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INTRODUCTION

The fast and continuous urbanization trend, observed in Brazil since the early 1960's, associated with a chronic lack of adequate mass transport systems and increasing individual motorization has led the major cities to traffic congestion and motor vehicle pollution.

As it has been observed in many other countries, vehicle air pollution has also been imposing socio economic costs and environment damage in Brazil. The recognition of these facts led to the establishment of the national Air Pollution Control Program for Automotive Vehicles: PROCONVE.

AIR QUALITY

Some of the Brazilian metropolitan areas, such as São Paulo, Rio de Janeiro, Belo Horizonte, Recife, Salvador, Porto Alegre and Curitiba, with a population of approximately 40 million people have been experiencing increased air pollution in the last years, being São Paulo the worst case.

It has been observed that when one considers carbon monoxide, photochemical smog, nitrogen dioxide, hydrocarbons and

Note: This paper updates our previous SAE paper nº 871073 - Automotive Emission - The Brazilian Control Program.

particulates, São Paulo has one of the most severe vehicle related air pollution problems in the world (1), since all these pollutants exceed the air quality standards simultaneously in this area. The air quality data generated by CETESB, the Environment Control Agency for the State of São Paulo, support this conclusion. Carbon Monoxide (CO) and Ozone (O₃) ambient concentrations routinely exceed the air quality standards, as shown in Figures 1 and 2.

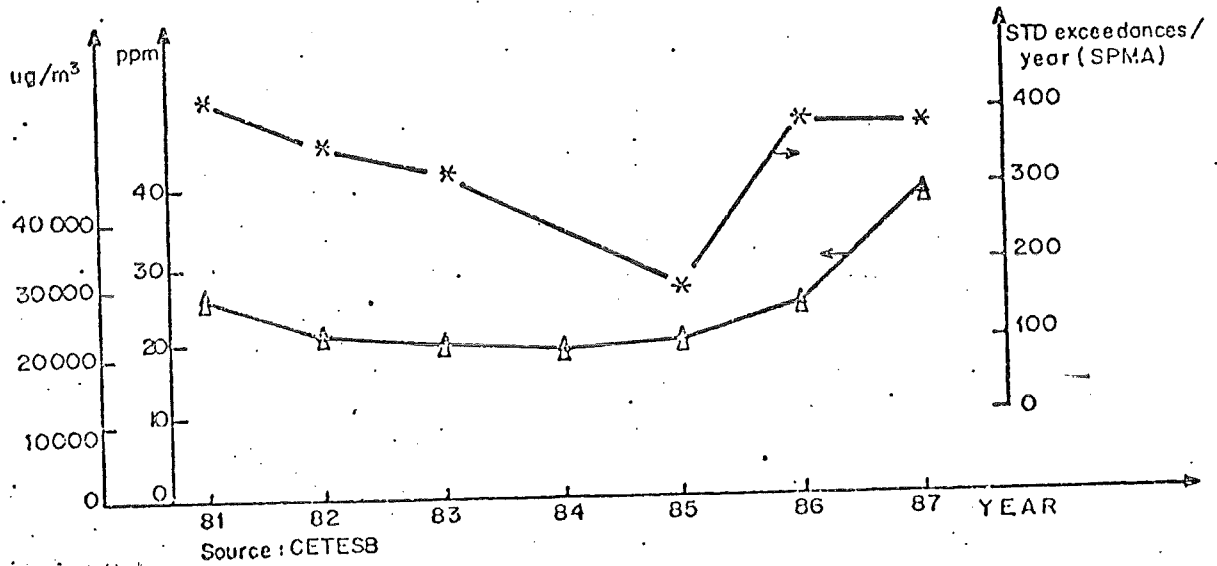


Fig. 1 - Carbon monoxide

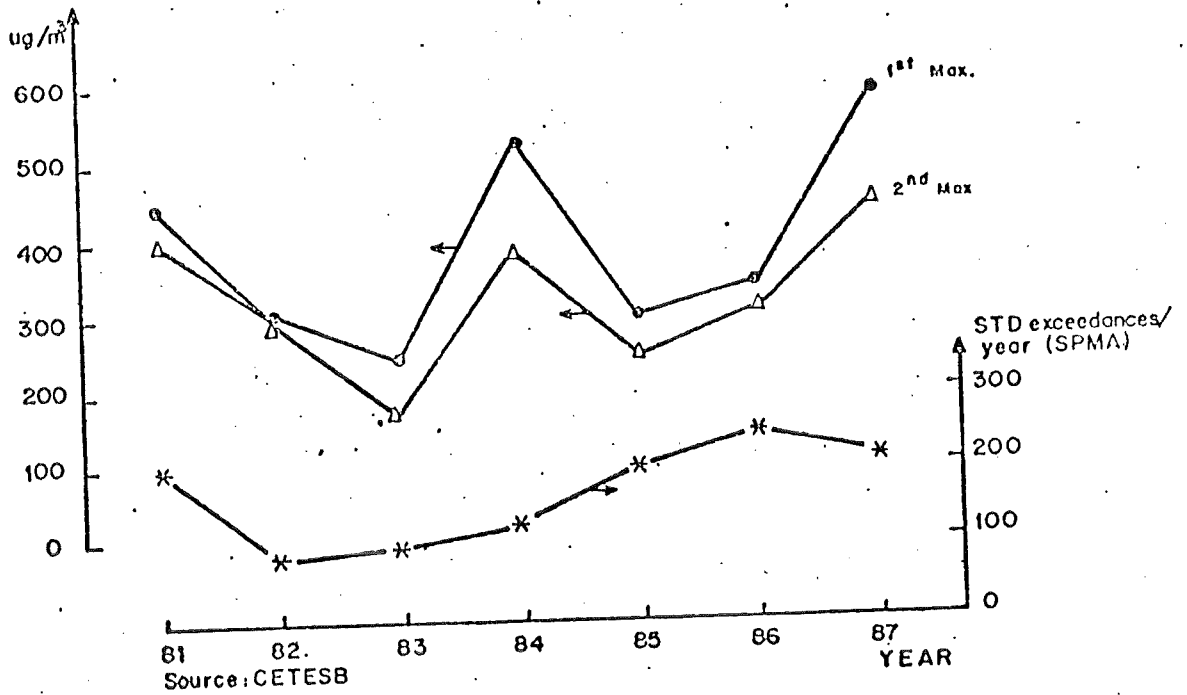


Fig. 2 - Ozone

Peak concentrations have reached 38,6 ppm (8-hour average) for CO and 584 $\mu\text{g}/\text{m}^3$ (1-hour average) for O_3 . For comparison, Table 1 shows the Brazilian air quality standards for the regulated pollutants and Table 2 the air pollution acute episode criteria for the State of São Paulo.

Table 1 - National Air Quality Standards

Pollutant	Sampling Time (h)	Standard ($\mu\text{g}/\text{m}^3$)	Reference Method
Total Suspended Particulate	24*	240	Hivol Sampler
	AGM**	80	
Sulfur Dioxide	24*	365	Pararosaniline
	AAM**	80	
Carbon Monoxide	1*	40.000	NDIR*****
	8*	10.000	
Photochemical Oxidants (as ozone)	1*	160	Chemiluminescence

* Not to be exceeded more than once a year

** Annual geometric mean

*** Annual arithmetic mean

**** Non dispersive infra red

Table 2 - Air Pollution Acute Episode Criteria
for the State of São Paulo

Parameter	Levels		
	Attention	Alert	Emergency
Sulfur dioxide ($\mu\text{g}/\text{m}^3$)-24h	800	1600	2100
Total Suspended Particulate (TSP) ($\mu\text{g}/\text{m}^3$)-24h	375	625	875
$\text{SO}_2 \times \text{TSP}$ ($\mu\text{g}/\text{m}^3$) ² -24h	65×10^3	261×10^3	393×10^3
Carbon Monoxide (ppm)-8h	15	30	40
Photochemical Oxidants (as O_3) ($\mu\text{g}/\text{m}^3$)-1h	200	800	1200

Although Brazil has not established air quality standards for non methane hydrocarbons (NMHC) and nitrogen dioxide (NO_2) yet, recorded peak concentrations for these pollutants in São Paulo City are 4 ppmC(6-9 a.m. average) and 254 ppb (annual average), respectively. These data represent about 17 times for NMHC and 5 times for NO_2 the U.S. Air Quality Standards.

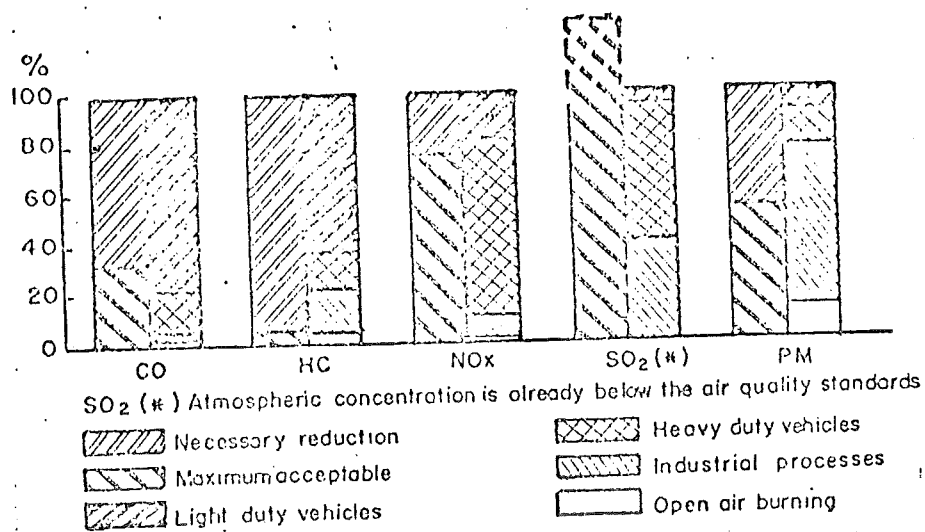
The emission inventory, presented in Table 3, shows the amount of pollutants emitted in the São Paulo Metropolitan Area - SPMA.

Table 3 - SPMA - Atmospheric Emission Inventory
1987 (1000 tons/year)

Source	Pollutant				
	CO	HC	NO _x	SO ₂	Particles
Gasoline (Exhaust)	835	77,7	28,9	4,5	4,3
Alcohol (Exhaust)	172	14,3	10,0	-	-
Diesel (Exhaust)*	218	35,6	159,0	73,0	9,9
Motorcycle (Exhaust)	32	6,1	0,21	0,26	0,11
Taxi (Exhaust)	52	4,6	2,2	0,13	0,16
Evaporative Emission	-	47,5	-	-	-
Crankcase Emission	-	10,6	-	-	-
Tire Emission	-	-	-	-	6,4
Gasoline Transfer	-	10,9	-	-	-
Industrial Processes	38	50	23	53	59
Open Air Burning	44	14	3	0,36	12
Total	1391	271,3	226,3	131,2	91,8

* Heavy Duty Vehicles
Source: CETESB.

Figure 3 resumes an indicative comparison, between the relative contribution from each source type and the reduction needs, to bring down the present maximum pollutant concentrations to the Air Quality Standards. It is important to note that industrial control programs, already implemented, have been responsible for the general SO₂ air quality standard attainment. However, sulfur reduction in the Diesel fuel is still necessary to improve air quality, particularly, in the most congested areas and, also, to reduce diesel particulate emission and improve engine durability.



Source: CETESB

Fig. 3 - Total emission reduction compared to the source emissions in SPMA

Despite the fact that motor vehicles are not the major source of particulates (PM), their contribution to air pollution is of great concern because the vehicles discharge these pollutants at street level. Therefore, public exposure to them is generally greater than it is to industrial stack emissions. Additionally, it is worthy of note that the PM emitted by motor vehicles, due to its tiny size (averaging about $0,2 \mu$), chemical properties, emission at street level and persistence in the atmosphere, may pose a greater risk to the public health than some of the particulates generated by industrial sources.

Precise evaluation of automotive contribution to air pollution, in most Brazilian cities, has not been possible because the existing air quality monitoring networks are either inadequate or insufficient for this purpose. However, based on available data regarding motor vehicle fleet, growth rate, traffic conditions and emissions, the motor vehicle generated air

pollution is probably severe in the major cities and may become a problem in the foreseeable future in many other cities, if no actions are taken to control emission. Therefore, to cope with this problem, CETESB presented to the federal government a proposal for the establishment of an emission control program. This proposal was submitted for analysis to all interested parties and after two years of discussion and a few modifications, became the National Automotive Emission Control Program.

THE EMISSION CONTROL PROGRAM

Figure 4 identifies motor vehicle emission sources and the major pollutants emitted. Table 4 shows the exhaust emission factors for the Brazilian light duty vehicles.

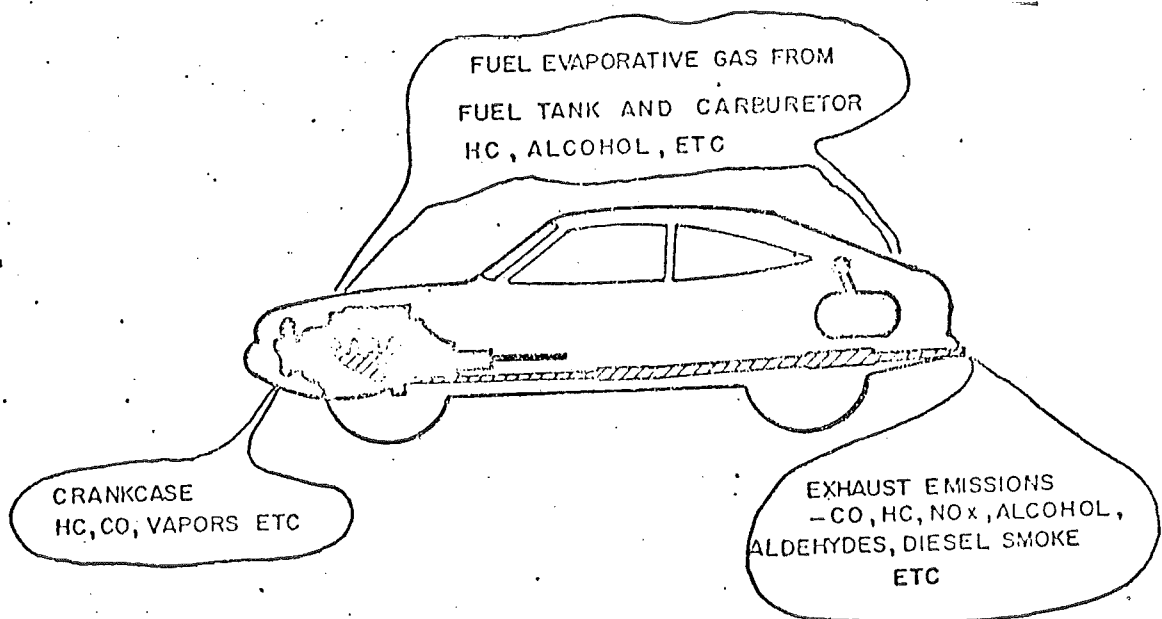


Fig. 4 - Motor Vehicle Emissions

Table 4 - Brazilian LDV Emission Factors - g/km

Vehicle Type		Pollutant			
		CO	HC	NO _x	Aldehydes
Pre 80 gasoline		54	4,7	1,2	0,05
84/85 - gasoline		37	3,3	1,4	0,05
84/85 - alcohol		18,5	0,9(**)	1,2	0,18
86/87 - gasoline		22	2	1,9	0,02
86/87 - alcohol		16	1,6(**)	1,8	0,06
In-use fleet average (*)	alc.	18,8	1,56(**)	1,09	- -
	gas.	40,5	3,77	1,4	- -

Source: CETESB

(*) These average emission factors were calculated considering the model year distribution, mileage average and vehicle age, as well as the emission deterioration factors from the "Mobile Sources Emission Factors", published by the USEPA, 1981.

(**) The alcohol engine HC data present an uncertainty due to differences in gas density and detector response for oxygenated organic compounds and propane.

The above data indicate similar technological stages for international and Brazilian uncontrolled vehicle designs. In addition, figure three indicates that the Brazilian control program must be conceived on the same basis as the most stringent programs that are being enforced elsewhere.

Starting from these points, PROCONVE was designed to control emissions, in such a way as to promote technological

development and fuel quality improvement. The PROCONVE is also associated to environmental education, transportation and inspection/maintenance complementary programs.

The PROCONVE was established by the National Environment Council (Conselho Nacional do Meio Ambiente - CONAMA) on May 6th, 1986, and it is regulated by CONAMA's Resolution nº 18. Its administration is under the responsibility of the Secretary of Environmental Affairs - SEMA, which has been assisted by CETESB.

Since this program prescribes vehicle prototypes and assembly line certification, there is a normative complement, the "National Automotive Vehicle Emission Conformity Certification Program - PROVEM", which was established by the National Council for Metrology, Standards and Industrial Quality - CONMETRO of October 22nd, 1987 and it is regulated by CONMETRO's Resolution nº 01. Its administration is under the responsibility of the Industrial Development Secretary - SDI and carried out with CETESB's laboratories and personnel participation.

The program strategy is based on successful international experience and can be defined by the following key points:

- . Only new engines and vehicles are required to comply with the established emission limits.

- . Emission limits, that progressively become more stringent, are phased in according to a schedule which is based on the state of technology in Brazil and the international experience.

- . Emission test methodologies follow international trends and therefore promote standardization and the use of state of the art test procedures.

- . Prototype, assembly-line and aftermarket parts certification is required in order to guarantee product quality and conformity.

- . Manufacturers are required to warrant emission conformity in order to guarantee the emission control systems durability.

- . Adjustable components, which may significantly affect emission, are required to be sealed by the manufacturers or incorporate inviolable limiting devices for the permissible

gauging range, in order to avoid maladjustment during tune-ups.

For the general management of the program, manufacturers are required to present, semesterly, emission data from their production vehicles and the sales projection for each configuration. For the period prior to the emission limits implementation, the emission data is based on a few vehicles and it is known as "Typical Emission Data". Once the limits come into effect, the data will be obtained from the manufacturers regular quality control programs, which shall provide statistically significant results. Based on the quality control data, production approval for certain engines or vehicle configurations may be withdrawn, therefore optimizing the certification process.

State or City Administrations are authorized at their discretion, to implement inspection and maintenance programs (I/M), in order to verify the effectiveness of the emission control systems in consumer use and to foster adequate maintenance.

New types of fuels and modification of present fuel specifications may be adopted only after approval by the Administration.

The Administration may order a recall, if through special checks or I/M programs it is verified that adequately maintained in use vehicles do not comply with the emission limits. All costs involved in such action shall be borne by the manufacturer.

Due to the use of ethanol as an automotive fuel, the Administration may establish emission limits for the so-called unregulated compounds, such as aldehydes, alcohols and other organic compounds. As for hydrocarbons, this class of pollutants is defined as the total amount of organic substances, including unburned fuel fractions and combustion byproducts, occurring in exhaust gas and which are detected by the flame ionization detector (FID).

To promote public awareness with respect to the program and the issue of air pollution by motor vehicles, the manufacturers are required to furnish specifications and recommendations to the owner, to the service network and to the pu-

blic through the owner's and services guides, labels placed on all vehicles and the media.

The National Petroleum Board (CNP) is requested to establish a program for reducing the total sulfur content from the Diesel fuel, to specify and oversee the total exclusion of lead in the ethanol/gasoline blend and to ensure that ethanol is not contaminated by lead during transport or storage.

For the purposes of management and permanent evaluation, the National Environment Council instituted the "PROCONVE Follow-up and Evaluation Committee", coordinated by the SEMA and composed of eleven top government officials which have the competence to identify and propose measures for optimizing the program, deliberate on penalties to be imposed, supervise and control the enforcement of the program, grant exemptions, waivers etc.

EMISSION TEST PROCEDURES

The emission test procedures standardized in Brazil and summarized in Table 5, are versions of actual international procedures and represent a combination of the state of the art and cost effectiveness.

Table 5 - Emission Test Procedures Adopted in Brazil

Type of Emission	Type of Vehicle	Emission Test Procedure
Exhaust	LDV - Otto Engine	U.S. - 75 FTP
	LDV/HDV - Diesel Engine	U.S. "13 Mode" FTP European Full-Load Steady State Test Procedure (smoke)
	HDV - Otto Engine	U.S. "9 Mode" FTP
Evaporative	LDV - Otto Engine	U.S. SHED FTP
Crankcase	All vehicles except Diesel turbocharged	Engine Design Analysis for closed crankcase ventilation system

For the light duty vehicles powered by OTTO engines, the U.S. - 75 test procedure was chosen because it better reflects actual driving conditions than the European or Japanese emission tests; the sampling and analytical systems are more suitable for alcohol and gasohol fuels than the European emission test and, because its gradual adoption by a number of countries, it may well become the international reference test procedure.

In contrast to the European emission test, the adoption of the U.S. procedure represents the confidence that considerable investments in emission laboratories will not be lost in a few years due to obsolescence.

Also because it considers the actual friction and aerodynamic vehicle power in a wide speed range, the U.S. test procedure incentives the manufacturer to improve the whole vehicle design instead of just improving the power system.

For the evaporative emission, the SHED FTP (U.S. Federal Test Procedure) was adopted for the light duty vehicles, because it evaluates the evaporation from the complete fuel system. The adoption of the SHED test has resulted elsewhere in improvements in the tightness of the fuel systems. For alcohol engines, a new analytical equipment calibration is being tested with ethanol instead of propane, due to the differences in FID response and fuel vapour density.

For the Diesel engines, whether they power light duty or heavy duty vehicles, the U.S. "13 mode" and the European "Full load steady state" engine test procedures were chosen for gaseous emissions and smoke, respectively. These emission tests are presently adopted in Europe (the European version has some calculation differences from the U.S. procedure) and, although they are not as sophisticated as the U.S. transient test, can be adapted to existing engine laboratories. The European experience has shown that these tests, despite the fact that they do not adequately represent actual engine operating conditions, can be successfully used to develop emission limits which cut down the gross exhaust pollution. At this point, it is important to note that Diesel vehicles are used in Brazil mainly for commercial

purposes and mass transport and represented approximately 80% of the total motor vehicle fleet in 1985. Due to the European experience with the 13-mode test, CETESB is evaluating the use of the European version in place of the U.S. version.

In a lower priority for emission control, we have the heavy duty vehicles powered by OTTO engines, because they represented only 1% of the total motor vehicle fleet and there are no signs that this percentage may increase substantially in the near future. Therefore, the emission test procedure adopted for the OTTO engines is the U.S. "9 mode", simply because it utilizes the same basic equipment and instruments needed for the "13 mode" test.

Finally, for crankcase emission, the PROCONVE does not establish any special procedure, but recommends an engine design analysis in order to fully evaluate the closed crankcase ventilation system. Only turbo charged diesel engines are not required to have such a control system.

STANDARD FUELS FOR EMISSION TESTS.

The Brazilian emission limits are being developed with the help of the previously referred test procedures and shall be attained in official tests by vehicles or engines fueled with the standard emission test fuels, presented in Tables 6 and 7.

These fuels were specified in such a way as to represent the typical Brazilian commercial fuels, but with tighter tolerances. The gasoline - anhydrous alcohol blend shall be prepared from the corresponding test fuels, in the proportion of $22,0 \pm 1,0$ of alcohol, by volume.

The standard diesel fuel specification is being revised, therefore, it is not presented in this paper.

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Table 6 - Standard Alcohol Fuels (CNP Resolution nº 1 - 1985)

Item	Anhydrous Ethanol	Hydrated Ethanol	Test Method
Alcohol grade at 20°C, °INPM	99.5 ± 0.2	93.2 ± 0.4	CNP Resolution No. 7 - 1982
Residue, mg/l, maximum	50.0	50.0	
Total acidity, mg/l, maximum	20.0	20.0	
Aldehydes, mg/l, maximum	-	60.0	
Esters, mg/l, maximum	-	80.0	
Higher alcohols, mg/l, maximum	-	60.0	
Alcalinity	negative	negative	
Copper, mg/kg, maximum	0.03	-	
Sodium, mg/kg, maximum	2.0	2.0	Flame photometer
Sulfate, mg/kg, maximum	2.0	2.0	Gravimetric
Conductivity, µS/m, maximum	600.0	600.0	Conductivimeter
Density at 20°C, kg/m ³	790.9 ± 0.6	809.4 ± 1.1	NBR-5992
Aspect	clean and without suspended particles	clean and without suspended particles	Visual

Table 7 - Standard Gasoline (Brazilian Standard NBR-8689 --
December 1984)

Item	Specification	Test Method
Motor octane number	73 - 75	ASTM D-2700
Sensitivity	3 minimum	-
Tetraethyl lead, ml/l	0.4 maximum	ASTM D-3237
Distillation range IBP, °C	35 - 50	ASTM D-86
10% point, °C	55 - 71	
50% point, °C	78 - 98	
90% point, °C	135 - 155	
E.P., °C	170 - 205	
RVP at 37.8°C, kPa	29.42 - 53.94	ASTM D-323
Sulfur, weight %	0.15 maximum	NBR-6563
Gum, mg/100 ml	5 maximum	ASTM D-381
Hydrocarbon Composition		ASTM D-1319
Olefins, volume %	20 maximum	
Aromatics, volume %	40 maximum	
Saturates, volume %	to be recorded	
C/H ratio	to be recorded	
Relative density, 20°C/4°C	to be recorded	NBR-7148
Copper corrosion, 3h at 50°C	1 maximum	ASTM D-130
Induction period, min.	1500 minimum	ASTM D-525
Aspect	clean and without suspended particles	visual
Alcohol content, % vol.	nihil	CNP-DIPAB-209/ 81

THE EMISSION LIMITS

The emission limits, for light duty vehicles powered by Otto engines and heavy duty vehicles, are presented in Tables 8 and 9, respectively. For the light duty vehicles, the emission limits were established under the premise that by 1999, CO concentrations in ambient air should conform to the air quality standards in the SPMA. Therefore, for this pollutant the proportional Rollback model was used to define the limits until 1997. For the other two pollutants, the limits were established according to an engineering analysis of possible emission reductions that can be achieved with present emission control technologies. These reductions were correlated with the already defined CO emission limits.

The idle CO emission limits were based on the best available information regarding the control of this type of emission and were established because many Brazilian cities have a congested traffic. Furthermore, they will provide a baseline for maintenance and future inspection and maintenance programs.

The smoke emission limits were established according to the criteria of best proven control strategy for this pollutant. The European experience with smoke control has been more successful than others.

Table 8 - Emission Limits for Brazilian Alcohol and Gasoline Light Duty Vehicles

Type of Emission	Effective Date	Remarks	Emission Limits			
			g/km			%
			CO	HC	NO _x	Idle CO
E X H A U S T	Jun 1st,88	Brand new vehicle configurations				
	Jun 1st,89	50% of sales is the minimum required	24,0	2,1	2,0	3,0
	Jan 1st,90	100% of sales except LDT				
	Jan 1st,92	Only LDT				
	Jan 1st,92	100% of sales except LDT	12,0	1,2	1,4	2,5
	Jan 1st,97	All LDV	2,0	0,3	0,6	0,5
Evaporative	Jan 1st,90	All LDV	-	g/test 6,0	-	-
Crankcase	Jan 1st,88	All LDV	emission shall be null under any engine operating conditions.			

Note: LDV - light duty vehicles

LDT - light duty trucks

Table 9 - Emission Limits for Brazilian Heavy Duty Vehicles

Type of Emission	Effective Date	Remarks	Emission Limits
E X H A U S T	Oct. 1st, 87.	only for urban buses powered by Diesel engines	k = 2,5 (smoke)
	Jan. 1st, 89.	all vehicles powered by Diesel engines	
	to be proposed until December 31, 1988.	- only for vehicles powered by Diesel engines	k = 2,0 (smoke)
		- for vehicles powered by either Diesel or Otto engines	shall be proposed until December 88 for CO, HC, NOx
Evaporative	to be proposed	only for vehicles powered by Otto engines	to be proposed
C R N K C A S E	Jan. 1st, 93	only for urban buses powered by Diesel engines	emission shall be null
	to be proposed until Dec.31,1987	all vehicles powered by Diesel engines	under any engine
	Jan. 1st. 89.	all vehicles powered by Otto engines	operating conditions

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The emission limits shall be warranted in writing by the manufacturer according to the requirements summarised in Table 10, as follows:

Table 10 - Emission Limits Warranty

Type of Vehicle	Warranty Requirements	Remarks
Light duty vehicles	80,000 km/5 years whichever occurs first	Testing procedure to be established; in the meantime, the warranty may be replaced by a 10% reduction in the emission limits, except for idling CO.
Heavy duty vehicles	160,000 km/5 years whichever occurs first or equivalent results on a dynamometric testing procedure	

Notes: 1) The light duty vehicles powered by Diesel engines shall follow the same prescriptions established for the heavy duty vehicles.
 2) The smoke limit was established according to the European procedure which is based on the equation $c = k \sqrt{G}$, where c is the carbonic concentration, in g/m^3 , G is the nominal gas flow in l/s and k is a constant that represents the smoke level.

EMISSION REDUCTION

The effect of the PROCONVE on exhaust emission from light duty vehicles (Otto Engines) was evaluated by CETESB for the São Paulo Metropolitan Area (2).

The study, based on the temporal evolution of the 1984 emission inventory data, according to ten fleet growth scenarios, indicates potential emission reductions of 63% for CO, 50% for HC and 35% for NO_x , expected by 1999.

If, for the same study scenarios, instead of the established emission limits starting from 1988, Brazil would have adopted the present U.S. emission limits, enforced in 1987, then the potential emission reductions would be 90% for CO, 85% for

HC and 67% for NO_x , as shown in Fig. 5. Although this hypothesis might be highly desirable, it would not be feasible mainly due to the unavailability of advanced emission control technologies in Brazil and due to the necessity to adapt, in a very short time, emission control systems developed elsewhere for the Brazilian vehicles and fuels. However, PROCONVE was designed in such a way to produce the same air quality improvements, as the hypothetical "US case", with a delay no longer than 4 years.

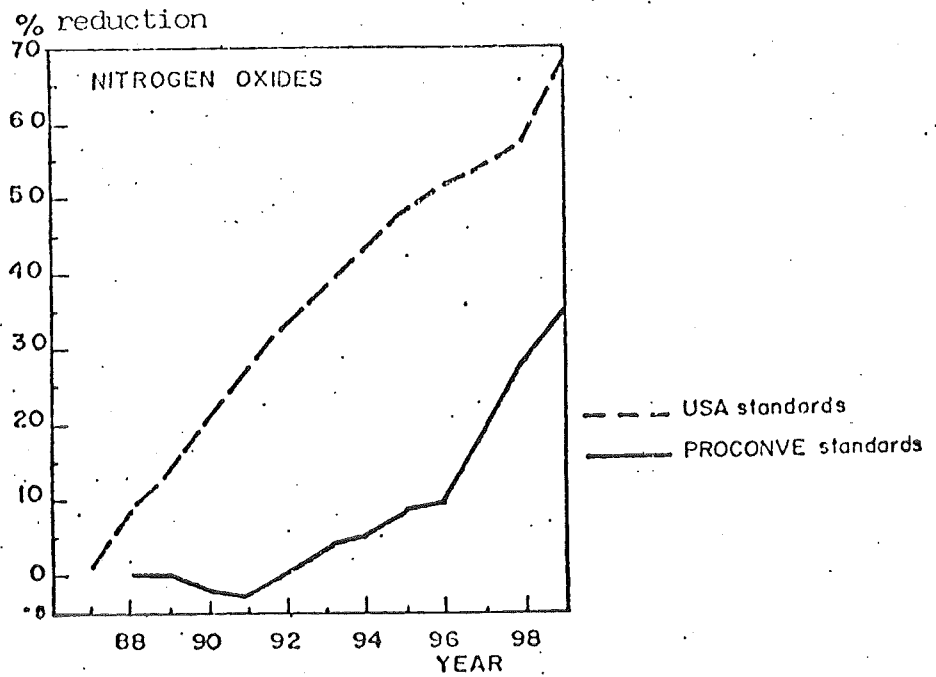
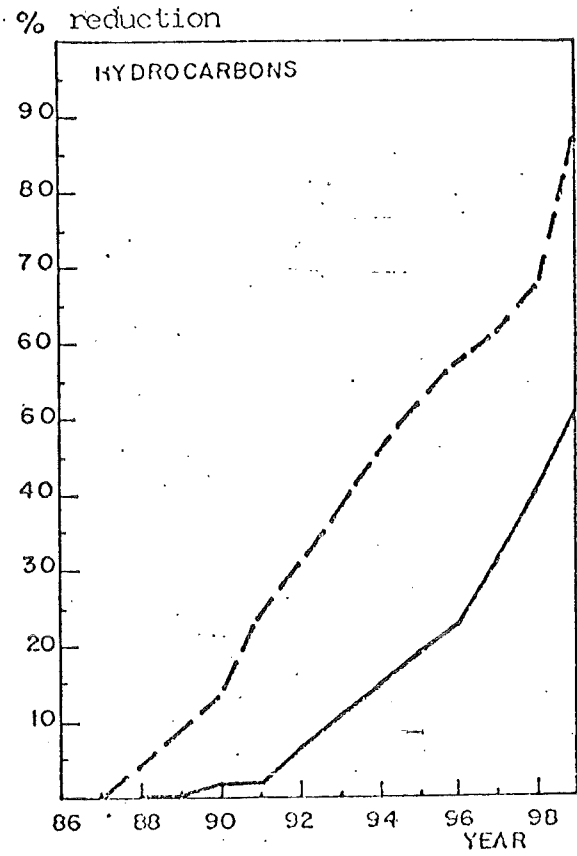
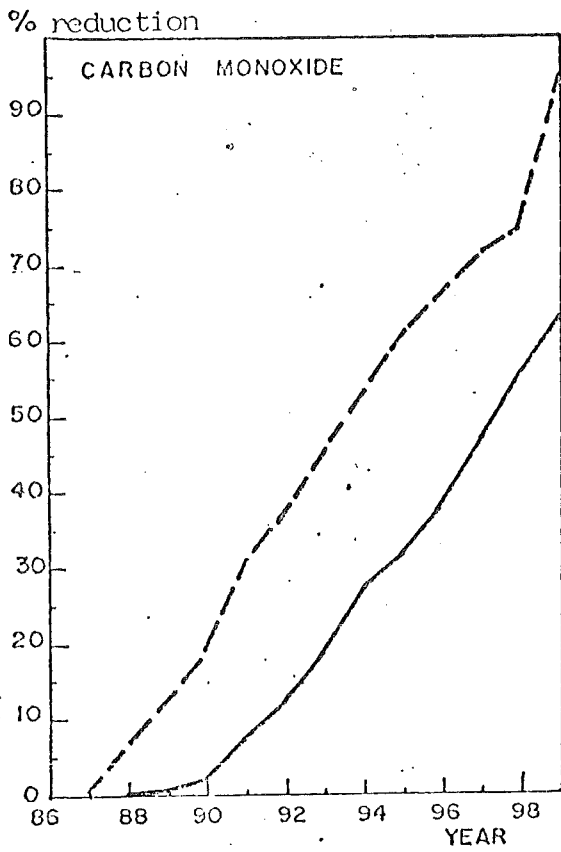
As for the evaporative emissions, it can be said that emission reduction for certain vehicle configurations will be higher than 80%.

As far as Diesel smoke emissions are concerned, the first approach of the program deals with the maximum "k" smoke levels, presently reaching up to 6, for the worst engines. Initially, the "k" levels have to come down to 2,5 and later on to 2.0, for all Diesel engines.

Although detailed emission reduction forecasts for all pollutants are not available yet, it can be inferred that automotive emission control will have a positive impact on air quality, either through corrective action in the polluted areas or through preventive action in the still unpolluted areas.

THE FEASIBILITY OF THE CONTROL PROGRAM

When considering the establishment of a motor vehicle emission control program, especially in a developing country, one has to analyse local conditions in order to verify the possibilities of adopting, successfully, the international experience which has been acquired in the so-called industrialized countries. In the case of Brazil, this is possible because there is a well established motor vehicle industry, capable of designing and producing control systems that have proved to be efficient, durable and cost-effective elsewhere.



Source REF 2 and 5

Fig. 5 - PROCONVE Efficacy

Actually, the Brazilian motor vehicle industry has been exporting engines, vehicles and components to countries like the U.S.A., Canada and Sweden which have ongoing emission control programs. In addition, Brazil represents a market of about one million vehicles/year which, according to industry sources, may reach 1,5 million vehicles/year in 1990. Such a considerable market has certainly caught the attention of emission control manufacturers.

Furthermore, the alcohol fuel program has fostered fast technological development which resulted in new advances in materials engineering, engine optimization, fuel economy and some emission reduction.

The "Typical Emission Data Report", summarised by Figures 6, 7, 8 and 9 for carbon monoxide, hydrocarbons, nitrogen oxides and smoke, respectively, shows the emission factors (average per configuration) for the present Brazilian models. The data indicates:

a) The first control step for LDV, in effect since June 1988, represents an "emission dispersion reduction" and an improvement in "production quality control", in order to average all vehicle configurations to a technological stage which has already been achieved by a number of models.

b) The second control step for LDV, to come into effect in January 1992, means a "design standardization", upgraded to the lowest emission levels, presently observed in some models.

c) The third control for LDV, to come into effect in January 1997, represents the program's goal which is the implementation in Brazil of the "best available technology in the world".

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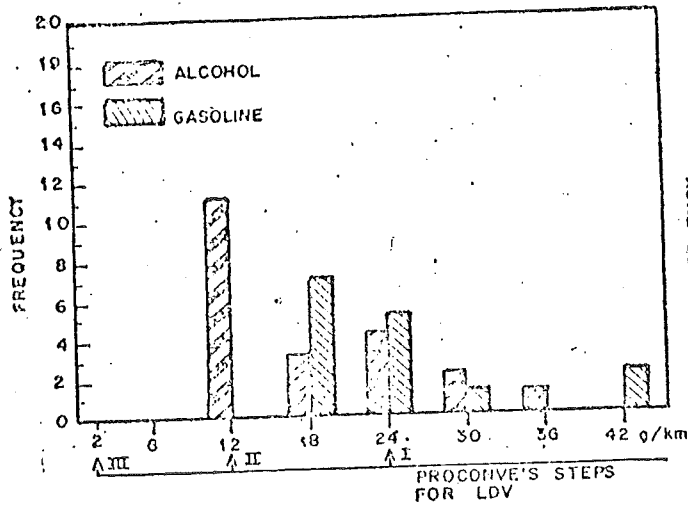


Fig. 6 - CO Typical emission data (g/km) 2nd semester/87

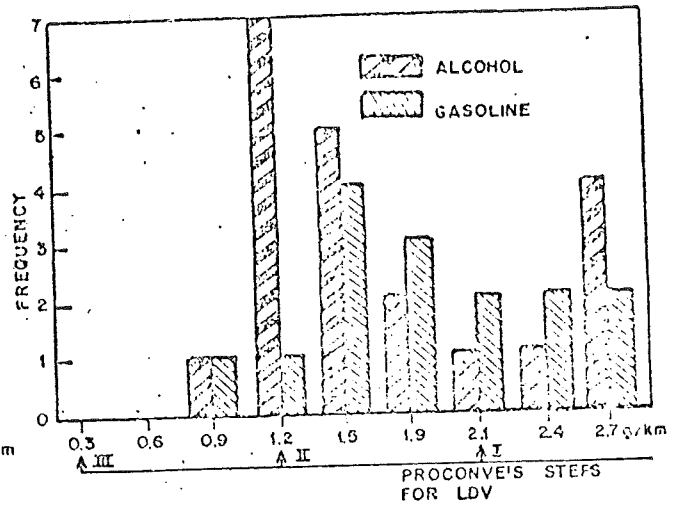


Fig. 7 - HC Typical emission data (g/km) 2nd semester/87

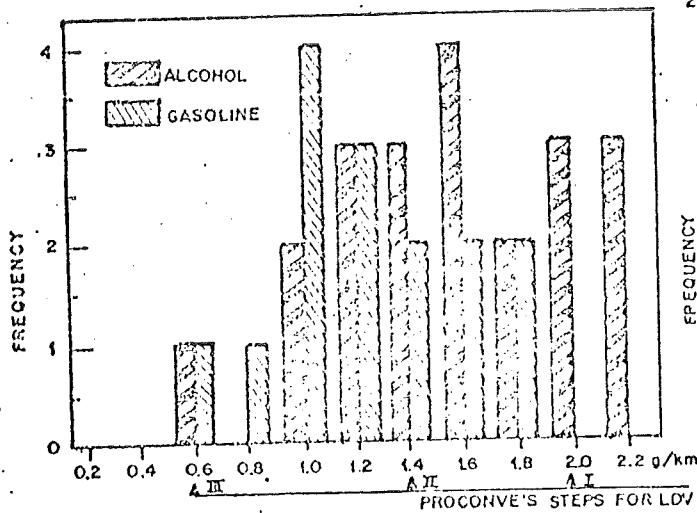


Fig. 8 - NOx Typical emission data (g/km) 2nd semester/87

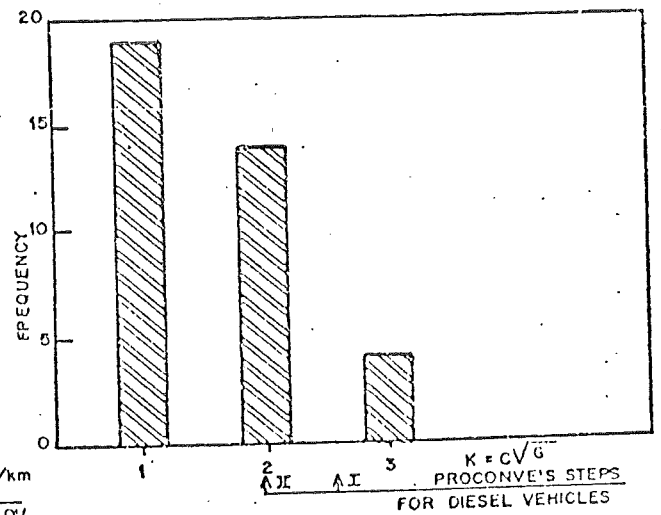


Fig. 9 - Smoke Typical emission data (k) 2nd semester/87

Due to the blend of 22% ethanol to gasoline, lead levels have been substantially lowered and the impact of reduced lead emissions on air quality can be seen in Figure 10.

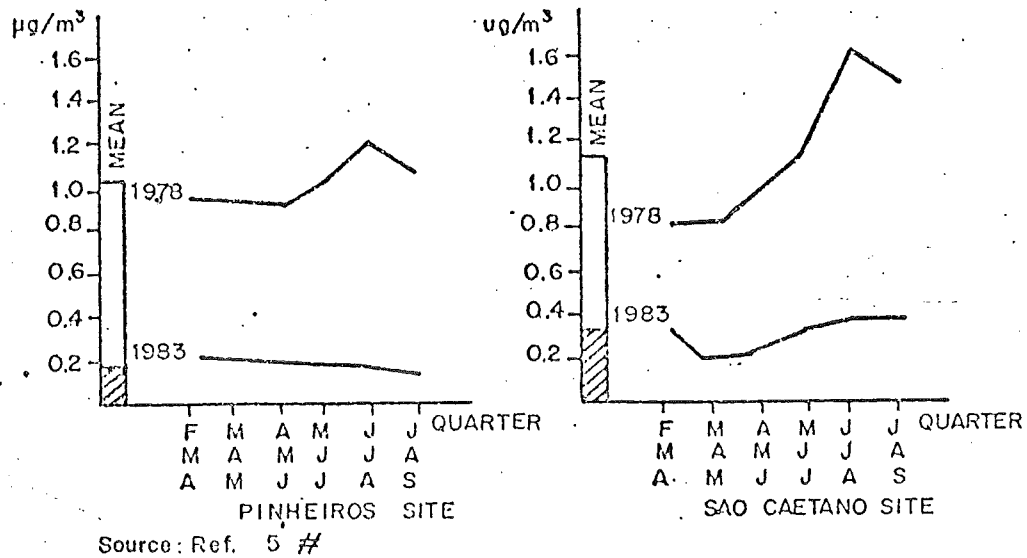


Fig. 10 - Lead quarterly average concentrations at two sampling sites on SPMA during 1978 and 1983

However, unleaded fuels are still necessary within a short period of time, considering that catalytic converters have become an important technological choice for compliance of step two for a number of models and that converter will certainly be required for all vehicles, to comply with step three. Therefore, SEMA is proposing a lead phase-out program, as described below:

1) a 70% reduction in the gasoline lead content by 1991, in order to guarantee that lead contamination of alcohol, which eventually occurs during storage, transportation and distribution operations, is kept at minimum. Therefore it is expected that alcohol will always have less than 0,01 ml/l tetraethyl lead.

2) Use of lead-free gasoline, nationwide, in mid 1993, since the oil industry (PETROBRAS) has made public that it needs about 5 years to modify the refining processes.

As for the Diesel fuel, the sulfur content is still high, being the national average 0.7% weight. However, desulfurization plants are being built and planned, so, it is expected that in few years, low sulfur Diesel fuel will be available.

Unfortunately, sulfur is not the only problem; Diesel fuel specifications need to have tighter tolerances and fuel quality has to be improved. Therefore, a working group involving the oil industry, the Diesel vehicle manufacturers and government agencies has been established to discuss the possibilities of upgrading the diesel fuel.

Another important point is the in-use vehicles maintenance. In June 1988, CETESB conducted an inspection program for volunteers. About 7000 vehicles were submitted to a CO and RPM check at idle and it was found that 72% of the test fleet needed a tune-up. Two hundred and twenty vehicles were tuned-up and retested and the result was not much better: 69% of the vehicles failed the retest. The poor maintenance can be blamed on three basic reasons:

- 1) Service personnel are, in general, poorly prepared having in most cases, hands on experience rather than technical training.
- 2) Only few service stations have check-up equipments.
- 3) Preventive maintenance has become an economic burden for the average car owner, because of the high cost of maintenance services and parts. Furthermore, many customers fear that preventive maintenance may have a negative effect on the vehicle performance.

Therefore, a training program directed to improve the mechanics expertise and to get them acquainted with emission control systems, must be implemented.

Although at present there are no official inspection and maintenance programs in Brazil, it is felt that certain critical areas, like the SPMA, will have to begin with such programs in a few years.

One additional point of interest is the cost of the emission control systems for the consumer. To this question, we would like to refer to the public survey conducted by CETESB in São Paulo City in 1985. When asked about the willingness to pay 10% more for a new vehicle, which would be equipped with "filters" to reduce pollution, 79% of the interviewed people agreed to pay the extra cost in order to have less pollution,

17% answered no and 4% did not have any opinion. The "10%" value was arbitrarily chosen in order to give an "impact" to the question. Nevertheless, it is expected that emission control systems will add no more than 5% to the vehicle cost.

Considering this broad picture, it is safe to say that Brazil has the basic conditions to adopt an emission control program comparable to present similar foreign programs.

FIRST EFFECTS OF THE CONTROL PROGRAM

The PROCONVE, as a recently established program, has not had the time to cause any positive impact on air quality yet. However, it produced some side effects that can be reported already.

The first effect worthy of mention is the removal of certain barriers which set apart the environment control officials and the motor vehicle manufacturers. It is clear that only a combined effort of industry and government can lead to a successful program.

A second effect is the progress in technological expertise which is being observed. In fact, considerable efforts in human resources training are presently being made, particularly by the industrial sector, with a significant impact on Brazilian automotive engineering.

Another important effect is the practical experience which is being acquired due to the requirement of the semesterly report of "typical emission data". To prepare such a report, the manufacturer has to pay attention to emissions, a fairly new topic to a great number of engineers. Besides the training effect, which will be highly valuable during the emission control stages of the program, important data come out from these reports giving to the program administration a more comprehensive panorama of the state of emissions in Brazil.

An effect which cannot be overviewed is the influence on the economy. In fact, the PROCONVE created a new market for equipment, instruments, parts, systems and services related to R&D, emission testing, quality control, emission control and vehicle maintenance.

Furthermore, the PROCONVE can be a key factor to promote or expand Brazilian automotive exports, therefore contributing to the balance of payment.

Other effects are being observed, such as research of non-noble metals for catalytic converters but, by now there is no available information about this work.

JAPANESE PARTICIPATION IN THE PROCONVE

The Japanese participation in the PROCONVE has been, up to now, very small. This is mainly due to the tiny participation of the Japanese motor industry in the Brazilian market. It is worthy of note that most emission laboratories use analytical equipment which were designed by a Japanese company. The authors believe that the Japanese experience particularly in emission control and fuel economy should be shared with Brazil.

CONCLUDING REMARKS

The PROCONVE is at initial stage and it is not the author's intention to claim that it is perfect or that it should not be modified in the future. In fact, a lot of work is necessary from the government, the motor and fuel industries and research institutes in order to make it a reality. Also public and political support are essential.

The environment is not a garbage box with infinite capacity, in fact, it is just the other way round. This is true for both industrialized and developing countries.

The PROCONVE is a feasible program for Brazil and certainly similar programs may be adopted by other developing countries.

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