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A STUDY OF THE EFFECTIVENESS OF TUNE-UPS
IN CONTROLLING VEHICLE EMISSIONS
IN SALT LAKE COUNTY

by

Howard B. McIntosh

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Industrial Education

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1972

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Howard McIntosh

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
Origin and nature of problem	1
Statement of the problem	2
Objectives	2
Method of procedure	2
Definition of terms	4
REVIEW OF LITERATURE	6
Background and history	6
Legislation	10
Testing procedures	12
PRESENTATION OF DATA	14
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	22
Summary	22
Conclusions	24
Recommendations	25
BIBLIOGRAPHY	26
VITA	29

LIST OF FIGURES

Figure		Page
I.	Average emission Level	17
II.	Scattergrams - CO emission Vs. Mileage.	18
III.	Scattergram - HC emission Vs. Mileage	19
IV.	Average emission level (1970-71 cars)	20
V.	Average emission level (tuned Vs. untuned cars)	21

ABSTRACT

A Study of the Effectiveness of Tune-ups in Controlling
Vehicle Emissions in Salt Lake County

by

Howard B. McIntosh

Master of Science

Utah State University, 1972

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Department: Industrial and Technical Education

The Federal Government has placed stringent standards on the manufacturers of automobiles to control vehicle emissions. Few states standards have been set for used vehicles to insure the vehicle continues to meet this standard.

Studies have shown that vehicles that are properly tuned are emitting less harmful pollutants from the exhaust. Additional studies are needed to determine if cars are being adequately tuned to meet exhaust emissions.

The study showed 93 per cent of the new 1971 model cars were not meeting the standard established by the Environmental Protection Agency. Eighty-seven per cent of the 1970 model cars and 83 per cent of the used 1971 model cars tested would not meet the same standards.

There was a very low correlation between emission level and the mileage driven since the vehicle was tuned indicating a need for more emphasis on tune-ups and maintenance of automobiles to meet emission standards. (34 pages)

INTRODUCTION

Origin and nature of problem

The first serious consequence of air pollution occurred in Donora, Pennsylvania. Pollutants emitted primarily by industry combined with an unusual atmospheric condition and caused some deaths in 1948. Little was done to correct the situation at this time. Meanwhile in Los Angeles, California, people were already concerned about the yellowish-brown haze hanging over the city. Research done by Dr. Aire J. Haagen-Smit concluded that it was caused by the sunlight acting upon the otherwise invisible pollutants in the air. He termed it "photo-chemical smog." It was soon discovered that the transportation vehicles were most responsible for the emissions causing this type of air pollution.

In 1952, a killer smog moved into London and caused an estimated 4,000 deaths. Automobile travel was restricted in an effort to alleviate the problem. Los Angeles authorities began writing letters to auto makers and government officials to encourage action to control exhaust emissions. In 1955, the Air Pollution Control Act was passed. Since that time, there has been an ever increasing concern with air pollution especially as it relates to the automobile.

Statement of the problem

There is much written concerning the progress being made in controlling exhaust emission from the automobile. The air pollution problem however still exists. There needs to be additional studies done to determine why air pollution is not being reduced sufficiently. Federal legislation to date, which restricts exhaust emissions, only applies to new cars. The major controversy concerns the effectiveness of exhaust emission devices as the automobile ages. Studies have indicated that emissions are reduced if a vehicle has been properly maintained. Little has been done to indicate the effectiveness of tune-ups the consumer gets on his automobiles as it pertains to exhaust emissions.

Objectives

The purpose of this study is outlined in these three objectives.

1. To determine if there is a significant difference in the exhaust emission of new and used 1970-71 automobiles.
2. To determine if there is a significant difference in the exhaust emissions of recently tuned automobiles and those that have not been tuned.
3. To determine if tune-ups done in Salt Lake County are being done adequately to meet exhaust emissions standards.

Method of procedure

Seventy new 1971 model automobiles were tested for emission of carbon monoxide (CO) and hydro-carbons (HC). Samples were taken from vehicles from

seven different dealerships in Salt Lake County. Only vehicles manufactured in the United States were used.

Over two hundred samples were taken from vehicles in use from five locations in Salt Lake County. Forty-six were 1971 model cars and fifty-six were 1970 model cars. The remainder were older model cars. Information as to the tune-up was asked of all the vehicles owners. Seven 1970-71 model cars were tested at Cottonwood Conoco Service station while the customer stopped for gasoline. Eleven were tested at Heiner's Texaco, and twenty-one at Magna Phillips. The service stations were selected so as to give a sampling from different parts of Salt Lake County. Twenty-three samples were taken at the Valley Fair Mall parking lot and thirty-one at the Cottonwood Mall parking lot. An additional ten vehicles were tested at the Ford and General Motors training center parking lots. These cars were being driven by their employees. Samples were collected from July 28, 1971 to August 6, 1971.

An effort was made to test all the 1970-71 vehicles that entered the service station and parking lots. Response was very gratifying as few who were driving this year vehicle refused to have their automobile tested. Dealer response was also very gratifying. Not one dealer that was contacted refused to cooperate with the study. Several expressed a desire to see the results of the study.

The testing device used was an infra-red emission tester, model EET-910 manufactured by the Sun Electric Corporation, Chicago, Illinois. All tests for emissions were made while the engine was idling with the engine at its normal operating temperature.

Definition of terms

Anti-smog devices - equipment added to the automobile to reduce the exhaust emissions.

Blowby - refers to leakage past the piston rings whose job it is to seal between the combustion chamber and the crankcase.

Carbon monoxide (C) - a colorless odorless gas, a product of incomplete combustion, generally controlled by the carburetor of the automobile.

Combustion chamber - the compartment in which the burning of the fuel takes place.

Crankcase - the compartment that contains the oil which is used for lubrication of the internal parts of the engine.

Exhaust emission - those elements coming from the automobile's exhaust pipe which contribute to air pollution.

External combustion engine - a heat engine in which the burning of the fuel takes place outside the cylinder of the engine.

Fuel evaporative control system - a system which controls the evaporation of fuel from the automobiles gasoline tank and carburetor vent.

Hydro-carbons (HC) - Microscopic particles of gasoline particularly those escaping unburned from the engine. These can also result from evaporation from the gasoline tank and carburetor of the automobile.

Internal combustion engine - a heat engine which burns the fuel inside the cylinder of the engine.

Nitrogen oxides (No_x) - compounds of nitrogen and oxygen that react with sunlight forming noxious gasses. Products of engine combustion.

PCV valve - a valve in the positive crankcase ventilating system which controls emissions from the crankcase of the automobile by routing them to the combustion chamber.

TDC Top Dead Center - the extreme upward movement of the piston, when it is farthest away from the crankshaft.

Timing or ignition timing - the moment of ignition of the fuel in the engine, measured in degrees rotation of the crankshaft.

REVIEW OF LITERATURE

Background and history

Air pollution became a problem as early as 1940 in the city of Los Angeles. "Between 1940 and 1946 dust fall in the city increased from 100 tons to nearly 400 tons per day." (Commoner, 1971, p. 66) This was easily controlled by the use of dust precipitators on industrial smoke stacks and incinerators. Open burning of trash was also prohibited. Although the dust fall soon decreased to the pre-war level, a yellowish brown haze still remained in the mountain ringed basin.

Dr. Arie J. Haagen-Smit was studying the effects of light on compounds at this time. He soon discovered that the throat searing, eye burning noxious haze was caused by the sunlight acting upon the exhaust of automobiles. He termed it "photo-chemical smog." (Schultz, 1971, p. 48)

Further research found many elements coming from the exhaust of the internal combustion engine. Lessing (1967, p. 80) says that over 200 have now been identified. Of these elements there are three that are most important because of their effects on health and environment and the large amounts that are emitted to the atmosphere. Carbon monoxide (CO) is the largest amount by weight. One hundred ninety thousand tons are emitted daily by automobiles in the United States. Hydro-carbons (HC) ranks second in elements of

pollution. Twenty-seven thousand tons are emitted daily. Nitrous oxides rank third with 9,000 tons per day.

Automobiles are not the only air polluters. Industry, power plants, space heating and open burning all contribute to the problem. However, Dr. Dixon (1966, p. 19) reported at the Third National Conference on Air Pollution, that transportation vehicles in the United States produce eighty-five million tons of pollutants annually.

The situation has prompted much concern with the pollution problem as it relates to the automobile. Walch (1971, p. 1) reports that environmental material read into the Congressional Record in 1969, was exceeded only by material on Viet Nam. Senator Gaylord Nelson from Wisconsin, (1970, S12614) has even proposed the replacement of the internal combustion engine as a power source for the automobile.

Others point to the progress that has been made in reducing automobile emissions.

Thanks largely to the prodding of environmentalists, the automobile air pollution situation has already improved considerably; in fact, with the existing emission controls we have already turned a corner. From a peak in 1967, the total volume of automotive air pollution in the U.S. has declined by an estimated 15 per cent to 20 per cent, thanks largely to new devices added at about \$80 a car--to the 1968 models. Once earlier cars disappear from the roads, pollution should decline even further. (Graves, 1971, p. 32)

Senator Robert Griffin from Michigan says that earlier figures which identify 60 per cent to 90 per cent of the air pollution with the automobile are too high. "Last month the Council on Environmental Quality submitted data

attributing 42 per cent of man made pollutants to transportation." (Griffin, 1970, p. S16221)

So the controversy still rages. Detroit is doing a lot of work to reduce the emissions of automobiles. Research is being conducted on other types of engines to propell the vehicle (Graves, 1971; Norbye, 1970; Schultz, 1969; and Wargo, 1970). Particular interest is centered around the wankel engine. This is a rotary piston design that produces the same horsepower as the conventional engine but is much smaller. This then leaves more room in the engine compartment to add other control devices (Lamm, 1971; Lansner, 1972; and Cristy, 1971). Use of different types of fuels are also being experimented with (Billings, 1972).

All of these different approaches show some promise but also bring about additional problems of their own. Production of new engines, distribution of new parts and fuels, and qualified technicians to repair them is only part of the problem. Costs would be tremendous. Even if a change could be made today, what about the 120 million vehicles already on the road. This means we have to do something with the present engine to control emissions. We cannot afford to wait for a pollution free car to solve our problem.

Prior to 1960, automobile pollutants came from three different sources. Fuel evaporating from the gasoline tank comprised approximately 20 per cent of the total automotive emission. Oil vapors and fumes coming from the vent of the crankcase comprised another 20 per cent. The remaining 60 per cent came from the exhaust pipe (Middleton, 1979, pp. 2-12). Anti-pollution

devices added since that time have completely controlled the pollutants from the crankcase and gasoline tank.

Different devices have been used to control the exhaust emissions. Initially many vehicles used a method whereby air was pumped into the exhaust manifold to provide additional burning of the exhaust as it left the engine. This method is no longer used because it caused an increase in emissions of nitrous oxides and was difficult to maintain.

The method currently in use consists of controlling emissions by modifying the engine. Combustion chambers have been altered, advance and retard mechanisms are used on ignition timing and engine operating temperatures have been raised in an effort to obtain more complete burning. This method is effective in controlling CO and HC, but also has the adverse effect of increasing the emissions of No_x . Catalytic mufflers are now being considered to reduce No_x , but the lead additive used to increase octane rating in most gasolines contaminated the catalysts, and makes the device ineffective in about 1000 miles of driving. Leaded gasoline will have to be removed from the market if catalytic mufflers are used (Kendrick, 1971).

Some studies however indicate that because of deterioration of the emission devices control of pollutants is not adequate. Dr. John K. Hawley (1971, pp. 10-11) has referred to several. One was conducted by the Environmental Protection Agency - Division of Motor Vehicle Pollution Control, in 1969. In this test seven hundred rental vehicles were tested. One third of the vehicles exceeded certification level of CO and HC after only 10,000 miles.

He also cited a test conducted in California by the California Air Resources Board. Four thousand 1966-69 model vehicles were tested and 75 per cent of them failed either the HC or CO standard or both. Stern (1969, p. 41) states that emission control devices falter, get out of kilter, and are apt to become ineffective after 2,000 miles of city driving. The Congressional Quarterly Weekly Report also reports that "auto pollution will not decrease because of the increasing numbers of vehicles and the deterioration of emission control devices" (June, 1970, p. 1508).

Shinnar (1972) believes the answer is to design for ease of maintenance, and reliability and then conduct proper inspections to insure the vehicle is not polluting excessively. "We therefore need a nation wide inspection policy which will require vastly improved maintenance facilities and properly trained people." (Shinnar, 1972, p. 1360)

Legislation

The passage of the Air Pollution Control Act of 1955, represents the first Federal legislation regarding air pollution. This act provided "leadership and direction," but left the responsibility of controlling pollution with the states (Walch, 1970, p. 132). It also directed the Secretary of Health, Education and Welfare to provide research and technical assistance. In 1963, the "Clean Air Act" was passed. It provided grants to states to carry out anti-pollution enforcement work. It was amended in 1965 to provide federal standards for automobile exhaust emission.

The Air Quality Act of 1967 expanded the previous programs and also called for the establishment of regional organizations to combat air pollution and directed the secretary of Health, Education and Welfare to set standards and enforce them where states failed to act (Walch, 1970, p. 133). This reaction to the 1967 act was noted in the Congressional Quarterly Weekly Report.

The Air Quality Act of 1967 is the first federal law "with teeth enough to produce cleaner air," according to the Conservation Foundation. Previous federal laws were based on the premise that air pollution control would be handled by state and local governments. Yet at the time of the passage of the Air Quality Act, only 14 states were using their authority to adopt air quality and emission standards, and fewer than 100 local governments were operating air pollution control programs. (May 23, 1969, p. 281)

The standards for automobile emissions were set to become effective with the 1968 automobile at 1.5 per cent CO and 275 ppm HC.

The 1970 amendments to the Clean Air Act requires that Detroit produce a pollution free car by 1975. It also provided for the establishment of the Environmental Protection Agency to deal directly with problems of the environment. William D. Ruckelshaus was appointed secretary of this new agency and told to set standards for emissions. Nineteen-seventy to seventy-one levels were set at 1.0 per cent CO and 180 ppm HC. Standards were also expressed in total weight instead of a percentage. This was done because it was possible to dilute the exhaust to show a lesser percent of emissions, while the actual level of emissions remained the same. The standards for emissions in 1971 expressed in grams per mile are: CO- 23 g./mi. and HC - 2.2 g./mi. and No_x - 4 g./mi. (Middleton, 1970, pp. 3-5). There is however, no practical field test for the emission of No_x .

Abelson (1968, p. 257) reported that the level for 1960 automobiles was at 3.5 per cent CO and 900 ppm HC, and that 1968 automobiles were emitting 1.5 per cent CO and 275 ppm HC. Science Digest (Schultz, 1969, p. 49) reports a reduction of HC by 80 per cent and CO by 65 per cent on 1970-71 model cars.

Mr. Ruckelshaus has also set standards for 1975. HC - .46 g./mi., CO - 4.7 g./mi., and No_x is 3 g./mi. However 1976 standards call for a drastic reduction of No_x to .4 g./mi.

These figures apply only to new automobiles. To date, no federal standards have been set for used vehicles. In the state of California where we usually look for leadership in this area standards have been set. The California Highway Patrol has been given authority to conduct random checks for emission on used vehicles. The level of emission for 1970-71 model vehicles manufactured in the U.S. is set at 4.0 per cent CO and 350 ppm HC (Horvath, 1971, p. 1).

Testing procedures

There are two methods of testing for automobile pollutants. One gives the weight of the pollutants in grams per mile. This method is the most accurate, but is extremely costly since it requires that the automobile be run on a chassis dynamometer. The vehicle is run in a simulated road test of different phases. These include idling, acceleration, cruise, high and low speed and deceleration. Test phases vary to simulate driving conditions of different areas. One such test cycle recommended by the federal government is reported in Popular

Science (Norbye, 1970, pp. 56-57). All of the exhaust is then trapped and the pollutants are isolated and weighed for each vehicle.

The other method which is the best procedure from a practical standpoint is to check the exhaust while the engine is idling. In this test only a sample of the exhaust is taken. The amount of HC is then measured in parts per million (ppm) and the CO is given in a percentage of the exhaust sample. This test requires about one minute to complete and is accurate enough to give a good indication of the emission level of the automobile for standards set for 1970-71 model vehicles. The Atlantic Richfield Company in cooperation with the Salt Lake City-County Health Department conducted tests using this method on August 3-4, 1971. J. C. Penny's Automotive Center in Granger, Utah, conducted a similar test on August 18, 19, 20, 1971 using the same testing procedure. This type of testing device will not measure No_x emissions and will not measure accurately the level of HC and CO presently being considered for 1975.

PRESENTATION OF DATA

Data collected on the vehicles was categorized into three groups. Group I consisted of seventy 1971 model vehicles. These vehicles all had less than ten miles on the odometer. Group II was used 1971 model cars whose mileage ranged from 148 to 27,000 miles. Group III was used 1970 model cars. Their mileage ranged from 3,500 to 61,000 miles.

Group I emission level of CO averaged 3.5 per cent while the average HC was 284 ppm. The range of CO was from 8 to .2 per cent while the range of HC was from 1400 ppm down to 60 ppm.

There were 46 vehicles included in group II. The level of emission for this group ranged from 8 per cent to .2 per cent for CO. Emission of HC ranged from 480 ppm to 40 ppm. The average for all used 1971 model vehicles was 2.7 per cent CO and 191 ppm HC. Six vehicles had gone over 15,000 miles without being tuned. Their average emission was 2.8 per cent CO and 167 ppm HC. Twenty vehicles had between 5,000 and 15,000 miles and were reported as not having been tuned. The average for these vehicles was 2.35 per cent CO and 204 ppm HC. Twenty vehicles had less than 5,000 miles and no tune-up reported. Their average emission was 3.1 per cent CO and 183 ppm HC.

A total of fifty-six 1970 model cars were in group III. The level of emission varied from 8 per cent down to .2 per cent in CO and from 1,100 ppm to 80 ppm HC. The average of all 1970 model cars was 3.6 per cent CO and 290 ppm HC. Thirty vehicles had gone less than 10,000 miles since it

had been tuned. The average emission level for these was 3.5 per cent CO and 250 ppm HC. Nine vehicles had more than 15,000 miles since tune-up. Their average emission was 3.5 per cent CO and 435 ppm HC. Figure I is a graph showing a comparison of these three groups.

The 1970-71 model vehicles were then grouped together to compare emission level and the number of miles since the vehicle had been tuned. These results are shown in the following figures. Figures II and III are scattergrams showing the comparison of CO and HC emissions with mileage. Figure IV is a graph showing the average emission level of the cars falling within the mileage range listed.

Figure V shows a comparison of emission level and total mileage when the vehicle is tuned and when it is not tuned. Those considered as being tuned cars had less than 12,000 miles since work had been performed.

Forty-six 1970-71 model cars had gone more than 15,000 miles total. Twenty-five of these were classed as being tuned. The emission level for these vehicles was 3.3 per cent CO and 255 per cent ppm HC. Those that had more than 15,000 miles since being tuned averaged 4.4 per cent CO and 281 ppm HC.

A correlation coefficient was then computed for mileage since tune-up and the emission level. For 1970 model cars the correlation was .038 for CO and .009 for HC. For 1971 used cars there was a negative correlation. CO was -.233 and HC was -.138. This meant that the emission level decreased slightly as mileage increased. Since a figure of 1. is considered to be a perfect correlation, none of these figures would be considered significant.

A correlation coefficient was also computed for total mileage disregarding the fact that tune-ups had been done. All used vehicles had a correlation coefficient of .19 for CO and .29 for HC. When the new 1971 model cars were grouped with the used cars the coefficient went down to -.001 on CO and .001 for HC.

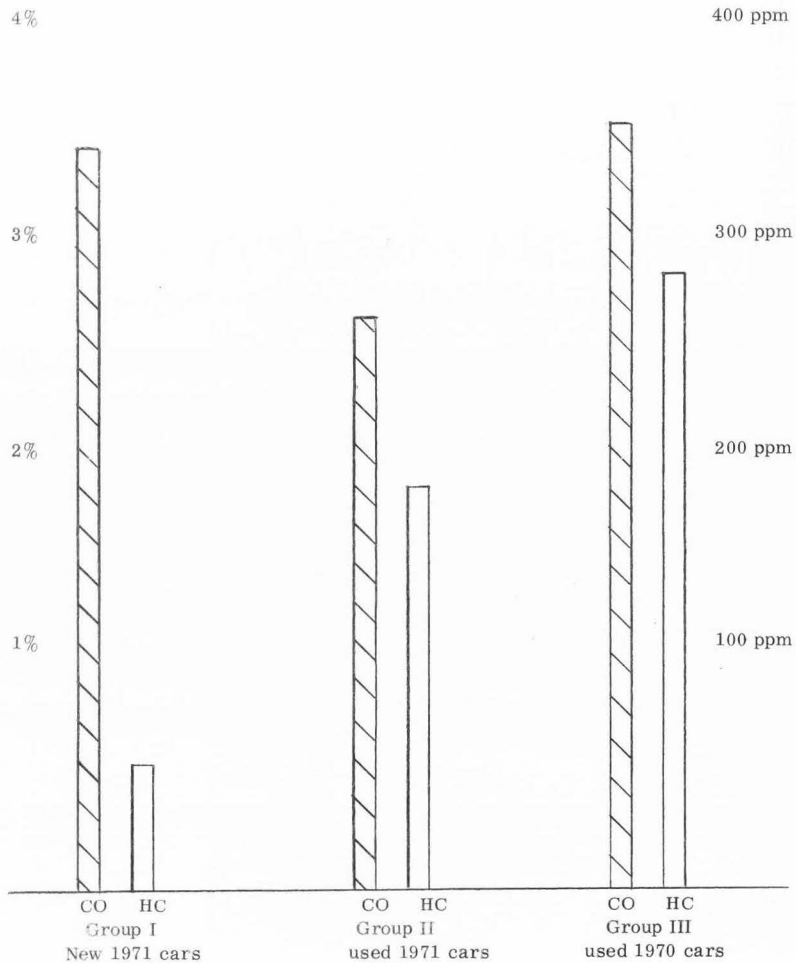


Figure I. Average emission Level

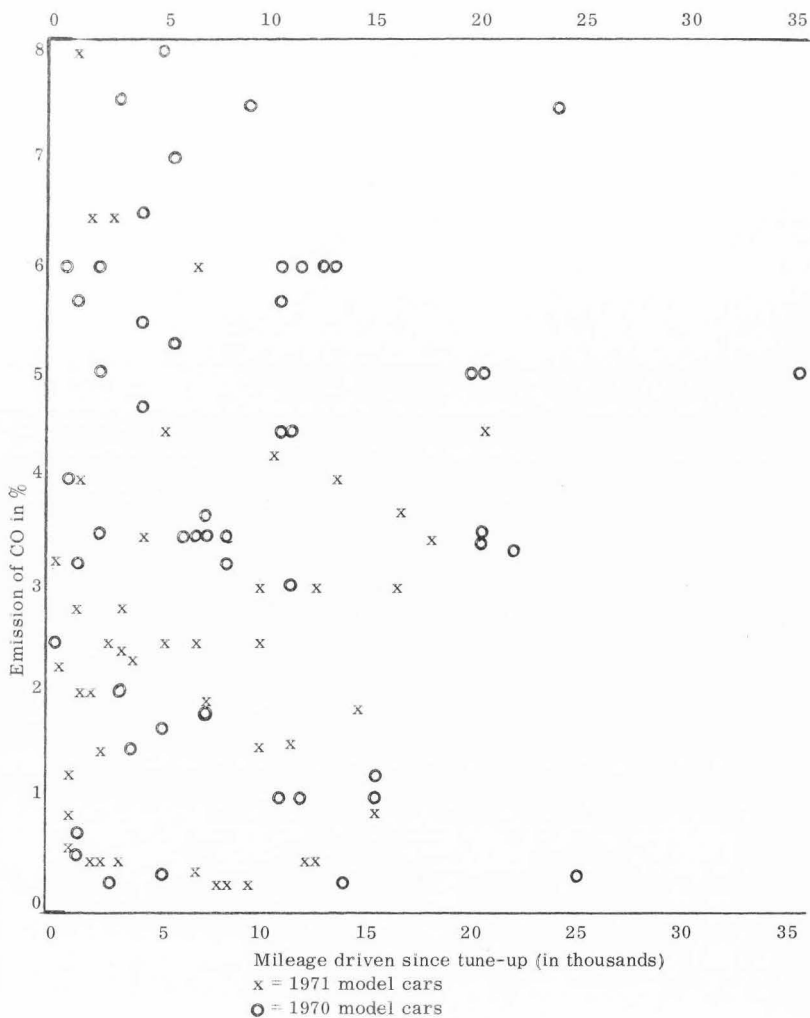


Figure II. Scattergrams - CO emission Vs. Mileage

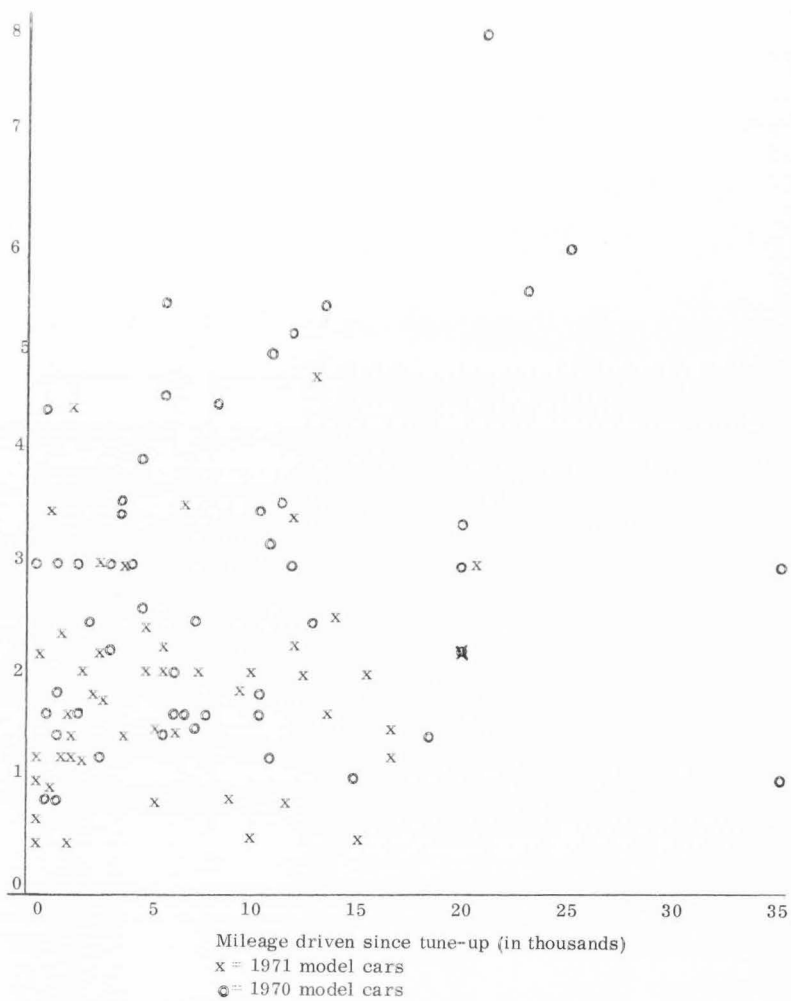


Figure III. Scattergram - HC emission Vs. Mileage

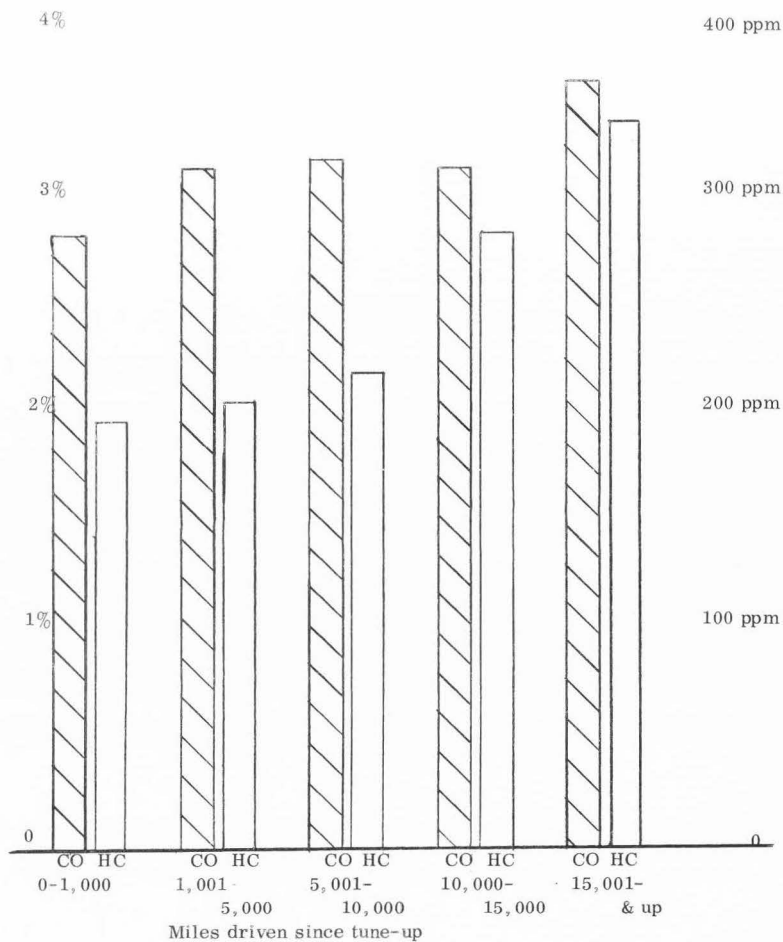


Figure IV. Average emission level (1970-71 model cars)

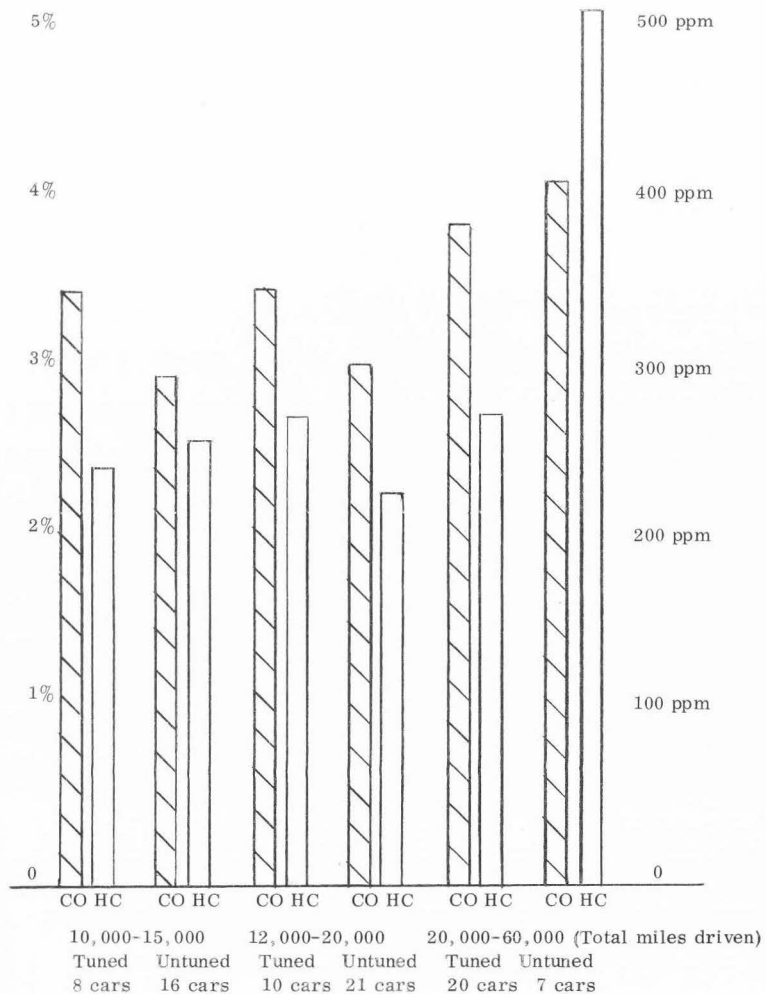


Figure V. Average emission level (tuned vs. untuned cars)

SUMMARY, CONCLUSIONS, AND
RECOMMENDATIONS

Summary

The purpose of this study was to obtain readings on the emissions of CO and HC from automobiles in Salt Lake County to determine if emission standards are being met by 1970-71 model automobiles.

More specifically the objectives were:

1. To determine if there is a significant difference in the exhaust emissions of new and used 1970-71 model automobiles.
2. To determine if there is a significant difference in the exhaust emissions of recently tuned automobiles and those that have not been tuned.
3. To determine if tune-ups done in Salt Lake County are being done adequately to meet exhaust emission standards.

Although different forms of air pollution have been with us for some time, it has only been in the last decade that serious action has been taken. The automobile was first identified with the air pollution problem by Dr. Haagen-Smit in the early 1950's. Since that time much has been written about its contribution to the problem. Some have praised the accomplishments of the automobile industry in controlling emissions, while others say the problem is getting worse.

Manufacturers are frantically trying to meet the emission standards. Some are experimenting with different types of engines that will emit less

polluting elements. At the same time the Federal Government is putting additional pressure by establishing more stringent standards.

Little is being done on the local level to help control the emissions of the automobile. A popular television advertisement states that if every car in the United States would get a tune-up, air pollution would be reduced by 50 per cent. Studies have indicated that exhaust emissions are in fact reduced when the vehicle is properly tuned. The question is whether the vehicles are in fact being tuned so that exhaust emission standards are being met.

Of the seventy new 1971 model vehicles that were tested, twenty-four (34 per cent) met the standard for HC emission set by the Federal Government. Ten (14 per cent) met the standard for CO. Only five (7 per cent) met both the CO and HC standard. Thirty-two (46 per cent) are emitting more CO and HC or both than the average reported for 1969 model vehicles when no emission controls were installed. Fifty-eight (83 per cent) would not meet the standard set for 1968 model vehicles. These vehicles were reported by the dealers as having been pre-delivered and ready for sale. After the vehicles arrived at the dealership from the factory there is a maintenance sequence established by the factory for the dealership to follow to insure that the vehicle is in proper working order. The term used for this is pre-delivery.

Only seven (13 per cent) 1970 model vehicles and eight (17 per cent) model vehicles would meet the standard set by the Federal Government for this year vehicle. Twenty-eight (50 per cent) of the 1970 model vehicles and twelve (24 per cent) 1971 model vehicles are operating above the 1960 level of emission.

Conclusions

After careful consideration of the data gathered in the study and a review of the available literature, the following conclusions are expressed.

1. Some automobiles are emitting higher amounts of CO and HC than is considered normal because the vehicles are not being returned for the proper maintenance at the recommended mileage schedule.
2. Most vehicles that have been recently tuned are exceeding the recommended level of CO and HC.
3. Automobiles manufactured in 1970-71 are capable of emitting less CO and HC than previous years models if they are properly adjusted and maintained.
4. Technicians lack the training, equipment and motivation to adjust the new vehicles so that emission standards are being met.
5. Although there is a growing interest in the problem of air pollution, people in general lack the desire to properly maintain their vehicles so that the lowest possible amount of exhaust emission is expelled from their automobiles.
6. Some owners are attempting to maintain their vehicles themselves without the proper tools and equipment to adequately do the job. These vehicles generally are adjusted to produce maximum performance and economy which may cause an increase in exhaust emissions.

Recommendations

The following recommendations are made for Salt Lake County. Because of the geography and population of this area, there is a possibility of serious environmental and health problems due to air pollution.

1. Controls need to be developed to insure that the automobile will be returned to a qualified technician for the required maintenance. A record of maintenance similar to that required by aviation is suggested. The technician doing the repair work would be required to certify that the emission level is properly set to meet the standard.

2. Procedures for licensy shops that are involved in doing tune-up work should be devised to insure that the shop maintains the necessary equipment to adequately tune vehicles.

3. A similar procedure for licensing technicians should also be devised. The technician should be paid at a higher rate as an incentive to keep himself up-dated and able to accurately do the job.

4. A program for policeing should have to be developed. Highway patrol cars would have to be equipped to make random checks of exhaust emission. Since HC and CO are not visible to the naked eye, all vehicles would have to be stopped.

A program very similar to these recommendations is already in effect in the state of California. New Jersey is also involved in a program to control exhaust emissions. Cars are being tested for exhaust emissions as part of the annual safety inspection. It is not known how effective these programs are because of the short time that they have been in operation.

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