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IMPROVEMENT OF EMISSIONS FROM MOTOR VEHICLES,

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FINAL REPORT *

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BACKGROUND

During 1984, the United Nations Industrial Development Organization (UNIDO) commissioned a study of the motor vehicle emissions problem in Hong Kong. The primary objective of the project is to evaluate the particulate emissions problem from diesel vehicles and to determine the adequacy of the existing inspection and maintenance (I/M) program in addressing it. For those shortcomings identified, it is intended to develop administrative or regulatory changes which would result in a practicable and efficient program. In addition to diesel particulate, other motor vehicle problems, if any, are to be reviewed.

During the first phase of the project, the objective was to prepare an interim report assessing the shortfall in the existing inspection and maintenance program in Hong Kong, with emphasis on the impact that pollution has on public health. An interim report which attempted to analyze the existing problems and to identify potential areas of improvement was prepared based on a review of documents provided by the Government of Hong Kong during the middle of 1984 as well as an extended visit to Hong Kong during November, 1984. This final report builds on this earlier document and includes information gained during a follow on mission during June and July, 1985.

CONCLUSIONS

1. A significant motor vehicle air pollution problem exists today in Hong Kong.

2. Smoke and particulate emissions from diesel vehicles are the primary concern.

3. These environmental problems will likely retard industrial and economic development in the future unless they are addressed.

4. The problem of motor vehicle pollution is likely to get much worse in the future.

5. The existing programs are not sufficient to solve the vehicle emissions problems. New vehicle controls are not adequate, either for diesel particulates or for the gaseous pollutants. More important, however, the controls on in-use vehicles are deficient.

6. In order to upgrade the motor vehicle control program, it is necessary to consider certain other fundamental underlying problems:

A. Organization

No agency or element of government at present has both the responsibility and authority to solve the diesel smoke problem. The net result is that no single organization is either responsible for or accountable for addressing motor vehicle pollution problems.

B. Resources

The EPA has no resources devoted solely to the motor vehicle problem. While Transport and Police do expend resources in this area, they are not specifically earmarked for pollution control. As a result, they can be easily shifted to other responsibilities as routine priorities for these Departments shift.

Specific Recommendations

1. A program element should be set up within EPA with specific full time responsibility for motor vehicle pollution control.

2. EPA should be delegated the direct responsibility for the conduct of the random roadside smoke checks which were formerly carried out (prior to September 1984) by the Royal Hong Kong Police.

3. After delegation, the EPA roadside smoke check program should be substantially modified from its present form.

4. The retest fee charged to owners for failure to pass the test should be increased to HK $400 (as previously recommended by EPCOM) to provide an incentive to maintain vehicles.

5. Staffing at EPA to institute this program should include at a minimum a Senior Environmental Protection Officer, an Environmental Protection Officer, 8 Technicians (roughly equivalent in grade to Motor Vehicle Examiners) as well as 6 clerical staff.

6. In the long run, it is recommended that the Air Pollution Control Ordinance be amended to provide the authority to call up vehicles for the purpose of checking compliance with smoke emission levels directly to EPA. At the same time, EPA in consultation with the Transport Department should be empowered to modify the test procedure and standards, as EPA deems appropriate as the vehicle population changes, as well as to set standards for new vehicles, imported used vehicles and in-use vehicles and to set appropriate fees.

7. The plan to introduce routine emission inspections for private cars 6 years old or more through an annual private system should be implemented.

8. An idle CO and HC emissions test should be included as part of the inspection for all spark ignition vehicles. After a period of time for the overall program to be phased in, it is further recommended that newer cars be included in the program.

9. The Transport Department plans to conduct taxicab smoke inspections twice yearly at a facility being constructed at Tsuen Wan should be implemented and be fully in place during 1986.

10. The Transport Department plans to include annual inspections of light buses at the Tsuen Wan facility should also be fully implemented for 1986.

11. After the program is fully implemented for a reasonable period of time further evaluation should be conducted to determine if the improvement is sufficient or whether more frequent inspections or higher retest fees or both will be needed to achieve appropriately low emissions from these high mileage vehicles

12. Starting in 1987, annual inspections should be required for light and heavy goods vehicles as part of the private inspection program.

13. Unleaded petrol should be introduced into Hong Kong as soon as practicable. This will have health advantages as well as allow a wider variety of vehicles to be used in Hong Kong.

14. For private cars, Hong Kong should adopt ECE Regulation 15-04 standards which are currently in effect in Europe, require no unleaded fuel and will lower CO, HC and NOX below currently mandated levels at very little cost.

15. Extensive air quality monitoring should be conducted over the next few years, with particular focus on NO2, ozone and fine particulates to determine if even tighter new vehicle standards should be mandated.

16. All new taxicabs starting with the 1988 model year should be required to achieve the 0.2 gram per mile particulate standard (one year later than required in the United States).

17. As soon as practicable, all new vehicles should be

designed to operate on unleaded gasoline without valve problems.

18. A demonstration project should be initiated in Hong Kong to determine the practicability of retrofitting diesel buses with particulate trap oxidizers.

19. The Hong Kong Government should attempt to foster a closer working relationship with its neighbors with a view to regional harmonization of motor vehicle pollution control. Specific consideration should be given to routine annual or semi-annual meetings between officials responsible for motor vehicle pollution control.

BACKGROUND

During 1984, the United Nations Industrial Development Organization (UNIDO) commissioned a study of the motor vehicle emissions problem in Hong Kong. The primary objective of the project is to evaluate the particulate emissions problem from diesel vehicles and to determine the adequacy of the existing inspection and maintenance (I/M) program in addressing it. For those shortcomings identified, it is intended to develop administrative or regulatory changes which would result in a practicable and efficient program. In addition to diesel particulate, other motor vehicle problems, if any, are to be reviewed.

During the first phase of the project, the objective was to prepare an interim report assessing the shortfall in the existing inspection and maintenance program in Hong Kong, with emphasis on the impact that pollution has on public health. An interim report which attempted to analyze the existing problems and to identify potential areas of improvement was prepared based on a review of documents provided by the Government of Hong Kong during the middle of 1984 as well as an extended visit to Hong Kong during November, 1984.1 This final report builds on this earlier document and includes information gained during a follow on mission during June and July, 1985.

THE PROBLEMS

1. A significant motor vehicle air pollution problem exists today in Hong Kong.

There is currently a widespread particulate problem across Hong Kong as is evidenced by monitored Total Suspended Particulate (TSP) in excess of accepted healthy levels. As noted in EPA's summary of 1983/1984 monitoring data, "Observed levels of particulate matter were relatively high at all monitoring stations."2 While many sources contribute to the Hong Kong particulate problem, based on observed roadside TSP data, ambient coefficient of haze measurements, and knowledge of diesel particulate characteristics, especially size and toxicity, motor vehicles must be considered a significant source. For example, starting with total suspended particulate which is usually primarily a stationary source problem, a twenty-eight month survey of vehicle generated air pollution conducted at 22 roadside locations in Hong Kong found overall average TSP levels ranging from 90to 1680 ug/m3. As the authors noted, "If the USEPA ambient TSP standards are used for comparison, all sites, except for Beacon Hill,indicates that...street level concentrations of TSP in Hong

Kong are high by international standards."3 Other evidence indicates that diesel vehicles are the primary motor vehicle cause. This is most apparent in the coefficient of haze (COH) data, ranging from 1.0 to 6.3. When compared to the classification system originally adopted by the New Jersey Department of Health, the levels range from moderate to extremely heavy. Statistical analysis of the data collected found "that the strongest correlation found was between COH and diesel traffic flow, which showed a correlation coefficient, 'r', of 0.50."3

Extensive data collected in the United States has shown that diesel particles average about 0.2 microns in size.4 (Since studies have also shown that very fine carbon particles are major contributors to haze3, this further supports the importance of the diesel in causing the high COH readings in Hong Kong.

In some ways, the motor vehicle problem is more hazardous than is reflected in the monitored TSP levels, since diesel particles are very small (and therefore able to penetrate to the deepest recesses of the alveolar region of the lung) and are emitted in close proximity to the actual breathing zones of people rather than from tall stacks. (Environmental concerns associated with diesel particles are summarized in Appendix A.)

Other motor vehicle related pollution problems also exist in Hong Kong - most notably NO_2, lead and non-methane hydrocarbons (NMHC), although these are not as severe as the diesel particulate problem. With regard to NO_2, the roadside survey found overall averages ranging from 14 to 181 parts per billion (ppb) with sites at Mong Kok and North Point exceeding the 1-hour Canadian acceptable range objective of 210 ppb. Although these levels are not excessive by international standards, they are a cause for concern because of the variety of problems with which NO_x is associated -direct adverse health effects, photochemical smog, acid rain. It is also important to consider the difficulty experienced in lowering NO_x levels from sources other than motor vehicles around the world. The Economic Commission for Europe (ECE) regulations have been adopted for motor vehicles but so far these only require modest reductions in NO_x emissions. Much greater reductions have been demonstrated to be feasible in Japan and the United States. (Environmental concerns associated with nitrogen oxides emissions are summarized in Appendix B.)

With regard to lead, significant progress has been made in Hong Kong - gasoline lead content was reduced from 0.84 to 0.6 grams per liter in 1981, and then to 0.4 in 1983, and to 0.25 in January 1985. Health effects studies around the world, however, continue to lower the threshold for "acceptable" lead exposure in children and adults, making even lower lead levels a prudent public policy objective. (The adverse effects associated with lead are summarized in appendix C.) In addition, the unavailability of even a single grade of unleaded gasoline prevents the use of catalyst technology to reduce CO, HC and NOx from vehicles.

NMHC concentrations in the roadside survey ranged from 3.1 to 104 parts per million (ppm). The authors accurately concluded that these levels "are quite high by world experience and when considered together with the NO2 levels ...strongly suggest that oxidant formation downwind of Hong Kong is a possibility."3 In addition, many NMHC are known or suspected human carcinogens.

Carbon monoxide measurements have generally been found quite low in Hong Kong, with the exception of the Airport arrivals road, Kai Tak. However, while this is encouraging, the data is too limited in scope of coverage to become complacent. In addition, vehicle test data indicates that a significant portion of vehicles may be excessively polluting. Specifically, a 1981 study of 100 Government vehicles found that 39% did not comply with the EEC standard of 4.5% CO at idle.5 Only three vehicles with more than 50,000 miles met the standard out of 17 tested.

2. Smoke and particulate emissions from diesel vehicles are the primary concern.

Diesel taxis accumulate very high mileage (about 50,000 miles) annually (with many of them in operation 24 hours each day) and they tend to be concentrated in the central business district where congestion of vehicles and people is greatest. Buses and goods vehicles also emit significant quantities of smoke.

Diesel smoke is composed primarily of unburned carbon particles from the fuel and usually results when there is an excess amount of fuel available for combustion. This condition is most likely to occur under high engine load conditions such as acceleration and engine lugging when the engine needs additional fuel for power. Further, a common maintenance error, failure to clean or replace a dirty air cleaner, may produce high smoke emissions because it can choke off available air to the engine resulting in a lower than optimum air-fuel mixture. Vehicle operation can also be important since smoke emissions from diesel engines are minimized by selection of the proper transmission gear to keep the engine operating at the most efficient speeds. Moderate accelerations and lower highway cruising speed changes as well as reduced speed for hill climbing also minimize smoke emissions. Conversely, overloading a diesel engine, forcing it to perform more work than the amount for which it has been designed, can significantly increase smoke emissions.

3. These environmental problems will likely retard industrial and economic development in the future unless they are addressed.

These environmental problems are not just important from the standpoint of public health but have significant potential to retard future economic development. In the first instance, particulate emissions are generated by many sources. Failure to clean up the motor vehicles will likely shift more of the burden to stationary source control, in effect necessitating tighter restrictions on stationary sources - factories and plants which create jobs. In addition, diesel emissions cause a strong negative public reaction because they are visible and they smell. It seems quite likely that the tourism industry which is such a significant ingredient of the Hong Kong economy will be adversely affected as the tourists recoil against these noxious fumes.

4. The problem of motor vehicle pollution is likely to get much worse in the future.

The population of Hong Kong has been growing dramatically and is projected to continue to do so in the future. It increased by 26% from 1971 to 1981 with an additional 19% estimated between 1981 and 1991.6 This growth will inevitably lead to increases in the number of vehicles and in the use of those vehicles. For example, the government projects the car population will grow by about 5% per year over the next decade.6 As illustrated in Figure 1, overall growth would be quite substantial under this "restrained growth" scenario.7

In view of the diesel particulate problem in Hong Kong, this should be a special concern because a relatively large proportion (approximately half) of the existing vehicle usage is from diesel fueled vehicles.8

Type	Annual Veh-Km Millions	Diesel Veh-km Millions
Motor Cycle	175.26	-
Private Car	1905.90	57.18
Taxi	1130.34	1130.34
Passenger Van	460.89	-
Public Light Bus	317.33	317.33
Lt. Goods Vehicle	207.38	-
Hvy. " "	885.57	887.57
Coach	74.22	74.22
Bus (single deck)	9.43	9.43
Bus (double deck)	181.23	181.23
total	5347.55	2657.30

Goods vehicles (which are responsible for over a third of the diesel miles at present) have been growing at a faster rate than cars over the last decade, averaging over 8 percent per year. If this rate were to continue, this segment of the population could almost double again by the end of the decade.

THE EXISTING PROGRAM TO SOLVE THE PROBLEMS

The present motor vehicle pollution control program includes five specific areas of responsibility in the Hong Kong Government:

1. Certification of imported vehicles by the Transport Department.
2. Smoke checks during routine inspections by the Transport Department.
3. Road side smoke checks by the Royal Hong Kong Police.
4. Call up of smoking vehicles by the Transport Department in response to public complaints and police reports.
5. Policy advice to all of the above by the Environmental Protection Agency.

In the Certification process, the Transport Department checks that any vehicle imported into Hong Kong complies with the emissions control requirements set out in the Road Traffic Ordinance. This Ordinance requires that all new positive ignition engines (petrol engines) comply with ECE Regulation No. 15 or its equivalent and that all imported diesel engines comply with ECE Regulation No. 24 or its equivalent. Every motor vehicle shall be constructed and maintained so that it does not emit more than 60 Hartridge Smoke Units (HSU) of smoke or its equivalent. A system has evolved whereby approximately one-half man year within the TD is devoted to assuring that imported vehicles have been type approved in the EEC. Physical checks on vehicles are generally not conducted.

Approximately 70,000 routine smoke checks are conducted by TD each year at vehicle inspection centers at Kowloon Bay (minibuses, goods vehicles), To Kwa Wan (taxis, buses), Soo Kun Po (taxis) and Lantau Island (operated twice per month). There are in total approximately 40 motor vehicle examiners devoting a small portion of their time (perhaps 1/2 hour per day) conducting these smoke checks in conjunction with more comprehensive overall vehicle inspections.

Until approximately September 1984, regular kerbside smoke checks were conducted by Royal Hong Kong Police smokemeter teams consisting of a Sergeant in charge, two or three Police Constables, and two Artisans. Two such teams operated daily on Hong Kong Island, two in Kowloon and one in the New Territories. Since September 1984, the RHKP have replaced the previous teams with a less personnel intensive system of roadside examinations. Vehicles which are issued with a fixed penalty ticket are required to be presented for examination at a later date to assure that remedial action has been taken. Since changing the system, the number of fixed penalty tickets issued has declined from about 1100 per month to approximately 50 to 70.

TD currently requires about 300 vehicles per month to be presented for inspection at Sheung Kwai Cheung in response to complaints by the public or reports by the police. For smoke emissions, staff resources include approximately one-half man year for testing (Motor Vehicle Examiner) and two clerical support staff.

Within EPA, no individual is assigned full time responsibility for motor vehicle issues. It is estimated that approximately 20% of the time of one Senior Environmental Officer is devoted to this subject area.

INADEQUACIES IN THE EXISTING PROGRAM

The existing programs are not sufficient to solve the vehicle emissions problems.

New vehicle controls are not adequate, either for diesel particulates or for the gaseous pollutants. For example, with regards to particulates, Hong Kong is no where near the state of the art. During the past several years, starting in 1980, the U.S. EPA has adopted a sequence of regulations to lower particulate emissions from cars, light trucks, heavy trucks and buses. In the case of cars and light trucks, the State of California has adopted even tighter standards. As a result, vehicle emissions rates have started to decrease significantly. Other countries are also now starting to consider adopting diesel particulate standards, including Japan and the European member states of the Common Market. In Hong Kong, there is no requirement that diesel cars and taxis meet U.S. particulate standards, even though many of the new vehicles are similar to models which comply in the U.S.In addition, a significant proportion of goods vehicles are imported into Hong Kong, second hand, after having been used extensively in Japan. These vehicles emit more pollution than new vehicles.

With regard to petrol fueled vehicles, this situation in Hong Kong is equally serious. Automobile emissions standards have gradually been adopted by countries all across the world over the last ten to fifteen years.[9] Initial controls were adopted in the United States in 1963, followed by Japan in 1966, Europe (the ECE), Canada and Sweden in 1971, the United Kingdom and Australia in 1972 and Finland in 1975. For a wide variety of reasons - differing types and degrees of air pollution problems, varying vehicle characteristics, economic conditions, etc. - the emissions control approaches differ significantly between countries.

A comprehensive review of the emissions control programs indicates wide disparities as shown below.

Pollutant Standards From Motor Vehicles
(grams per kilometer)

Country	Test	Model Year	CO	HC	NOx
United States	75FTP	'81	2.1	0.25	0.6
Japan	10/11 Mode	'78	2.7	0.39	0.48
Australia	75FTP	'86	9.3	0.93	1.9
Canada	75FTP	'88	2.1	0.25	0.6
Sweden	72FTP	'76	24	2.1	1.9
	72FTP	'88	9.3	0.93	1.2*
	75FTP	'88	2.1	0.25	0.6*

Switzerland	72FTP	'86	9.3	0.93	1.2
ECE	ECE	'88-93	6-11	1.6-3.75#.9-1.5	

*proposed
HC plus NOx

Japan and the United States are in the forefront of emissions control at the present time with all new vehicles equipped with the most advanced equipment available. While Japan started later, it moved more quickly than the United States and is actually more advanced in terms of the almost complete switch to unleaded gasoline.

Canada has the next level of control but will hortly be surpassed by Australia, Sweden and witzerland as their programs come on line over the next several years. By 1988, however, Canada will move to current U.S. levels.

Of the major industrialized areas of the world, the European Community has the least advanced emissions control program. Not only are the standards most lenient, they do not include vehicle durability testing and their test procedure inadequately represents typical driving conditions. In addition, none of the European Countries currently regulates evaporative hydrocarbons thus foregoing a relatively easy and inexpensive means of hydrocarbon control. Hong Kong is not even at the European state of the art, however, only adopting initial European standards to date. By doing so, emissions of NOx have either remained the same per mile driven or actually worsened.10

Emissions Within European Community Under Different Driving Modes

Model Year	CO g/km				HC g/km				NOx g/km			
	A	B	C	D	A	B	C	D	A	B	C	D
1968	40	22	18	16	5.0	3.0	2.3	2.0	1.5	1.6	1.9	4.5
1972	22	22	18	16	3.5	2.6	2.0	1.8	1.8	1.85	1.9	4.5
1975	18	20	18	16	3.0	2.4	2.0	1.8	1.9	1.9	1.9	4.5
1979	15	18	18	16	2.6	2.2	2.0	1.8	1.95	1.95	1.95	4.5
1982	12	16	17	16	2.2	2.0	2.0	1.8	1.7	1.8	1.9	4.5

A = congested inner city traffic
B = flowing suburb traffic
C = traffic on rural roads
D = traffic on motorways (ca. 110 km/h)

Even considering that unleaded petrol is not available in Hong Kong, thus precluding emissions standards which would require catalysts which are poisoned by lead, Hong Kong's standards are much more lenient than the above discussion shows to be both necessary and technologically feasible. (Control technologies for new diesel fueled vehicles are summarized in Appendix D while gasoline engine technologies are summarized in Appendix E.)

More important than controls on new vehicles, however, the controls on in-use vehicles are deficient. Taxis, for example, receive a routine inspection for smoke but only once per year. This is inadequate incentive to encourage good, low emissions maintenance because the vehicles accumulate in excess of 100,000 km. in a year whereas particulate emissions can increase after only 20,000 km. without proper maintenance. Therefore, taxis can spend 75 or 80% of the year in an excessively smoky condition.

In addition, the charge for failing the annual inspection is too low (HK $160) to encourage good maintenance. It is cheaper for owners to ignore maintenance costs (including loss of time on the road) and to pay this charge or an occasional fine. In fact, the charge is so low that many taxi operators appear to use the inspection as a diagnostic device i.e., rather than checking and repairing vehicles prior to the scheduled annual inspection, they will subject the vehicle to the inspection and make repairs based only on those faulty items identified.

During the year, taxis are subject to random roadside inspections but even these do not appear to provide sufficient incentive to maintain vehicles because the risk of being caught is low (and getting lower since as noted above, the Police Department program devoted to this effort was cut back in September 1984), and the fixed penalty ticket issued for failure is only HK $200.

The in use problem is even worse for goods vehicles because they are not subject to an annual inspection until they are 9 years old.11 While they are subject to the random roadside checks, the risk of being caught is minimal because police avoid the disruption associated with pulling over large bulky vehicles. Further, many trucks have odd shaped tailpipes which preclude testing by the Hartridge smokemeter without an adaptor; therefore, they are effectively exempted from the test. Because competition for business is very intense, goods vehicle operators appear willing to carry loads in excess of their vehicles design capacity; this leads to even more smoke emissions.

Private cars are currently exempted from annual inspections entirely. It is anticipated that this will change next year when a private inspection system is scheduled to be instituted.12 Private cars are not, however, major contributors to the smoke problem as only about 3 percent are diesel, and the annual distance travelled is low (about 20,000 km.).

Without inspections to assure proper maintenance, there is very little incentive to reduce smoke emissions for all but large bus fleets or other large companies which have an image to protect. In fact, for many goods vehicles and taxicabs which are run as small businesses, there appears to be a disincentive in that owners attempt to minimize all costs including routine maintenance until repairs are necessary to keep the vehicle running. While fuel costs will tend to rise without good maintenance, this is usually the responsibility of the operator who "rents" the vehicle for the shift or the day.

In order to upgrade the motor vehicle control program, it is necessary to consider certain other fundamental underlying problems:

1. Organization

No agency or element of government at present has both the responsibility and authority to solve the diesel smoke problem. The Transport Department which conducts the annual inspections of vehicles perceives its major responsibility to be safety and allocates its resources toward this end. The Police, who conduct the roadside inspections, are responsible for protecting lives and property with only minimal concern with vehicle emissions. The Environmental Protection Agency, for whom emissions control is a high priority, has no operational responsibility for motor vehicle emissions. The net result is that no single organization is either responsible for or accountable for addressing motor vehicle pollution problems.

2. Resources

The EPA has no resources devoted solely to the motor vehicle problem. While Transport and Police do expend resources in this area, they are not specifically earmarked for pollution control. As a result, they can be easily shifted to other responsibilities as routine priorities for these Departments shift. For example, as noted earlier, about 25 man years were devoted to random road checks by the Police for most of 1984 (Five teams of 5 men each); late in the year these resources were shifted and the total effort declined to about 4 or 5 man years with a dramatically scaled down program.

Discussion of Solutions and Recommendations

While there is some temptation to completely revamp the entire Hong Kong motor vehicle control program, such a step could be very disruptive and in the "real world" much less likely to actually occur. It is possible however to make relatively straightforward incremental modifications to the existing program which could result in many of the gains from a new program without nearly the degree of disruption and difficulty. This philosophy has guided the author in the development of many of the specific recommendations.

To start with, therefore, the new program should retain five specific elements:

1. Certification of imported vehicles.
2. Smoke checks during routine inspections by the Transport Department.
3. Identification of excessively smoking vehicles on the road..
4. Call up of smoking vehicles.
5. Policy advice to all of the above by the Environmental Protection Agency.

However, to make each of the above elements work better and in a more coordinated fashion, one element of the government must be assigned lead responsibility (and accountability) for the conduct of the overall program. Since responsibility for air pollution control generally is the overall mandate of the Environmental Protection Agency, this role and the resources necessary to carry it out should be assigned to the EPA.

This organization should have broad responsibility for all aspects of motor vehicle pollution control within the Hong Kong Government. This does not however mean that all elements of the existing program should be immediately transferred to EPA; on the contrary, most program elements should at least initially be left in their present organizational entity. The most notable exception to this is that EPA should be delegated the direct responsibility for the conduct of the random roadside smoke checks which were formerly carried out (prior to September 1984) by the Royal Hong Kong Police. The program should also be substantially modified from its present form. Specific details follow.

The new smoke surveillance system would consist of a small team of well trained EPA spotters routinely touring Hong Kong and identifying smoking vehicles. Vehicle license numbers will be recorded by these teams and the vehicles called in for inspection. (At the time the smoking vehicle is identified, a marker will be placed by its computer registration listing to assure that the vehicle is not re-registered until the smoke problem is corrected.) If the vehicle is not smoking when it reports for inspection, the registration marker will be removed. If excessive smoke is still observed, the vehicle will be tested with the Hartridge smoke meter; if it passes, the registration marker will be removed. If it fails, however, the owner will be required to pay a retest fee and to repair the vehicle prior to presenting it for a retest. This sequence will be continued until the vehicle passes the inspection, at which time the registration marker will be removed.

This system would have the following advantages compared to the present system:

1. surveillance would not be selective against any particular class of vehicles.
2. All vehicles identified as smoking will be required to be repaired and to pass a test before they can be re-registered
3. The visual screen of vehicles on the road rather than the reliance on instrument checks will very substantially increase the efficiency of the on-road examiners. The test with the Hartridge smokemeter takes from twenty minutes to a half-hour from the time a vehicle is pulled over until it is sent on its way (records checks, instrument calibrations, test operation, etc.) which reduces the number of tests which can be run in any given time period. A visual spotting and recording of data should take less than a minute.

Other advantages from an organizational standpoint are also apparent:

1. Since EPA will be responsible for both the spotting of the excessively smoking vehicles as well as the follow up testing it can continuously shift people back and forth so as to maintain a very low backlog in vehicle call-ups.
2. EPA staff can occasionally be used to conduct surveys (to identify the proportion of the population smoking in a given standardized location) to determine the overall program efficacy, to determine trends and priority problem areas.

While this change alone should significantly improve the effectiveness of the Hong Kong program, it should be coupled with an increased penalty for failure to pass the test. EPCOM has previously recommended that the penalty be increased to HK $400 and this should be adopted as the penalty for failure of a roadside test and the charge for re-submission of a vehicle which fails its routine inspection to provide an incentive to maintain vehicles.

Staffing at EPA to institute this program should include a Senior Environmental Protection Officer, an Environmental Protection Officer, 8 Technicians (roughly equivalent in grade to Motor Vehicle Examiners) as well as 6 clerical staff. Such a staff would not only enable EPA to fully operate the random inspection program but should provide leadership to the entire Hong Kong effort and provide an EPA input to other ongoing activities such as routine vehicle inspections. They should be able to conduct surveillance, issue call up notices to vehicle owners, conduct inspections on vehicles presented to them as well as to provide direct input to other Hong Kong programs such as new car certification and routine vehicle inspection. In addition, and most important, they should be able to provide a comprehensive overview for the entire motor vehicle pollution control effort and lead the routine improvements and modifications which will inevitably be needed.

The resources devoted to this effort would replace the approximately 25 full time positions devoted to the random roadside inspection by the Royal Hong Kong Police prior to September 1984, thereby resulting in a more effective program with somewhat less resources. In addition the Smokemeters currently used by the Police could be transferred to EPA. In addition to personnel, EPA would need a computer terminal to access the Transport Department vehicle licensing databank (at a cost of approximately HK $50,000) and several vehicles to conduct surveillance (six motorcycles costing approximately HK $70,000 and one mobile test center costing HK $300,000 should be sufficient). Space for the staff and the vehicles will also be needed as well as an area to conduct inspections on vehicles called up; as excess space appears to already be available within the Government due to previous overestimates of vehicle growth, this should not be a problem.

Legally, this program could proceed through a direct delegation to the Commissioner for Environmental Protection of the power of the Commissioner for Transport to call up vehicles for the purpose of checking compliance with smoke emission levels as provided in the Road Traffic Ordinance. In the long run, the Air Pollution Control Ordinance should be amended to provide this authority directly to EPA. (At the same time, EPA in consultation with the Transport Department should be empowered to modify the test procedure and standards, as EPA deems appropriate as the vehicle population changes, as well as to set standards for new vehicles, imported used vehicles and in-use vehicles.)

Several changes are also needed with regard to the routine vehicle inspection programs. As noted above, at the present time there are no routine emission inspections for private cars. Plans to introduce such inspections for vehicles 6 years old or more through an annual private system have been developed and this plan should be implemented. However, the current plan has several deficiencies which should gradually be improved. Specifically, at present, it is planned to conduct only smoke tests on these vehicles; since over 95% of these vehicles use spark ignition engines and since pollution from these vehicles is mainly gaseous (carbon monoxide, hydrocarbons and nitrogen oxides) rather than smoke, an idle CO and HC test should be included as well. After a period of time for the overall program to be phased in, it makes sense that newer cars be included in the program. Ultimately, the aim of the program should be to assure that all vehicles receive good maintenance from the time they are introduced to Hong Kong (thereby assuring continuous low emissions) rather than solely trying to correct the problems of poor maintenance after vehicles have been possibly polluting excessively for several years and in many cases have been passed on to second or third owners.

Beyond private cars, there is a need to upgrade the routine inspection programs for taxicabs, light and heavy goods vehicles and light buses. Taxicabs currently receive an adequate annual inspection but from an emission standpoint the frequency is not sufficient for vehicles driven so much each year. It would be ideal to conduct inspections consistent with manufacturers recommended major maintenance intervals. This does not appear very practical however as it would require testing almost every month or two for some vehicles at considerable inconvenience to owners and drivers and at considerable expense to the government. However, it is possible to double the rate of inspection to at least semi-annually without much inconvenience since taxis are currently presented for a semi-annual meter and odometer check. The Transport Department plans to conduct smoke inspections twice yearly at a facility being constructed at Tsuen Wan13 should be implemented and be fully in place during 1986. Transport Department also plans to include annual inspections of light buses at this same facility and this proposal should also be fully implemented for 1986. Directionally, it is certain that the increased frequency of inspection coupled with the more efficient roadside screening and the higher fines will improve the smoke emissions from these high mileage vehicles. After the program is fully implemented for a reasonable period of time further evaluation should be conducted to determine if the improvement is sufficient or whether more frequent inspections or higher recest fees or both will be needed to achieve healthy air quality.

Light and heavy goods vehicles are currently the most ignored segments of the in use vehicle population. While the improved EPA surveillance effort should improve this situation, it is also necessary to institute a routine inspection program for all these vehicles. Fortunately, in terms of the total vehicle population they represent only a small percentage, 22%.7 Therefore, it would not appear to be a substantial additional burden to add these vehicles to the private inspection program. Starting in 1987, annual inspections should be required for these vehicles as part of the private inspection program.

Unleaded petrol must be introduced into Hong Kong in the near future for several reasons. First, as noted earlier, evidence continues to grow that lead at virtually any level can represent a health hazard to some individuals; therefore prudence dictates that steps should be initiated to gradually eliminate its usage. Second, a growing proportion of the vehicles being manufactured around the world are being designed for unleaded fuel because they use catalytic converters. All new cars designed to be sold in Japan and the U.S. have needed unleaded fuel for several years. By January of 1986, this will start to be true for Australian cars; by 1988 for all Canadian cars (a significant percentage of which are already catalyst equipped); by the end of the decade, for many European models. With each passing year it will be increasingly true that a smaller and smaller percentage of new cars will be able to enter the Hong Kong market unless unleaded petrol is made available. Increasingly, these will also likely be the better cars in terms of performance and fuel economy as well as emissions since manufacturers will naturally expend the greatest development effort on car models designed for the largest and most profitable markets. Finally, failure to have unleaded fuel will prevent Hong Kong from adopting emissions standards which would require catalysts on a significant fraction of models. With the already serious hydrocarbon problem and the marginal, but likely growing NOx problem, this could be a source of serious concern in the future.

While there are difficulties in introducing unleaded petrol in Hong Kong, especially with retail fueling stations which currently only have one tank, these problems are not insurmountable. Of the 131 retail fueling stations in Hong Kong14, it should be possible to selectively introduce unleaded fuel in the not too distant future. The problems of octane and valve lubrication as detailed in Appendix C should not present insurmountable impediments to introduction of unleaded petrol.

With regard to new vehicle standards, significant improvement is also needed. For private cars, Hong Kong should adopt ECE Regulation 15-04 standards which are currently in effect in Europe, require no unleaded fuel and will lower CO, HC and NOX below currently mandated levels at very little cost. Extensive air quality monitoring should be conducted over the next few years, with particular focus on NO2, ozone and fine particulates to determine if even tighter standards should be mandated. With regard to diesel taxicabs, there is no fuel problem which would preclude adoption of particulate standards. Since a variety of diesel models are made available by Toyota and Nissan, the major suppliers of taxicabs to Hong Kong, for the U.S. market, there should be no difficulty in requiring that new taxicabs achieve the U.S. standard of 0.2 grams per mile. Therefore, this standard should be mandatory for all new taxicabs starting with the 1988 model year (one year later than required in the United States). Finally, as of January 1986, all new vehicles should be designed to operate on unleaded petrol without valve problems.

An additional issue is whether tighter control should be mandated for existing diesel fueled vehicles, especially trucks and buses. Such a strategy appears attractive because these vehicles have very long average lifetimes and it will be many years before the existing high polluting vehicles leave the roads. Therefore, retrofitting particulate control on these vehicles could result in very substantial long term benefits. On the other hand, many questions exist with regard to these devices -- the emission reduction potential, their durability, cost, impact on fuel consumption, etc. The best way to answer these questions appears to be to conduct a trial demonstration program by inviting potential manufacturers to provide devices and to test them on buses for a one year period. It therefore seems wise to conduct a retrofit demonstration project in Hong Kong to determine the practicability of such a strategy.

As Hong Kong moves to address its serious motor vehicle air pollution problems, it appears important to recognize the similar problems of several of its neighbors. However, several factors can make it difficult for each country individually to adequately address the problems. For example, countries such as Hong Kong, Singapore and even the People's Republic of China are relatively small new car markets. Therefore, it is difficult for each of them to dictate stringent emissions requirements to the automobile industry. Further, they also frequently import much of their fuel; again it is difficult for each individually to efficiently impose special requirements such as unleaded fuel on the petroleum industry. In addition, these countries will frequently not be in a position to support their own comprehensive new vehicle compliance programs, especially if extensive testing is involved using complex and expensive test equipment.

Many of these problems can be overcome if a regional approach is adopted to address the pollution problem. While each country individually may be a relatively small market for vehicles or fuels, in combination with neighboring countries they can wield substantially more influence. Such regional programs have advantages for each country as well as for the auto and fuel industries serving that area. Regional harmonization can allow vehicles and parts to be used interchangeably in different countries, common fuels to be prepared and distributed for larger markets and greater government efficiency in the design and implementation of compliance programs and monitoring networks.

It therefore seems desirable for the Hong Kong Government to foster a closer working relationship with its neighbors in the area of motor vehicle pollution control. Specific consideration should be given to routine annual or semi-annual meetings between officials responsible for motor vehicle pollution control.

Specific Recommendations

1. A program element should be set up within EPA with specific full time responsibility for motor vehicle pollution control.

2. EPA should be delegated the direct responsibility for the conduct of the random roadside smoke checks which were formerly carried out (prior to September 1984) by the Royal Hong Kong Police.

3. After delegation, the EPA roadside smoke check program should be substantially modified from its present form.

   The new smoke surveillance system should consist of a small team of well trained EPA spotters routinely touring Hong Kong and identifying smoking vehicles. Vehicle license numbers will be recorded by these teams and the vehicles called in for inspection. If the vehicle is not smoking when it reports for inspection, no penalty should be imposed. If excessive smoke is still observed, the vehicle will be tested with the Hartridge smoke meter; if it passes, no penalty should be imposed. If it fails, however, the owner should be required to pay a retest fee and to repair the vehicle prior to presenting it for a retest. This sequence should be continued until the vehicle passes the inspection.

4. The retest fee charged to owners for failure to pass the

test should be increased to HK $400 (as previously recommended by EPCOM) to provide an incentive to maintain vehicles.

5. Staffing at EPA to institute this program should include at a minimum a Senior Environmental Protection Officer, an Environmental Protection Officer, 8 Technicians (roughly equivalent in grade to Motor Vehicle Examiners) as well as 6 clerical staff.

> Such a staff would not only enable EPA to fully operate the random inspection program but should provide leadership to the entire Hong Kong effort and provide an EPA input to other ongoing activities such as routine vehicle inspections. They should be able to conduct surveillance, issue call up notices to vehicle owners, conduct inspections on vehicles presented to them as well as to provide direct input to other Hong Kong programs such as new car certification and routine vehicle inspection. In addition, and most important, they should be able to provide a comprehensive overview for the entire motor vehicle pollution control effort and lead the routine improvements and modifications which will inevitably be needed.

6. In the long run, it is recommended that the Air Pollution Control Ordinance be amended to provide the authority to call up vehicles for the purpose of checking compliance with smoke emission levels directly to EPA. At the same time, EPA in consultation with the Transport Department should be empowered to modify the test procedure and standards, as EPA deems appropriate as the vehicle population changes, as well as to set standards for new vehicles, imported used vehicles and in-use vehicles and to set appropriate fees.

7. The plan to introduce routine emission inspections for private cars 6 years old or more through an annual private system should be implemented.

8. An idle CO and HC emissions test should be included as part of the inspection for all spark ignition vehicles. After a period of time for the overall program to be phased in, it is further recommended that newer cars be included in the program.

9. The Transport Department plans to conduct taxicab smoke inspections twice yearly at a facility being constructed at Tsuen Wan should be implemented and be fully in place during 1986.

10. The Transport Department plans to include annual inspections of light buses at the Tsuen Wan facility

should also be fully implemented for 1986.

11. After the program is fully implemented for a reasonable period of time further evaluation should be conducted to determine if the improvement is sufficient or whether more frequent inspections or higher retest fees or both will be needed to achieve appropriately low emissions from these high mileage vehicles

12. Starting in 1987, annual inspections should be required for light and heavy goods vehicles as part of the private inspection program.

13. Unleaded petrol should be introduced into Hong Kong as soon as practicable. This will have health advantages as well as allow a wider variety of vehicles to be used in Hong Kong.

14. For private cars, Hong Kong should adopt ECE Regulation 15-04 standards which are currently in effect in Europe, require no unleaded fuel and will lower CO, HC and NOX below currently mandated levels at very little cost.

15. Extensive air quality monitoring should be conducted over the next few years, with particular focus on NO_2, ozone and fine particulates to determine if even tighter new vehicle standards should be mandated.

16. All new taxicabs starting with the 1988 model year should be required to achieve the 0.2 gram per mile particulate standard (one year later than required in the United States).

17. As soon as practicable, all new vehicles should be designed to operate on unleaded gasoline without valve problems.

18. A demonstration project should be initiated in Hong Kong to determine the practicability of retrofitting diesel buses with particulate trap oxidizers.

19. The Hong Kong Government should attempt to foster a closer working relationship with its neighbors with a view to regional harmonization of motor vehicle pollution control. Specific consideration should be given to routine annual or semi-annual meetings between officials responsible for motor vehicle pollution control.

Hong Kong Follow Up Effort

The Government of Hong Kong is well suited to follow up on the recommendations noted above. First and foremost, it has already initiated steps to institute the reorganization noted in Recommendation 1, which is the key element necessary to bring about all other items. In addition, it has already made a firm decision to institute a private safety inspection system for cars. However to fully implement all the recommendations, it will need considerable UNIDO assistance. Areas requiring the most help include the implementation of the diesel bus particulate trap retrofit demonstration. UNIDO will need to provide technical consultancy support, equipment and training funds. Each of these items will be discussed briefly below.

Technical Consultancy Support

During the past two years, a technical consultant has been provided to Hong Kong by UNIDO to review the motor vehicle pollution control program and to develop these recommendations. It will be necessary for UNIDO to provide similar services over the next two years to support the implementation phase and to assist in the development and application of new elements. Specific tasks will include the following:

1. Initial design of the retrofit demonstration project to assure that all necessary and appropriate data is collected and collected properly.
2. Periodic analysis of the data to assure that it is being collected properly and to determine if any mid-course corrections are needed.
3. Preparation of a final report at the conclusion of the retrofit study to analyze the results and draw any appropriate conclusions.
4. Brief EPCOM and other appropriate community groups as recommendations proceed to the implementation stage, to assist appropriate officials in properly communicating the reasons for the steps as well as the benefits expected.
5. Review the details of EPD's smoke testing program as it is instituted to help in smoothing out any bugs.
6. With regard to new vehicle standards, assist EPD in instituting its type approval system. As part of this effort, the consultant will review the draft regulations to institute R 15-04 for passenger cars as well as the taxicab particulate standards requirements.
7. As the private safety inspection system is implemented, the consultant will be used as a resource

to assist in the implementation of passenger car CO and HC requirements as well as goods vehicle smoke requirements.

8. As unleaded petrol becomes more necessary, the consultant can assist in defining the appropriate worldwide market situation concerning those vehicles which have traditionally been imported into Hong Kong Also he can assist in the evaluations and determinations regarding which stations will provide such fuel.

It is expected that this effort will require approximately the same level of effort as during the past two years, two man months per year. A portion of this will include two annual visits to Hong Kong of five to ten days duration each time.

Training

As the implementation stages proceed, it will be necessary to hire and promote individuals to positions of increasing responsibility with greater and greater demands on their technical and administrative expertise. Training will be a critical element of such a process. Therefore, Unido will be called upon top provide additional resources for this effort.

A detailed project description is contained as Appendix F.

References

1. "Interim Report: Hong Kong Motor Vehicle Emissions Problem", Walsh, December, 1984.

2. "Air Quality in Hong Kong, Results From The EPA Air Quality Monitoring Network 1983/84", Hong Kong Environmental Protection Agency, November 1984.

3. "A Survey of Vehicle Generated Air Pollution at Roadside Locations in Hong Kong", EPA/TM/10/84, May 1984.

4. "The Benefits and Costs of Light Duty Diesel Particulate Control", Walsh, SAE.

5. Memo from Principal Government Electrical and Mechanical Engineer to Commissioner for Environmental Protection, 6 April 1982.

6. Personal Communication, Census and Statistics Department, Permanent Comfort Building, Central.

7. Traffic and Transport Digest, August 1984.

8. Annual Vehicle Kilometrage by Type in 1982, Memo from Chief Engineer Traffic and Transport Survey Division to Environmental Protection Agency, 7 December 1983.

9. "Global Trends in Motor Vehicle Air Pollution Control", Walsh, SAE.

10. "The Influence of the Testcycle on Passenger Car NOx Control," Rijkeboer, Commission of the European Communities. July 30, 1982.

11. "Study on the Economic and Transport Aspects of the Trucking Industry in Hong Kong", prepared for Economic Services Branch Government Secretariat, July 1984.

12. "Proposed Scheme of Private Car Inspection By Authorized Car Testing Centres", 1984.

13. Personal Communication from Mr. R. J. Pole-Evans, Department of Transport, May 1985.

14. Personal communication from Mr. Webb-Peploe, November, 1984.

15. "Fuel Economy Guide 1981", Dept. of National Development and Energy, Australia.

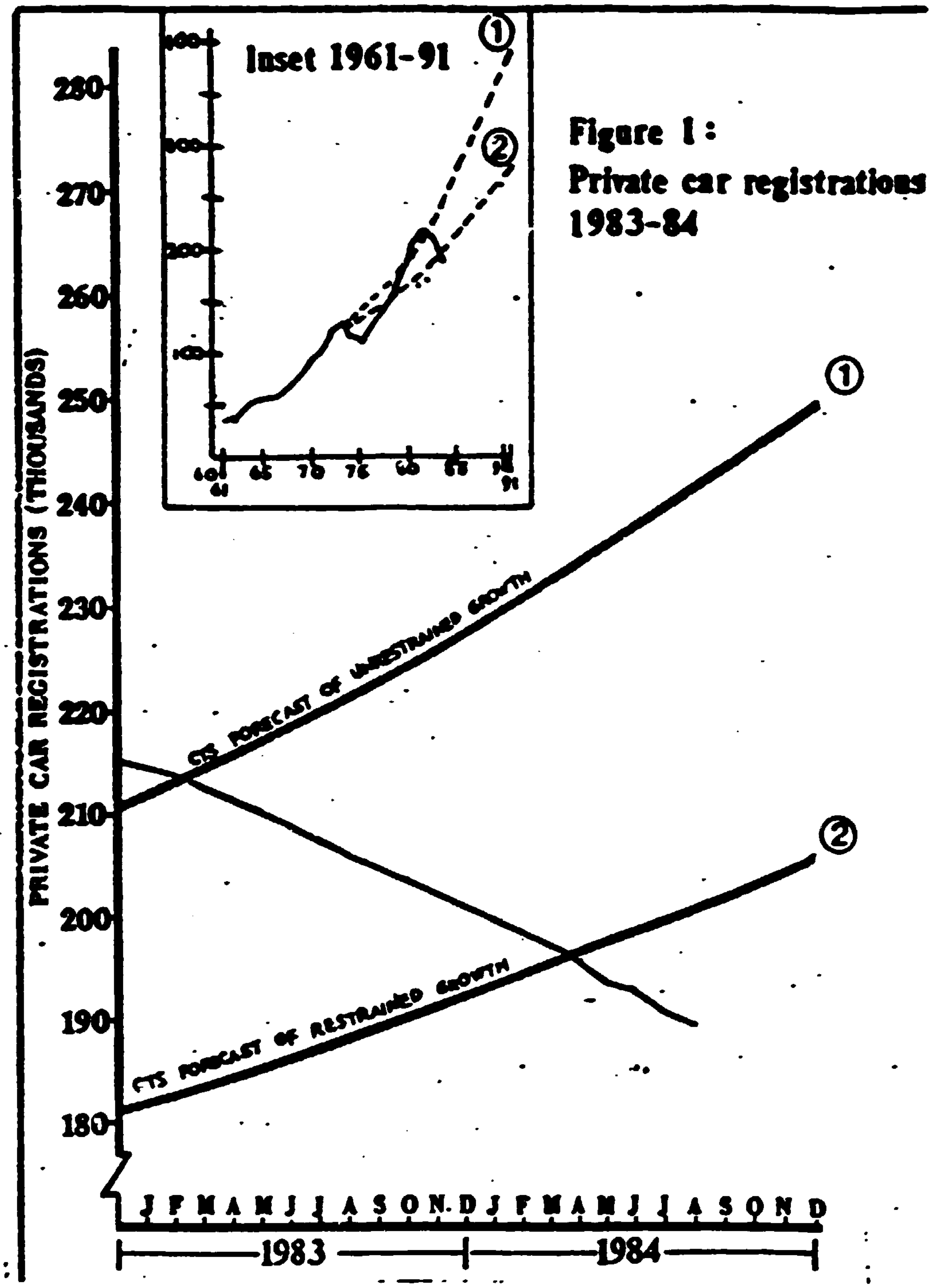

Figure 1: Private car registrations 1983-84

Appendix A
Adverse Health and Environmental Concerns
Associated with Diesel Particulate Emissions

There is currently a widespread particulate problem across Hong Kong as is evidenced by monitored Total Suspended Particulate (TSP) in excess of accepted healthy levels. Diesel fueled motor vehicles are a significant contributor to this problem. In some ways, the motor vehicle problem is more hazardous than is reflected in the monitored TSP levels, since diesel particles are very small (and therefore able to penetrate to the deepest recesses of the alveolar region of the lung) and are emitted in close proximity to the actual breathing zones of people rather than from tall stacks.

Smoke and particulate emissions from diesel vehicles are a concern because a strong correlation between suspended particulate and variations in infant mortality and total mortality rates has been established. Further, clear evidence emerges from the body of epidemiological literature that implicates particles in aggravating disease among bronchitics, asthmatics, cardiovascular patients and people with influenza.

In addition, with diesel particulate emissions especially, there are concerns about potential carcinogenicity. For example, the National Academy of Science notes that "because of their small size, (diesel particles) remain suspended in the air for a week or more and they can be inhaled and deposited in the narrowest passages of the lungs. Because of their small size, however, they offer a relatively large surface on which toxic, mutagenic, and carcinogenic compounds can be absorbed." A pilot study of U.S. railroad workers, conducted by researchers at Harvard, indicated that the risk ratio for respiratory cancer in diesel exposed subjects relative to unexposed subjects could be as great as 1.42, i.e., the possibility of developing cancer may be 42 percent greater in individuals exposed to diesels than in individuals which are not exposed. A follow up study supports the initial conclusion.

Because of their size and composition, diesel particles can also have a major, negative effect on visibility. A study conducted for the State of California, found that because diesel particles are composed largely of elemental carbon and because this "elemental carbon strongly absorbs light in addition to scattering light, fine soot particles have a light extinction efficiency of 3 to 4 times that of other fine aerosols."

Soiling is the accumulation of particulate matter on the surface of a material which arises from the impingement of these particles on the surfaces. Soiling due to particles can result in increased cleaning and painting costs for building and other materials and reduction in the useful life of fabrics. Diesel particles may be especially harmful from a soiling standpoint since the soiling of fabrics and vertical surfaces has been ascribed to fine particles, particularly dark carbonaceous materials. In addition, the National Academy of Sciences has determined that "there are grounds for believing that the oiliness of diesel particulates suspended in the atmosphere might cause a more serious soiling problem than an equal weight of particulates from other sources."

Particles affect structural materials principally by promoting and accelerating the corrosion of metals, the degradation of paints, and the deterioration of building materials such as concrete and limestone. It has been demonstrated that moist air polluted with SO_2 and particulate matter results in a more rapid corrosion rate than air polluted with SO_2 alone.

Appendix B
Adverse Health and Environmental Effects Associated With Nitrogen Oxides Emissions

As a class of compounds, the oxides of nitrogen impact adversely on a host of human health and welfare concerns. Nitrogen dioxide (NO2) has been linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics, and decreased pulmonary function. Even short term exposures to NO2 have resulted in a wide ranging group of respiratory problems in school children -- cough, runny nose and sore throat are among the most common. Asthmatics are especially sensitive to even one hour exposures. A small group of asthmatics were initially exposed to carbachol, a bronchoconstrictor representative of urban pollen, and then to NO2; adverse effects such as increased airway resistance were experienced by some of the individuals at levels as low as 0.1 parts per million (ppm) for 1 hour.

The World Health Organization concluded that a maximum 1 hour exposure of 190-320 micrograms per cubic meter (0.10-0.17 ppm) should be consistent with the protection of public health and that this exposure should not be exceeded more than once per month.

While nitrogen dioxide alone does not significantly reduce visual range, it is responsible for a portion of the brownish coloration observed in polluted air. In addition, nitrogen dioxide and particulate nitrates also contribute to pollutant haze.

Oxides of nitrogen have also been shown to affect vegetation adversely. This effect is even more pronounced when nitrogen dioxide and sulfur dioxide occur simultaneously. Further, nitrogen dioxide has been found to cause deleterious effects on a wide variety of textile dyes and fabrics, plastics and rubber.

The oxides of nitrogen also play a significant role in the formation of that family of compounds known as photochemical oxidants as well as acid deposition. These problems have not been demonstrated to be serious concerns in Hong Kong but a careful review is underway at this time. These problems have not been demonstrated to be serious concerns in Hong Kong but a careful review is underway at this time.

Appendix C
Adverse Health and Environmental Effects Associated With Lead in Gasoline

With regard to lead, significant progress has been made in Hong Kong - gasoline lead content was reduced from 0.84 to 0.6 grams per liter in 1981, and then to 0.4 in 1983, with a planned further reduction to 0.25 in January 1985. Health effects studies around the world, however, continue to lower the threshold for "acceptable" lead exposure in children, making even lower lead levels attractive.

The toxic properties of lead at high concentrations have been known since ancient times as lead has been mined and smelted for more than 40 centuries. Precautions in its use have been widespread for centuries, but it has only been recently that its adverse impacts at very low levels have been fully appreciated. There has been an explosion of knowledge during the last decade with regard to the adverse health impact of long term exposure to low levels of ambient lead.

The seminal work in this area is the 1979 report by Dr. Herbert Needleman and his colleagues which concluded that children with high levels of lead accumulated in their baby teeth experienced more behavioral problems, lower IQ's and decreased ability to concentrate.

The latest series of health studies in the U.K. tends to confirm the Needleman work. They add further evidence that low levels of lead contributes to behavioral problems, lower IQ's and decreased ability to concentrate. Even after taking up to 15 social factors into account, a 3 IQ number deficit is consistently found. While not necessarily statistically significant in any individual study (a factor which is largely influenced by the size of the sample among other factors), the body of data consistently shows the effects. It is important to note that it is not only the length and severity of exposure to lead which results in the health damage but the age at which exposure occurs. This is especially important because "Of all the persons in the community, the newborn child is the most prone to injury from overexposure to lead for several reasons, and the damage that may be caused then will have the greatest long-term social and economic consequences."

The studies of Dr. Winneke in Germany offer further evidence that "neuropsychological effects are causally related to very low blood lead levels." The effects are not necessarily the dominant ones in any particular instance but they are real, a matter of concern and preventable.

Other health concerns with lead are receiving increasing attention. For example, in the United States, the National Cancer Institute has just completed a review of metals for the selection of candidates for further study; based on this review and the potential for considerable human exposure as well as "the high suspicion of potential carcinogenic activity", it has ranked lead as a high candidate for more careful analysis.

When lead additives were first discovered to improve gasoline octane quality, they were also found to cause many problems with vehicles. Notable among these was a very significant build up of deposits in the combustion chamber and on spark plugs, which caused durability problems. To relieve these problems, lead scavengers were added to gasoline at the same time as the lead to encourage greater volatility in the lead combustion by-products so they would be exhausted from the vehicle. These scavengers continue to be used today with leaded gasoline.

Ultimately, a significant portion of these additives are emitted from vehicles. These lead scavengers, most notably ethylene dibromide, have been found to be carcinogenic in animals and have been identified as potential human carcinogens by the National Cancer Institute. In October of 1983, the U.S. EPA concluded that the harmful effects were so serious that it banned the use of this material in pesticides.

Gasoline lead affects human health through several media. First, of course is air and it is generally recognized that over 90 percent of atmospheric lead concentrations in most urban areas are associated with gasoline lead emissions. Beyond this, however, gasoline lead increases the amount of lead ingested through the digestive system. This is especially true with children who not only receive this lead through the normal food chain, but through their playing in streets and yards which are contaminated with lead. When viewed in this context it is not surprising that "both average blood lead levels and cases of lead poisoning in children correlate more strongly to gasoline lead than to lead in the air alone." Because of this close relationship, reducing the lead content of gasoline has been demonstrated to significantly reduce the health risks in urban areas in the United States. For example, based on data collected in more than 60 United States cities by the Center for Disease Control (CDC), the decline in mean blood lead levels computed by six month intervals almost parallels the amount of lead used in the production of gasoline from 1976 to 1980. This study is generally referred to as the NHANES II study.

In addition to the direct adverse health effects from lead, the unavailability of even a single grade of unleaded petrol prevents the use of catalyst technology to reduce CO, HC and NOx from vehicles. With the already serious hydrocarbon problem and the marginal, but likely growing NOx problem, this could be a source of serious concern in the future.

While there are difficulties in introducing unleaded petrol in Hong Kong, especially with retail fueling stations which currently only have one tank, these problems are not insurmountable. Of the 131 retail fueling stations in Hong Kong, it should be possible to selectively introduce unleaded fuel in the not too distant future.

However, two problems are frequently raised as potential concerns when the introduction of unleaded fuel is considered:

1. Will gasoline of sufficient octane be available to satisfy the needs of existing engines which were designed for high octane fuels?
2. Can engines designed for use with leaded gasoline operate on unleaded fuel without experiencing increased valve seat damage?

OCTANE

If lead were no longer added to the high octane (98 RON) premium gasoline currently sold in Hong Kong, an unleaded grade of about 91 RON would result. For many existing engines this octane level would be adequate. A small percentage of older cars might need to be adjusted to allow operation with lower octane gasoline. The easiest remedy is to retard spark timing, which has been demonstrated to effectively lower octane requirements. Retarded spark, however, tends to raise exhaust gas temperatures which can increase exhaust valve temperatures as well as the engine cooling requirements.

Since passenger car engines tend to have excess cooling capacity and since most are used in a moderate duty cycle (light loads, relatively low speeds), retarded spark should not cause significant problems for these vehicles. If heavy duty vehicles, on the other hand, should need adjustments, they will be less tolerant of increased temperatures because of their more strenuous duty cycle and their limited excess cooling capacity. Because virtually all heavy duty engines are satisfied by lower octane fuel, however, they should not need spark retard. This is also true for the wide variety of other engines which have been designed for leaded petrol (e.g., farm tractors, outboard motors, etc.).

A related concern to some manufacturers is that while fuel of sufficient octane will be available, valve recession could occur.

VALVE RECESSION

Valve recession describes a phenomena in which contact between the exhaust valve in an engine and the seat which it meets results in a gradual wearing away of the seat. As the valve seat wears away, the engine experiences a gradual loss of power and performance; in extreme conditions catastrophic failure of the valves can cause the engine to cease functioning. Lead reduces valve seat wear by acting as a lubricant in the interface between the valve and the seat.

Valve seat recession is closely related to engine materials and engine operating conditions. With regard to materials, "hardened" valve seats have been available and used for many years, especially in car engines. Operating conditions which foster valve seat wear are high engine speeds and loads.

Until 1970, most cars were designed for use with leaded gasoline. In 1971, GM led the way toward unleaded gasoline by instituting a policy which required all its new cars to be able to run on 91 RON unleaded gasoline. Other manufacturers followed in scattered fashion over the next few years such that many 1975 and later vehicles designed for either the U.S. or Japanese markets can run on lead free fuel. Since the fraction of cars which have been designed for leaded gasoline could continue to use higher octane leaded fuel, and these older vehicles would tend to be operated in a moderate duty cycle, it is not anticipated that there would be a significant national problem of valve recession with cars if unleaded gasoline were phased into Hong Kong. A recent U.S. EPA study, The EPA Cost-Benefit Analysis of Lead, shows that most fleet evaluations with cars showed no valve problems, even at a time when substantial portions of the population "required" leaded fuel. Only under artificially severe, laboratory conditions was there evidence of significant valve recession.

Since a ready supply of vehicles already exists in Hong Kong which could satisfactorily use low octane unleaded fuel, at least 15% of the existing cars, and that proportion should continue to grow yearly, it is recommended that unleaded petrol should be introduced into Hong Kong as soon as it is practicable.

Appendix D
Emission Control Technologies: Diesel Fueled Vehicles

The greater use of diesel equipped vehicles for private cars and all categories of commercial vehicles is the major trend observed worldwide over the last decade in the motor vehicle field. While the energy advantages of the diesel are unquestioned, concerns began to grow during the 1970's over the environmental consequences of increased dieselization. Although inherently cleaner than gasoline engines from the standpoint of carbon monoxide (CO) and evaporative hydrocarbons (HC), diesels produce more aldehydes, sulfur oxides (because of the higher sulfur content in diesel fuel than in gasoline) and nitrogen oxides. Offensive smoke and odor emissions are also a problem. Most importantly, however, uncontrolled diesels emit approximately 30 to 70 times more particulate than current gasoline-fueled engines equipped with catalytic converters.

Smoke and Particulate

Smoke is composed primarily of unburned carbon particles from the fuel and usually results when there is an excess amount of fuel available for combustion. This condition is most likely to occur under high engine load conditions such as acceleration and engine lugging when the engine needs additional fuel for power. Further, a common maintenance error, failure to clean or replace a dirty air cleaner, may produce high smoke emissions because it can choke off available air to the engine resulting in a lower than optimum air-fuel mixture. Vehicle operation can also be important since smoke emissions from diesel engines are minimized by selection of the proper transmission gear to keep the engine operating at the most efficient speeds. Moderate accelerations and lower highway cruising speed changes as well as reduced speed for hill climbing also minimize smoke emissions.

Two major approaches exist for meeting tight diesel particulate standards: engine modifications to lower engine out emission levels, and trap-oxidizers and their associated regeneration systems. Engine modifications include changes in combustion chamber design, fuel injection timing and spray pattern, turbocharging, and the use of exhaust gas recirculation. Using these techniques, average particulate emissions from light duty vehicles in the United States have been reduced from a mean of approximately 0.6 grams per mile in 1980 to about 0.3 grams per mile (based on U.S. certification data). These reductions are even more remarkable in that they occurred simultaneously with a lowering of NOx emissions levels from 2.0 grams per mile to under 1.5 grams per mile. This is significant because there is a trade off between certain NOx control techniques and particulate controls. Further particulate controls appear possible through greater use of electronically controlled fuel injection which is currently under rapid development. Using such a system, signals proportional to fuel rate and piston advance position are measured by sensors and are electronically processed by the electronic control system to determine the optimum fuel rate and timing.

Exhaust aftertreatment methods include traps, trap oxidizers, and catalysts. Trap oxidizer prototype systems have shown themselves capable of 70 to 90 percent reductions from engine out particulate emissions rates and with proper regeneration the ability to achieve these rates for high mileage. A very recent and comprehensive review concluded that three types of trap oxidizer systems show promise for commercial development:

* ceramic monolith trap/burner regeneration system
* catalyzed wire mesh trap/regeneration by HC and CO enrichment of exhaust, and
* ceramic monolith trap/self regeneration by means of fuel additives.

Prototypes of these systems have been successfully tested for extended periods on light duty vehicles and the first commercial system has now been introduced in the U.S..

NOx Control Techniques

Exhaust gas recirculation (EGR) is the principal technology used at present to reduce NOx emissions. EGR reduces combustion temperatures and thereby NOx emissions. In the short term, use of first generation systems which employ constant EGR, can also lead to increased particulate emissions. Concerns have also been raised regarding increased engine wear. However, in the longer term, electronically modulated EGR systems combined with careful control of fuel injection timing should minimize or even eliminate any trade-offs.

NOx control techniques likely to be available in the near future include variable injection timing and pressure, charge cooling, and possibly exhaust gas recirculation. Retarding injection timing, while a well known method of reducing NOx formation, can lead to increases in fuel consumption, particulate and hydrocarbon emissions. These problems can be mitigated by varying the injection timing with engine load or speed. Also, high pressure injection can reduce these problems. If coupled with electronic controls, it appears that NOx emissions could be reduced significantly with a simultaneous improvement in fuel economy.

Appendix E
Emission Control Technologies - Gasoline Fueled Vehicles

Before controls were required, engine crankcases were vented directly to the atmosphere Crankcase emissions controls which basically consist of closing the crankcase vent port were introduced on new cars in the early 1960's with the result that today, control of these emissions is no longer considered a serious technical concern.

The hydrocarbon evaporative emissions result from distillation of fuel in the carburetor float bowl and evaporation of fuel in the gas tank. To control these emissions, manufacturers generally feed these emissions back into the engine to be burned along with the other fuel. When the engine is not in operation, vapors are stored, either in the engine crankcase or in charcoal canisters which have a strong affinity for these emissions and then burned off when the engine is started.

By far the most difficult emission problems are those related to vehicle exhaust. Fortunately, great progress has been made during the last decade in the development of control technologies which are capable of dramatic reductions in the exhaust pollutants. The following section reviews briefly the combustion factors which most influence emissions rates, the critical design variables which can be modified to reduce emissions and, finally, the technologies available for addressing the above problems.

Combustion and Emissions

Emissions of hydrocarbons, thousands of different chemical compounds, are largely the result of incomplete combustion of the fuel. The amounts emitted are related to the air/fuel mixture inducted, the peak temperatures and pressures in each cylinder, whether lead is added to the gasoline, and such hard to define factors as combustion chamber geometry.

The oxides of nitrogen are generally formed during conditions of high temperature and pressure and excess air (to supply oxygen). Peak temperatures and pressures are affected by a number of engine design and operating variables and, accordingly, so are the concentrations of nitrogen oxides in the exhaust.

Carbon monoxide results from incomplete combustion of the carbon contained in the fuel and its concentration is generally governed by complex stoichiometry and equilibrium considerations. The only major engine design or operating variable which seems to affect its concentration is the air/fuel mixture; the leaner the mixture or the more air per quantity of fuel, the lower the carbon monoxide emission rate.

Finally, lead compounds (and their associated scavengers) are exhausted by an automobile almost directly in proportion to the amounts which are fed into the vehicle.

Engine Modifications

Certain key engine design variables are capable of causing significant increases or decreases in emissions. Most notable among these are air/fuel ratio and mixture preparation, ignition timing, and combustion chamber design and compression ratio,.

Air/Fuel Ratio and Mixture Preparation

Air/fuel ratio has a major effect on all three pollutants from gasoline engines. In fact, CO emissions are almost totally dependent on air/fuel ratio whereas HC and NOx emissions rates can be strongly influenced depending on other engine design parameters. CO emissions can be dramatically reduced by increasing air/fuel ratio to the lean side of stoichiometric. HC emissions can also be reduced significantly until flame speed becomes so slow that pockets of unburned fuel are exhausted before full combustion occurs or in the extreme misfire occurs. Conversely, NOx emissions increase as air/fuel mixtures are enleaned up to the point of maximum or peak thermal efficiency; beyond this point, further enleanment can result in lower NOx emission rates.

Ignition Timing

Ignition timing is the second most important engine control variable affecting "engine out" HC and NOx from modern engines. When timing is optimized for fuel economy and performance, HC and NOx emissions are also relatively high (actual values depending of course on other engine design variables). As ignition timing is delayed (retarded), peak combustion temperatures tend to be reduced thereby lowering NOx and peak thermal efficiency. By encouraging combustion to continue after the exhaust port is opened, thereby resulting in higher exhaust temperatures, oxidation of unburned hydrocarbons is greater and overall hydrocarbon emissions reduced.

Compression Ratio and Combustion Chamber Design

According to the fundamental laws of thermodynamics increases in compression ratio lead to improved thermal efficiency and concomitantly increased specific power and reduced specific fuel consumption. In actual applications, compression ratio increases tend to be limited by available fuel octane quality; over time, a balance has been struck between increased fuel octane values (through refining modifications and fuel modifications such as the addition of tetraethyl lead to gasoline) and higher vehicle compression ratios.

Compression ratios can be linked to combustion chamber shapes and in combination can have a significant impact on emissions. Higher surface to volume ratios will increase the available quench zone and lead to higher hydrocarbon emissions; conversely, more compact shapes such as the hemispherical or bent roof types reduce heat loss thus increasing maximum temperatures which tends to increase the formation of NOx while reducing HC. Further, combustion chamber material and size and spark plug location can impact emissions. In general, because of its higher thermal conductivity, aluminum engine heads lead to lower combustion temperatures and therefore lower NOx rates but at the expense of increased HC emissions. Since the length of the flame path has a strong influence on engine detonation and therefore fuel octane requirement, larger combustion chambers which can lower HC emissions tend to be used only with lower compression ratios.

Intake Charge Dilution by Exhaust Gas Recirculation

Dilution of the incoming charge has been shown to reduce peak cycle temperature by slowing flame speed and absorbing some heat of combustion. Recirculating a portion of the exhaust gas back into the incoming air/fuel mixture (EGR) thereby lowering peak cycle temperature has therefore become frequently used as a technique for lowering NOx.

Charge dilution of homogeneous charge engines by excess air and by exhaust gas recirculation has been used for many years. They have been used separately and together. The use of excess air alone seems limited to relatively small NOx reductions, on the order of 35-40%; when EGR is incorporated, substantially higher NOx reductions have been demonstrated. Excessive dilution can result in increased HC emissions, driveability problems or fuel economy losses.

Fuel consumption can be decreased, maintained, or improved when EGR is utilized. Brake specific fuel consumption and exhaust temperature decrease with increasing EGR because dilution with EGR decreases pumping work and heat transfer, and increases the ratio of specific heats of the burned gases.

Improvements in mixture preparation, induction systems, and ignition systems can increase dilution tolerance. The latest technique for improving dilution tolerance is to increase the burn rate or flame speed of the air-fuel charge. Dilution can then be increased until the burn rate again becomes limiting. Several techniques have been used to increase burn rate including increased swirl and squish, shorter flame paths, and multiple ignition sources.

Electronics

With so many interrelated engine design and operating variables playing an increasingly important role in the modern engine, the control system has taken on increased importance. Modifications in spark timi g must be closely coordinated with air-fuel ratio changes and degrees of EGR lest significant fuel economy or performance penalties result from emissions reductions, or NOx emissions increase as CO goes down. In addition, controls which can be much more selective depending on engine load or speed have been found beneficial in preventing widespread adverse impacts.

To address these problems, electronics have begun to replace more traditional mechanical controls. For example, electronic control of ignition timing has demonstrated an ability to optimize timing under all engine conditions and has the added advantage of reduced maintenance and improved durability compared with mechanical systems. When coupled with electronic control of EGR, it has been demonstrated that NOx emissions can be reduced with no fuel economy penalty and in some cases with an improvement.

Over the last several years, automotive engineers have worked diligently on the development of engine "maps"; these define optimal adjustments or calibrations of critical engine parameters such as air/fuel mixture, spark timing, EGR rate, etc. to minimize emissions and fuel consumption while maximizing performance over a wide range of engine operating conditions. With electronic controls, it is possible to make much greater use of this information than in the past resulting in much lower "engine out" emissions levels prior to any exhaust aftertreatment.

Exhaust Aftertreatment Devices

Two alternative approaches which receive close scrutiny when tighter exhaust emissions standards (especially hydrocarbons or nitrogen oxides) are considered are: a) exhaust aftertreatment devices such as catalytic converters and thermal reactors or b) advanced combustion techniques such as high compression, lean burn engines.

Oxidation Catalysts

Quite simply, an oxidation catalyst is a device which is placed on the tailpipe of a car and which, if the chemistry and thermodynamics are properly maintained, will oxidize almost all the HC and CO in the exhaust stream. In general, monolith systems lend themselves to smaller size and weight whereas pelleted systems tend to be slightly less expensive.

Starting with 1975 model year cars, catalysts have been placed on upwards of 80 per cent of all new cars sold in the United States. In 1981, they were placed on 100 per cent of the new cars. In Japan and Canada, oxidation catalysts are also widely used to meet emission standards. Starting in 1986, they will be required on most new cars in Australia.

A major impediment to the use of catalysts is lead in gasoline. Existing, proven catalyst systems are poisoned by the lead in vehicle exhaust. A substantial effort to develop "lead tolerant" catalysts has been underway over the last several years with the result that significant progress has occurred. However, these systems appear to still be in the development stage and remain unproven in any actual vehicle applications.

One of the unique advantages of catalysts is their ability to selectively eliminate some of the more harmful compounds in vehicle exhaust such as aldehydes (which are especially high in alcohol fueled vehicles) , reactive hydrocarbons and polynuclear hydrocarbons.

Three-way Catalysts

Three-way catalysts (so called because of their ability to lower HC, CO and NOx levels simultaneously) were first introduced in the United States in 1977 by Volvo and subsequently became widely used when the U.S. NOx standard was made more stringent (1.0 grams per mile). To work effectively, it is necessary to control air/fuel mixtures much more precisely than is needed for oxidation catalyst systems. As a result, three way systems have indirectly fostered improved air/fuel management systems such as advanced carburetors and throttle body fuel injection systems as well as electronic controls.

Three-way catalyst systems also are sensitive to the use of leaded gasoline. An occasional tankful of leaded gasoline will have a small but lasting effect on the level of emitted pollutants.

Thermal Reactors

Thermal reactors are well insulated vessels with internal baffling to ensure several passes of the exhaust gas to maintain the temperature and extend the residence time thus promoting oxidation of CO and HC emitted from the engine. To maintain the sufficient high temperatures, they are often used in conjunction with exhaust port liners which reduce heat losses. In spite of this, a major problem with these systems is the difficulty in maintaining exhaust temperatures sufficiently high to promote combustion. Measures to increase exhaust temperatures such as retarded ignition, richer air/fuel ratios or valve timing delays result in increased fuel consumption. Ethyl Corporation has developed a hybrid reactor concept which they report to be capable of lowering HC and CO emissions to extremely low levels. Experiments on V-8 engines were reported with results below 0.41 HC and 3.4 CO. In combination with the use of EGR, this system has reportedly also achieved 1.0 NOx.

Advanced Combustion Techniques

Modification of the basic combustion process is proceeding along several fronts by a number of different engine manufacturers or research organizations. Summarized below are the major approaches receiving serious consideration.

High Compression Lean Burn Engines

An alternative to the catalyst which could achieve lower emission levels with leaded gasoline and with potentially good fuel economy is the high compression, lean burn engine. By designing combustion chambers with great turbulence to promote mixing, compression ratios as high as 13:1 and air/fuel ratios in the range of 20:1 have been demonstrated without detonation. Such systems have also demonstrated very good fuel economy; about 20 percent better than from more conventional engines. In addition, CO emissions are very low and NOx emissions are lower than from conventional engines without catalysts. However, because exhaust temperatures are low and a high amount of quench occurs, HC emissions tend to be quite high and have so far proved resistant to control. Further, high compression lean burn engines require very precise carburetion and mixture control as well as high energy ignition systems.

Stratified Charge Engines

In general, a stratified charge engine provides a controlled variation of air/fuel ratios within the combustion chamber - rich mixtures near the spark plug to initiate combustion, with the remainder, the largest portion of the charge, very lean. Such a system has several advantages compared to more conventional systems, lower emissions of all three regulated pollutants and low fuel consumption being the most notable. In addition, stratified charge engines can be designed to use a wide variety of fuels.

The only production stratified charge engine is the Honda CVCC which contains a prechamber where ignition of a fuel rich mixture takes place. The resulting combustion continues into the main chamber where a weak mixture is ignited. This engine produces substantially lower CO and NOx emissions than more conventional engines, without the need for exhaust aftertreatment; however, HC emissions are similar to normal systems. Therefore, if tight control of HC is needed, catalysts or thermal reactors may be needed.

Fast Burn Systems

The Fast Burn uses a single combustion chamber and a homogeneous mixture. More rapid combustion of the air/fuel mixture is promoted by reducing the flame travel distance. Thus end gas reaction time is lowered; concomitantly, engine octane requirements are reduced. Reliable ignition has to be provided by a sufficiently powerful ignition and rapid combustion by strong turbulence of the charge and/or dual ignition.

Increasing the burn rate of the air/fuel charge substantially increases dilution tolerance. Dilution can then be increased with very substantial reductions in NOx emissions until the burn rate again becomes limiting.

APPENDIX F

UNITED NATIONS DEVELOPMENT PROGRAMME

Project of the Government of

Hong Kong

PROJECT DOCUMENT

Title: Improvement of Emissions from Motor Vehicles (Phase 2)

Number: Duration: 2 years

Primary Function: Direct Support

Secondary function:

Government Implementing Agency: Environmental Protection Agency, HK

Executing Agency: UNIDO

Estimated starting date: 1986

Government Inputs: HK$147,440(in kind) UNDP inputs: US$ 50,500
(local currency)

Government Cost
Sharing:
(if any) Nil

Signed:

PART 1. LEGAL CONTEXT

This Project Document shall be the instrument (therein referred to as a Plan of Operation) envisaged in Article I. paragraph 2, of the Agreement between the Government of United Kingdom and the United Nations Development Programme concerning assistance under the Special Fund sector of the United Nations Development Programme, signed by the Parties on 7 July 1960.

PART II. A. Development Objective

The Main development objective is to implement the program elements developed in Phase 1 of this project with the overall aim to preserve and improve the environment of Hong Kong.

PART II. B. Immediate Objective

The immediate objective is to support the Hong Kong EPA in its implementation of the program developed in Phase 1 of this project. Specific tasks will include the following:

1. Initial design of the retrofit demonstration project to assure that all necessary and appropriate data is collected and collected properly.
2. Periodic analysis of the data to assure that it is being collected properly and to determine if any mid-course corrections are needed.
3. Preparation of a final report at the conclusion of the retrofit study to analyze the results and draw any appropriate conclusions.
4. Brief EPCOM and other appropriate community groups as recommendations proceed to the implementation stage, to assist appropriate officials in properly communicating the reasons for the steps as well as the benefits expected.
5. Review the details of EPD's smoke testing program as it is instituted to help in smoothing out any bugs.
6. With regard to new vehicle standards, assist EPD in instituting its type approval system. As part of this effort, the consultant will review the draft regulations to institute R 15-04 for passenger cars as well as the taxicab particulate standards requirements.
7. As the private safety inspection system is implemented, the consultant will be used as a resource to assist in the implementation of passenger car CO and HC requirements as well as goods vehicle smoke requirements.
8. As unleaded petrol becomes more necessary, the consultant can assist in defining the appropriate worldwide market situation concerning those vehicles which have traditionally been imported into Hong Kong Also he can assist in the evaluations and determinations regarding which stations will provide such fuel.

PART II C. Special Considerations

As I/M programmes for motor vehicles and bus retrofit are rather new concepts in most of the SE Asian countries, the proposed project should provide a data base and serve as a training background regarding environmental protection measures for vehicular emissions for nearby countries such as Thailand, Brunei, Malaysia, etc. upon future needs. To this end, an environmental protection information centre might be set up within the EPA of HK and environmental personnel could enter a short-term exchange programme for training and technical cooperation purpose.

PART II. D. Background and Justification

During the past two years, a technical consultant has been provided to Hong Kong by UNIDO to review the motor vehicle pollution control program and to develop a series of recommendations. The Government of Hong Kong is well suited to follow up on these recommendations noted above. First and foremost, it has already initiated steps to institute the reorganization noted in Recommendation 1, which is the key element necessary to bring about all other items. In addition, it has already made a firm decision to institute a private safety inspection system for cars. However to fully implement all the recommendations, it will need considerable UNIDO assistance. Areas requiring the most help include the implementation of the diesel bus particulate trap retrofit demonstration. UNIDO will need to provide technical consultancy support, equipment and training funds.

It will be necessary for UNIDO to provide technical consultancy support similar to that provided over the last two years, over the next two years to support the implementation phase and to assist in the development and application of new elements. In addition, as the implementation stages proceed, it will be necessary to hire and promote individuals to positions of increasing responsibility with greater and greater demands on their technical and administrative expertise. Training will be a critical element of such a process. Therefore, UNDP will be called upon top provide additional resources for this effort.

PART II. E. Outputs

The major output of this project will include:

1. Initial design of the retrofit demonstration project to assure that all necessary and appropriate data is collected and collected properly.

2. A final report at the conclusion of the retrofit study to analyze the results and draw any appropriate conclusions.

3. A final report on the implementation of specific recommendations with particular focus on;

a. the details of EPD's smoke testing program

b. assessment of EPD's type approval system for new cars and taxicabs

c. a review of the passenger car CO and HC requirements as well as goods vehicle smoke requirements.

d. An analysis of the unleaded petrol implementation.

PART II. F. Activities

In order to achieve the project goals and outputs, extensive survey and research activities of familiarization and inspection visits, data collection, emission testing and monitoring as well as conferences and committee meetings, would be pursued. However, the scale of activities would be dependent upon the availability of manpower, especially that of E.P.A. .

PART II. G. I-puts

1. Governmenc Inputs

(a) Manpower

As only 4 man-month working capacity at expert level is to be provided by UNDP over the two years of the second stage, local consultation and administrative assistance in the form of 1 man-month (expert level) capacity, work assistance of 3 man-month (1 at professional level, 2 at technician level) capacity and a clerical assistance of 1 man-month capacity would be required throughout each month of the project. The cost equivalent is depicted below:

No. and level of personnel req.	Existing Salary per man-month	No of man-months required	Total cost required
1 (expert)	HK$ 18,225	4	HK$ 72,900
1 (prof.)	8,285	4	33,140
2 (technician)	4,165	8	33,320
1 (clerical)	2,020	4	8,080
		Grand Total:	HK$ 147,440

(b) Instrumental and Supportive Facilities

Existing instrumental facilities in the Air Group Laboratory of EPA would be utilized in the project along with six Hartridge smokemeters which will be transferred to EPA by the HK Police Department.

2. UNDP inputs

The UNDP input will provide for the assignment of one international consultant on the improvement of emissions from motor vehicles for 2 man-months each in 1986 and 1987.

PART II. H. Preparation of Work Plan

A detailed work plan for the implementation of the project will be prepared by the international expert assigned to the project, in consultation with the Commissioner for Environmental Protection. This will be done at the start of the project and brought forward periodically. The agreed upon work plar will be attached to the Project Document as Annex I and will be considered as part of that document.

PART II. I. Preparation of the Framework for Effective Participation of National and International Staff in the Project

The activities necessary to produce the indicated outputs and achieve the project's immediate objective will be carried out jointly by the national and international staff assigned to it. The respective roles of the national and international staff will be determined by their leaders, by mutual discussion and agreement, at the beginning of the project, and set out in a Framework for Effective Participation of National and International Staff in the Project. The Framework, which will be attached to the Project Document as an annex, will be reviewed from time to time. The respective roles of the national and international staff shall be in accordance with the established concept and specific purposes of technical cooperation.

PART II. J. Development Support Communication

The most significant development support communication will continue to be an information network among the HK government departments concerned with the vehicle I/M programme. In addition, communication will routinely be necessary with participating bus fleets and retrofit device suppliers. Furthermore, information from nearby SE Asian Countries and the Western Countries on vehicle I/M programmes and related data would be used.

It is expected that routine communication between EPA and the other government departments during the project months supplemented by contacts initiated by the consultant would suffice to serve the first purpose. The consultant and the EPA will share responsibility for the second purpose with a comprehensive meeting at the initiation of the retrofit study serving as a key role. The exchange of international data in question will be initiated by the international expert in the project and communicated through the service of the HK government during the project months in 1986 and 1987.

PART II. K. Institutional Framework

The Environmental Protection Agency (EPA), which is the implementing government agency for the proposed project, has been set up in recent years to deal with the environmental problems in Hong Kong. Basically, EPA functions as both a policy making and coordinating department among the various government departments concerned.

The EPA exercises its jurisdiction along 4 streams, namely, the Air Quality, the Water Quality, the Noise and Vibration, and the Waste Management Groups. The International Expert would be attached to the Air Quality Group for the proposed project.

PART II. L. Prior Obligations and Prerequisites

None.

Part II. M. Future UNDP Assistance

Not envisaged at present.

PART III. SCHEDULES OF MONITORING, EVALUATION and REPORTS

PART III. A. Tripartite Monitoring Reviews, technical reviews

The project will be subject to periodic review in accordance with the policies and procedures established by UNDP for monitoring project and programme implementation.

Further reviews on a joint consultation basis would be arranged for the relevant departments and institutions concerned.

PART III. B. Evaluation

The project will be subject to evaluation, in accordance with the policies and procedures established for this purpose by UNDP. The organization, terms of reference and timing of the evaluation will be decided by consultation between the Government, UNDP, and the Executing Agency concerned.

Evaluation of the project would be conducted simultaneously with the final review at the end of the two year period.

PART III. C. Progress and Terminal Reports

Progress assessment reports for the project would essentially be undertaken by EPA staff. It is expected that the first progress report for the project segment in 1986 would be produced by mid year and the second progress report would be produced before June 1987.

PART IV. BUDGETS

PART IV. A. Project Budget Covering UNDP Contribution
(In US Dollars)

Country: Hong Kong

Project No.:

Title: Improvement of Emissions from Motor Vehicles (Phase 2)

	TOTAL mm $	1986 mm $	1987 mm $
10. PROJECT PERSONNEL			
11. Experts			
11-01 Consultant	4 32,000	2 16,000	2 16,000
16-00 UNIDO Travel	8,000	4,000	4,000
19 Component Total	40,000	20,000	20,000
32-00 Training	10,000	5,000	5,000
51 Sundry	500	250	250
99 GRAND TOTAL:	50,500	25,250	25,250

PART IV. A. Project Budget Covering Government Contribution in Kind
(In local currency)

Country: Hong Kong

Project No.:

Title: Improvement of Emissions from Motor Vehicles

	TOTAL mm $	1986 mm $	1987 mm $
10. PROJECT PERSONNEL			
Officer at expert level	4 72,900	2 36,450	2 36450
Officer at prof. level	4 33,140	2 16,570	2 16570
Officer at tech. level	8 33,320	4 16,660	4 16660
Clerk	4 8,080	2 4,040	2 4,040
11-99 Sub-Total	21 147440	10 73720	10 73720
19 Component Total	147,440	73,720	73,720
99. GRAND TOTAL	147,440*	73,720	73720

* Excluding other physical support like instrumentation, etc.

ng Kong Follow Up, Revision 8, 2/16/86
epared by Michael P. Walsh

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                                1986                               1987                          1987                                                             1988
b Description                   Jul  Aug  Sep  Oct  Nov  Dec  Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec  Jan  Feb  Mar  Apr  May  Jun
                                2    3    4    5    6    7    8    9    10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25
1 Visit HK                      O----..........>
2 Analyze Implementation Pr.         ----------.........>
3 HK Follow Up Visit                                     O====X
4 Design Retrofit Project                      -----------.........>
5 HK Visit                                                                         O====X
6 Seidel Visit                            O----..................................................................
7 HK Visit                                                                                                                 O====>
8 Interim Retrofit Report                                                                   O---------------...................>
9 Initiate Retrofit Project                              ------------------------------------------------------------>.........>
0 Initiate Impl. Reports                       --------------->................................................................>
1 Final Retrofit Report                                                                                                         >=========X
2 Final Report                                                                                                                  >==============X
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	Jul 2	Aug 3	Sep 4	Oct 5	Nov 6	Dec 7	Jan 8	Feb 9	Mar 10	Apr 11	May 12	Jun 13	Jul 14	Aug 15	Sep 16	Oct 17	Nov 18	Dec 19	Jan 20	Feb 21	Mar 22	Apr 23	May 24	Jun 25
consulting=	1	1	1	2	2	2	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0
Total manpower level=	1	1	1	2	2	2	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	[illegible]	0	0
Manpower cost=	1.2K	1.2K	1.2K	2.5	2.5K	2.5K	0	0	0	0	0	0	1.2K	1.2K	1.2	0	0	0	1.2K	1.2K	1.2K	[illegible]	0	0
Direct cost=	4K	0	4K	0	0	104K	0	0	0	0	0	0	0	0	0	0	0	0	4K	0	0	[illegible]	0	0
Total cost=	5.2	1.2K	5.2K	2.5	2.5K	106K	0	0	0	0	0	0	1.2K	1.2K	1.2	0	0	0	5.2K	1.2K	1	[illegible]	0	0

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mbol - Explanation
--->   Duration of a normal job
...>   Slack time for a normal job
===>   Duration of a critical path job
:::>   Duration of a completed job
       Job with zero duration
--->   Job with no prerequisites
---X   Job with no successors
```