affect vehicle drivability. Effective I/M programs, however, can identify these problem cars and assure their repair. Targeted I/M programs can contribute substantially to reduce the pollution caused by such vehicles.

Experience both in developed and developing countries has shown that it is much easier to implement a poor program than a successful one. Too often the focus is solely on the technical test procedure or the standards to be applied without realizing there are many critical elements which must be addressed in order to have an effective program. A mandatory vehicle inspection (I/M) program is not only a question of implementation of a system where in-use vehicles will be subjected to an inspection or where emission performance and/or safety aspects of the vehicle will be verified. It is a gradual implementation and enforcement of a new system where the main components are:

- Vehicle registration
- Emission requirements for new vehicles
- Emission requirements for used vehicles, including imported used vehicles
- Regulations for the technical inspection
    - Inspection program
    - Quality assurance
    - Pass/Fail criteria
    - Training of personnel
- Type of inspection (decentralized vs. decentralized)
- Ownership of the inspection stations
- Operation of the inspection stations
- Institutional arrangements

Further, as vehicle emissions control technology has advanced, an important element of the program has increasingly included a spot check (road-side inspection) of vehicles.

Vital parts of the inspection system also include ***enforcement*** of the program and ***compliance*** with the requirements.

I/M DESIGN

STRUCTURE OF THE PROGRAM - The first decision that is usually made regarding an I/M system is the fundamental structure of the program and this is often the key determinant of the overall success or failure of the effort. Several key principles have emerged from the international experience with I/M efforts which should guide policymakers in deciding on the I/M program structure. Foremost among these is that centralized I/M systems (sometimes called test only systems) where the inspection function is separated from the maintenance function have produced the best result. Decentralized systems where inspections and repairs are combined are very difficult to supervise and audit and have been found to be subject to corruption and poor quality control. Policymakers should be especially cognizant of the international experience in this regard and resist the adoption of programs that combine testing with repair and that are very unlikely to achieve significant emissions reductions.

(This issue will be discussed further below in a review of the Mexico City case study.)

Regarding the role of governments, experience has demonstrated that **governments should regulate I/M programs** but the actual implementation of I/M programs can best be carried out by the private sector. Government policymakers therefore should assure that a carefully designed and well thought out bidding document is prepared in an open and transparent manner and that all potential bidders are given a fair opportunity to compete for the final contract.

Governments contemplating the establishment of an I/M system or expanding the scope of an I/M system need to consider (a) whether they have adopted the appropriate in use vehicle emissions standards and test procedures on which to base I/M, (b) if there is the institutional capacity and willingness to enforce an I/M program, and (c) whether the repair sector has been trained sufficiently to be able to carry out the repairs on cars which fail the tests. If any of these aspects are found to be deficient, policymakers should take appropriate steps to rectify the situation.

INSTITUTIONAL –ADMINISTRATIVE SET UP - The single most important determining factor for success of I/M is support by senior decision makers and the institutional capacity to manage and regulate the system. This is often weak and as a consequence a weak regulatory framework results. Inadequate funding and weak enforcement frequently lead to a system that is plagued by corruption and poor quality control. Government policymakers should adhere to the following principles, therefore, in setting up the I/M system:

Policymakers must assure that an adequate fee structure is developed in which the affected **vehicle owners pay the full costs of the I/M program** including the costs of auditing and overseeing the program by government or private auditors.

Within countries that have a combined roadworthiness and emission-testing program, the responsibility is often shared between the Departments of Transport and Environment. Very often, there is very poor coordination between these two departments, which has hampered efforts to strengthen Inspection and Maintenance. There must be a full dialogue with all appropriate ministries or departments at the early stages of program design and full agreement must be worked out at this early stage regarding specific roles and responsibilities.

Further, in those countries where responsibility is shared between national and local government organizations coordination problems also frequently occur in the implementation of existing I/M programs as well as in the strengthening of the I/M system. In Brazil, failure to reach agreement between the State of Sao Paulo, the Municipality of Sao Paulo and the national government has delayed implementation of I/M for several years. Again policymakers should assure that there is a full dialogue with all appropriate ministries or departments at the early stages of program design and that full agreement is worked out regarding specific roles and responsibilities. In fact, in defining the structure of the I/M system, policymakers should assure that there is a careful and thorough dialogue among all relevant stakeholders. These include providers, regulators, enforcers/police, vehicle manufacturers, the driving public and media.

Any I/M system needs to account for new vehicle emissions standards, which in most cases are issued by national governments. Policymakers should strive to develop I/M systems within a national framework.

Apart from the privatization of the inspection centres, policymakers should also consider whether to outsource roadside apprehension to the private sector. They should insure that the inspection fee **fully provides for the costs of an adequate roadside apprehension program**.

Overall success in an I/M program depends in part on assuring that all vehicles that are intended to participate in the program are actually inspected and repaired if necessary. Experience from around the world has

demonstrated that the most effective I/M programs are those that are linked to registration of vehicles, i.e., failure to present proof of passing an inspection leads to denial of registration. Policymakers should therefore carefully develop and implement a registration based enforcement system for all affected vehicles.

A well functioning I/M system will include a data management system that ensures that all test data are transmitted on a regular basis to a central database. This will be easier if I/M stations are linked by computers that transmit information on a real time basis. This is much easier in a centralized system with a limited number of contractors than in the case of a decentralized system with a large number of independent workshops. In designing the program, policymakers should assure that a good data management system is included and assure that **sufficient funds** are included in the fee structure to manage and operate the system. Policymakers should also be aware that increased reliance on data management centres will make it necessary to strengthen the quality of the overall database on vehicles in actual use.

TECHNICAL ISSUES

Many I/M systems, especially those operated by the government, lack the commitment of resources or the requirement to assure that hardware is maintained and upgraded as appropriate. Also funds for calibration of equipment are often inadequate. Often, limited attention is paid to assure adequate training of staff that carries out the inspections. One remedy noted earlier which policymakers should carefully consider is privatizing such programs and adopting a fee structure which provides adequate funds.

The shift towards more stringent emission standards for new vehicles should be followed by tighter in-use standards for the newer models. The test procedure should be shifted to a “loaded test” rather than “idle test” when new vehicle standards result in the introduction of catalyst technology on vehicles. This will require new, additional test equipment including chassis dynamometers. (See example of IM240 test in discussion of the BC program below.) The costs of such equipment will make it difficult for small-scale workshops to take part in the implementation of an I/M program, which is another reason for considering a centralized system.

A potentially serious problem, especially where most vehicles still are equipped with simple carburettor technology, is the “Clean for a Day” syndrome, in which vehicles are tuned to pass the test and then immediately readjusted to a high pollution condition afterwards. To deal with this problem, policymakers must give attention to complementary in use test programs such as roadside screening or remote sensing. Also as illustrated in the Mexico City case study below, the use of more sophisticated tests will also minimize this problem.

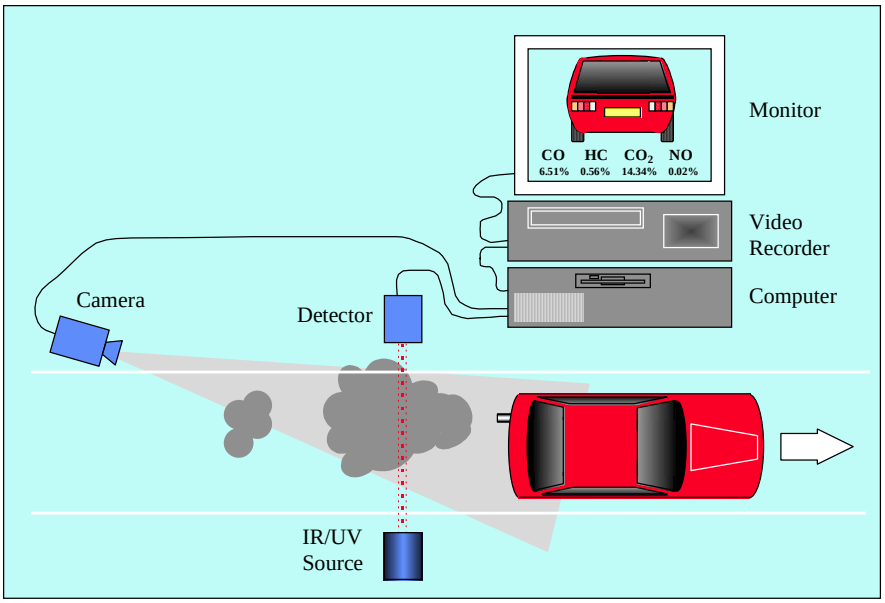
There are certain countries or cities which are leading the way with respect to testing of certain types of vehicles such as the Smoky Vehicle Control Program in Hong Kong which involves dynamometer smoke testing for light and heavy duty diesel vehicles. Policymakers should consult with the technical leaders as they develop their programs.

Emphasis in I/M should be on identification of gross polluters. Remote sensing (RSD) is evolving and may play an important role in identifying the gross polluting vehicles. (see Figure below) Currently, most experience with RSD has been with clean screening as a means to reduce the testing load although dirty screening programs are also in effect or being developed.

In designing programs, policymakers should assure that frequency of inspections varies for vehicles with differing mileage accumulation rates and with more or less durable emission control systems. For example, taxicabs which are continuously in operation throughout the day should be candidates for more frequent inspections.

PUBLIC PARTICIPATION IN I/M

Public perceptions regarding the effectiveness and transparency of I/M



systems will heavily influence the willingness of the general public to cooperate with I/M regimes imposed by the government. To ensure a positive public perception it is important that the public understand the public health need for the program and believe that it is fair and effective.

To ensure the required public acceptance of emissions related I/M programs and their participation in maintenance and inspection of vehicles I/M programs will have to considerably strengthen the public awareness-raising component of their programs. Particular emphasis should be placed on the **health benefits** that can result from a successful program.

Environmental NGOs need capacity building and often have limited understanding of vehicle emission standards and I/M issues. This limits the effectiveness of these groups in pressuring government officials to assure that **good quality** I/M programs are put in place.

Considering the above, policymakers should develop a strong and ongoing public awareness component to the program that routinely informs the public regarding the need for the program, the benefits which it is having and the overall performance. A special focus of the public awareness campaign should be on environmental NGOs who need to have their understanding and capacity upgraded. Again, policymakers must assure that sufficient funds for this effort are included in the inspection fee structure.

To assure strong public support, policymakers must develop performance standards for I/M stations that will guarantee fast and reliable testing for the public; poorly performing stations must be penalized as well.

Policymakers also need to think about methods to be employed to get a better cooperation from the public in I/M programs. Consideration should be given to tax incentives, lower registration fees for cleaner vehicles, or linkage to vehicle insurance rates. Also the experience in British Columbia, described below, shows how the I/M system can work closely with the service sector to prevent consumers from undergoing the so called ping-pong effect, bouncing back and forth between the repair facility and the inspection centre. In addition, the Mexico City experience in linking their one day without a car program to the I/M results is another positive example.

QUALITY ASSURANCE – AUDIT

I/M programs have often been associated with fraud and corruption. Failure to address these issues will seriously compromise the

credibility and effectiveness of I/M systems.[2] Governments frequently experience difficulties in setting up effective quality assurance and audit mechanisms of the I/M systems. Yet, a well functioning audit and quality assurance system is crucial for the acceptance and success of any I/M system. Audits can be implemented by a special unit in the responsible government department or can be outsourced to a private sector firm provided it is not operating a part of the I/M system.

Policymakers must assure that such auditing functions are fully built into the overall program design and **accounted for in the fee structure**. Further, in designing such auditing systems, as a general rule, it can be stated that the less reliance there is on human judgment or manual actions, the more reliable the result.

Policymakers should also assure that test fees are set at a reasonable level that will allow private sector operators to make a **sufficient profit to maintain, replace and upgrade equipment** as required.

The duties of the regulatory agency are often not well defined and the agency is usually not well staffed. Policymakers should define the duties of the regulatory agency to include design of the I/M system, setting appropriate test procedures and standards, assuring proper operation of the I/M program and careful auditing. Where audits identify problems, policymakers should insure that the regulatory agency is authorized to and has the capacity to enforce the requirements, including the removal of the license to carry out the inspection by offending operators.

A key element of a successful I/M program that is frequently neglected in the program design is how to enforce the case against corrupt entities, especially inspectors. Policymakers must give careful attention and thought to what are appropriate sanctions so as to assure that a workable system is in place.

ROADSIDE TESTING PROGRAMS

Roadside testing can complement a more comprehensive Motor Vehicle Inspection System but not replace it. Policymakers should insure that roadside testing is designed as a complement to but not an alternative to testing in fixed stations. The roadside testing should primarily have the function of identification of gross polluting vehicles.

THE "M" IN I/M

While a great deal of attention is being paid to the I in I/M, it is the M that actually reduces emissions. Very often, the quality of repairs is weak and needs special attention. Therefore, in designing I/M programs policymakers need to include a particular focus on this issue.

The service industry must have sufficient equipment to properly repair vehicles. In addition, adequate training must be made available so that the mechanics and technicians are sufficiently skilled to repair the failed vehicles that come to their shops.

In tightening the I/M requirements, policymakers must pay careful attention to assuring that the service industry has sufficient lead-time to equip itself to repair failing vehicles.

Policymakers must also insure that good lines of communication exist between the repair industry and the I/M managers so that problem vehicles can be resolved. One mechanism for resolving disputes or difficulties with individual vehicles is the introduction of referee stations, where owners can get a second opinion and advice about appropriate repairs. Policymakers should carefully consider provision of one or more referee stations in the overall design of the program.

Policy makers should also address quality assurance for spare parts.

[2] Rogers, John, Lessons on Audit Quality Assurance Mechanisms, presented at Workshop on Strengthening Vehicle Inspection & Maintenance, sponsored by Asian Development Bank, Chongqing, China, November 7-9, 2001.

With regard to the repair sector, the vehicle manufacturers can play an important role in providing training and policymakers should take steps to involve them in the development of an overall strategy to upgrade the repair industry.

INSTITUTIONAL ARRANGEMENTS

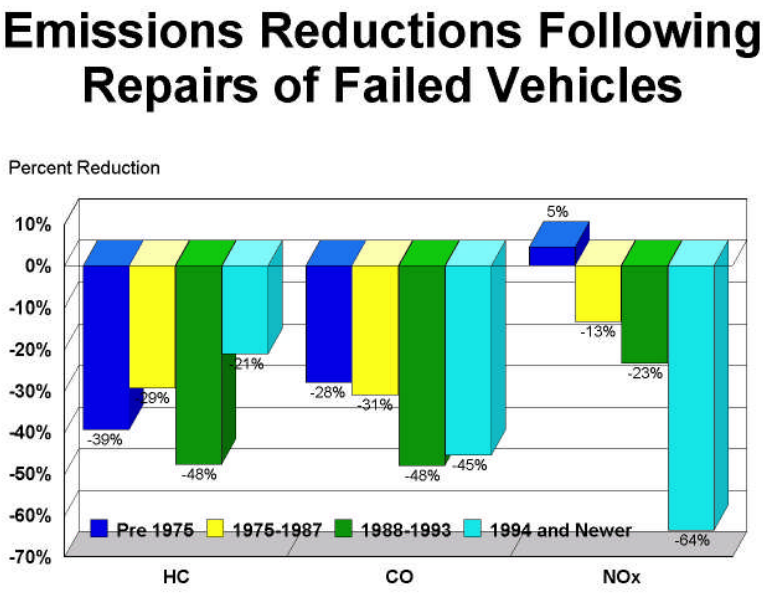
Experience show that a major obstacle for a successful implementation of an I/M program is lack of defined responsibilities. In many cases the governmental body would like, for various reasons, to have full control of the program. In such cases the concerned Ministry or agency will issue the law and the detailed regulation and in addition also be the operator of the program. With such an organization it is very difficult to achieve an optimal program; therefore such an approach is usually not recommended. The main reasons are:

- The Ministry will not have the detailed competence to cover all areas of the program
- The agency can not operate the program because it is supposed to write the detailed regulation
- There must be a body supervising the whole system, and it should not be a part of the actual testing of vehicles

AIR QUALITY BENEFITS: THE EXPERIENCE IN BRITISH COLUMBIA

It has been well established that properly designed and operated I/M programs are capable of significantly reducing emissions. For example in one evaluation of the long term benefits of the British Columbia I/M program, it was determined that over the first 8 years of the program, HC emissions were reduced by 34%, CO by 38% and NOx by 10%.[3]

In an effort to determine the mass emissions reductions from the program, a sample of 957 vehicles was tested in the laboratory before and after normal repairs. Substantial decreases in average emissions were evident in all cases but one. An increase in average NOx emissions of 4.5% was observed among the oldest vehicles. The newest vehicles on the other hand tended to show reductions in NOx.



In addition to the emissions reductions, the audit program found that fuel economy for the failed vehicles improved by approximately 5.5% for an estimated annual savings of $72 per year per vehicle.

The audit program also demonstrated that the centralized program was resulting in a very high quality test program. For example, after reviewing over 2 million tests, the auditor concluded that in only 1.1% were incorrect emissions standards applied. Not one instance was found where a vehicle was

[3] "Results and Observations Relating to the First Eight Years of Operation (1992-2000)", by Stewart, Gourley and Wong, December 2001.

given a conditional pass or waiver inappropriately. [4] About 1% of the failed vehicles were found to be receiving waivers even though their emissions are excessive, i.e., they exceed either 10% CO, 2,000 ppm HC or 4,000 ppm NOx. If the cost limits were increased such that these percentages were halved, the auditor concluded that HC and CO reductions from the program would each increase by about 5%.

Available data also indicates that many vehicles are repaired sufficiently that they remain low emitting. For example, almost 53,000 vehicles that failed the test the first year were repaired well enough to pass the following year.

Overall these data confirm that I/M programs when properly performed in a centralized facility using a loaded mode test can and do achieve a substantial reduction in emissions. Substantial fuel savings accompanies these reductions. According to the auditor, improvements to the program such as including evaporative testing, reducing or eliminating cost waivers, adding the IM240 test or tightening the standards could all increase the overall benefits significantly.[5]

AirCare regularly conducts detailed scientific reviews to assess overall program effectiveness and report on total reductions in vehicle emissions attributed to the program. The British Columbia AirCare program is considered by many to have the most in depth technical reviews in the inspection and maintenance industry. These reviews follow established scientific methodology and are fair appraisals of the program's strengths and weaknesses.

The most recent report entitled "AirCare – Results and Observations in 2001 and 2002" clearly shows that the program continues to be highly effective at reducing light-duty vehicle emissions, the single largest source of regional air pollution. Here are some of the highlights from the 2001-2002 technical review:

Inspections

- AirCare inspected 748,068 light-duty vehicles in 2001 and 778,521 in 2002
- 84% of vehicles passed initial inspection
- 16% failed initial inspection
- Of the 16% that failed the initial inspection: 70% were correctly repaired and received a full pass on the re-test, 10% were partially repaired and received a conditional pass and 20% were "retired" from the fleet

Introduction of the enhanced inspection using IM240 for 1992 and newer vehicles has had a dramatic effect on the failure rate for these vehicles. Prior to 2001, the failure rate for 1992 and newer vehicles was less than 3%. In 2002, the failure rate for 1992 and newer vehicles reached 9.6%. It is fair to conclude that this enhanced test is identifying excessively emitting vehicles that were not being identified by the previous test, the ASM.

Repairs

Reductions in vehicle emissions cannot be achieved without effective repairs.

- There are currently about 1,300 AirCare Certified Repair Technicians
- There are about 430 AirCare Certified Repair Centres
- AirCare Certified Repair facilities handle about 30% of all vehicles that fail AirCare
- The average cost to repair a failed vehicle was $343 in 2001 and $377 in 2002.

[4] If the vehicle is taken to an authorized technician and spends at least $200 on repairs, it can receive a conditional pass or waiver even if it does not meet the emissions standards.

[5] Effective January 1, 2001, the AirCare program was enhanced in several significant ways including: IM240 Testing for most 1992 and newer vehicles and biennial inspections for these vehicles.

Benefits

- In 2001 and 2002, AirCare data shows that Hydrocarbons (HC), Carbon Monoxide (CO) and Oxides of Nitrogen (NOx) were reduced by 23,208 tons.
- In its first ten years (1992-2002) the AirCare program reduced total vehicle emissions by 35% for a total reduction of 731,790 tons of HC, CO and NOx.

MEXICO CITY CASE STUDY

The vehicle inspection program in Mexico City is one of the most successful in a developing country. But it underwent many missteps and mistakes along the way which provide important lessons for others initiating or upgrading programs in the future. The program now operates well, through high-volume, test-only centres entirely in the hands of the private sector.

HOW THE SYSTEM HAS EVOLVED - All motorists, whether their vehicles are registered in the Federal District or the State of Mexico (Mexico City's two jurisdictions), have to display a sticker showing that their vehicle has passed an annual emissions test or risk a fine. The sticker also shows when the vehicle can be driven. Since 1996 Mexico City's "day without a car" program has placed restrictions on when vehicles can be operated, depending on their emission levels. Today there are four categories of emission levels, with cars in the cleanest two allowed on the road any day of the week. The emissions standards, which define pass-fail as well as the four categories, initially applied to hydrocarbons and carbon monoxide. They were progressively tightened between 1994 and 1999. The changes in the standards were aimed at removing older and more polluting vehicles from the city.

COMPARING TEST AND TEST-AND-REPAIR CENTRES - The annual inspections, made mandatory in 1988 for vehicles of a certain age, were initially conducted in test-only centres operated by the city government. But soon independent test-and-repair garages were authorized. In 1991 the government launched a program to create independent, multi-lane, test-only "macro-centres" in which some testing lanes would be equipped with dynamometers. By 1993 there were 500 test-and-repair centres and 24 macro-centres in full operation, all privately owned. The test-and-repair centres were considered to be convenient for vehicle owners. They arguably provided a one-stop solution, eliminating the "ping-pong" effect of a vehicle owner being caught between a garage arguing that it had correctly repaired and tuned a vehicle and a macro-centre reporting that the vehicle exceeded the emissions standards. As a result, most private vehicles went to the test-and- repair garages.[6]

Because the macro-centres limited their services to testing, they were far easier for the government inspectors to supervise. In addition, the concentrated ownership of these centres (they were owned by a few industrial groups specializing in emissions inspection) aided the adoption of new technology and led to more uniform results among centres. Over time the quality of testing by the test and-repair centres deteriorated. The garages soon found that they could offer lower prices if they cheated in the emissions testing. So, while the test and-repair garages were convenient for users, they had considerably less impact on emissions than the test-only centres. Indeed, as problems worsened, an estimated 50 percent of the vehicles going through the test-and-repair centres obtained their approval certificate fraudulently. The public began to see the emissions control program as highly flawed, and it came close to being shut down.

MOVING TO TEST-ONLY VERIFICENTERS - These problems led to complete restructuring of the program in January 1996. Despite the political difficulties, licenses were withdrawn from all 600 test-and-repair centres, while the number of test-only macro-centres was

[6] Vehicles that were not privately owned **had** to go to the macro-centres for the dynamometer test, which was unavailable at the test-and-repair centres.

increased from 26 to 33, for a total of 180 test lanes. The program introduced a series of stringent quality controls and technical changes in the operation of the multi-lane centres and created a new public identity for these centres-as test-only "verificenters."

Besides making technical adjustments to the testing procedures, the verificenters introduced elaborate precautions to prevent testers from giving false passes. These included "blind" test lanes where the tester could not see the test results (available only at the station exit), central computer and video monitoring of testing, and technical audits of centres by government inspectors. As a result of these actions, the share of failing tests increased substantially. In the second half of 1995-before the restructuring-the test-and-repair centres had reported a rejection rate of 5.8 percent, and the macro-centres a rejection rate of 10.3 percent. In the first half of 1996, under the new operating rules, the verificenters had a rejection rate of 22.5 percent.

FACING PERSISTENT PROBLEMS - Still, even though an estimated 73 percent of vehicles obtained correct emissions certificates in the first half of 1997, 8 percent obtained false passes because of incorrect testing practices by the verificenter, and another 19 percent received false passes because of practices by the garage that tuned the vehicle before the test. Even so, these rates of false passes compared very favourably with the rates of more than 50 percent estimated for the test-and-repair centres.

Despite the improvements in the emissions control program by 1997, several issues still needed to be addressed:

- Eliminating the test-and-repair centres caused a large bottleneck in the verificenters. This problem was particularly evident at the end of each month, when extremely long queues formed as irate vehicle owners tried to get a test during the last few days of their assigned time slot.
- The conditions specified in the testing protocol were insufficient to warm up and ignite the catalytic converter on many vehicles, preventing testers from seeing whether it was working.
- The standards were easy to circumvent by tuning late and lean. Since NOx was not being measured, there were no controls against this practice.

In addition, the testing protocol neither generated sufficiently stable or replicable test results nor produced sufficiently low levels of uncertainty to allow its use with the new, tighter standards introduced in 1996.

STRENGTHENING QUALITY CONTROL - The program solved the problem of inadequate capacity by increasing the number of verificenters to 76 and authorizing 337 test lanes. The higher number of centres provided a balance between the quality of service to users (such as waiting time) and the centres' profitability. If there were too many centres, the waiting time would be negligible, but so would the centres' return on investment. The low returns would create pressure for unethical behaviour if that could improve profitability. Indeed, some centres did modify their procedures to attract more clients-charging no fee for vehicles that failed to pass, turning a blind eye to visual inspection failures, and, in some cases, giving false passes.

When there were fewer centres, the companies had been so profitable that they were willing to police themselves to ensure that they could remain in this excellent business. With the increase in centres, the quality of service for vehicle owners increased dramatically, but so did the need for government supervision.

Two other changes probably led to higher emissions than would otherwise have been the case. First, in 1997 a requirement that vehicles registered in the Federal District be tested there was lifted, allowing the owners to choose either the State of Mexico or the Federal District for testing. In 1998 the State

of Mexico authorized additional verificenters and test lanes, many of them near the Federal District. By 1999 the two jurisdictions had a total of 154 verificenters operating 572 test lanes. But they did not share a similar determination to maintain high standards in the emissions inspection program, and many vehicle owners-particularly those with the most polluting vehicles-sought out testing centres in the State of Mexico that would issue a pass more easily. Between the first half of 1997 and the second half of 1999 an estimated 500,000 vehicles that earlier would have been tested in the Federal District were tested in the State of Mexico or not at all. The requirement was reimposed in January 2001, resulting in a significant increase in the vehicles tested in the Federal District and in the fines collected there on vehicles that had not been tested.

Second, during 1998 and 1999, in a move to reduce the public perception of corruption in the police force, traffic police were forbidden to stop vehicles because of inspection sticker violations. This became the prerogative of the ecological police, of which there were few at the time. As a result, it became possible to drive around the city without a sticker with little risk of being stopped.

To address technical problems in the testing procedures, in 1995-96 the Mexico City government had defined a new protocol-the acceleration simulation mode-and put it into effect for the second half of 1997. The changes in the testing protocol were aimed at generating more certain test results, permitting the use of tighter standards, and reducing false approvals.

During the first half of 2000 the government established NOx limits, eliminating the possibility for polluting vehicles to pass by being tuned late and lean. The limits caused too high a failure rate, however, so the government relaxed the standards by maintaining the same emission limits but slightly modifying the testing protocol.

CONCLUSIONS REGARDING MEXICO - The experience in Mexico City shows that, to be effective, a vehicle inspection and maintenance program needs several ingredients:

- A legal and regulatory framework that allows independent monitoring of the testing stations and sanctions for failure to carry out the testing protocols correctly.
- Testing protocols designed to minimize the chances of testers giving false passes.
- An easily monitored certificate for passing the test, sufficient monitors (such as traffic police) to ensure a high probability of catching vehicles without such a certificate, and a fine for lacking a certificate that is high enough to act as an incentive to pass the test.
- Testing technology capable of preventing temporary tuning that enables a vehicle to pass the test but that cannot be sustained for regular driving. In the absence of such technology, motorists and garages become adept at circumventing the purpose of the testing procedure-to identify the most polluting vehicles.
- Equally rigorous implementation of protocols and inspection of procedures at all testing centres. Otherwise, owners of the most polluting vehicles can easily identify the "softest" centres.
- The optimal number of centres relative to the volume of traffic to be tested must be found. If there are too many small centres, the tests tend to become less rigorous as each garage tries to increase market share.

One of the key aspects of any emissions testing program is the relationship between testing and enforcement. The experience in Mexico City shows that for a testing program to be effective, a number of conditions must be met:

- The testing stations should provide accurate evaluations of the emissions levels and should not issue false pass certificates ("false

passes") to vehicles exceeding the legal limits.

- A legal framework has to be established that allows sanctions to be applied for failure to carry out the testing protocols correctly. The testing stations must be subject to monitoring by independent bodies, and in cases of non-compliance, sanctions must be applied.
- The certificate for passing the test must be easy to monitor, and there should be sufficient monitors (for example, traffic police) to ensure a high probability of catching vehicles that do not display such a certificate.
- The fine for not displaying or not having a legal emissions test certificate must be high enough to act as an incentive to pass the test.
- The testing technology has to be able to prevent the use of temporary "tuning," which enables a vehicle to pass the test but cannot be sustained for regular driving. In the absence of such a technology, motorists and garages become adept at circumventing the purpose of the testing procedure, which is to identify high-polluting vehicles.
- All testing centres must be subject to equally rigorous implementation of protocols and inspection of their procedures. Otherwise, owners of the highest polluting vehicles easily identify the "softest" centres for passing the test.
- The private sector in Mexico was able to provide a competitive supply of testing centres. However, as always with such an arrangement, the government had to regulate the sector to prevent profit-seeking activities that were against the public interest (for example, supplying false pass certificates to motorists, thus saving them money but increasing pollution levels).
- The optimal number of centres, relative to the volume of traffic to be tested, has to be licensed. If there are too many small centres, the rigor of the tests tends to be watered down as each garage tries to increase market share.
- The use of garages permitted to both test and repair resulted in very poor implementation, leading to a high level of false pass certificates and, ultimately, the closure of all test-and-repair garages.

CASE STUDY OF I/M IN DELHI[7]

Technical revisions and measurements of vehicles must be done in a way that everyone is convinced that the measure is truly an objective test and there is no self-interest in carrying out these tests. It must be a high quality inspection and the equipment must be calibrated to the degree needed to ensure that the equipment is in working order. The personnel doing the inspection must be well trained and must be familiar with the reasons for the inspection. Test procedures must be appropriate for the technology being tested.

Contrast these principles with the actual experience in Delhi with the PUC programme.

Currently, there are about 400 Pollution Under Control (PUC) centres authorized by the Delhi transport department to carry out prescribed emission tests for all types of private vehicles. The locations of the PUC centres are either at the premises of gasoline filling stations or service workshops. There are no well-defined criteria for authorising or registering PUC centres. Organisational structure is not conducive to objective, high quality tests. The authority responsible for authorizing and registering PUC centres does not carry out a sufficient number of audits at the PUC centres. Further, no systematic procedure for collection of results from testing for further analyses exists.

Another major problem with the PUC centres is the maintenance and calibration of the instruments. One precondition for

[7] Erlandsson, L. and M. Walsh, Motor Vehicle Inspection in the National Capitol Area (NCR) of India: A Plan for Progress, prepared for the Centre for Science and Environment, March 7, 2003.

authorization or registration of the Centres is that the operator must have a signed contract with the manufacturer of instrument to assure regular calibration and maintenance (AMC requirement). In reality this seems to be rarely implemented or enforced.

Another and perhaps fatal drawback of this system is that only 15 – 20 % of the vehicle population comes to the PUC centres and is subjected to the PUC check. The reasons can be summarized as follows:

- Lack of enforcement
- Poor system for identifying vehicles not visiting the centres
- Imperfect system for auditing

Perhaps the most important reason of all is that there is no public confidence in the system.

Clearly the current program in Delhi is a model of how not to implement an effective program. Fortunately steps are underway to substantially upgrade both the emissions and safety inspection programs.[8]

CONCLUSIONS

Vehicles that are properly tuned and adjusted tend to be cleaner than vehicles out of tune. Modern vehicles equipped with advanced pollution controls are even more dependent on properly functioning components to keep pollution levels low. Minor malfunctions in the air/fuel or spark management systems can increase emissions significantly. Major malfunctions can cause emissions to skyrocket. A relatively small number of vehicles with serious malfunctions frequently cause the majority of the vehicle-related pollution problem. Unfortunately, it is rarely obvious which vehicles fall into this category, as the emissions themselves may not be noticeable and emission control malfunctions do not necessarily affect vehicle driveability. Effective vehicle inspection programs based on periodically subjecting vehicles to a short test can identify these problem cars and, by requiring a retest after necessary maintenance assure their repair. Targeted I/M programs can contribute substantially to reduce the pollution caused by such vehicles. Great care must be exercised in designing and implementing such programs, however, if the potential benefits are to be achieved. A careful review of the experiences in British Columbia and Mexico City shows several program elements which should be emulated if I/M is to be a success.

[8] "Approach towards development of effective in-use vehicle emission inspection for India", Balraj Bhanot, Director, The Automotive Research Association of India (ARAI), Pune, India, BAQ 2004, 6-8 December 2004.