Mobile Sources and Air Pollution in Brazil

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SUMMARY

In general, air pollution from mobile sources in Brazil affects mainly the large metropolitan areas. The São Paulo Metropolitan Region (SPMR), with a population of about 15 million people is clearly the worst case. In the SPMR motor vehicles are responsible for more than 80% of carbon monoxide, nitrogen oxides and unburned fuel emissions, about 60% of sulfur oxides and approximately 40% of inhalable particulate emissions.

In an effort to address this problem, the National Environment Council enacted in 1986 the federal automotive emission control program which regulates emissions of new vehicles.

Additionally, the most developed States have ben enforcing diesel smoke limits for in-use vehicles. Further progress is expected to occur with regional implementation of inspection and maintenance programs, improvement of diesel and gasoline fuel characteristics, increased use of natural gas and implementation of environmentally sound transport and energy policies.

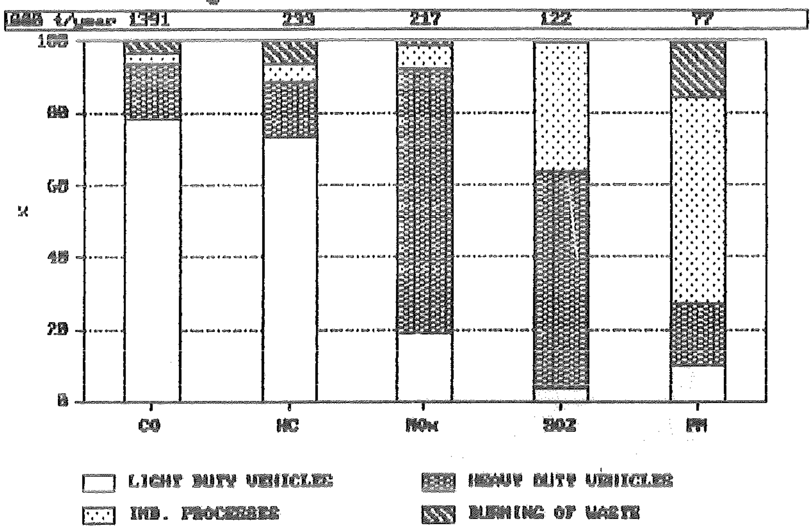
The extensive use of alcohol as an automotive fuel has played an important role in the control of emissions and it is considered a major component of the overall control strategy.

I. INTRODUCTION

The fast and continuous urbanization trend observed in Brazil since the early sixties, associated with a chronic lack of adequate mass transport has fostered growing individual motorization. The increase in the vehicle population and in the number and length of trips has caused traffic congestion and environmental degradation, particularly, in major urban areas. The three largest metropolitan regions in Brazil - São Paulo, Rio de Janeiro and Belo Horizonte - which comprise a population of approximately 30 million, have experienced increasing air pollution levels, being São Paulo the worst case.

The contribution of the 4 million motor vehicles to air pollution in the São Paulo Metropolitan Region (SPMR) is well known and it is shown in Figure 1. As can be seen, motor vehicles are the predominant source of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x) and sulfur oxides (SO_x) emissions. Although the industrial processes are the major source of particulates (PM), vehicle generated particles are discharged at street level rather than from elevated stacks. This is important because emissions from industrial stacks are usually dispersed before reaching the receptor while street level emissions may frequently expose the public to very high pollutant concentrations. Additionally, because these particles are within the inhalable size range, are very persistent in the atmosphere and have toxic properties, may pose a greater risk to the public health than those generated by many industrial sources.

Figure 1 - RELATIVE EMISSIONS



2. AIR POLLUTION CONTROL FRAMEWORK AND MONITORING

Brazil is a federal republic made up of 26 States which have the independent right to lay down requirements for environmental control. In addition, there is a general framework for control drawn up by the federal government which is valid in those regions with no legislation of their own.

The National Environmental Policy of Brazil is laid down in Law No. 6938 of 31 August 1981 and in Decree No. 88351 of July 1983. The National Environmental System (SISNAMA), which was created by this legislation, is made up of organizations and bodies at the differente levels of public administrations; these are responsible for the protection and improvement of the quality of the environment; the National Environment Council (CONAMA) sets standards and maintains the SISNAMA. The central organization for technical and administrative support is the Brazilian Institute for the Environment and Renewable Resources (IBAMA) which comes under the Ministry of the Environment.

The basis of air pollution control and prevention in Brazil is laid down in CONAMA Resolution No. 05/89 of 15 June 1989, which created the National Programme for Air Quality Control (PRONAR).

The basic strategy of the PRONAR is the limitation of emissions according to source type and priority of pollutant, by means of establishing maximum emission limits. These limits are set by CONAMA Resolutions.

Mobile sources pollution control is regulated mainly by CONAMA; the States legislate complementary regulations for in-use sources.

The standards for air quality (primary and secondary) were established by CONAMA Resolution No. 03/90 of 28 June 1990 for total suspended particles (TSP), inhalable particles (PM_{10}), smoke, sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and nitrogen dioxide (NO_2). The criteria for acute air pollution episodes were also specified in this Resolution. The national standards for air quality and the criteria for acute episodes are shown in Tables 1 and 2.

It is worthy of mention that a number of States established their own air quality standards well before the Federal Government. In São Paulo State this occurred in 1976.

Table 1 - National Standards for Air Quality - CONAMA Resolution No. 03 of 28/06/1990

POLLUTANT	AVERAGING TIME	PRIMARY STANDARD (ug/m^3)	SEC'RY STANDARD (ug/m^3)	MEASURING SYSTEM
Sulfur dioxide	24 hour (1) AAM (3)	365 80	100 40	Pararosaniline
Total suspended particles	24 hour (1) AGM (2)	240 80	150 60	High volume sampler
Inhalable particles < 10 um	24 hour (1) AAM (3)	150 50	150 50	Inertial separation/ Filtration
Smoke	24 hour (1) AAM (3)	150 60	100 40	Reflectance
Carbon monoxide	1 hour (1) 8 hour (1)	40,000 (35 ppm) 10,000 (9 ppm)	40,000 (35 ppm) 10,000 (9 ppm)	Non-dispersive infrared
Ozone	1 hour (1)	160	160	Chemiluminescence
Nitrogen dioxide	1 hour (1) AAM (3)	320 100	190 100	Chemiluminescence

(1) Should not be exceeded more than once per year
(2) Annual geometric mean
(3) Annual arithmetic mean

Table 2 – Criteria for Acute Air Pollution Episodes – CONAMA Resolution No. 03 of 28/06/1990

PARAMETER	LEVELS		
	CAUTION	ALERT	EMERGENCY
Sulfur dioxide (ug/m^3) – 24 h	800	1,600	2,100
Total suspended particles (TSP) (ug/m^3) – 24 h	375	625	875
SO_2 X TSP (ug/m^3) – 24h	65,000	261,000	393,000
Inhalable particles (ug/m^3) – 24 h	250	420	500
Smoke (ug/m^3) – 24 h	250	420	500
Carbon monoxide (ppm) – 8 h	15	30	40
Ozone (ug/m^3) – 1 h	400	800	1,000
Nitrogen dioxide (ug/m^3) – 1 h	1,130	2,260	3,000

At the present time, there are only a few independent sampling networks which have been set up by some of the States. These are: São Paulo, Rio de Janeiro, Rio Grande do Sul, Parana, Minas Gerais, Espirito Santo, Bahia, Ceara and Pernambuco. There are big differences between the State systems. The methodology in use ranges from stationary methods (rate of sulphation, rate of settled dust) in less developed States to automatic methods in São Paulo and Rio de Janeiro [1].

In general the air quality assessment programmes leave quite a lot to be desired since they are frequently subject to interruptions due to limited resources. In the majority of cases, the sequences of data contain flaws making them considerably less meaningful. In a great majority of cases the information is not made available to the general population, as it is only published in papers circulated within administrative organizations.

The exception – principally in regard to publication – is the air quality assessment programme of the State of São Paulo. Measurements have been routinely carried out by CETESB, the State

Environmental Protection Agency, for more than a decade; the information is released daily to the press and compiled annually in a widely distributed report.

CETESB's data shows that CO concentrations exceeded the air quality standard and the attention level during almost 24% and 1% of the time, respectively, at the most critical CO monitoring site (Cerqueira Cesar). The CO peak level reached at this site was 15.7 ppm (8 hour average). With regard to ozone levels, in 1992 the air quality standard was exceeded 4.7% of the days in one monitoring site (Mooca) and the attention level was exceeded 1.5% of the days in another site (Congonhas). At the latter site the peak concentration of 272 ug/m^3 (1 hour average) was recorded.

Some very high concentrations (1 hour average) of NO_2, which is a major precursor of photochemical smog have been also recorded in three sites i.e. 704 ug/m^3 at Cerqueira Cesar; 552 ug/m^3 at Congonhas and 405 ug/m^3 at Parque D. Pedro II. These levels are probably due to the high density of diesel traffic nearby the monitoring sites. This is partly confirmed by the high levels of inhalable particulates measured at the sites which are emitted mainly by diesel buses, vans and trucks. The measured PM_{10} concentrations ranged between 92 ug/m^3 (Cerqueira Cesar) to 49 ug/m^3 (Parque D. Pedro II).

Conversely to other pollutants, concentrations of SO_2 are well under control and currently all 32 monitoring sites in the SPMR show concentrations in compliance with the air quality standards. Although lead concentrations are not monitored routinely, the complete phase out of lead additives in 1991 and the available monitoring data show that atmospheric levels are significantly below the World Health Organization recommended standard of 1.5 ug/m^3.

Data recorded in 1990 show that acetaldehyde and ethanol ambient concentrations ranged between 4 to 47 ppb and 0,08 to 2.26 ppm, respectively [2].

3. EFFECTS OF POLLUTION

The effects of motor vehicle pollution are abundantly documented in international literature. In Brazil, especially in the last ten years, there has been an increase in the number of scientific investigations carried out to determine the nature of these effects, particularly on health.

The investigations have been conducted principally in the SPMR. The evidence indicates a relationship between the high levels of observed pollution and a rise in morbidity mainly related to cardio-respiratory diseases.

A point worth recording is that susceptibility to the effects of air pollution is normally greater in populations which show nutritional deficiencies. In Brazil – as in the majority of developing countries — a large part of the population is undernourished, and this gives the level of Brazil's air pollution an even more worrying character.

4. EMISSION CONTROL OF NEW VEHICLES

Concerned with the severity of the pollution caused by motor vehicles in the SPMR, CETESB developed in 1985 a control program for new and in—use vehicles (PROCONVE).

The program for new vehicles was submitted to CONAMA and was enacted as a national regulation in 1986. Tables 2 and 3 summarize the emission limits and the implementation dates.

IBAMA is the federal agency in charge of this program and within its responsibilities and duties are included new vehicles licensing, enactement of rules and enforcement; IBAMA named CETESB as PROCONVE's executive Agency and, consequently, all technical and research activities which support IBAMA's actions are normally carried out by CETESB.

Table 3 — Emission Limits - Otto Cycle Engines

LIGHT DUTY VEHICLES

YEAR*	EXHAUST EMISSION					EVAPORATIVE EMISSION	CRANK-CASE EMISSION
	CO	HC	NO_x	ALDE-HYDES	CO IDLE SPEED		
	g/km	g/km	g/km	g/km	%	g/test	
1988	24	2.1	2.0	-	3.0	-	nil
1990	24	2.1	2.0	-	3.0	6.0	nil
1992	12	1.2	1.4	0.15	2.5	6.0	nil
	24**	2.1**	2.0**	0.15	3.0**	6.0	nil
1997	2.0	0.3	0.6	0.03	0.5	6.0	nil

(*) 1988 — only for new models
1989 — for 50% of the production
1990 — all models, except for those not derived from light duty vehicles

(**) permited only for models not derived from light duty vehicles

Test Procedures:

a) FTP—75 for exhaust emission;
b) SHED for evaporative emission.

TABLE 4 - Emission Limits - Diesel Cycle Engines

HEAVY DUTY AND LIGHT DUTY VEHICLES

YEAR	EXHAUST EMISSIONS				CRANKCASE EMISSION
	CO	HC	NO_x	SMOKE	
	g/kW.h	g/kW.h	g/kW.h	k	
1988*	-	-	-	2.5	nil
1993	11.2	2.8	18	2.5	nil **
1995	11.2	2.8	14.4	2.5	nil **
New limits for the coming years are being proposed by CETESB and are aimed to reduce 1995 standards by approximately 60% in 2002.					

$k = c \sqrt{G}$
c = carbon concentration (g/m^3)
G = rated flow of exhaust gas (l/s)

(*) only for urban buses

(**) optionally added to the exhaust emission for comparison with the HC limit in turbocharged engines

Test Procedures:

EEC 13 mode for gaseous emissions and EEC full-load steady state for smoke.

Emission control of light duty vehicles has been emphasized because these vehicles make up the largest fleet, are intensively used and therefore, represent the major problem to be tackled.

Manufacturers compliance with legal requirements resulted in an average emission reduction of 80% for the 1992/1993 model-year light duty vehicles in relation to the uncontrolled 1985/1986 model-year vehicles. With regard to diesel smoke, it can be said that production of the most polluting engines (10% of engine models in 1986 with k greater than 2.5) was discontinued and in 1992, 89% of engine models had the smoke level lower than k = 2.0 and 11% were in the range 2.0 - 2.5. For comparison, in 1986 the figures were 74% and 16%, respectively.

Although the emission control program was designed to control pollution in the large brazilian metropolitan regions and prevent environmental degradation in the remaining urban areas, it will also bring benefits for the member countries of MERCOSUL since it has been already accepted as the baseline directive.

In spite of the fact that emission reduction from new vehicles is absolutely necessary in the long term, it does not ensure by itself the attainment of the air quality standards. Therefore, this measures have to be supplemented by further actions envolving coordinated transport, traffic and energy policies and in-use vehicle control programs.

5. FUEL CHARACTERISTICS

The characteristics of the automotive fuels are one of the main factors influencing the emission of air pollutants.

Due to the heavy demand for diesel oil, because of an excessive use of road transport (almost 80% of freight in Brazil is by road), the quality of this fuel is low. This happens because PETROBRÁS (the state oil company) needs to convert about 35% of a barril of crude into diesel oil to meet fuel demand and this can only be achieved by adding heavy and light hydrocarbon fractions in the "diesel" fraction. The result is an increase of particulate formation during combustion.

A further problem related to diesel oil is the high sulfur content which inhibits the use of more advanced vehicle emission control systems such a catalytic converters and results in a significant sulfur compounds emission, as shown in Figure 1.

CETESB is negotiating with PETROBRÁS the possibility of having the so-called "Metropolitan diesel oil", which has a maximum sulfur content of 0.5% by weight, as the only diesel fuel distributed in the SPMR. This is an important step to be taken because the actual sulfur content is very variable (the national average content is 0.7% wt) and present federal specification permits up to 1.3%. Besides the SPMR, eight other metropolitan regions have the "Metropolitan diesel oil" available and do benefit from its use. Some additional progress is expected to occur in 1996 with the availability of a 0.3% sulfur diesel oil.

Conversely to diesel, the widespread use of ethanol, either as a fuel itself or as a blending constituent of gasoline has brought environmental benefits.

In Brazil, all gasoline is blended with 22% anhydrous ethanol, by volume, therefore, the term gasohol in this paper refers to this blend.

The use of gasohol helped to accelerate the complete phase out of lead additives. In addition, the presence of ethanol avoids the necessity to increase the content of aromatics in gasoline to boost octane levels, and reduces the high sulfur levels of gasoline, to an extent that makes possible the adoption of catalytic converters, which started to be used in Brazil in 1992.

The unburned fuel emissions (UBF), commonly refferred as HC, consist mainly of HC (~97%), ethanol (~1,7%) and aldehydes (~1,3%) [3]. In addition, emission of aldehydes can be broken in formaldehyde (~55%), acetaldehyde (~44%) and higher aldehydes (~1%).

Extensive use of ethanol fueled vehicles in Brazil, which represent 40% of the total light duty vehicle fleet, i.e. 4.2 million vehicles, has avoided further air quality deterioration in the Metropolitan Regions. Ethanol fueled vehicles emit negligible amounts of sulfur compounds and combustion generated particulates, do not require octane boosters such as lead additives and have lower CO, NO_x and evaporative emissions than similar gasohol fueled vehicles. The UBF of alcohol vehicles consist mainly of unburned ethanol, as shown in Table 5, aldehydes and hydrocarbons. Ethanol is known to have a lower photochemical reactivity than most hydrocarbons, especially olefins, and is considerably less toxic. Aldehyde emissions consist of approximately 85% acetaldehyde, 14% formaldehyde and 1% higher aldehydes. Although aldehyde emissions from ethanol vehicles are usually three times higher than from gasohol vehicles, which produce mostly formaldehyde, it must be recognized that acetaldehyde is of less concern than formaldehyde, because it is less toxic and has a lower photochemical reactivity.

Table 5 - Ethanol Vehicles

TYPICAL ETHANOL CONTENT IN EXHAUST GAS	
TECHNOLOGY	ETHANOL (% wt)
Carburetor (1st phase control)	86.4 ± 5.8 (FTP-74)
Carburetor + open loop cat. (2nd. phase control)	58.3 ± 10.2 (FTP-74) 49.4 ± 6.8 (FTP-75)
Single point injection (2nd. phase control)	77.0 ± 10.4 (FTP-74) * 63.3 ± 5.8 (FTP-74) 83 ± 5.5 (FTP-75) * 63.2 ± 1.3 (FTP-75)

(*) Vehicle fueled with the MEG blend (33% methanol - 60% ethanol - 7% gasoline)

Source: CETESB

A comparison of emission data from alcohol and gasohol vehicles is shown in Table 6. As can be seen, aldehyde emissions from both alcohol and gasohol vehicles have been reduced significantly since 1986 and emissions from 1992 alcohol vehicles are much lower than those of uncontrolled 1986 gasohol vehicles.

Table 6 - Emission Limits and Average Values for Light Duty Vehicles (Otto Engine)

YEAR	NOTE	EXHAUST EMISSIONS (g/Km)				EVAPORATIVE EMISSION
		CARBON MONOXIDE-CO	HYDROCARBONS HC	NITROGEN OXIDES-NO_X	ALDEHYDES CHO	g/test
Pre 1980	Gasoline	54.0	4.7	1.2	(na)	(na)
1986 (no control)	Alcohol	16.9	1.6	1.2	0.160	10.0
	Gasohol	28.0	2.4	1.6	0.040	23.0
1990 (a) (1st phase)	Limit	24.0	2.1	2.0	-	6.0
	Alcohol	10.8(-36%)	1.3(-19%)	1.2(0%)	0.110(-31%)	1.8(-82%)
	Gasohol	13.3(-52%)	1.4(-42%)	1.4(-12%)	0.040(0%)	2.7(-88%)
1992 (b) (2nd phase)	Limit	12.0	1.2	1.4	0.150	6.0
	Alcohol	3.9(-77%)	0.6(-62%)	0.5(-58%)	0.030(-81%)	1.2(-88%)
	Gasohol	5.9(-79%)	0.5(-79%)	0.6(-62%)	0.010(-75%)	2.3(-90%)

Notes: % between parenthesis refers to the reduction in relation to 1986 vehicles.
(a) production average
(b) type approval results average
(na) not available

In order to alleviate the alcohol crisis which started in 1989, CETESB gave a fundamental contribution to the development of an alternative fuel for the alcohol vehicles. The research studies showed that a blend of 60% ethanol - 33% methanol - 7% gasoline would be fully compatible with the alcohol engines and would not require special calibrations or engine adjustments for its use. Additionally, fuel consumption and emissions would be also very similar to those from ethanol combustion [4]. Since 1990, about seven billion liters of this blend were consumed, mainly in the SPMR, and therefore fuel rationing, engine conversions and other undesired measures such as reduction of the alcohol content in gasoline, which would greatly increase CO and HC emissions, were avoided.

In terms of air pollution, the use of methanol could result in unacceptable public exposure to methanol and formaldehyde. To address this question CETESB established a monitoring program for ambient concentrations of methanol, ethanol, formaldehyde and acetaldehyde, in addition to the routine monitoring of CO, ozone and other common air pollutants.

The monitoring program [5] evaluated air quality from March through September 1990 at two monitoring stations, in the City of São Paulo. The Cerqueira Cesar station is directly affected by heavy traffic while the Mooca station, though located in an area of dense traffic, is less affected by direct emissions due to the distance from the traffic ways. The reported data shows that methanol was detected in only 12.8% of the 86 samples collected at the Cerqueira Cesar station. At the Mooca station methanol was not detected in any of the 24 samples. The detection limit of the gas chromatography analytical procedure used for methanol is 0.15 ppm. The highest methanol recorded value was 0.42 ppm at Cerqueira Cesar.

Formaldehyde concentrations were detected in all of the 50 Cerqueira Cesar samples and 12 Mooca samples. The highest values recorded for formaldehyde were 41 ppb and 17 ppb at Cerqueira Cesar and Mooca, respectively. Only 14.0% of formaldehyde results were higher than 24 ppb.

According to Harvey et alii [6], ambient concentrations lower than 3.44 ppm for methanol and 24 ppb for formaldehyde are below the range of concern from a toxicological point of view. These values represent the lower limit of the range and are not believed to result in adverse physiological effects. For methanol, CETESB's results indicate that concentrations are about one tenth of the lower limit of the range. For formaldehyde, 86% of the recorded values are below this limit. The remaining 14% are still below 120 ppb which was defined by Harvey et alii as the intermediate limit of the range of concern and it is believed to have a more solid basis for concern than the lower limit.

Despite of the measured peak of 41 ppb, previous monitoring work has shown that formaldehyde concentrations usually reach considerable levels in São Paulo. For instance, in 1986, a peak of 59 ppb was measured at a downtown location (Praça do Correio) and no methanol blend was in use at that time. Therefore, it is believed that the use of methanol has not contributed to an increase in formaldehyde concentrations in the City of São Paulo.

In terms of the other pollutants which are routinely monitored, the use of the blend has not resulted in any negative effects on air quality.

When discussing the safety aspects related to the blend use, it is worthy of note that the presence of gasoline in the blend inhibits ingestion (which is the major cause of methanol acute intoxication), because the blend acquires the distinctive odor and taste of gasoline.

Another point of interest is that ethanol is a known "antidote" in case of methanol poisoning because it greatly slows methanol's entrance into its metabolic pathway [7]. Considering all possible ways of body intake (ingestion, skin absorption or inhalation) ethanol will be always associated to methanol, in at least a 2:1 ratio. Therefore, it is possible to infer that the risk of public exposure to methanol is considerably lowered by the presence of ethanol.

Furthermore, for ease of recognition, the blend received a red dye which gives the fuel a pinky color, therefore differentiating the blend from other fuels.

The use of compressed natural gas (CNG), is gaining space in the Cities of São Paulo, Rio de Janeiro and some northeastern cities where CNG is available. To date, there are about 80 buses and 4000 taxis using CNG in the SPMR.

Although the first generation of natural gas buses has shown poor performance and high CO and NO_x emissions, the achieved reduction of sulfur compounds, particulates and toxic HC is highly desirable. To overcome the performance and emission problems, bus manufacturers are promising, in the near future, a second generation of "green" buses.

In relation to taxi conversions to natural gas, CETESB and COMGÁS (the São Paulo State gas company) are discussing the need to certify both conversion kits and conversion shops, because preliminary data shows that some of the converted vehicles have greater CO emission at idle than before conversion, and have a poor performance.

The only CNG converted vehicles which comply with current emission standards are two models of General Motors vehicles equipped with ethanol EFI 1.8 and 2.0 liters engines. The conversion is based on the use of a KOLTEC electronic gas injection system connected to the original control unit of the vehicle. Performance, driveability and fuel consumption are very good. Further emission reductions can be obtained with the help of a three-way catalytic converter and optimization of the electronic control unit. Certification results for the two dual fuel vehicle are presented in Table 7.

Table 7 - Emission Results from two Dual-Fuel Brazilian Vehicles FTP-75

EMISSION (g/km)				
	KADETT 1.8 L		MONZA 2.0 L	
POLLUTANT	ALCOHOL	CNG	ALCOHOL	CNG
CO	6.57	7.30	6.74	5.50
HC	0.89	0.97	0.97	0.66
NO_x	1.02	0.92	0.78	1.08

Source: CETESB

With regard to electric energy, there are only a few trolley buses in service in Brazil. Unfortunately, due to the lack of incentives, there are no prospects, on the short term, that trolley buses or other type o electrical vehicles may play a more important role in the control of air pollution in the metropolitan areas affected by air pollution.

6. CONTROL OF IN-USE VEHICLES

Concerned with the control of emissions from in-use vehicles, CETESB started to enforce diesel smoke emissions in 1976. In addition to routine on road and roadside inspections to enforce the Ringelmann n. 2 limit, CETESB inspects regularly the bus and truck fleet of major transport companies and promotes training courses. The same sort of enforcement is also observed in some other States mainly in the most developed ones.

To improve this on-going activities and expand the control actions to the light duty vehicles, CETESB is developing the technical requirements of an inspection and maintenance program which is planned to start in 1995. This is a specially important program because field data indicates that about 75% of in-use vehicles do not comply with the manufacturers specifications for CO at idle and idle rpm. If ignition timing is also considered, the proportion of noncomplience is increased to about 90%.

Therefore, if no action is taken to promote proper repair and tune up, the efficiency of the whole emission control program will be seriously affected.

7. FURTHER ACTIONS

A number of actions related to formal and informal environmental education have been developed since 1987. For instance, twenty electronic panels are already in service along major thoroughfares, indicating air quality levels for the guidance of the population of the City of São Paulo. Air quality levels and pollution dispersion forecasts are also published on dayly newspapers. An action of great importance occurred in 1988, when CETESB promoted a one day voluntary vehicle ban on the whole São Paulo city center, simulating a State of Alert against vehicle generated air pollution. The idea was to prepare the population for the possible occurrence of a State of Emergency. The ban was a success and received the support of members of the Civil Defense and public services. Nearly 200,000 vehicles, about 90% of the usual traffic, stopped running for a day in the area and CO concentrations fell about 60%.

An important work in the field of environmental education was the development by CETESB, in association with SENAI (the training institute mantained by the industry), of a course on vehicle tune up and emission control for mechanics. This course is aimed to prepare present and future mechanics and garage managers to properly repair and tune up motor vehicles. In conjuction with this course, CETESB has been certifying and auditing repair garages that are adequately equiped and have trained mechanics. To date, about hundred garages which have voluntarily submitted a request for this certification make up the so-called "CETESB's vehicle repair network".

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