CETESB

COMPANHIA DE TECNOLOGIA DE SANEAMENTO AMBIENTAL

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PROCOP

PROGRAMA DE CONTROLE DE POLUIÇÃO

PROGRAMA DE ASSISTÊNCIA TÉCNICA

RELATÓRIO REFERENTE À CONSULTORIA PRESTADA PELO DR. MICHAEL P. WALSH

RELATÓRIO DE CONSULTOR:

MOTOR VEHICLE POLLUTION CONTROL
THE PROGRESS IN BRAZIL

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CETESB

MOTOR VEHICLE POLLUTION CONTROL: THE PROGRESS IN BRAZIL

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EXECUTIVE SUMMARY

An analysis of the motor vehicle pollution problem in Brazil was carried out in 1984, under a project sponsored by PROCOP and the World Bank. The study concluded that a very serious problem existed and recommended a series of steps to bring about improvement. Since then, Brazil has made rapid progress, incorporating many of the recommendations resulting from that study as well as others. Most important, emissions standards have been adopted on the following approximate schedule.

DATE	EXHAUST EMISSIONS STANDARDS (G/KM)				VEHICLES
	CO	HC	NOX	IDLE CO (%)	
JUNE '88	24.0	2.1	2.0	3	NEW MODELS
JAN '89	24.0	2.1	2.0	3	50% CARS
JAN '90	24.0	2.1	2.0	3	100% CARS
JAN '92	24.0	2.1	2.0	3	LDT's
JAN'92	12.0	1.2	1.4	2.5	100% CARS
JAN '97	2.0	0.3	0.6	0.5	100% LDV'S

A careful assessment of the impact of the program adopted has been carried out and indicates that the standards adopted will lower HC, CO and NOx emissions significantly over what would be the case if current levels remained in effect. Even projecting a 3% annual growth in overall vehicle miles travelled (VMT), CO levels will decline while HC levels will remain stable; NOx emissions, however, will increase due mainly to heavy duty vehicle emissions.

However, the analysis also indicates that increased congestion reflected in a gradual decline in vehicle speeds could reduce the potential gains from the adopted program. Further analysis shows that supplementing the car program with heavy duty vehicle standards and Inspection and Maintenance (I/M) could substantially enhance overall program effectiveness.

CONCLUSIONS

Brazil has taken a major step forward in addressing its motor vehicle pollution problem. The program which has been adopted is comprehensive, practical and potentially very effective. Substantial effort will be needed over the next decade to implement the decisions and to turn the potential gains into reality. In addition, the National Environment

Board should consider a few additional steps which could enhance the overall program effectiveness. Specifically:

1. Every effort should be made to introduce unleaded fuel before the 1992 standards go into effect. This is feasible and would likely accelerate the introduction of the most advanced emission control technology. This technology would not only lower emissions of regulated pollutants such as HC, CO and NOx, but would also reduce known carcinogens and result in better performing and more fuel efficient cars.

2. Vehicle growth and increased congestion must be contained if the program adopted to date is to actually result in improved air quality.

3. Inspection and maintenance programs should be introduced in conjunction with more stringent new vehicle standards to assure these standards have the maximum positive environmental effect.

4. More stringent heavy duty vehicle standards for HC, NOX and particulate should be introduced as rapidly as possible.

I. Background

During early September 1986, a visit was made to Sao Paulo, Brazil at the request of the Companhia De Tecnologia De Saneamento Ambiental (CETESB). The specific purposes of the visit were to follow up on an earlier consultation in 1984, to participate in a conference with the automotive industry discussing the program developed by CETESB and SEMA, and to assist CETESB in refining its motor vehicle air pollution control program as it proceeds toward the implementation stage.

Overall, the visit was quite successful and all the objectives were achieved. The Brazilian motor vehicle pollution control program (named PROCONVE), which was established by the National Environmental Council (CONAMA) on May 6, 1986, was found to be comprehensive and practical. The Conference between Government and Industry went quite well with extensive discussion and interaction. During these discussions, it appeared that all the participants were again impressed with not only the competence of the CETESB personnel but also with the scope of their program.

Based on the earlier visit and discussions, a series of recommendations had been made. The remainder of this report will list the 1984 conclusions, summarize the program adopted by CONAMA, review this program in terms of the 1984 recommendations, and assess the remaining problems.

II. 1984's Conclusions

1. Sao Paulo has a very serious motor vehicle related air pollution problem today and it is expected that many other areas in Brazil are in the same situation.
2. This problem will get even worse without significant, aggressive action toward tight emissions control.
3. The pollutants generated cause loss of work and school, unnecessary suffering, premature deaths, loss of crops, poor visibility and a general decline in the quality of life. The adverse impacts tend to fall most heavily on the very old, the very young and those least able to cope.
4. Technology exists which is capable of bringing about very significant improvements in emissions per mile driven. This technology has been demonstrated to work well on literally millions of vehicles in the US and Japan.
5. Other steps such as Inspection and Maintenance (I/M) programs to improve vehicle maintenance can enhance and supplement the benefits from the use of these technologies.
6. Adoption of these technologies has been shown to be compatible with strong national energy conservation

programs.

III.. The Program Adopted By Brazil

The brazilian automotive emission control program, named PROCONVE, was established by the National Environment Council (CONAMA) on May 6th, 1986, and it is regulated by the Resolution no 18.

The control strategy was established after two years of discussion between the Government and the motor industries, and contains the following key elements:

-- New engines and vehicles are required to comply with the following emission limits. (The time schedule indicated is slightly simplified for ease of explanation.)

DATE	EXHAUST EMISSIONS STANDARDS (G/KM) CO	HC	NOX	IDLE CO (%)	VEHICLES
JUNE '88	24.0	2.1	2.0	3	NEW MODELS
JAN '89	24.0	2.1	2.0	3	50% CARS
JAN '90	24.0	2.1	2.0	3	100% CARS
JAN '92	24.0	2.1	2.0	3	LDT's
JAN'92	12.0	1.2	1.4	2.5	100% CARS
JAN '97	2.0	0.3	0.6	0.5	100% LDV'S

-- Emission test methodologies adopted follow international trends and therefore promote standardization.

-- 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.

-- Prototype certification and assembly-line testing 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 manufacturer or incorporate inviolable limiting devices for the permissible range in order to avoid maladjustments during tune-ups.

-- Manufacturers are required to present biannual emission data from their quality control programs; based on this data, production approval (certification) for certain engines or vehicle configurations may be withdrawn.

-- 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.

-- The Administration may order a recall, if through special checks or I/M programs it is verified that adequately maintained vehicles in-use 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 a aldehydes, alcohols and other organic compounds.

-- 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, the service network and to the public through the owner's and services guides, the media and labels placed on all vehicles.

For the purposes of management and permanent evaluation, the National Environment Board instituted the PROCONVE Follow-Up and Evaluation Committee, coordinated by the Special Secretary for Environment Affairs (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.

IV. Review of the Program In View of the 1984 Recommendations

1. The use of lead should be completely eliminated from motor vehicle fuel.

The decision has been made to implement this recommendation by 1997 at the latest. It should be noted that the auto industry has requested that this step be accelerated to perhaps 1992 and PETROBRAS is considering this possibility.

2. Passenger cars (Otto cycle engines) should adopt the most stringent possible standards (i.e., equivalent to those of the US and Japan) as rapidly as possible.

US standards will be introduced in 1997, as the third step in a program which is just getting underway. This is a very dramatic and positive development.

3. In conjunction with these standards, because of the alcohol fuel program, it may be necessary to adopt a separate aldehyde standard.

Aldehyde standards are under review and a specific proposal is expected by December 31, 1988.

4. If it will take several years before the US standards can go into effect, interim standards at the 1977 US levels should be adopted, probably for the 1987 Model Year.

Interim standards have been adopted according to the following schedule:

DATE	EXHAUST EMISSIONS STANDARDS (G/KM) CO	HC	NOX	IDLE CO (%)	VEHICLES
JUNE '88	24.0	2.1	2.0	3	NEW MODEL
JAN '89	24.0	2.1	2.0	3	50% CARS
JAN '90	24.0	2.1	2.0	3	100% CARS
JAN '92	24.0	2.1	2.0	3	LDT's
JAN'92	12.0	1.2	1.4	2.5	100% CARS
JAN '97	2.0	0.3	0.6	0.5	100% LDV'S

5. Parameter adjustment regulations to limit the adjustability of critical emissions related items should be adopted simultaneously with the 1977 US standards.

These regulations have been adopted and will go into effect on January 1, 1988.

6. An evaporative hydrocarbon standard of 2 grams per test should be adopted simultaneously with the 1977 US exhaust requirements.

An evaporative hydrocarbon emission standard of 0.6 grams per test has been adopted, to go into effect for all light duty vehicles equipped with Otto cycle engines by January 1, 1990.

7. The hydrocarbon measurement method should be

adjusted to compensate for the use of ethanol in the fuel.

This issue is still undergoing review and a specific proposal is expected by December 31, 1988.

8. Inspection and Maintenance programs should be adopted as quickly as possible to maximize the potential air quality gains associated with the new car exhaust emissions requirements.

The introduction of Inspection and Maintenance programs has not yet been decided. However, some of the necessary foundation has been prepared by the requirement that engine tuning specifications must be provided in the owners manuals and service handbooks as of January 1, 1987. In response, some manufacturers are substantially upgrading their dealer equipment, test procedures and training methods. Similarly, Production line personnel training is being improved.

9. The in-use diesel smoke test program should be upgraded to increase the incentive for fleet operators to improve overall fleet maintenance.

Not yet decided.

10. The US test procedure for heavy duty diesel NOx and Particulates should be adopted immediately with a long term goal of adopting stringent emissions standards based on this procedure.

Alternatively, it has been decided to introduce the steady state test (9 and 13 modes) and it is anticipated that specific heavy duty emissions standards will be proposed by December 31, 1988.

11. To pave the way for more stringent requirements, European smoke standards should be adopted immediately for new engines.

Existing European requirements have been adopted. A second step, k=$\sqrt{2.0}$, is under consideration.

12. The trolley network in Sao Paulo should be expanded to replace diesel buses.

This proposal has not been implemented. A few exclusive trolley lanes are planned but this will not be sufficient to have a significant impact.

13. Research which could lead to a switch from diesel fuel to alcohol for urban buses should be accelerated as a means to lower NOx and particulates. Specific aldehyde standards may also need to be adopted.

This proposal is still under consideration, but is not specifically provided for in the decisions to date.

14. Diesel fuel quality should be maintained more consistently and sulphur levels reduced.

This proposal has not yet been implemented although it is planned to lower the fuel sulfur content by December 31, 1987.

15. To minimize the adverse environmental consequences associated with the high projected future growth in Brazil, greater focus on environmental impact evaluations prior to project ground breaking is needed and should be considered. Even with stringent emissions standards, high growth rates can overwhelm the environment and result in many significant problems. These problems can be reduced through wise planning; a critical element of this planning should be environmental impact statements.

This proposal has not yet been implemented.

16. To better define the air quality problem, comprehensive air quality monitoring programs should be instituted in all of Brazil's major cities.

Adopted in Sao Paulo

V. Assessment

A careful assessment of the impact of the program adopted has been carried out and is summarized in Tables 1 through 9 and Figures 1 through 12. The cases analyzed are summarized below:

Case	Annual Growth	Standards	VMT Mix	Average Speed	HDV Standards	I/M
A	none	PROCONVE	constant	19.6m.p.h.	none	no
B	3%	"	"	"	"	".
C	"	"	"	10	"	"
D	"	"	decline#	"	"	"
E	"	"	Alcohol	10	"	"
F	"	Base	"	10	"	"
G	"	PROCONVE	"	"	yes	"
H	"	"	"	"	"	yes

#	year	speed
	1985	19.5
	1990	15.0
	1995	10
	2000	7.5
	2005	6.0
	2010	5.0

Figures 1, 2 and 3 illustrate that the standards adopted will lower HC, CO and NOx emissions significantly over what would be the case if current levels remained in effect. Even projecting a 3 % annual growth in overall vehicle miles travelled (VMT), CO levels will actually decline while HC levels will remain stable; NOx emissions, however, will continue to increase due mainly to heavy duty vehicle emissions.

Figures 4, 5 and 6 illustrate that even if VMT remains constant in the future, increased congestion reflected in a gradual decline in vehicle speeds could eliminate many of the potential gains from the adopted program. Figures 7, 8 and 9 show that if this is coupled with 3% annual growth in VMT, congestion could actually cause the problem to get much worse in the future.

Figures 10, 11 and 12 show that supplementing the car program with heavy duty vehicle standards and I/M could substantially enhance overall program effectiveness. Heavy duty vehicles were estimated to emit at the following rates:

	HC	CO	NOx
Diesel Trucks			
Base Case			
Low Mileage	5.10	10.0	20.50

Deterioration	0.05	0.15	0.00
Standards Introduced 1993			
Low Mileage	2.43	10.0	10.89
Deterioration	0.02	0.15	0.05
Gasoline Trucks			
Base Case			
Low Mileage	7.31	90.0	6.12
Deterioration	0.19	4.00	0.07
Standards Introduced 1993			
Low Mileage	2.43	13.26	4.30
Deterioration	0.02	0.58	0.09

In estimating the benefits of I/M, it was assumed that a program was introduced in 1990, with a 30% stringency, included mechanic training, applied to all cars and light trucks under 6000 pounds GVW, and used a two-stage idle test (1.2% CO, 220 PPM HC).

VI. The Health and Environmental Problems Caused By Diesel Particulate

The most significant area which has not been adequately addressed to date in the Brazilian program is diesel particulate. Therefore, it may be useful to review the reasons why this is a cause for serious concern and why new data which has become available since the last report indicates even greater problems.

Uncontrolled diesels emit approximately 30 to 70 times more particulate than gasoline-fueled engines equipped with catalytic converters and burning unleaded fuel. These particles are small and respirable (less than 2.5 microns) and consist of a solid carbonaceous core on which a myriad of compounds adsorb. These include:

* unburned hydrocarbons
* oxygenated hydrocarbons
* polynuclear aromatic hydrocarbons
* inorganic species such as sulfur dioxide, nitrogen dioxide and sulfuric acid.

These emissions cause cancer and exacerbate mortality and morbidity from respiratory disease. In addition, the core is largely elemental carbon which is believed to be the most abundant light absorbing aerosol species in the atmosphere and is associated with visibility deterioration. These problems will be described in more detail below.

A Health Effects

1. Total Suspended Particulate

Brazil already experiences unhealthy air quality levels for total suspended particulate (TSP) matter. TSP comes from many sources but diesels are a major contributor. These particles in urban air are of 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.

2. Fine Particles Are More Hazardous To Health
Beyond the overall impact on TSP, diesel particles raise a special health concern because they are very small (averaging about 0.2 microns in size). Small particles, which are much more likely to be deposited in the deepest recesses of the lung (alveolar region) and which require much longer periods of time to be cleared from the respiratory tract, have a greater potential to adversely affect human health than larger particles. In addition, when emitted, they remain suspended in the air near the breathing zones of people for long periods of time. For these reasons, the Harvard University Health Effects Project recently concluded that "particulate pollution should be a public health concern because, even at current ambient concentrations, it may be contributing to excess mortality and morbidity. Furthermore, our recent analyses...indicate that fine particles (FP) and sulfates (SO_4) are among the most harmful particles to public health."

3. Cancer

In addition, diesel particulate has also been singled out as especially hazardous and toxic because of its composition. As noted in the Harvard project "most of the toxic trace metals, organics, or acidic materials emitted from automobiles or fossil fuel combustion are highly concentrated in the fine particle fraction". The US EPA has noted that up to 10,000 chemicals may be adsorbed on the surface of diesel particles and drawn deep into the lung with them. Many of these chemical compounds are known to be mutagenic in short term bioassays, and to be capable of causing cancer in laboratory animals. Based on an exhaustive multiyear program of in vitro and in vivo studies by EPA and others focusing on the comparative potency of diesel particulate with other known human carcinogens, EPA estimated the risk to range from 0.26×10^{-6} to 1.4×10^{-6} lung cancers per person per year due to a constant lifetime exposure to one microgram per cubic meter of diesel particulate. Since total national urban exposure to diesel particulate in the United States ranges from 3 to 5 micrograms per cubic meter by 1995, it is easy to see why this has been a cause of great concern. In Brazil, the concentrations are even higher.

Epidemiological Studies

Other, epidemiological studies have tended to reinforce these concerns. For example, a 1983 study of heavy construction workers found positive trends in lung cancer by length of union membership and a higher than expected rate among retirees. Further, a pilot study of US 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. The follow up study which has now been completed appears to be equally alarming - "Using multiple logistic regression to adjust for smoking and asbestos exposure, workers age 64 or less at the time of death with lung cancer had increased relative odds (1.2-1.4, p less than 0.05) of having worked in diesel exhaust exposed jobs."

Recent Animal Studies

During late 1985, the results of several new animal studies were presented which increased concerns regarding adverse health effects from diesel particulate emissions. In particular;

1. Stoeber (Fraunhofer Institute) reported on carcinogenicity in rodents after long term high dose diesel inhalation. On both mice and rats, malignant tumors increased with exposure to diesel exhaust. With the mice, however, gaseous phase emissions seemed most important whereas with the rats the particles seemed to be the main cause.
2. Brightwell (Battelle-Geneva) reported that unfiltered diesel exhaust produced an increase in lung tumor incidence from 1% to 40%; gasoline emissions reportedly showed no effect.
3. In a summary presentation, McClellan (Lovelace) described the issue as no longer whether diesel exhaust is carcinogenic but rather under what conditions and at what potency.

Health Effects Summary

Based on the earlier studies as well as these new epidemiological and animal results, it continues to be prudent to conclude that diesel particulate results in a significant cancer risk. In addition, other health problems such as aggravating disease among bronchitics, asthmatics, cardiovascular patients and people with influenza, which are related to particulates in general, especially small particles such as diesels emit, continue to be a reason to lower emission rates.

4. Nuisance Effects

Beyond the adverse health effects, diesel particles are a nuisance. They degrade aesthetics and material usage through soiling and contribute directly, or in conjunction with other pollutants, to structural damage by means of corrosion or erosion.

5. Visibility Effects

They also contribute to impaired visibility. Because of their composition (primarily carbon based) and size (in the size range of 0.2 microns), they are very high light absorbers and scatterers and therefore are especially harmful to visibility.

6. Odor

Finally, exhaust odor from diesel buses has been a significant public concern for many years. Problems associated with diesel odor include "nausea, headache, and coughing; upsetting of sleep, irritation of eyes, nose and throat; and destruction of the sense of well-being and enjoyment of food, home, and external environment."

VII.Conclusions

1. Every effort should be made to introduce unleaded fuel before the 1992 standards go into effect. This is feasible and would likely accelerate the introduction of the most advanced emission control technology. This technology would not only lower emissions of regulated pollutants such as HC, CO and NO_x, but would also reduce known carcinogens and result in better performing and more fuel efficient cars.

2. Vehicle growth and increased congestion must be contained if the program adopted to date is to actually result in improved air quality.

3. Inspection and maintenance programs should be introduced in conjunction with more stringent new vehicle standards to assure these standards have the maximum positive environmental effect.

4. More stringent heavy duty vehicle standards for HC, NOX and especially particulate should be introduced as rapidly as possible. As noted by Daimler Benz at the Symposium, this will likely require adoption of the US transient test.

TABLE 1 COMPOSITE EMISSION FACTORS (GRAMS/MILE)

YEAR	CASE D	C	A&B	E	F	G	H
CY1985							
HC	6.92	10.76	6.92	10.76	6.92	10.76	10.76
CO	51.68	75.3	51.6	75.35	51.68	75.35	75.35
NOX	8.06	9.9	8	9.96	8.06	9.96	9.96
CY1990							
HC	7.46	9.45	6.15	9.19	6.39	9.19	9.19
CO	49.18	62.6	46	61.34	48.29	61.34	61.34
NOX	8.87	10.1	8	9.94	8.08	9.94	9.94
CY1995							
HC	7.97	7.97	5.25	7.93	6.19	7.5	6.63
CO	49.48	49.4	36.2	49.74	47.09	48.4	38.69
NOX	9.9	9.9	7.8	9.69	8.09	8.8	8.68
CY2000							
HC	7.5	6.6	4.38	6.86	6.14	5.58	4.81
CO	46.97	36.4	25.4	38.69	46.91	34.53	26.68
NOX	9.99	9.2	7.3	9.17	8.1	6.81	6.62
CY2005							
HC	7.03	5.69	3.8	6.1	6.14	4.36	3.75
CO	45.74	29.4	19.5	32.52	46.9	26.78	20.79
NOX	10.16	8.8	7	9.06	8.1	6.05	5.84
CY2010							
HC	7.17	5.47	3.66	5.95	6.14	4.08	3.52
CO	50.71	28	18.4	31.44	46.89	25.23	19.72
NOX	10.49	8.8	6.9	9.06	8.1	5.89	5.69

TABLE 2: COMPOSITE EMISSION FACTORS BY POLLUTANT

HC	D	C	A&B	E	F	G	H
CY1985	6.92	10.76	6.92	10.76	6.92	10.76	10.76
CY1990	7.46	9.45	6.15	9.19	6.39	9.19	9.19
CY1995	7.97	7.97	5.25	7.93	6.19	7.5	6.63
CY2000	7.5	6.6	4.38	6.86	6.14	5.58	4.81
CY2005	7.03	5.69	3.8	6.1	6.14	4.36	3.75
CY2010	7.17	5.47	3.66	5.95	6.14	4.08	3.52

CO	D	C	A&B	E	F	G	H
CY1985	51.68	75.3	51.6	75.35	51.68	75.35	75.35
CY1990	49.18	62.6	46	61.34	48.29	61.34	61.34
CY1995	49.48	49.4	36.2	49.74	47.09	48.4	38.69
CY2000	46.97	36.4	25.4	38.69	46.91	34.53	26.68
CY2005	45.74	29.4	19.5	32.52	46.9	26.78	20.79
	50.71	28	18.4	31.44	46.89	25.28	19.72

NOX	D	C	A&B	E	F	G	H
CY1985	8.06	9.9	8	9.96	8.06	9.96	9.96
CY1990	8.87	10.1	8	9.94	8.08	9.94	9.94
CY1995	9.9	9.9	7.8	9.69	8.09	8.8	8.68
CY2000	9.99	9.2	7.3	9.17	8.1	6.81	6.62
CY2005	10.16	8.8	7	9.06	8.1	6.05	5.84
	10.49	8.8	6.9	9.06	8.1	5.89	5.69

TABLE 3 VMT MIX (ALCOHOL CASE)

YEAR	LDGV	LDAV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
1985	0.443	0.182	0	0.032	0.013	0	0.284	0.046
1986	0.419	0.205	0	0.032	0.013	0	0.284	0.046
1987	0.396	0.228	0	0.032	0.013	0	0.284	0.046
1988	0.372	0.252	0	0.032	0.013	0	0.284	0.046
1989	0.349	0.275	0	0.032	0.013	0	0.284	0.046
1990	0.325	0.299	0	0.032	0.013	0	0.284	0.046
1991	0.302	0.322	0	0.032	0.013	0	0.284	0.046
1992	0.278	0.346	0	0.032	0.013	0	0.284	0.046
1993	0.255	0.369	0	0.032	0.013	0	0.284	0.046
1994	0.232	0.392	0	0.032	0.013	0	0.284	0.046
1995	0.208	0.416	0	0.032	0.013	0	0.284	0.046
1996	0.185	0.439	0	0.032	0.013	0	0.284	0.046
1997	0.161	0.463	0	0.032	0.013	0	0.284	0.046
1998	0.138	0.486	0	0.032	0.013	0	0.284	0.046
1999	0.114	0.510	0	0.032	0.013	0	0.284	0.046
2000	0.091	0.533	0	0.032	0.013	0	0.284	0.046
2001	0.068	0.557	0	0.032	0.013	0	0.284	0.046
2002	0.044	0.580	0	0.032	0.013	0	0.284	0.046
2003	0.021	0.603	0	0.032	0.013	0	0.284	0.046
2004	0	0.625	0	0.032	0.013	0	0.284	0.046
2005	0	0.625	0	0.032	0.013	0	0.284	0.046
2006	0	0.625	0	0.032	0.013	0	0.284	0.046
2007	0	0.625	0	0.032	0.013	0	0.284	0.046
2008	0	0.625	0	0.032	0.013	0	0.284	0.046
2009	0	0.625	0	0.032	0.013	0	0.284	0.046
2010	0	0.625	0	0.032	0.013	0	0.284	0.046

HYDROCARBONS

TABLE 4 HC EMISSIONS VS. TIME NO VMT GROWTH

Year	A	D	C	E	F	G	H
1985	6.92	6.92	10.76	10.76	6.92	10.76	10.76
1986	6.766	7.028	10.49	10.44	6.814	10.44	10.44
1987	6.612	7.136	10.23	10.13	6.708	10.13	10.13
1988	6.458	7.244	9.974	9.818	6.602	9.818	9.818
1989	6.304	7.352	9.712	9.504	6.496	9.504	9.504
1990	6.15	7.46	9.45	9.19	6.39	9.19	9.19
1991	5.97	7.562	9.154	8.938	6.35	8.852	8.678
1992	5.79	7.664	8.858	8.686	6.31	8.514	8.166
1993	5.61	7.766	8.562	8.434	6.27	8.176	7.654
1994	5.43	7.868	8.266	8.182	6.23	7.838	7.142
1995	5.25	7.97	7.97	7.93	6.19	7.5	6.63
1996	5.076	7.876	7.696	7.716	6.18	7.116	6.266
1997	4.902	7.782	7.422	7.502	6.17	6.732	5.902
1998	4.728	7.688	7.148	7.288	6.16	6.348	5.538
1999	4.554	7.594	6.874	7.074	6.15	5.964	5.174
2000	4.38	7.5	6.6	6.86	6.14	5.58	4.81
2001	4.264	7.406	6.418	6.708	6.14	5.336	4.598
2002	4.148	7.312	6.236	6.556	6.14	5.092	4.386
2003	4.032	7.218	6.054	6.404	6.14	4.848	4.174
2004	3.916	7.124	5.872	6.252	6.14	4.604	3.962
2005	3.8	7.03	5.69	6.1	6.14	4.36	3.75
2006	3.772	7.058	5.646	6.07	6.14	4.304	3.704
2007	3.744	7.086	5.602	6.04	6.14	4.248	3.658
2008	3.716	7.114	5.558	6.01	6.14	4.192	3.612
2009	3.688	7.142	5.514	5.98	6.14	4.136	3.566
2010	3.66	7.17	5.47	5.95	6.14	4.08	3.52

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TABLE 5 CO EMISSIONS VS. TIME NO VMT GROWTH

Year	A	D	C	E	F	G	H
1985	51.6	51.68	75.3	75.35	51.68	75.35	75.35
1986	50.48	51.18	72.76	72.54	51.00	72.54	72.54
1987	49.36	50.68	70.22	69.74	50.32	69.74	69.74
1988	48.24	50.18	67.68	66.94	49.64	66.94	66.94
1989	47.12	49.68	65.14	64.14	48.96	64.14	64.14
1990	46	49.18	62.6	61.34	48.29	61.34	61.34
1991	44.04	49.24	59.96	59.02	48.05	58.75	56.81
1992	42.08	49.3	57.32	56.7	47.81	56.16	52.28
1993	40.12	49.36	54.68	54.38	47.57	53.57	47.75
1994	38.16	49.42	52.04	52.06	47.33	50.98	43.22
1995	36.2	49.48	49.4	49.74	47.09	48.4	38.69
1996	34.04	48.97	46.8	47.53	47.05	45.62	36.28
1997	31.88	48.47	44.2	45.32	47.01	42.85	33.88
1998	29.72	47.97	41.6	43.11	46.98	40.07	31.48
1999	27.56	47.47	39	40.9	46.94	37.30	29.08
2000	25.4	46.97	36.4	38.69	46.91	34.53	26.68
2001	24.22	46.72	35	37.45	46.90	32.98	25.50
2002	23.04	46.47	33.6	36.22	46.90	31.43	24.32
2003	21.86	46.23	32.2	34.98	46.90	29.88	23.14
2004	20.68	45.98	30.8	33.75	46.90	28.33	21.96
2005	19.5	45.74	29.4	32.52	46.9	26.78	20.79
2006	19.28	46.73	29.12	32.30	46.89	26.48	20.57
2007	19.06	47.72	28.84	32.08	46.89	26.18	20.36
2008	18.84	48.72	28.56	31.87	46.89	25.88	20.14
2009	18.62	49.71	28.28	31.65	46.89	25.58	19.93
2010	18.4	50.71	28	31.44	46.89	25.28	19.72

TABLE 6 NOX EMISSIONS VS. TIME NO VMT GROWTH

Year	A	D	C	E	F	G	H
1985	8	8.06	9.9	9.96	8.06	9.96	9.96
1986	8	8.222	9.94	9.956	8.064	9.956	9.956
1987	8	8.384	9.98	9.952	8.068	9.952	9.952
1988	8	8.546	10.02	9.948	8.072	9.948	9.948
1989	8	8.708	10.06	9.944	8.076	9.944	9.944
1990	8	8.87	10.1	9.94	8.08	9.94	9.94
1991	7.96	9.076	10.06	9.89	8.082	9.712	9.688
1992	7.92	9.282	10.02	9.84	8.084	9.484	9.436
1993	7.88	9.488	9.98	9.79	8.086	9.256	9.184
1994	7.84	9.694	9.94	9.74	8.088	9.028	8.932
1995	7.8	9.9	9.9	9.69	8.09	8.8	8.68
1996	7.7	9.918	9.76	9.586	8.092	8.402	8.268
1997	7.6	9.936	9.62	9.482	8.094	8.004	7.856
1998	7.5	9.954	9.48	9.378	8.096	7.606	7.444
1999	7.4	9.972	9.34	9.274	8.098	7.208	7.032
2000	7.3	9.99	9.2	9.17	8.1	6.81	6.62
2001	7.24	10.02	9.12	9.148	8.1	6.658	6.464
2002	7.18	10.05	9.04	9.126	8.1	6.506	6.308
2003	7.12	10.09	8.96	9.104	8.1	6.354	6.152
2004	7.06	10.12	8.88	9.082	8.1	6.202	5.996
2005	7	10.16	8.8	9.06	8.1	6.05	5.84
2006	6.98	10.22	8.8	9.06	8.1	6.018	5.81
2007	6.96	10.29	8.8	9.06	8.1	5.986	5.78
2008	6.94	10.35	8.8	9.06	8.1	5.954	5.75
2009	6.92	10.42	8.8	9.06	8.1	5.922	5.72
2010	6.9	10.49	8.8	9.06	8.1	5.89	5.69

TABLE 7 HC EMISSIONS VERSUS TIME 3% VMT GR

A	D	C	E	F	G	H
6.92	6.92	10.76	10.76	6.92	10.76	10.76
6.968	7.238	10.81	10.75	7.018	10.75	10.75
7.014	7.570	10.85	10.74	7.116	10.74	10.74
7.056	7.915	10.89	10.72	7.214	10.72	10.72
7.095	8.274	10.93	10.69	7.311	10.69	10.69
7.129	8.648	10.95	10.65	7.407	10.65	10.65
7.128	9.029	10.93	10.67	7.582	10.56	10.36
7.120	9.425	10.89	10.68	7.760	10.47	10.04
7.106	9.837	10.84	10.68	7.942	10.35	9.695
7.084	10.26	10.78	10.67	8.128	10.22	9.318
7.055	10.71	10.71	10.65	8.318	10.07	8.910
7.026	10.90	10.65	10.68	8.554	9.850	8.673
6.989	11.09	10.58	10.69	8.796	9.598	8.414
6.943	11.29	10.49	10.70	9.046	9.322	8.132
6.888	11.48	10.39	10.70	9.302	9.021	7.826
6.823	11.68	10.28	10.68	9.565	8.693	7.493
6.842	11.88	10.29	10.76	9.852	8.562	7.378
6.856	12.08	10.30	10.83	10.14	8.416	7.249
6.864	12.28	10.30	10.90	10.45	8.253	7.105
6.866	12.49	10.29	10.96	10.76	8.073	6.947
6.863	12.69	10.27	11.01	11.08	7.874	6.772
7.017	13.12	10.50	11.29	11.42	8.006	6.890
7.173	13.57	10.73	11.57	11.76	8.139	7.009
7.333	14.04	10.96	11.86	12.11	8.273	7.128
7.496	14.51	11.20	12.15	12.48	8.407	7.248
7.663	15.01	11.45	12.45	12.85	8.542	7.370

TABLE 8 CO EMISSIONS VERSUS TIME 3% VMT GR

A	D	C	E	F	G	H
51.6	51.68	75.3	75.35	51.68	75.35	75.35
51.99	52.71	74.94	74.72	52.53	74.72	74.72
52.36	53.76	74.49	73.99	53.38	73.99	73.99
52.71	54.83	73.95	73.15	54.24	73.15	73.15
53.03	55.91	73.31	72.19	55.11	72.19	72.19
53.32	57.01	72.57	71.10	55.98	71.10	71.10
52.58	58.79	71.59	70.47	57.37	70.15	67.83
51.75	60.63	70.49	69.73	58.80	69.07	64.29
50.82	62.52	69.26	68.88	60.26	67.86	60.48
49.79	64.48	67.90	67.92	61.75	66.52	56.39
48.64	66.49	66.38	66.84	63.28	65.04	51.99
47.11	67.79	64.78	65.79	65.13	63.15	50.23
45.45	69.11	63.01	64.61	67.03	61.09	48.31
43.64	70.45	61.09	63.30	68.99	58.85	46.23
41.68	71.80	58.99	61.86	71.01	56.42	43.98
39.57	73.17	56.71	60.27	73.08	53.79	41.56
38.86	74.97	56.16	60.10	75.27	52.92	40.92
38.08	76.82	55.53	59.86	77.52	51.94	40.20
37.21	78.70	54.81	59.56	79.85	50.86	39.40
36.26	80.63	54.00	59.18	82.24	49.67	38.52
35.21	82.61	53.09	58.73	84.70	48.36	37.54
35.86	86.93	54.17	60.09	87.24	49.26	38.27
36.52	91.45	55.26	61.48	89.85	50.16	39.01
37.18	96.15	56.36	62.90	92.54	51.07	39.76
37.85	101.0	57.48	64.35	95.32	51.99	40.52
38.52	106.1	58.62	65.82	98.17	52.93	41.28

TABLE 9 NOX EMISSIONS VERSUS TIME 3% VMT G

A	D	C	E	F	G	H
8	8.06	9.9	9.96	8.06	9.96	9.96
8.24	8.468	10.23	10.25	8.305	10.25	10.25
8.487	8.894	10.58	10.55	8.559	10.55	10.55
8.741	9.338	10.94	10.87	8.820	10.87	10.87
9.004	9.800	11.32	11.19	9.089	11.19	11.19
9.274	10.28	11.70	11.52	9.366	11.52	11.52
9.504	10.83	12.01	11.80	9.650	11.59	11.56
9.740	11.41	12.32	12.10	9.942	11.66	11.60
9.982	12.01	12.64	12.40	10.24	11.72	11.63
10.22	12.64	12.96	12.70	10.55	11.77	11.65
10.48	13.30	13.30	13.02	10.87	11.82	11.66
10.65	13.72	13.51	13.26	11.20	11.63	11.44
10.83	14.16	13.71	13.51	11.54	11.41	11.20
11.01	14.61	13.92	13.77	11.88	11.16	10.93
11.19	15.08	14.12	14.02	12.24	10.90	10.63
11.37	15.56	14.33	14.28	12.61	10.60	10.31
11.61	16.08	14.63	14.67	12.99	10.68	10.37
11.86	16.62	14.94	15.08	13.38	10.75	10.42
12.12	17.18	15.25	15.49	13.78	10.81	10.47
12.37	17.75	15.57	15.92	14.20	10.87	10.51
12.64	18.35	15.89	16.36	14.62	10.92	10.54
12.98	19.02	16.37	16.85	15.06	11.19	10.80
13.33	19.72	16.86	17.35	15.52	11.46	11.07
13.69	20.44	17.36	17.88	15.98	11.75	11.34
14.06	21.18	17.88	18.41	16.46	12.03	11.62
14.44	21.96	18.42	18.96	16.95	12.33	11.91

FIGURE 1: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

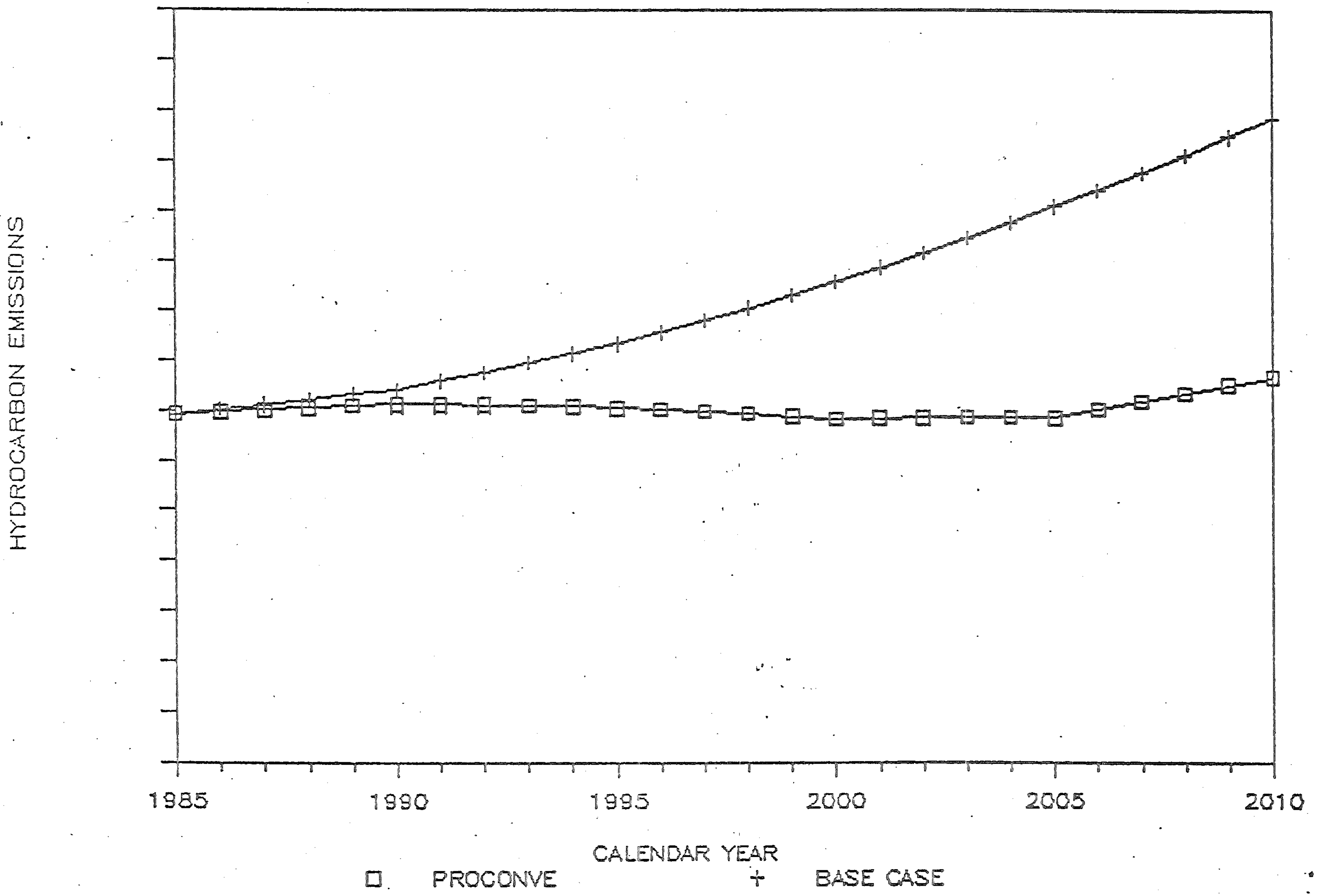

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FIGURE 2: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

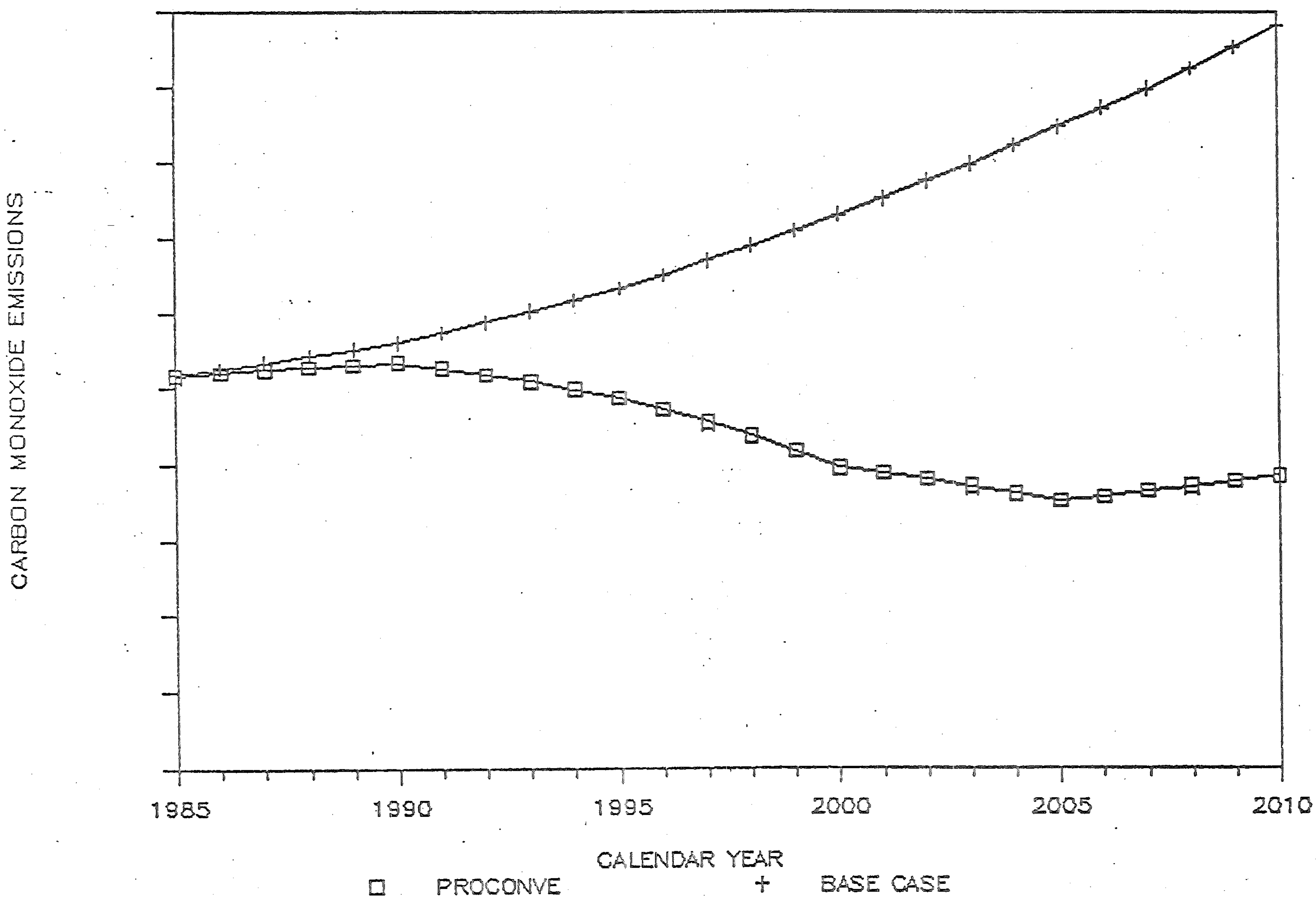

FIGURE 3: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

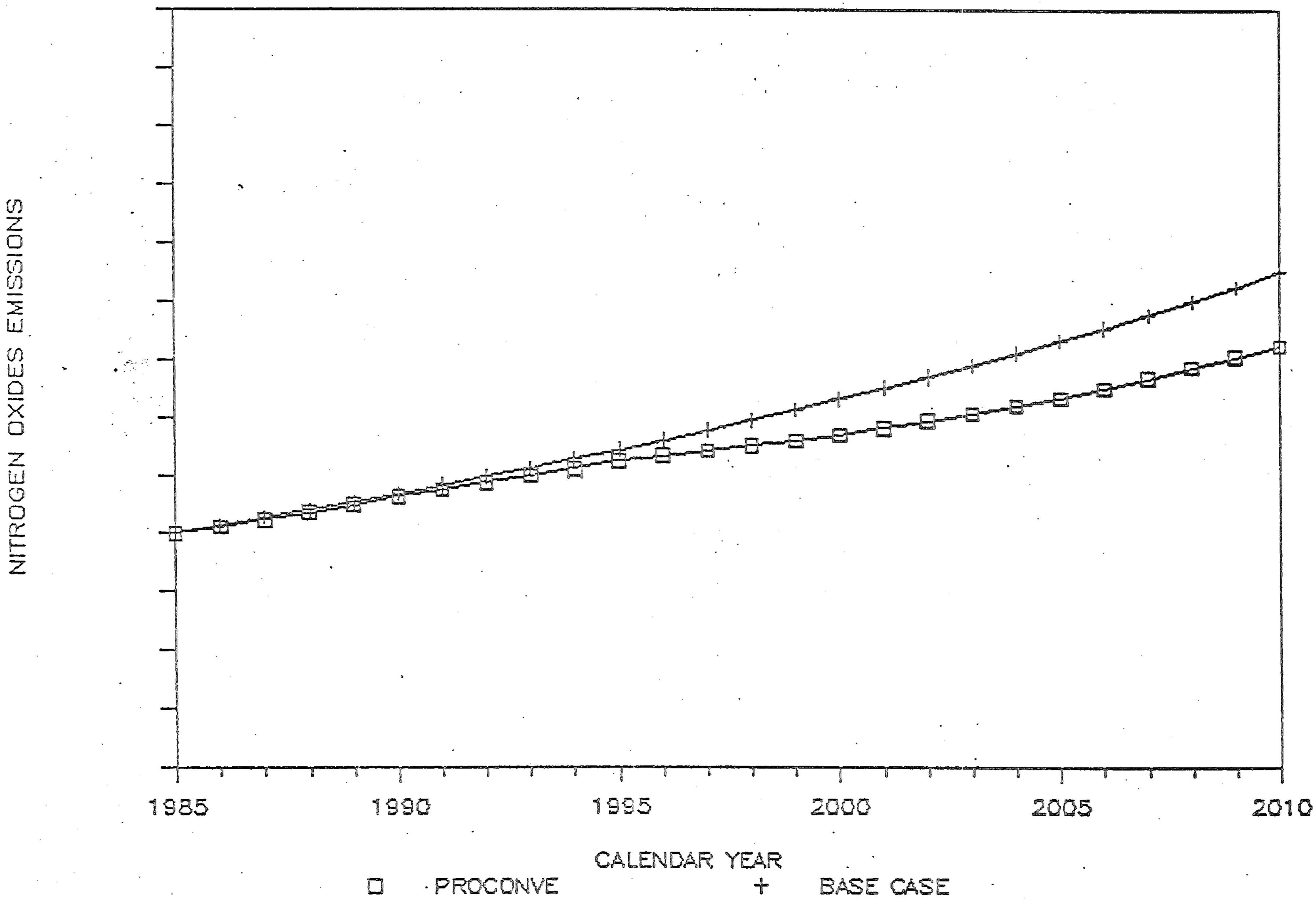

FIGURE 4: EMISSIONS VERSUS TIME

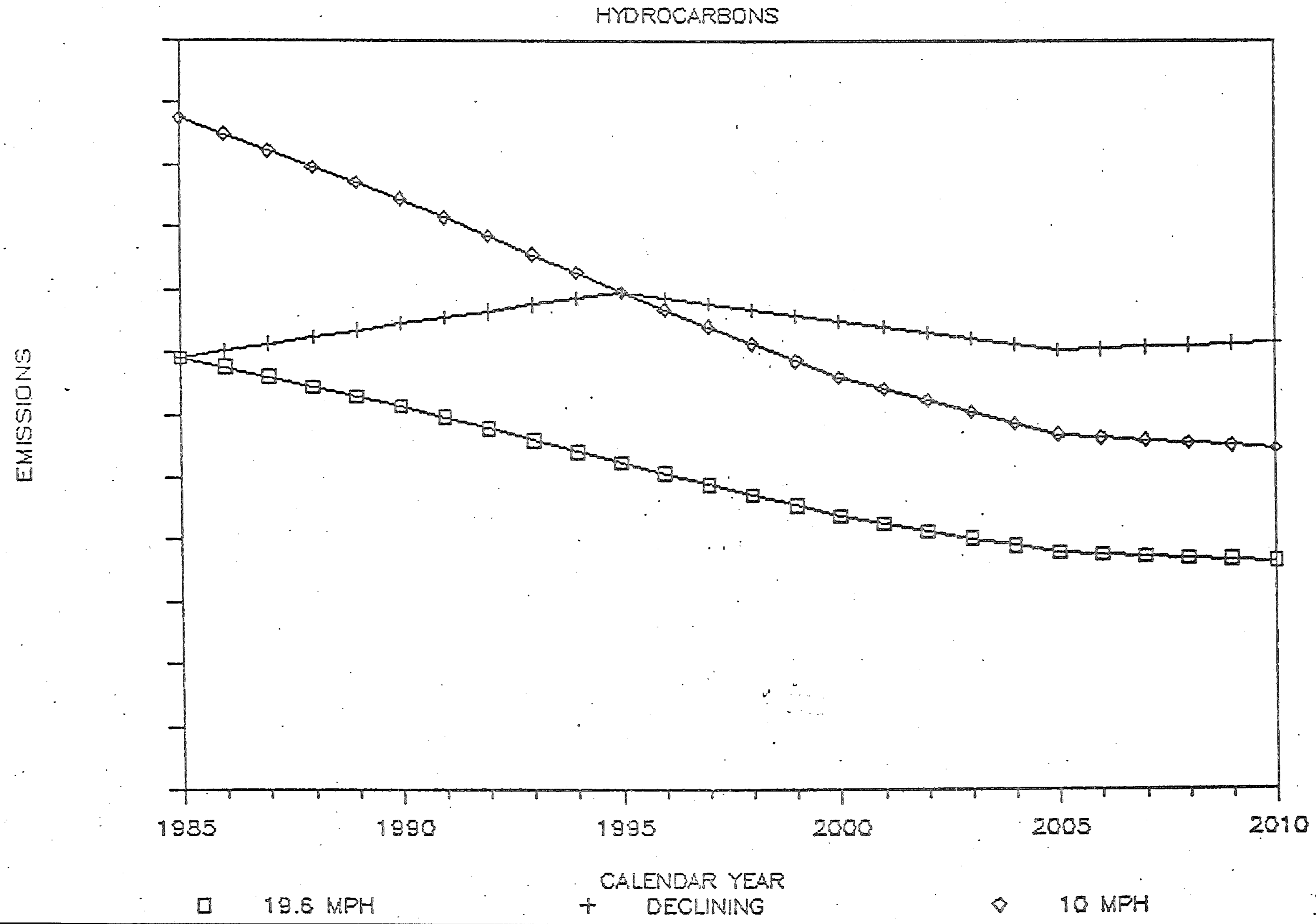

FIGURE 5: EMISSIONS VERSUS TIME

CARBON MONOXIDE

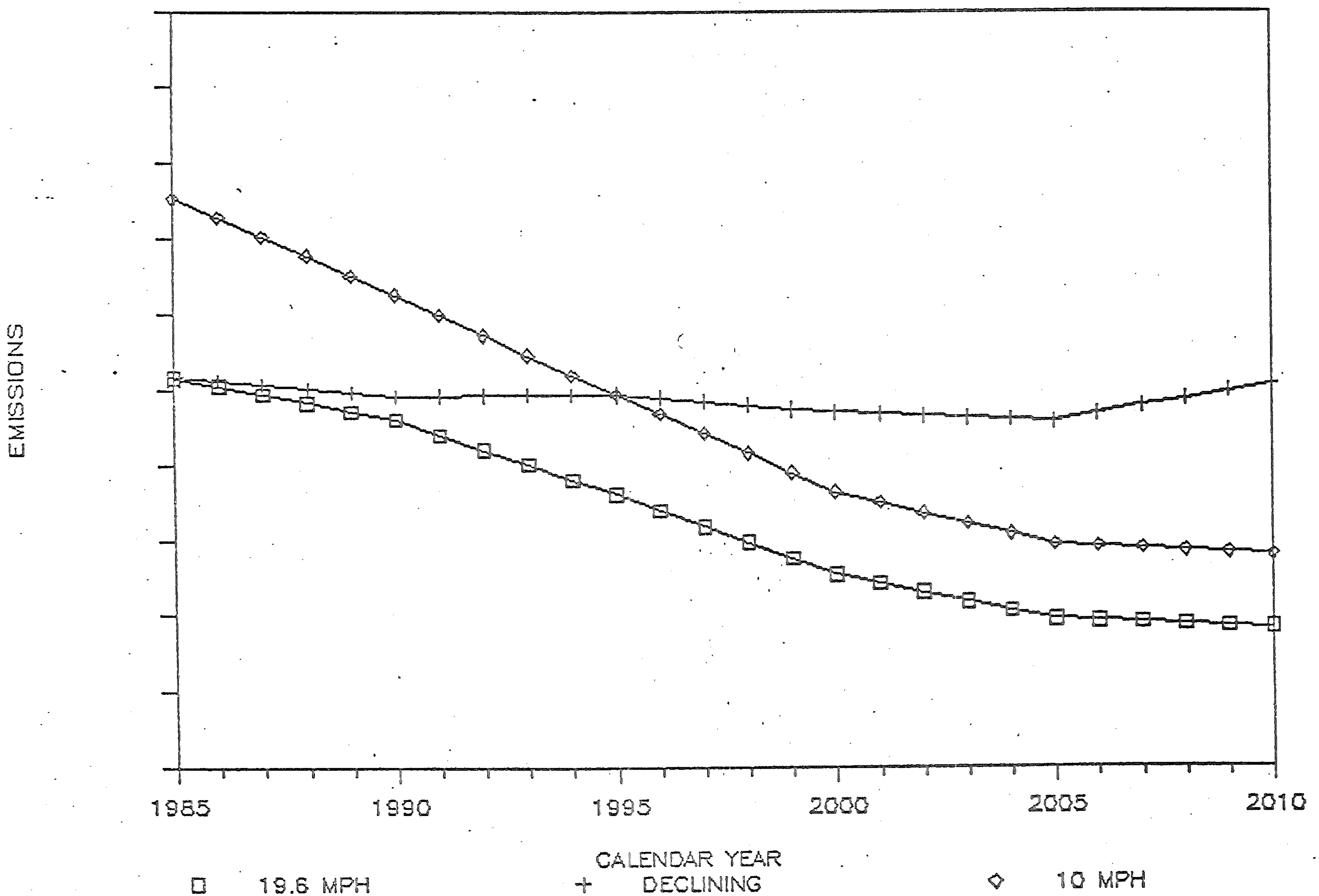

FIGURE 6: EMISSIONS VERSUS TIME

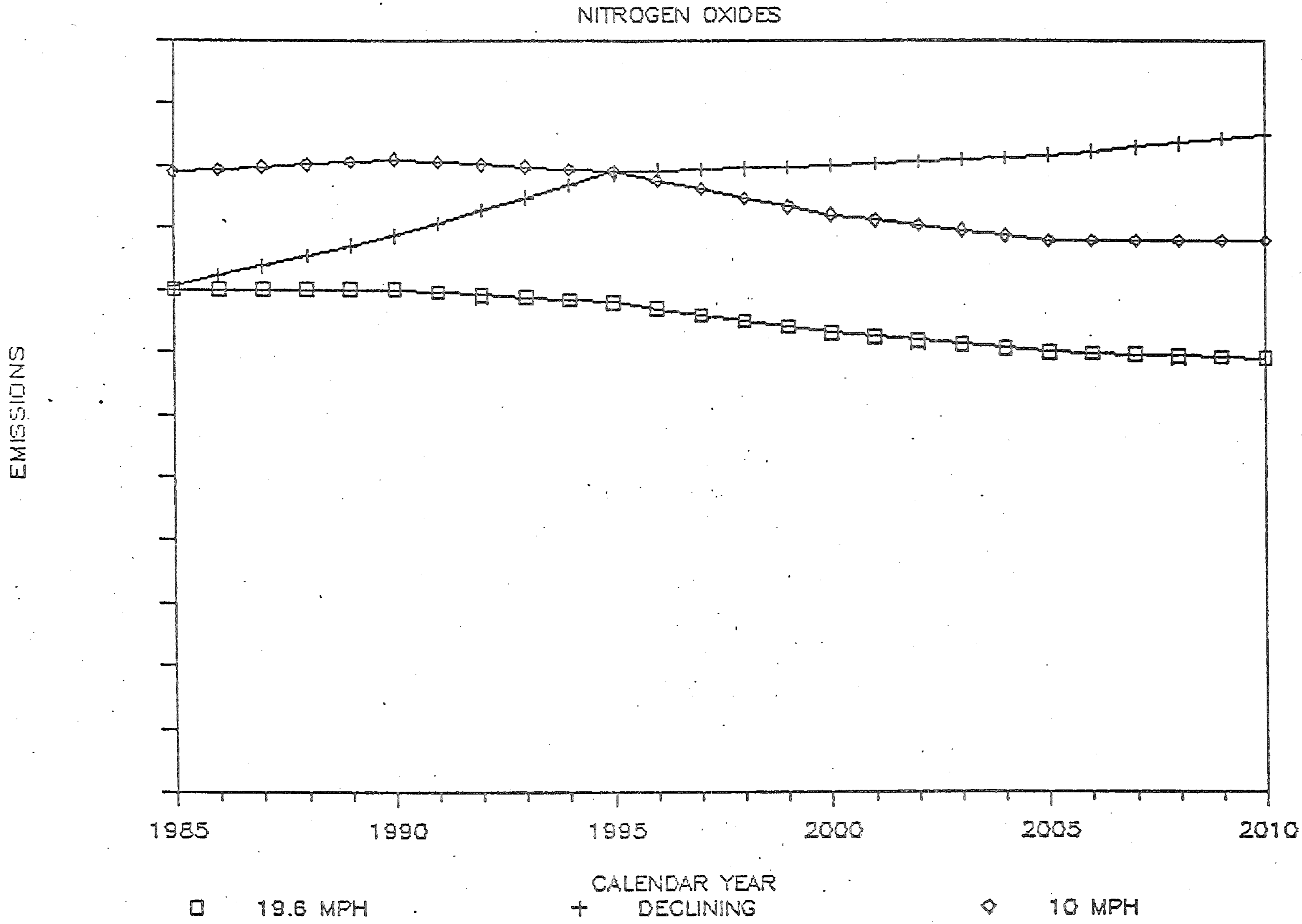

FIGURE 7: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

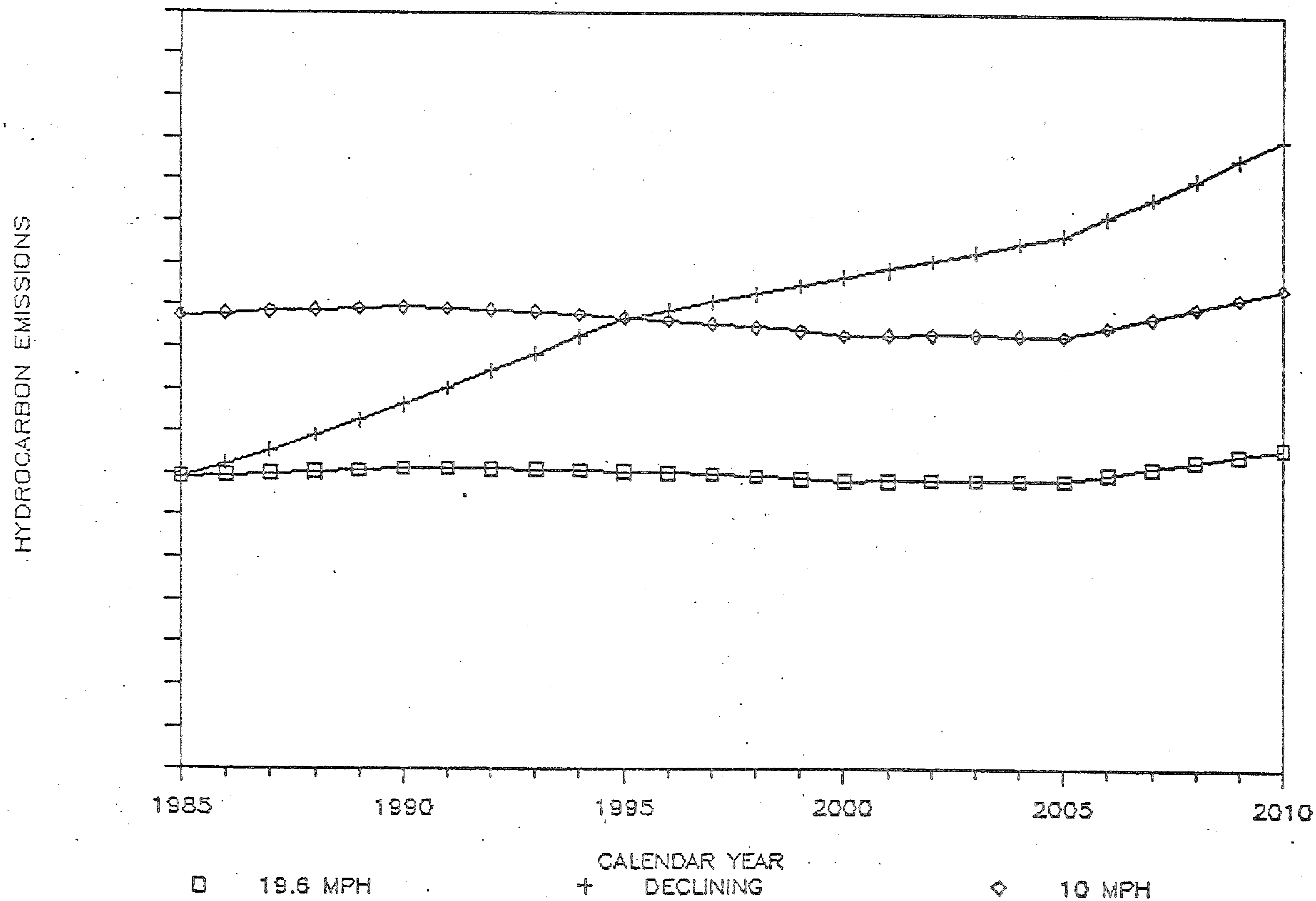

FIGURE 8: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

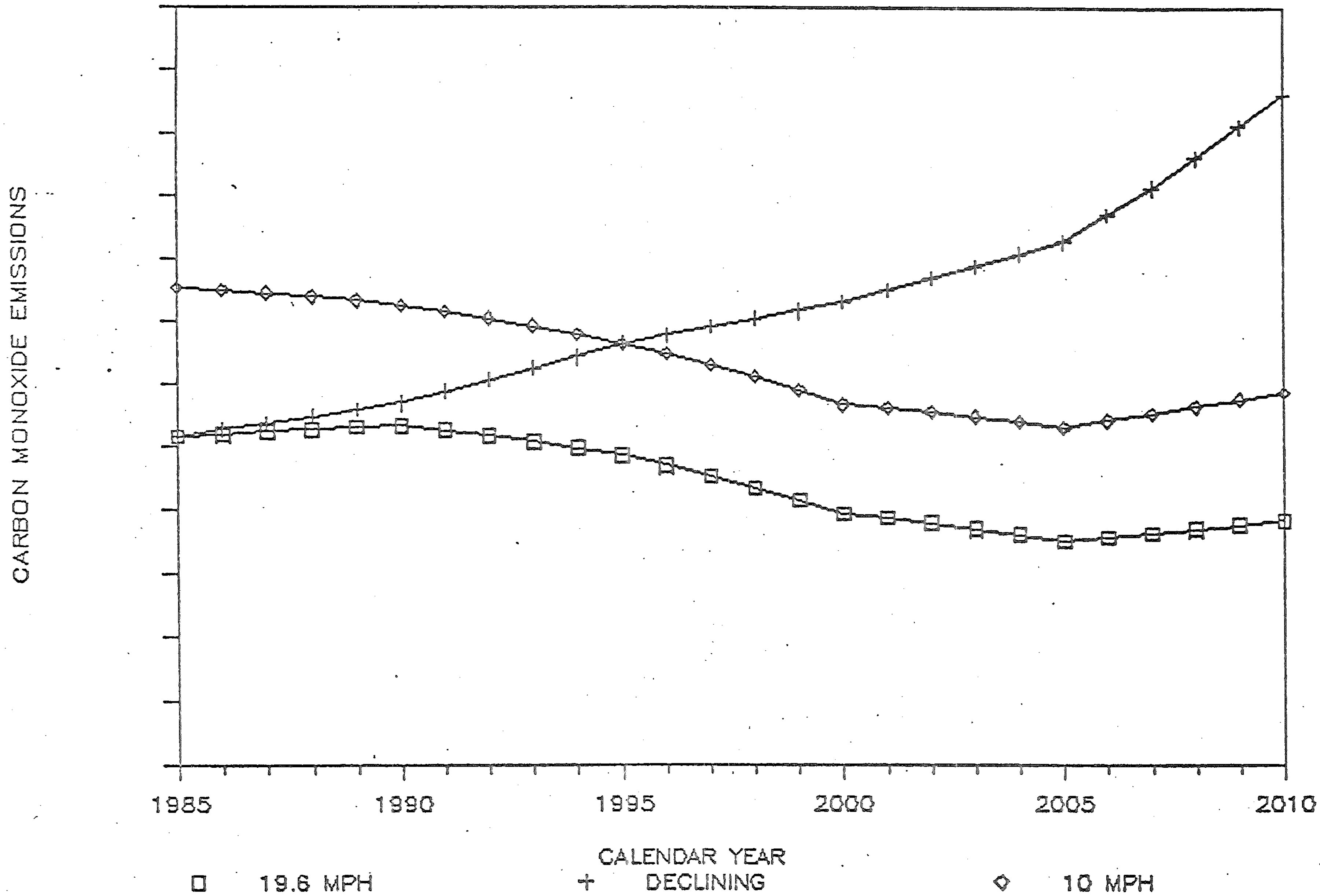

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FIGURE 9: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

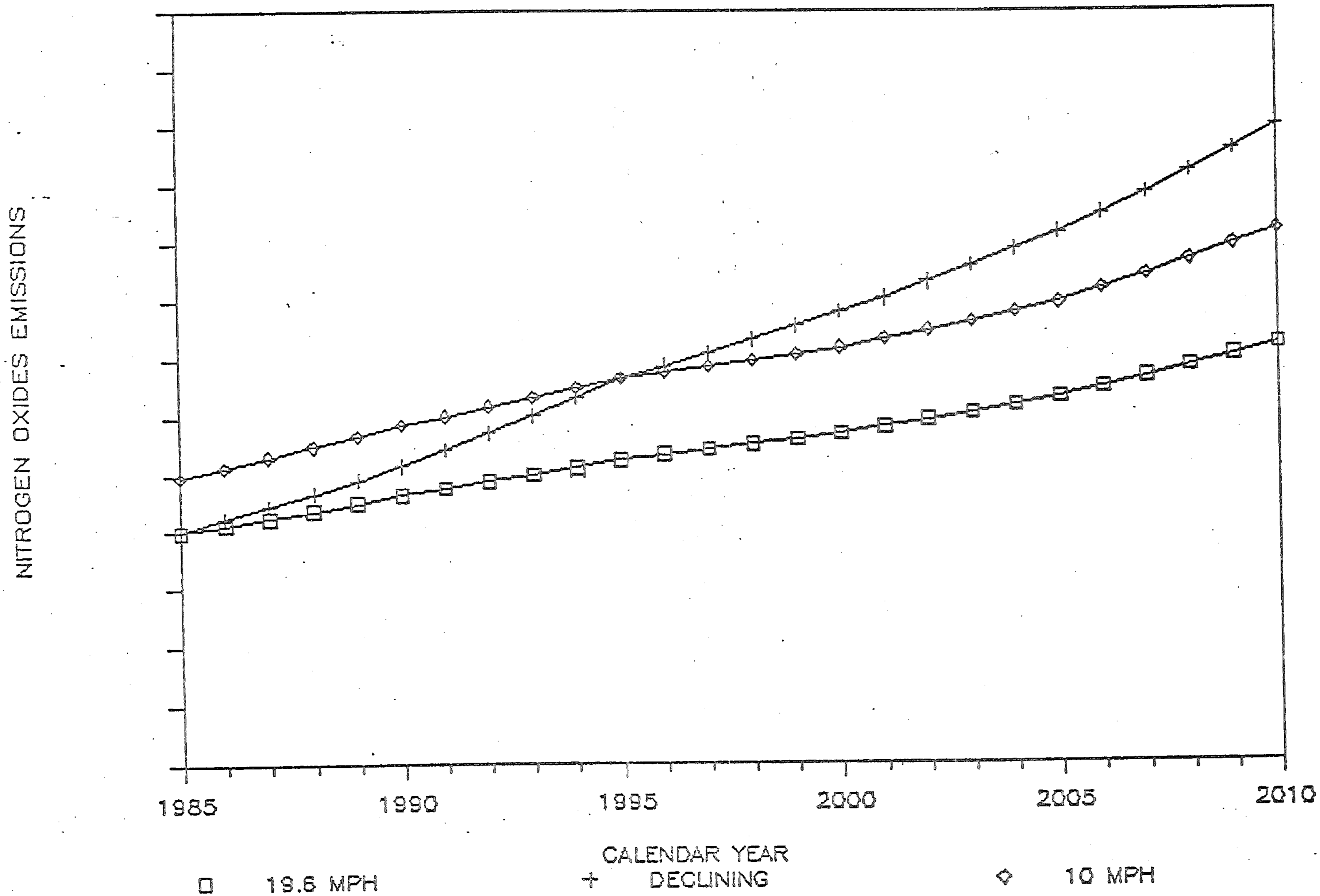


FIGURE 10: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

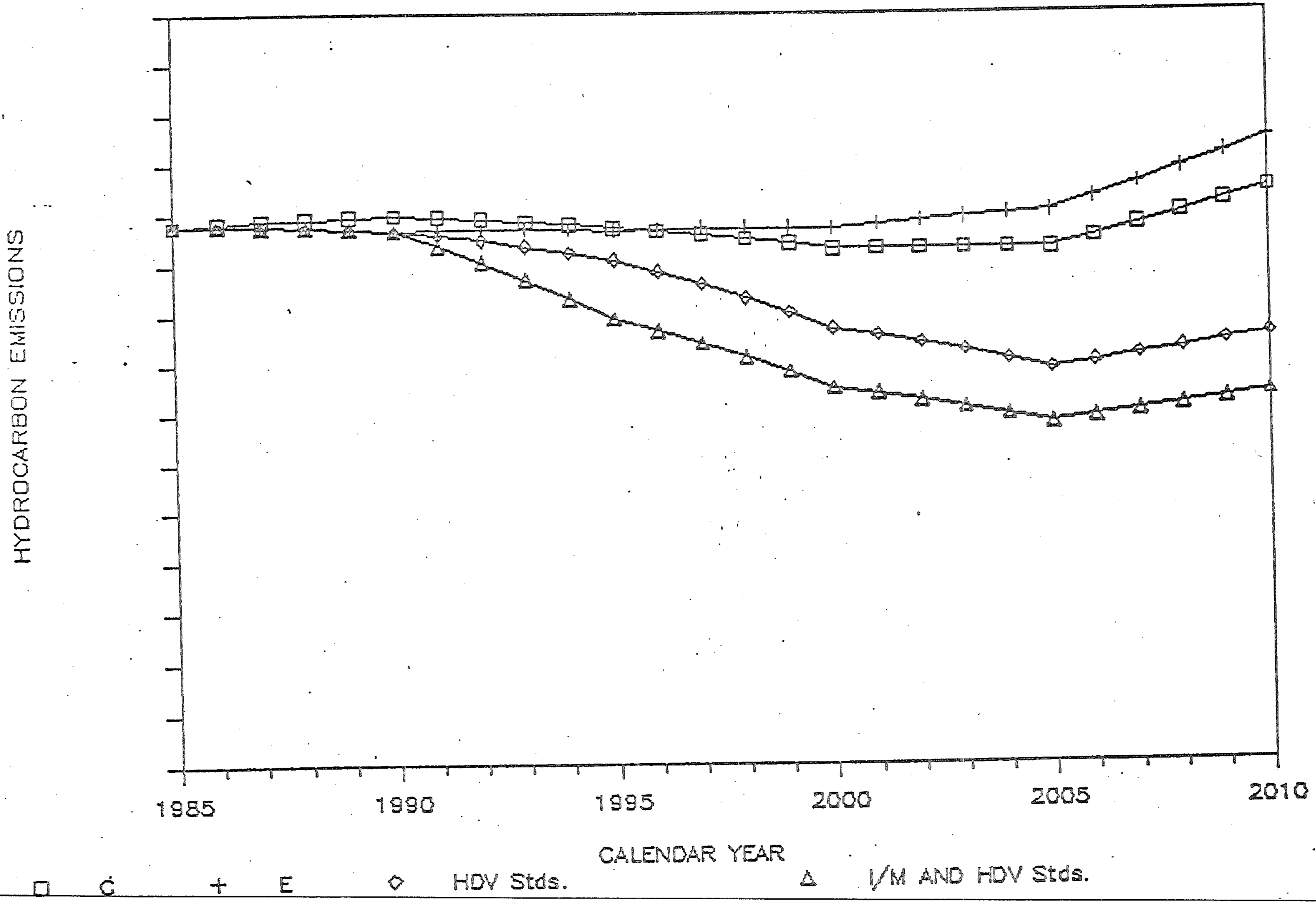


FIGURE 11: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH

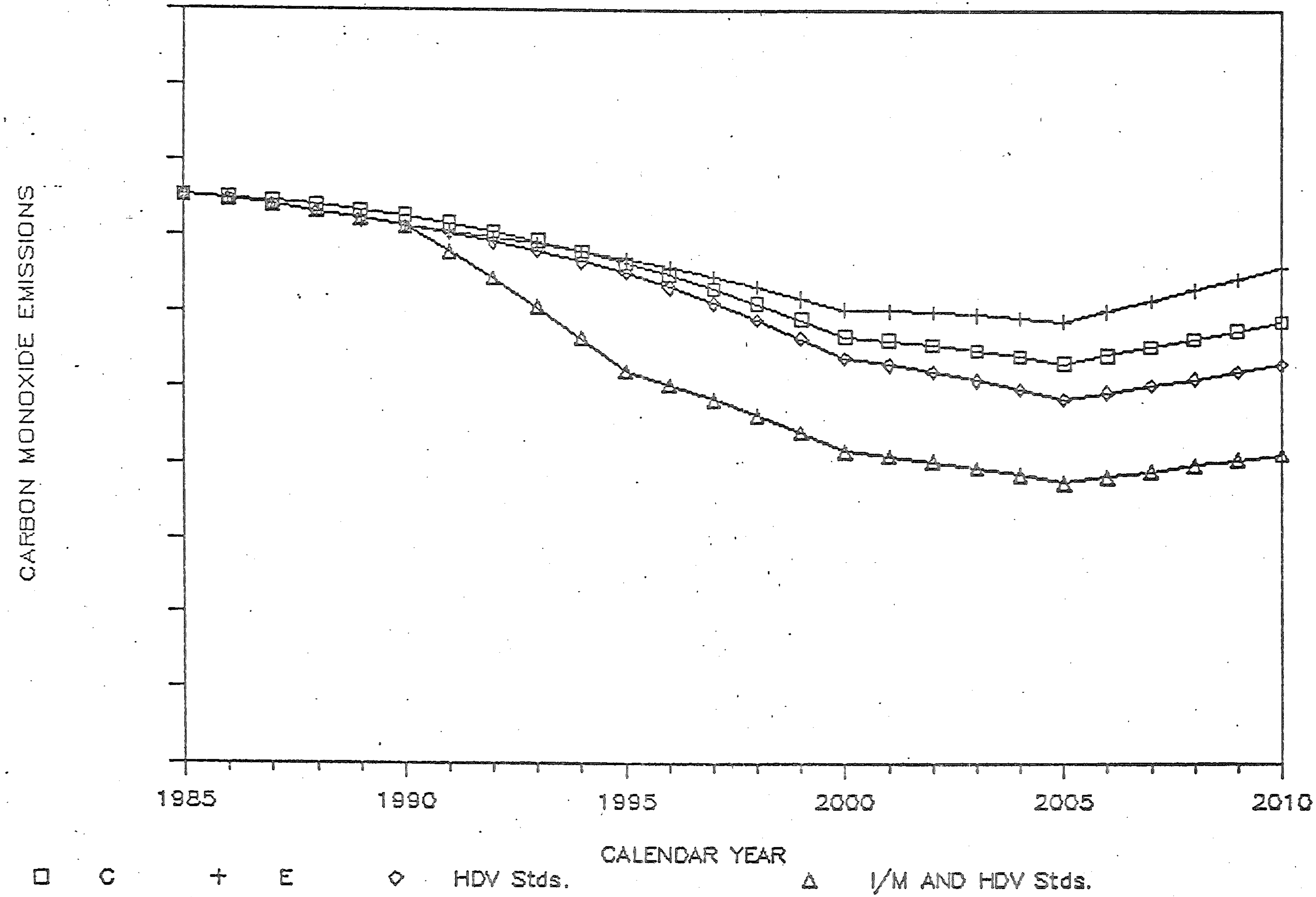
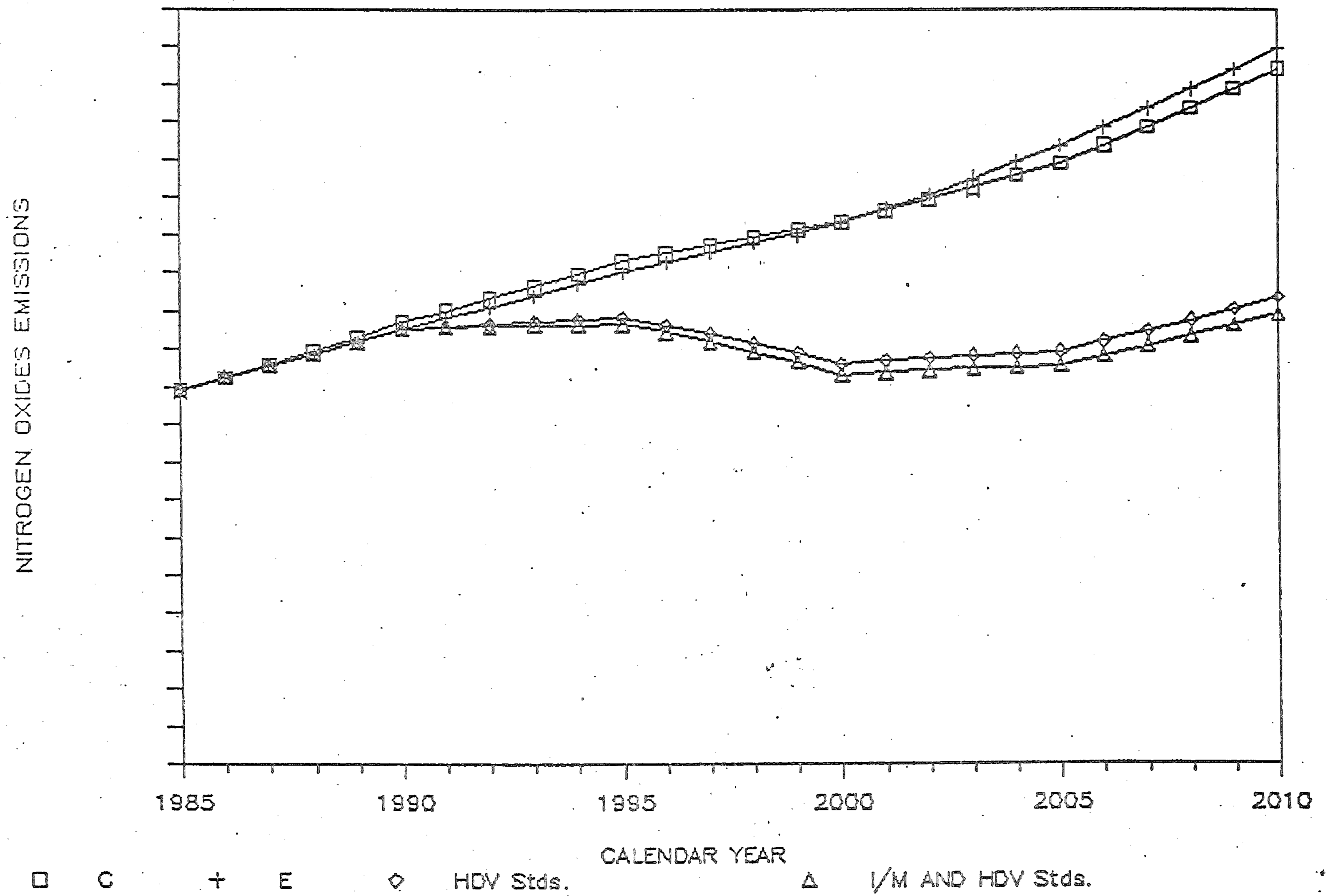


FIGURE 12: EMISSIONS VERSUS TIME

3% ANNUAL GROWTH



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