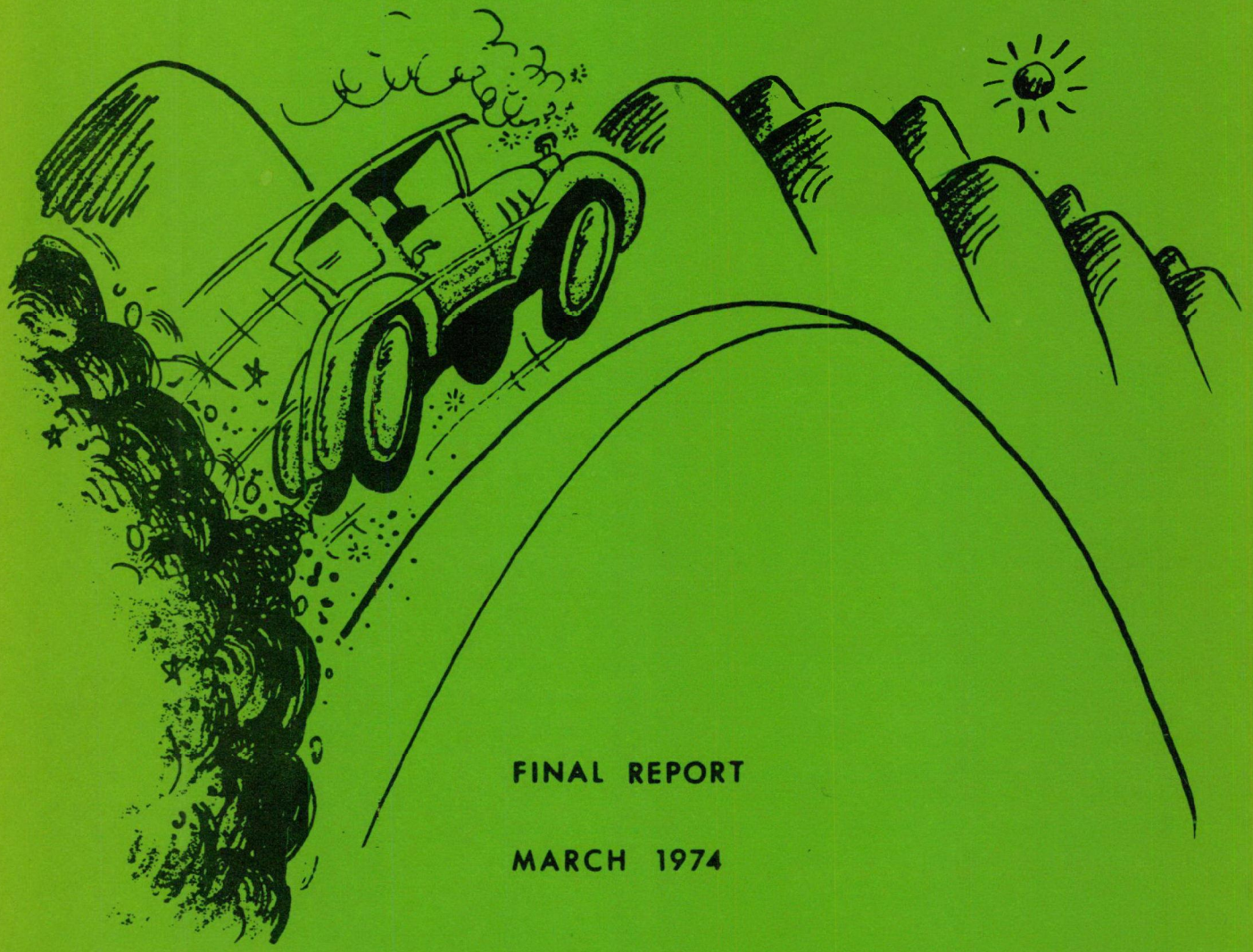
HIGH ALTITUDE VEHICULAR EMISSION CONTROL PROGRAM

VOLUME VIII. PILOT TRAINING PROGRAM

RESULTS FOR MOTOR VEHICLE EMISSION CONTROL



FINAL REPORT

MARCH 1974

PREPARED FOR:

STATE OF COLORADO
DEPARTMENT OF HEALTH
DENVER, COLORADO 80220

ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
DENVER, COLORADO 80203

CSU / COLORADO STATE UNIVERSITY

ATL / AUTOMOTIVE TESTING LABORATORIES

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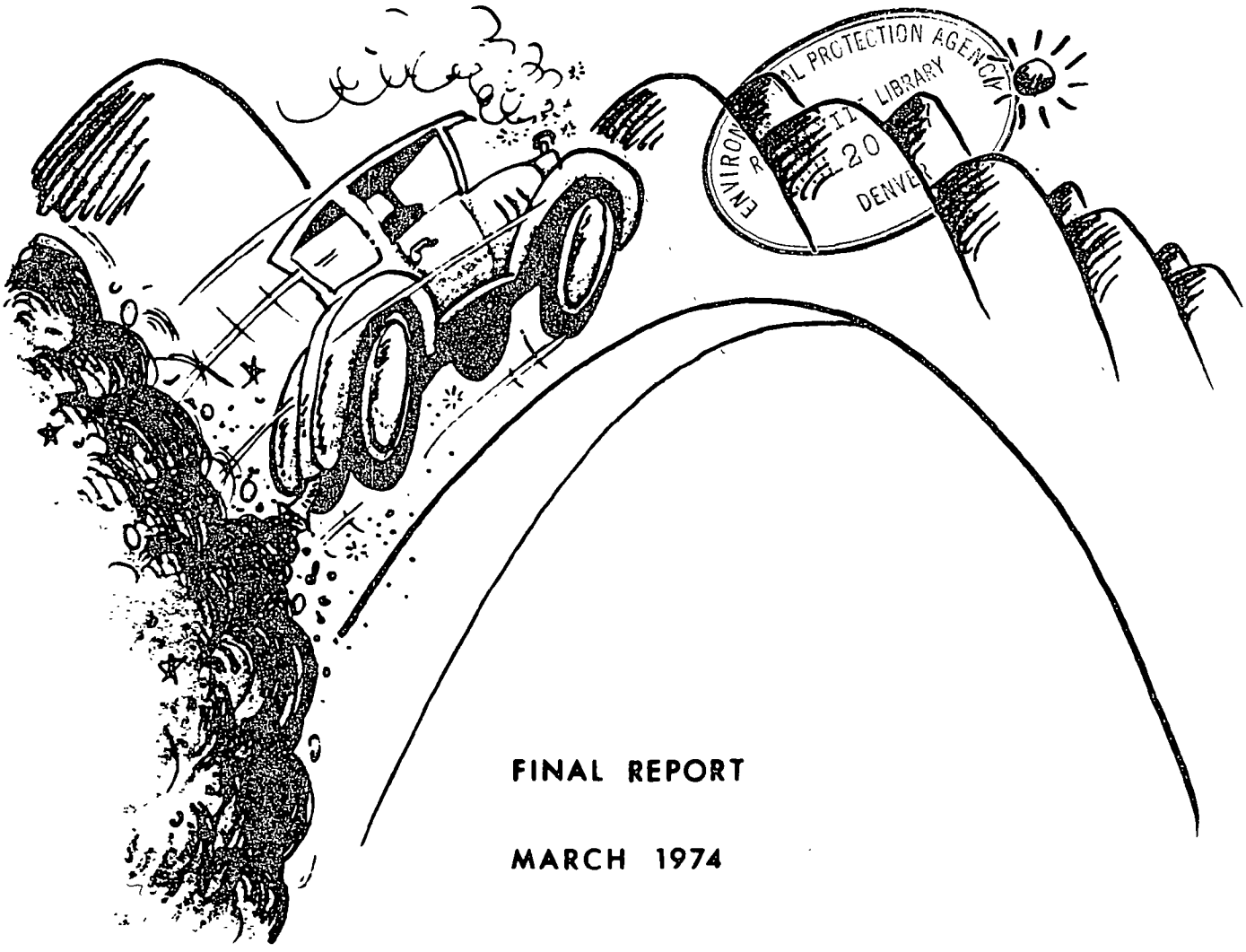
VOLUME VIII. PILOT TRAINING PROGRAM RESULTS FOR MOTOR VEHICLE EMISSION CONTROL



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DISCLAIMER

This report was prepared for the State of Colorado Department of Health by the Industrial Sciences Department at Colorado State University under contract number C-290-760 and contract number 99-3-0002-021-01A from the Region VIII Environmental Protection Agency.

The conclusions, opinions and findings are those of the project team members and not necessarily those of the sponsoring agencies. Mention of company or product names does not constitute endorsement by the project team members, the Environmental Protection Agency, or the State of Colorado.

The results and conclusions presented are based on data gathered by Automotive Testing Laboratory and by pilot programs conducted by the Industrial Sciences Department at Colorado State University.

The limited number of people involved in the pilot programs could have a significant impact on the conclusions and recommendations.

PREFACE

This report, "High Altitude Vehicular Emission Control Program," consists of eight volumes. Listed in the following are the subtitles given for each volume:

* Volume I - Executive Summary, Final Report, January, 1974.

* Volume II - Experimental Characterization of Idle Inspection, Exhaust Control Retrofit and Mandatory Engine Maintenance, Final Report, December, 1973.

* Volume III - Impact of Altitude on Vehicular Exhaust Emissions, December, 1973.

* Volume IV - Analysis of Experimental Results, Final Report, December, 1973.

* Volume V - Development of Techniques, Criteria and Standards to Implement a Vehicle Inspection, Maintenance and Modification Program, Final Report, December, 1973.

* Volume VI - The Data Base, Final Report, January, 1974.

* Volume VII - Experimental Characterization of Vehicular Emission and Engine Deterioration, Final Report, June, 1974.

* Volume VIII - Pilot Training Program Results for Motor Vehicle Emissions Control, Final Report, March, 1974.

The first volume summarizes the general objectives, approach and results of the study. The second volume presents a detailed description of the experimental programs conducted to define the data base. Volume III reports the methods and analysis used in developing the basic relationships between mass emissions and altitude. A quantitative analysis of the results from the experimental program is presented in Volume IV.

The fifth volume provides an analysis of the techniques and criteria required in establishing a vehicle emission control program for the Denver area. The actual data base developed from the experimental program is given in Volume VI. Volume VII reports the results of the six month deterioration program. Lastly, Volume VIII reports the results of pilot training programs for inspectors, state investigators and repairmen.

The work presented herein is in part the product of a joint effort by several consulting firms. Automotive Testing Laboratories (ATL) was responsible for the design and implementation of the basic experiments. TRW provided the data management and analysis of the experimental results. Olson Laboratories evaluated the feasibility of conducting an emission control program for the Denver area. Colorado State University conducted pilot training programs to evaluate the training needs for the automotive emission control.

ACKNOWLEDGEMENTS

The Industrial Sciences Department at Colorado State University would like to acknowledge the efforts extended by the Colorado Department of Health and the Environmental Protection Agency, Region VIII. In particular, the contributions of Messrs. Don Sorrels, Robert Taylor and Steve Haines of the Colorado State Department of Health were of great help.

Additionally, the Industrial Sciences Department wishes to acknowledge the Automotive Testing Laboratory for its assistance and also the many participants in the pilot training programs that were conducted.

A special thanks must be extended to Mr. Douglas Graham and Mr. Brian Iler for their great effort and excellent teaching.

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1.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations presented herein highlight the findings from the six (6) hour instructional program conducted for inspectors and state investigators in the pilot program on emission control.

CONCLUSIONS

1. Evaluation of the tests and observation of the class by the instructors indicate that six hours of instruction was not enough time to provide the needed information for the inspectors or the state investigators.

2. State regulatory laws and guidelines are needed to give guidance to the automotive emissions program. Inspectors and investigators are rather reluctant to attend classes where the information received may not be used.

3. A certification program needs to be implemented to insure the quality of the inspectors and investigators.

4. Test sites and equipment will be required to train the existing and future inspectors and investigators.

5. With the proper equipment and enough training sites, an effective automotive emissions control program can be established for the State of Colorado.

RECOMMENDATIONS

1. Instructional time be extended from six (6) hours to nine (9) hours for the inspectors and investigators. It is recommended that the additional three hours be used for better understanding of the test equipment and procedures used in the laboratory.

2. A state handbook be developed that would cover the laws and give the guidelines for the automotive emissions control program for Colorado.

3. A state certification program be established whereby an inspector or investigator could take appropriate tests to validate his competency in the area of auto emissions control and be awarded a certificate signifying this competency.

4. Appropriate training sites be established at strategic locations. These training sites would operate to train the existing inspectors and investigators and provide periodic classes to upgrade various personnel involved with the implementation of the emissions control program.

5. A larger sampling of inspectors (approximately 300) from safety inspection stations in the DAQCR be randomly selected and taught the proposed nine (9) hour instructional program. All pertinent data would be tabulated on these individuals to test and validate the proposed program content.

6. All state investigators (approximately 30-35) be encouraged to attend the recommended program of nine (9) hours of instruction. Data would be compiled to test and validate the proposed program content for these investigators.

2.0 PROJECT OBJECTIVES

1. Investigation of training programs for state investigators, inspectors and motor vehicle repairmen.

2. Develop and conduct pilot training programs and measure the effectiveness of such programs for state investigators and inspectors.

3. Develop orientation and basic maintenance procedures on air pollution control systems installed by manufacturers.

4. Conduct a pilot training program for state investigators and inspectors.

5. Prepare and submit to the Colorado State Department of Health, on completion of pilot training programs, a written final report setting forth the cost of such programs and the effectiveness thereof, and prescribing the conclusions and recommendations resultant from having conducted the training program and completed the training requirements pursuant to enacted Senate Bill No. 393.

3.0 INTRODUCTION

This is the final report on the Pilot Training Program for inspectors and state investigators on motor vehicle emissions control. It is Volume VIII of the High Altitude Vehicular Emissions Control Program. The overall objective of the total program was to examine the feasibility of implementing several vehicular emissions control alternatives in the Denver AQCR. Both the achievable exhaust emissions reductions and associated control costs were used in the feasibility assessments.

This volume provides information on how the State of Colorado might establish a training program for state investigators and inspectors with some suggestions on a certification program for all personnel involved in inspection, service and maintenance pertaining to emission control systems.

In order to implement an effective and efficient program on motor vehicle emissions control, it is necessary to: (1) identify the needs; (2) develop a delivery system consisting of the appropriate component parts; (3) produce and test adequate instructional materials; and (4) educate and train personnel involved in carrying out the total program.

In line with these requirements, the Department of Industrial Sciences at Colorado State University, under contract with the Colorado State Department of Health, developed and implemented a pilot training program on motor vehicle emissions control for fifteen (15) inspectors

and six (6) state investigators.

In addition, a pilot training program for emission control repairmen is being conducted by the Department of Industrial Sciences under contract with Region VIII of the Environmental Protection Agency.

The following procedures were followed in the development, teaching and evaluation of the pilot program:

1. Reviewed service and maintenance requirements for the motor vehicle emissions control for state investigators, inspectors and repairmen.

2. Reviewed "State of the Art" in Colorado concerning service stations, equipment and personnel as it relates to vehicle emissions control.

3. Reviewed data collected by Automotive Testing Laboratories, Inc. concerning the field test of idle test emissions on randomly selected automobiles.

4. Reviewed instructional materials now available concerning motor vehicle emissions control.

5. Compiled results of these reviews and analyzed the implications for needed instructional materials and programs on motor vehicle emissions control.

6. Compiled and developed instructional materials to be used in conducting pilot training program for state investigators and inspectors.

7. Conducted pilot training programs for six (6) state investigators and fifteen (15) inspectors.

8. Reviewed results of these pilot training programs.

9. Revised instructional program as needed in terms of findings from pilot programs.

It should be noted that interim reports on the pilot program for training (114) repairmen on vehicle emissions control for the Manpower Division, E.P.A., Region VIII are being filed with the Regional VIII Office in Denver and a final report on this project will be available August 31, 1974.

As outlined in (Appendix D), a complete "Delivery System on Motor Vehicle Emissions Control for Colorado" has been submitted to the Air Pollution Control Division for consideration.

4.0 PILOT TRAINING PROGRAM FOR AUTOMOTIVE EMISSIONS CONTROL

PILOT PROGRAM FOR INSPECTORS AND STATE INVESTIGATORS

The pilot program was designed to fulfill the requirement in SB 393 (Appendix Q) which called for researching training methods and recommending a training program for automotive emissions control for the State of Colorado.

A course of study and instructional materials had to be developed in order to implement the pilot training program. After researching the various manuals and other materials, the Emissions Control Manual by Gargano was selected as the text for the program. Mitchell Automotive Manuals were used as reference books and technical materials from Ethyl Corporation (Appendix L) were used for student notes. These materials were organized and arranged in appropriate packets in preparation for the first class in December, 1973.

Automotive Testing Laboratories, Inc. of Denver was contracted to furnish a teaching site and help with the instruction. On December 11, 1973, fifteen inspectors met at the Automotive Testing Laboratories training site. At first, there was confusion in the group as to the purpose and intent of the program. Effort was made to inform the participating inspectors of the intent of this pilot program and at the conclusion of the session each inspector was displaying a strong desire to acquire additional information.

On December 13, the class met for the second time and all students were present. The final three hours were spent reviewing the basic in-

formation presented and the students participated in some practical testing on the automobile. This practical work consisted of testing automobiles for HC-CO emissions and analyzing the results. Also, the students filled out simulated reports similar to the ones which would be used in an actual program.

At the close of the six (6) hour program, the students and instructors realized that six hours was not enough time to conduct an effective class in automotive emissions control. After discussing the major parts of the program, the instructors and students agreed that in order to have a more comprehensive program for inspectors, an additional three (3) hour session should be added to the program. The consensus of opinion was for six (6) hours to be spent covering technical material on automotive emissions control, state and federal laws, and testing equipment and three (3) hours be spent on the practical application where a variety of automobiles would be tested and the results analyzed.

On January 10, 1974, six (6) state investigators from the Department of Revenue met at the Automotive Testing Laboratories training site to participate in the pilot training program for the investigators. A group of fifteen (15) people were solicitated for this exercise but due to the work load of the Revenue Department, only six (6) could be released to attend the class. It was decided that instead of running two sessions (3 hours each) at different times it would cause less confusion for the Revenue Department if one day was set aside and the entire content of the course presented in one session.

Information was given to the group concerning the possible laws and requirements that might be involved in motor vehicle emissions control. Considerable time was spent covering basic laws, consumer protection,

equipment necessary for inspection, calibrating of inspection equipment, inspection procedures and related information. It was stressed that throughout the program this was a pilot effort and that all the non-technical information concerning possible regulations and requirements was simulated.

The interest of this group was very low, perhaps due to the participants not knowing for sure what the program was all about. As the class progressed, it became obvious that the interest of the group was increasing. By the end of the session, a high degree of interest had been generated and several of the participants indicated a desire to seek additional information.

PILOT PROGRAM FOR REPAIRMEN

The pilot program being conducted for Region VIII of the Environmental Protection Agency consists of training one hundred and fourteen (114) veteran mechanics on automotive emissions control theory, maintenance and service. The class size started out on a smaller scale with the Industrial Sciences Department agreeing to train sixty (60) mechanics but this figure was revised to include one hundred and eighty (180) mechanics. The figure was later amended to one hundred and thirty (130) mechanics. A total of one hundred and forty-four (144) mechanics signed up to take the emissions schooling; however, only one hundred and fourteen (114) are regularly participating in the program.

In setting up and conducting these classes, several problems immediately became clear. First, the interest was very low. Much effort was needed to generate enough interest to encourage the mechanics to attend the classes. The classes were conducted on Tuesday and Wednesday evenings from 7:00 to 10:00 for four weeks and the fifth week the students went

an extra two (2) hours to give them a total of thirty-two (32) hours of classroom preparation. The mechanics were then provided field experiences through on-the-job-training (OJT). They discussed problems with a visiting instructor for approximately four (4) hours each week for a total of one hundred and twenty-eight (128) hours OJT time. The total time being spent with each class is one hundred and sixty (160) hours.

Classes for the one hundred and fourteen (114) mechanics were conducted at the Automotive Testing Laboratory in Denver, and each participant was assigned an appropriate outline for his field experience while on the job.

In the beginning stages of the project, problems were encountered due to the lack of sufficient equipment to conduct the classroom studies and the OJT training. At least two (2) HC-CO analyzers were needed in the classroom in addition to several additional units needed for the OJT experience. An arrangement was made with Sun Electric Corporation for the loan of several units to carry on the needed education and training. Also, three (3) units were leased and purchased which solved these problems.

Even with the help of Sun Electric Corp., the total equipment needs are not adequate and equipment must be moved from garage to garage to facilitate the OJT.

Overall, the pilot program for the mechanics is progressing in a satisfactory manner and, as noted previously, a complete report will be available on August 31, 1974.

5.0 ANALYSIS OF RESULTS

This section contains the results from the six (6) hour pilot training program for the inspectors and state investigators. It should be noted, the program was designed to apply and test an instructional program on fifteen (15) individuals in each category. However, due to the time conflict and excessive work loads for the state investigators, the project team was only allowed to work with six (6) of the investigators for one day. Due to such a small number and such a short period of time, the team did not attempt to gather any data concerning a pre-test and a post-test with these individuals. Instead, an attempt was made to evaluate the overall effectiveness of the one day program for these six (6) individuals and the observations are reflected in the conclusions and recommendations section.

As materials were being designed for use in the pilot training program, many sources were explored and numerous individuals, companies and institutions were contacted concerning what training information was available on motor vehicle emissions control. Also, input was solicited as to the anticipated time which would be required to provide adequate instruction in a basic orientation program for inspectors and investigators. The suggestions ranged from three (3) hours to fifteen (15) hours with six (6) hours being the average. From these suggestions, the decision was to conduct the pilot program for a six (6) hour period. From all the various input, the following major areas were identified

as being important as basic information in the background of an inspector and/or investigator:

1. General engine knowledge
2. Ignition system
3. Carburetion system
4. Components in emissions system
5. Testing instruments

A sampling of questions was presented for each section in the pre-test as reflected in Appendix M and these were administered to the fifteen (15) inspectors selected for the pilot training program. The pre-test was administered before the start of the six (6) hour program.

As noted, input was received and evaluated concerning the information which should be the focus for the main thrust of the pilot program. This information became the basis for the outline of content reflected in Appendices H and I.

The outlines reflect emphasis in the general catagories of basic engine knowledge, carburetion and ignition, components, testing instruments, simulated state handbook, inspection procedures, data gathering and recording procedures and general safety precautions. Therefore, a post-test was designed (Appendix N) to reflect an evaluation on how the participants had progressed in these general areas with the major emphasis on the testing instruments and the inspection procedure and simulated handbook sections. The post-test was administered at the conclusion of the two three (3) hour sessions and the results are shown on the following pages.

Identified in the following tables is information on the fifteen (15) inspectors as well as the results from the pre-test and post-test.

PRE-TEST RESULTS

Table 1 reveals that the age range for the fifteen (15) inspectors was from 21 to 46 with an average age for the group of 29.8 years. The number of years experience in the automotive tune-up and carburetion area extended from a minimum of .25 to a maximum of 18 with an average of 7.4 years. Although several of the individuals had been involved in short courses offered by the various automotive dealers and manufacturers, the numbers of years of formal schooling ranged from 8 to 14 with an average of 12.9 years.

Table 2 provides information on the results from the general engine section of the pre-test. It reveals that several of the participants gave incorrect answers to questions pertaining to this catagory. Of the 4 sample questions used in this catagory, the overall range of incorrect responses was from zero to 12.

Table 3 provides information on the questions pertaining to the ignition system section. As revealed, with the exception of the one question concerning spark plug missfire, several participants revealed a lack of information in this area. The range of incorrect answers was from 1 to 9.

Table 4 reveals that most of the participants possessed basic knowledge about the carburetion system. Of the 7 questions utilized in this area, the range of incorrect answers from all fifteen (15) participants was 1 to 4.

TABLE 1. BASIC INFORMATION ON INDIVIDUALS CONCERNING AGE, EXPERIENCE AND EDUCATION

Individuals Participating	Age	Years of Exp. in Tune-up & Carburetion	Highest Grade of Schooling
Individual A	46	18	14
Individual B	31	15	9
Individual C	32	14	12
Individual D	32	12	8
Individual E	27	10	14
Individual F	27	10	12
Individual G	28	8	12
Individual H	31	6	12
Individual I	37	5.5	12
Individual J	25	5	12
Individual K	30	4	12
Individual L	28	2	12
Individual M	26	1	13
Individual N	21	.5	14
Individual O	27	.25	12

TABLE 2. PRE-TEST ON GENERAL ENGINE INFORMATION

Questions Used	Incorrect Answers by Individual	Total Incorrect Answers
Black smoke from a vehicle tail pipe indicates the engine is burning oil. (True or False)	None	0
You have worked on both a 1962 and a 1972 model car today. After both owners left you discovered the radiator caps got mixed up. If you were concerned only with the danger of overheating, which owner would you call back? A. Owner of 1962 model B. Owner of 1972 model C. Neither owner because neither car would overheat	G, H, N, O	4
You are driving in winter at 50 MPH. Suddenly, the heater blows cool air and the engine boils. The trouble is: A. Radiator froze while you drove B. Thermostat stuck while you drove C. Water pump failed while you drove	A, D, E, F, G, I, J, K, L, M, N, O	12
Exhaust temperatures are hottest if: A. Timing is advanced more than specs. B. Set "right on" specs. C. Retarded less than specs.	A, C, E, F, G, H, I	7

TABLE 3. PRE-TEST ON IGNITION SYSTEM

Questions Used	Incorrect Answers by Individual	Total Incorrect Answers
Two owners with identical cars are going together on a trip. Owner A is towing a 16' travel trailer. Owner B will tow nothing. Both engines need vacuum diaphragm in their distributors but you only have one. Considering only gas mileage so less combined fuel is burned by these two cars on this trip. Which owner should get the new dis. diaphragm? A. Owner towing trailer B. Makes no difference C. Owner not towing	E, G, H, I, J, K, L, M, O	9
If ignition specs. are: Initial timing 5, total advance 25^{o}, mechanical advance 10^{o}, how many degrees is vacuum advance? A. 15^{o} B. 35^{o} C. 30^{o}	A, G, K, L	4
You change the dwell on an engine from 30^{o} to 26^{o}. What effect does this have on timing? A. No change B. Advances it C. Retards it	E, G, K, L, N, O	6
An engine with this firing order: "14283675" which cylinder besides #1 will flash a timinglight so you can see the marks? A. 8 B. 5 C. 3	A, E, G, K, L, M, O	7

TABLE 3. (Cont.)

Questions Used	Incorrect Answers by Individual	Total Incorrect Answers
All domestic engines built since 1965 time the distributor on #1 cylinder. A. True B. False	A, B, F, H, I, L, O	7
Spark plugs that miss-fire because of "Bridging" one or two days after a tune-up are an indication of: A. Owner's bad driving habits B. Poor quality spark plugs C. Heavy combustion chamber deposits	N	1
A vacuum brake failure will be noticed: A. On a fully warm engine B. On cold engine drive-away C. When trying to start flooded cold engines	A, C, E, F, G, J, M, N	8

TABLE 4. PRE-TEST ON CARBURETION SYSTEM

Questions Used	Incorrect Answers by Individual	Total Incorrect Answers
An engine "diesels" or "runs on" after shut down. This is most often caused by: A. Overheated engine B. Too lean C. Idling too fast at shut down	0	1
A two barrel carburetor has a reasonably smooth idle. When you check the mixture adjustment, using instruments, you could find: A. One mixture needle too lean and one too rich B. Both needles too rich C. Both needles too lean D. All of the above	H	1
Not enough "float drop" will cause trouble when: A. Starting a warm engine B. Idling a warm engine C. Driving at high speed with wide open throttle D. Cruising on level road at 25 MPH	A, K, N	3
A "dash pot" failure will be noticed: A. On acceleration B. On starting engine C. On deceleration	N, O	2
Replacing main jets with leaner ones may: A. Raise gas mileage B. Lower gas mileage C. Mav do either of the above	E, K, N, O	4

TABLE 4. (Cont.)

Questions Used	Incorrect Answers by Individual	Total Incorrect Answers
You're cruising at 50 MPH on a level road. Your vacuum gauge reads 14". Which carburetor circuit is not operating? A. Float circuit B. High Speed circuit C. Power circuit	B, E, L	3
When manifold vacuum is 16" but venturi and spark port vacuum are 0", the engine is: A. Stopped B. Running at 2500 RPM in neutral C. Idling	L, N	2

Table 5 provides information on the questions pertaining to the components in an emissions system. As revealed, several of the participants had trouble in this section with the range of incorrect answers from the group being 5 to 9.

Table 6 provides information on questions from the section on basic testing instruments. As noted, six of the participants gave incorrect answers to 2 of the 3 questions in this section.

Table 7 reflects a summation of all questions answered incorrectly by each of the participants. The spread of incorrect responses to each of the twenty-five questions ranged from zero on question number 1 to 12 for question number 5.

Table 8 reveals data pertaining to each of the participants concerning a relationship to age, years of experience in the tune-up area, number of years of formal schooling and total number of incorrect responses to the twenty-five questions on the pre-test. As noted in this table, the range of incorrect responses to the questions was from 1 (4 percent) to 13 (52 percent) with the average number of incorrect responses for the group being 8 or (32 percent). The age and experience of the individual did not necessarily correlate to the number of incorrect responses on the pre-test. Individual A, the oldest participant, at age 46 with 18 years of experience and 14 years of formal schooling missed 10 questions (40 percent), while Individual N, the youngest participant, at age 21, with only one-half of a year's experience and 14 years of formal schooling missed 11 questions (44 percent).

TABLE 5. PRE-TEST ON COMPONENTS IN EMISSIONS SYSTEM

Questions Used	Incorrect Answers by Individual	Total Incorrect Answers
EGR is used to: A. Reduce HC-CO B. Reduce NOx C. Reduce NOx and increase gas mileage	A, F, J, K, L, M N, O	8
CEC solenoids and idle stop solenoids both hold the throttle plates slightly open. Which one is an emissions control? A. CEC solenoid B. Idle stop solenoid	A, G, H, K, O	5
The owner knows he has: (a) one open plug wire, (b) a weak coil, (c) high float level, (d) no vacuum advance in the distributor. He will pay to fix only one of these troubles. Which one would you fix if he only wants lower HC emissions? A B C D Which one would you fix if he only wants lower CO emissions? A B C D Which one would you fix if he can't start it cold? A B C D	C, E, F, G, I, J, K, N, O	9
PCV valves are used to: A. Control HC emissions B. Ventilate the crankcase C. Both of the above	A, E, F, G, M	5

TABLE 6. PRE-TEST ON BASIC TESTING INSTRUMENTS

Questions Used	Incorrect Answers by Individual	Total Incorrect Answers
A running compression test is done with: A. All the spark plugs out B. All the spark plugs in C. One spark plug out at a time	B, E, G, J, K, L	6
You suspect one flat lobe on the cam shaft. Which tests would you use. A. Compression test B. Cylinder leakage test C. Cylinder balance test	M	1
A cranking vacuum test is done with: A. All the spark plugs out B. All the spark plugs in C. One spark plug out at a time	B, F, G, H, K, M	6

TABLE 7. SUMMARY OF PRE-TEST RESULTS

All Questions Used (See Appendix M)	Incorrect Answers by Participants														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Question #1															
Question #2															X
Question #3								X							
Question #4							X	X						X	X
Question #5	X			X	X	X	X		X	X	X	X	X	X	X
Question #6	X					X				X	X	X	X	X	X
Question #7	X										X			X	
Question #8					X		X	X	X	X	X	X	X		X
Question #9	X						X				X	X			
Question #10														X	X
Question #11					X		X				X	X		X	X
Question #12	X				X		X				X	X	X		X
Question #13	X						X	X			X				X
Question #14					X						X			X	X
Question #15		X			X							X			
Question #16	X	X				X		X	X			X			X
Question #17														X	
Question #18			X		X	X	X		X	X	X			X	X
Question #19		X			X		X			X	X	X			
Question #20	X		X		X	X	X			X			X	X	
Question #21													X		X
Question #22														X	
Question #23		X				X	X	X			X		X		
Question #24	X		X		X	X	X	X	X						
Question #25	X				X	X	X						X		

TABLE 8. INFORMATION CONCERNING RELATIONSHIP OF AGE, EXPERIENCE, FORMAL SCHOOLING AND NUMBER OF INCORRECT RESPONSES TO TWENTY-FIVE QUESTIONS

Participants	Age	Years of Exp. in Tune-up & Carburetion	Highest Grade of Schooling	Total Number of Questions Missed
Individual A	46	18	14	10
Individual B	31	15	9	4
Individual C	32	14	12	3
Individual D	32	12	8	1
Individual E	27	10	14	11
Individual F	27	10	12	8
Individual G	28	8	12	13
Individual H	31	6	12	7
Individual I	37	5.5	12	5
Individual J	25	5	12	6
Individual K	30	4	12	12
Individual L	28	2	12	9
Individual M	26	1	13	8
Individual N	21	.5	14	11
Individual O	27	.25	12	13

POST-TEST RESULTS

Presented in Tables 9-13 are data pertaining to the questions identified for each division and the incorrect responses by individuals on the major sections of:

1. General engine knowledge
2. Carburetion and ignition
3. Components in emissions system
4. Testing instruments
5. Inspection procedure and simulated state handbook

As identified previously, the major sections of testing instruments, inspection procedures and simulated state handbook were deemed most important; therefore, the content outline and in turn the post-test design were directed toward these sections.

Table 9 reflects content on the safety precautions to be observed while inspecting a vehicle. The participants responded with a large degree of accuracy in this area with only two participants failing to respond appropriately.

Table 10 shows questions pertaining to the carburetion and ignition systems on the vehicle. As revealed in the Table, only 1 question created a problem for the participants. All participants answered the other 4 questions in this section correctly.

Table 11 reveals the participants acquired the basic information on the emissions system section with one question being answered incorrectly by four individuals.

Table 12 reveals the responses of the individuals pertaining to the testing instruments. With the exception of a couple questions, all individuals performed in an appropriate manner in answering these questions on "meter readings for HC and CO."

TABLE 9. POST-TEST ON GENERAL ENGINE INFORMATION

Questions Used	Incorrect Answers by Individuals	Total Incorrect Answers
You inspect a 1972 Rambler and find it has a 1970 engine in it. There is no Carbon Canister in the evaporation control system. You would "pass" this vehicle: A. True B. False	A	1
List five safety precautions to be observed while inspecting the vehicle: A. _____ B. _____ C. _____ D. _____ E. _____	J, K	2

TABLE 10. POST-TEST ON CARBURETION AND IGNITION SYSTEM

Questions Used	Incorrect Answers by Individuals	Total Incorrect Answers
A 1970 Buick should be "failed" if it has no: A. EGR valve B. PCV valve C. A.I.R. pump	NONE	NONE
Vehicles can be "failed" with the HC-CO readings well below the state standard if: A. the engine is very noisy and leaks oil B. the glass packed mufflers are very loud C. the exhaust manifold is cracked	NONE	NONE
Operating temperature of an engine is considered to be normal when: A. the block thermostat opens B. the automatic choke opens C. the "cold" light goes out D. the air cleaner heat door opens	NONE	NONE
What two operating modes are checked when performing an emissions inspection? A. _____ B. _____	A, E, G, K, N	5

TABLE 11. POST-TEST ON COMPONENTS OF EMISSIONS SYSTEM

Questions Used	Incorrect Answers by Individuals	Total Incorrect Answers
The TVS (Thermostatic Vacuum Switch) when used on a General Motors engine is located in the: A. Exhaust manifold B. Engine cooling system C. Canister evaporation system	N	1
On a retest of an "emissions failed vehicle:" A. Inspect all emissions items B. Retest HC-CO C. Inspect only emissions items that were failed	F, H, L, O	4
What could you do while the vehicle is warming up to operating temperature in preparation for emissions inspection?	F, J	2

TABLE 12. POST-TEST ON TESTING INSTRUMENTS

Questions Used	Incorrect Answers by Individuals	Total Incorrect Answers
Read meters for HC and CO (see Appendix N, Question #7, pages 76 & 78)	A, B, E, H	4
Read meters for HC and CO (see Appendix N, Question #8, page 76 & 78)	NONE	NONE
Read meters for HC and CO (see Appendix N, Question #9, page 76 & 78)	A, D, E, F, G, H K, L, N	9
Read meters for HC and CO (see Appendix N, Question #10, page 76 & 78)	NONE	NONE
Read meters for HC and CO (see Appendix N, Question #11, page 76 & 78)	D	1
Read meters for HC and CO (see Appendix N, Question #12, page 76 & 78)	D, K	2
Read meters for HC and CO (see Appendix N, Question #13, page 76 & 78)	NONE	NONE
Read meters for HC and CO (see Appendix N, Question #14, page 76)	NONE	NONE
Read meters for HC and CO (see Appendix N, Question #15, page 76)	NONE	NONE
Read meters for HC and CO (see Appendix N, Question #16, page 76)	NONE	NONE

Table 13 reflects the material on questions pertaining to inspection procedures and simulated state handbook. All participants revealed a good understanding of this section of instruction. One question was answered correctly by all participants and only 1 incorrect response was given to each of the other questions.

Table 14 presents a summation of the twenty-three questions and the incorrect responses by each individual. The range was from none incorrect to a maximum of 4 questions answered incorrectly with an average for the group of 2.3 for 10 percent.

SUMMARY OF PRE-TEST AND POST-TEST RESULTS

A pre-test was administered to the fifteen (15) inspectors at the start of the instructional program and a post-test was administered at the conclusion. Each test centered on a brief sampling of content drawn from the general areas of:

1. General engine knowledge
2. Ignition and carburetion systems
3. Components in emissions system
4. Testing instruments
5. Inspection procedure and simulated state handbooks

The pre-test attempted to sample the overall knowledge of the individuals. This in turn, was used as a guide in modifying course content. The post-test attempted to sample the individual's comprehension of the major areas of testing instruments, inspection procedures and the simulated state handbook.

TABLE 13. POST-TEST ON INSPECTION PROCEDURES AND SIMULATED STATE HANDBOOK

Questions Used	Incorrect Answers by Individuals	Total Incorrect Answers
Give the requirements to become a state inspector.	I	1
What Senate Bill has caused the initiation of this project? A. 939 B. 393 C. 353 D. 383	NONE	NONE
What adjustments or repairs may be charged for while making the emissions inspection?	M	1
Using the materials at hand in your inspection station you are not able to find the answer to your problem. What would you do?	M	1

TABLE 14. SUMMARY OF POST-TEST RESULTS

All Questions Used (see Appendix N)	Incorrect Answers by Participants														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Question #1														X	
Question #2															
Question #3	X														
Question #4															
Question #5															
Question #6						X		X				X			X
Question #7	X	X			X			X							
Question #8															
Question #9	X			X	X	X	X	X			X	X		X	
Question #10															
Question #11				X											
Question #12				X							X				
Question #13															
Question #14															
Question #15															
Question #16															
Question #17									X						
Question #18															
Question #19	X				X		X				X			X	
Question #20										X	X				
Question #21						X				X					
Question #22													X		
Question #23													X		

As revealed in pre-test tables, several of the individuals relected a lack of knowledge in the basic, identified areas. This warranted a revamping of the time allotment to provide additional content.

On the post-test tables, the participants responded to questions from the selected areas with more accuracy than on the pre-test. As noted, the time allocation was directed toward a review of basic concepts and centered on testing instruments and inspection procedures.

Table 15 reveals a range of incorrect responses from the individuals on the pre-test of 1 to 13 (4 to 52 percent) with an average of 8.1 for the group (32.2 percent). On the post-test, the range of incorrect responses by the individuals ranged from zero to 4 (0 to 17 percent) with an average of 2.3 for the group (10 percent).

As noted previously, it was not possible with such a small sampling to make any correlation between age, experience, years of schooling and results on the pre-test and post-test. A few observations can be noted however. The overall decrease in the average number of incorrect responses and percentages by the group between the pre-test and post-test on the major sections identified (from 8.1 to 2.3 questions and 32.2 to 10 percent) reveals good progress by the individuals during the six (6) hours of instructions.

From reviewing the results of the pre-test and post-test and from general input from the participants, the following recommendations are presented:

1. Instructional time be extended from six (6) hours to nine (9) hours for the inspectors and investigators. It is recommended that the additional three hours be used for better understanding of the test equipment and procedures used in the laboratory.

2. A state handbook be developed that would cover the laws and give the guidelines for the automotive emissions control program for Colorado.

3. A state certification program be established whereby an inspector or investigator could take appropriate tests to validate his competency in the area of auto emissions control and be awarded a certificate signifying this competency.

4. Appropriate training sites be established at strategic locations. These training sites would operate to train the existing inspectors and investigators and provide periodic classes to upgrade various personnel involved with the implementation of the emissions control program.

5. A larger sampling of inspectors (approximately 300) from safety inspection stations in the DAQCR be randomly selected and taught the proposed nine (9) hour instructional program. All pertinent data would be tabulated on these individuals to test and validate the proposed program content.

6. All state investigators (approximately 30-35) be encouraged to attend the recommended program of nine (9) hours of instruction. Data would be compiled to test and validate the proposed program content for these investigators.

TABLE 15. RESULTS FROM PRE-TEST AND POST-TEST CONCERNING PERSONAL DATA AND NUMBER OF INCORRECT RESPONSES TO QUESTIONS

Participants	Age	Years of Exp. in Tune-up & Carburetion	Highest Grade of Schooling	Number of Incorrect Responses on Pre-Test 25 Questions	Number of Incorrect Responses on Post-Test 23 Questions
Individual A	46	18	14	10	4
Individual B	31	15	9	4	1
Individual C	32	14	12	3	0
Individual D	32	12	8	1	3
Individual E	27	10	14	11	3
Individual F	27	10	12	8	3
Individual G	28	8	12	13	2
Individual H	31	6	12	7	3
Individual I	37	5.5	12	5	1
Individual J	25	5	12	6	2
Individual K	30	4	12	12	2
Individual L	28	2	12	9	2
Individual M	26	1	13	8	2
Individual N	21	.5	14	11	3
Individual O	27	.25	12	13	1

APPENDIX A

PROJECT INVESTIGATORS AND TEAM MEMBERS

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APPENDIX B

OUTLINE FOLLOWED UNDER CONTRACT #C-290-760

I. An investigation was conducted concerning:

1. The training requirements of the state investigators and inspectors on the orientation and basic maintenance of the motor vehicle emissions control systems.

2. The "State of the Art" in Colorado on service stations, inspectors and repairmen.

3. Summary and conclusions of data compiled and analyzed by Automotive Testing Laboratories, Inc. on field tests of selected automobiles on emissions control.

4. Instructional materials available from other sources on motor vehicle emissions control.

II. Instructional materials were developed for a six (6) hour pilot training program for state investigators and inspectors.

III. Fifteen (15) inspectors were selected from the Denver metropolitan area to attend the six (6) hour pilot training program at Automotive Testing Laboratories, Inc. on December 11-13, 1973.

IV. Six (6) state investigators attended a six (6) hour pilot training program at Automotive Testing Laboratories, Inc. on January 10, 1974.

APPENDIX C

TIME SCHEDULE

(Contract Period 11/1/73 - 3/1/74)

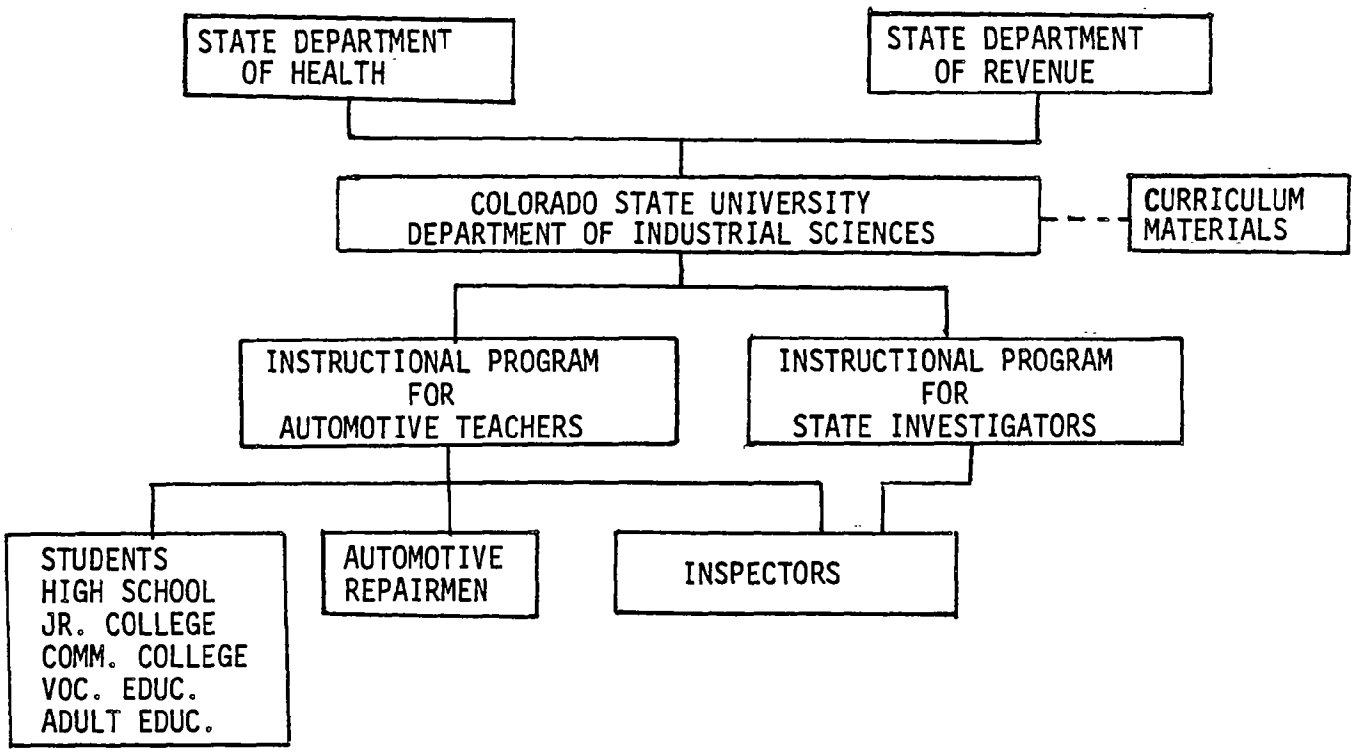
December 1, 1973:	Contract #C-290-760 Interim report on progress of project.
December 11-13, 1973:	Six (6) hour pilot training program for fifteen (15) inspectors.
January 10, 1974:	Six (6) hour pilot training program for six (6) state investigators.
February 1, 1974:	Preliminary report on the pilot training programs for the inspectors and state investigators.
March 1, 1974:	Final report on the six (6) state investigators and fifteen (15) inspectors pilot training programs with recommendations for effectiveness and cost estimates.
August 31, 1974:	Final report to Region VIII Environmental Protection Agency on pilot training program for autotive repairmen.

APPENDIX D

PROPOSAL FOR EDUCATIONAL TRAINING PROGRAM
ON MOTOR VEHICLE EMISSIONS CONTROL

In order to implement an effective and efficient program on Motor Vehicle Emissions Control, it is necessary to develop an instructional delivery system consisting of the appropriate components including adequate instructional materials and personnel. In line with such a requirement, the Department of Industrial Sciences at Colorado State University, with support and guidance from the Colorado State Departments of Health and Revenue, Colorado State Board of Community Colleges and Occupational Education, Vocational-Technical Training Institutions in Colorado, Department of Vocational Education at Colorado State University and many other support facilities, including the Media Center at Colorado State University, proposed the following system:

DELIVERY SYSTEM FOR
INSTRUCTIONAL PROGRAM ON MOTOR VEHICLE
EMISSION CONTROL FOR COLORADO



Identifying the qualified automotive teachers in the Vocational and Technical Training Institutions as being in a key position for implementing the total delivery system concerning motor vehicle emissions control instruction in Colorado, the initial steps in the program would be to provide these teachers with the appropriate educational and training background on motor vehicle emissions control, plus adequate materials and equipment, so they can provide instruction for inspectors, repairmen, and vocational and technical students throughout the state.

Since the educational program can be developed in stages to meet the demands of the total state program of motor vehicle emissions control, and since the Denver Air Quality Control Region has been identified as the first step, the following proposals are presented for consideration.

PROPOSAL A

Part I.

A. Develop instructional materials for teaching qualified automotive teachers (those certified by the SBCCOE) how to instruct and conduct programs on motor vehicle emissions control for inspectors and repairmen.

B. Select twenty-five (25) automotive teachers from the DAQCR to attend forty (40) hour instructional program at Colorado State University in the summer of 1974.

Part II.

A. Supply necessary supplementary equipment to adequately equip ten (10) vocational and technical institutions with the testing equipment needed for the motor vehicle emissions control instruction for inspectors and repairmen (it should be noted that the ten (10) sites would have to be approved by all agencies involved).

B. Supply necessary supplementary instructional software material for the ten (10) selected sites.

BUDGET

Part I.

Instructional Cost:		$ 2950.00
Lead teacher - one man month including preparation of materials, teaching and evaluation for twenty-five (25) teachers.	$ 1750.00	
Assistant teacher - Same as above	1200.00	

Office Supplies, Brochures, Telephones, Mailing, etc.		$ 350.00
Instructional Materials, Collecting, Compiling, Duplicating, Transparancies, Tapes, Slides, etc.		500.00
Travel for Field Work		200.00
Secretarial and Clerical Assistance		300.00
Twenty-five (25) Teachers (participants)		6543.75
Tuition (two credits) ($75) x 25 =	1875.00	
Reference manual ($30) x 25 =	750.00	
State Handbook ($4) x 25 =	100.00	
Text book ($3.75) x 25 =	93.75	
Travel (200 @12¢) (24) x 25 =	600.00	
Per Diem (5 Days @$25) ($125) x 25 =	3125.00	
Equipment to Supplement Existing Laboratory Equipment on Campus at Colorado State University		5125.00
Lease:		
Four (4) HC-CO Analyzers for two (2) weeks @$75.	525.00	
Purchase:		
One (1) HC-CO Analyzer	2200.00	
Four (4) Timing lights @$60.50ea.	242.00	
Four (4) OHM Meters @$86.00ea.	344.00	
Four (4) Tachometer-Dwell Meters @$124.00ea.	496.00	
Four (4) Vacuum gauges @$61.00ea.	244.00	
Four (4) Compression testers @$15.00ea.	60.00	
Four (4) Crank case vent gauges @$3.50ea.	14.00	
One (1) Oscilloscope @$1000	1000.00	

Part II.

Supplementary Equipment for Ten (10) Selected Training Sites (only purchased if needed)		42,787.50
For Each Site: ($4,278.75)		
Three (3) manuals (Mitchell or equivalent)($30 ea.)	90.00	
Five (5) State Handbooks ($4 ea.)	20.00	
Five (5) Textbooks ($3.75 ea.)	18.75	
One (1) complete instructional packet of developed training materials on motor vehicle emissions control ($250.00 ea.)	250.00	

One (1) HC-CO Analyzer ($2200 ea.)	$ 2200.00
Two (2) Timing lights ($60.50 ea.)	121.00
Two (2) OHM meters ($86 ea.)	172.00
Two (2) Tachometers-Dwell Meters ($124 ea.)	248.00
Two (2) Vacuum gauges ($61 ea.)	122.00
Two (2) Compression gauges ($15 ea.)	30.00
Two (2) Crank case vent gauges ($3.50 ea.)	7.00
One (1) Oscilloscope ($1000 ea.)	1000.00

	$58,756.25
PERA (wages & salaries $3250 x 10.5%)	341.25
8% Indirect Cost	4,727.80
TOTAL	$63,825.30

Teachers in each of these ten (10) selected sites, plus the potential of others from the remaining fifteen (15) teachers, would be able to conduct instructional programs for inspectors from the fleet stations in FY 1974-75. They would also be able to conduct similar sessions for other inspectors and repairmen as programs are needed.

PROPOSAL B

There are approximately fifty-seven to sixty (57-60) certified automotive teachers in the DAQCR, located in thirty-three (33) approved educational and training institutions. If Proposal A was expanded to include all sixty (60) teachers, the following procedure could be followed:

> Divide the remaining thirty-five (35) automotive teachers into two (2) groups of seventeen-eighteen (17-18) and conduct forty (40) hour instructional programs on the campus of Colorado State University during the summer of 1974.

The following budget is projected for these two groups:

> Since the instructional materials would have been developed with the original twenty-five (25) teachers, only brief preparation, teaching and final evaluations and revisions will be necessary for the additional thirty-five (35) teachers.

Instructional Cost:		$2950.00
Lead teacher - one man month for both forty (40) hour programs	$ 1750.00	
Assistant teacher - same as above	1200.00	
Office Supplies, telephone mailing, etc.		400.00
Instructional materials, duplicating, transparancies, tapes, slides, etc.		200.00
Secretarial and clerical assistance		350.00
Thirty-five (35) teachers (participants)		9161.25
Tuition (two credits)($75 x 35) =	2625.00	
Reference Manual ($30 x 35) =	1050.00	
State Handbook ($4 x 35) =	140.00	
Textbook ($3.75 x 35) =	131.25	
Travel (200 @ 12¢)($24 x 35) =	840.00	
Per Diem (5 days @ $25)($125 x 35)	4375.00	
SUBTOTAL		$13,061.25
PERA (Wages & Salaries) $3300 x 10.5%)		346.50
8% Indirect Cost		1,072.62
		$14,480.37

It should be noted that no allowance has been considered concerning cost for use of facilities in the vocational and technical institutions willing to participate in conducting programs for inspectors and repairmen. Also, no salary for the teachers who will be conducting the training sessions for inspectors and repairmen has been considered in these budgets.

PROPOSAL C

Since the key to an effective and efficient system on motor vehicle emissions control will be the development of certification and the initial implementation of the early phases of the program during FY 1974-75, the following proposal is submitted to help develop certification requirements and implementation under the direction of the State Department of Health and other appropriate State agencies.

One full-time position from July 1, 1974 to July 1, 1975 to:

1. Develop and field test appropriate materials.
2. Consult with teachers, inspectors, investigators and repairmen in the field.
3. Conduct seminars for selected groups on "What is happening on motor vehicle emissions control."
4. Collect and analyze appropriate data from the training sessions being conducted at the selected training sites.
5. Field test programs being developed on certification.
6. Finalize all results and recommend certification procedures to the appropriate State agencies.

BUDGET

Instructional Cost:		$21,600.00
12 person months	$18,000.00	
6 person months	3,600.00	
Office Supplies, telephone, duplicating, etc.		1,500.00
Travel (12,000 @ 12¢)		1,440.00
	Sub-total	$24,540.00
	PERA (Wages & Salaries) 2268 x 10.5%	2,268.00
	8% Indirect Cost	2,144.64
		$28,952.64

SUMMARY OF PROPOSALS

Proposal A:

Part I: To develop training and educational materials and teach a forty (40) hour program for twenty-five (25) automotive teachers from the DAQCR on the Colorado State University campus in the summer of 1974 on motor vehicle emissions control.	Sub-total	$15,968.75
Part II: Furnish motor vehicle emissions control equipment in ten (10) approved sites in the DAQCR (Cost of approximately $4,278.75 for each site).	Sub-total	42,787.50
	PERA (Wages & Salaries)	341.25
	8% Indirect Cost	4,727.80
	TOTAL	$63,825.30

Proposal B:

To provide education and training for two (2) groups (approximately thirty-five)(35) of automotive teachers in the DAQCR on the Colorado State University campus during the summer of 1974.	TOTAL	$14,480.37

Proposal C:

To provide for full-time position to: develop certification requirements; work with teachers, inspectors, investigators and repairmen in the field; and make final recommendations for implementation of certification and educational program.	TOTAL	$28,952.64

APPENDIX E

FACTORS TO BE CONSIDERED IN ESTABLISHING STATEWIDE MOTOR VEHICLE EMISSIONS CONTROL PROGRAM

1. Should the safety inspection and the emissions inspection be carried on at the same facility and time or should they be two separate entities?

2. Who should bear the cost of up-grading the inspection station with the required equipment, training and certification of the motor vehicle emissions control repairman?

3. Consideration of cost to the state and the individual garage and automobile owner.

4. Should the inspection rate be increased a proportional amount to the investment in equipment between safety and emission inspection or should a time factor for inspection be considered as the determining factor?

5. Length of time required for the garage owner to retrieve his initial investment for equipment via the inspection charge.

6. Should mechanics be certified only after completion of an approved training program or should there only be a test for certification with no class requirement?

7. Consideration of the public and the mechanic in the trade of the acceptance of this type of a program.

8. Criteria used to select teachers where approved vocational instructors are not available to present the program.

9. What criteria should be used to determine the location of the area training centers, times and dates of classes?

10. Should programs and specifications vary in different areas of the state, depending on population, elevation, etc?

11. Consideration of a form of communication to keep the repairmen up-to-date on new and modified pollution control devices.

12. Consideration of a spot check system to evaluate the effectiveness of the inspection system on vehicles and on the individual repairmen's performance.

13. Development of a State Handbook which could be used as a guide for the inspectors, state investigators, and the motor vehicle emissions repairmen in performing the duties as related to the pollution control program. This handbook could also include the information needed for a guide in licensing an inspection station.

APPENDIX F

STATE OF THE ART

Investigation and experience were used in generating this review of facilities, equipment and repairmen in on-going businesses of inspection, service and maintenance in the State of Colorado.

FACILITIES

The automotive inspection and maintenance facilities in Colorado vary from one-man operations to those of forty (40) or more employees. These facilities also vary in the types of services offered, from general repair type service to extremely specialized services on a specific make of automobile. The equipment in these on-going businesses will vary greatly, depending on the type of repair the facility is oriented to perform. With this diversification, the nature and the quality of the equipment found in the facilities will vary considerably throughout the state.

The pricing structure for services rendered is also a reflection of the variation among facilities. Statewide, an operation such as adjusting the timing on the automobile varies from $1.50 to $6.00. This difference in pricing for a seemingly comparable operation is a result of each facility adjusting to its particular clientel.

In most cases, owners and operators of automotive inspection service and maintenance facilities do not find it profitable to perform the required "Automobile Safety Inspection" as outlined by the State; however, most of the owners and operators believe this is a function of their operation and they have participated. The present charge which they are allowed to assess for the "Safety Inspection" does not provide the necessary time, and in turn the money, to cover the individual performing the inspection nor the equipment used during the inspection. Several of the owners and operators have indicated that if the "Motor Vehicle Emissions Inspection" is to become a part of the semi-annual "Safety Inspection," then sufficient amount of training, time and money will have to be provided for the individual and the facility involved in the inspection and/or maintenance.

EQUIPMENT

The equipment presently used for the semi-annual "Automobile Safety Inspection" is quite minimal and in most cases is sufficient. The equipment needed for the "Motor Vehicle Emissions Control" is of a different nature and will require a greater outlay of money for the owner and operator of the facility. A projection of $2500 to $3000 outlay for each facility is in line with the present cost of the basic equipment needed to perform a good "Emissions" inspection. This would include the necessary equipment to help diagnose the problem source concerning excessive "Emissions."

INSPECTORS AND REPAIRMEN

Unfortunately these two terms have broad implications throughout the state and are used quite loosely in many circles. They apply equally to well-trained and experienced personnel as well as to personnel with little or no background in the automotive service industry.

It is in this area that the most time, effort and money must be provided in the education and training for personnel to perform the necessary inspection and maintenance on "Motor Vehicle Emissions Control." The education and training necessary in this area will build on previous knowledge and skill in such sections as tune-up, carburation, etc. However, personnel will have to be developed to have a thorough understanding of the various systems and component parts pertaining to the total operation. These personnel should be distinctly identified as having appropriate credentials and be well-qualified to perform the necessary services as needed by the customer.

As a system is developed to provide the necessary education and training for up-grading present personnel in the field, as well as a certification and recertification program, it will be necessary to adjust the "charge" for the services rendered whereby the individual owner and operator can provide the needed service and still expect sufficient return on the time and investment involved.

APPENDIX G

FOUR STRATEGIES INVESTIGATED BY AUTOMOTIVE TESTING LABORATORIES, INC. WITH CONCLUSIONS AND RECOMMENDATIONS

I. Idle emissions inspection and maintenance.

II. Exhaust control retrofit.

III. Modified engine tuning adjustments.

IV. Mandatory engine maintenance.

CONCLUSIONS AND RECOMMENDATIONS FROM AUTOMOTIVE TESTING LABORATORIES, INC. ON IDLE TEST DATA (RESULTS OF COMPLETE STUDY IN OFFICE OF MOTOR VEHICLE DIVISION, COLORADO STATE DEPARTMENT OF HEALTH)

CONCLUSIONS

1. Each of the strategies investigated was found to be effective in reducing HC and CO emissions:

   1.1 The range of reduction for HC is from a low of about 1% for the high altitude kits to a high of about 75% for catalytic retrofit.

   1.2 The range of CO reduction is from a low of about 3% for idle emissions inspection at 20% rejection to a high of about 85% for catalytic retrofit.

   1.3 The range of NOx reduction is from a low of about -30% for the high altitude kits to a high of about 45% for VSAD/Air Bleed retrofit.

2. The range of cost effectiveness (CE) is wide:

   2.1 CE for HC ranges from a low of 5 milligrams/mile/dollar (mmd) for the high altitude kits and LPG conversion to a high of about 100 mmd for idle emissions inspection at 30 to 60% rejection and certain combinations of modified engine tuning adjustments.

   2.2 CE for CO ranges from a low of about 75 mmd for LPG conversion to a high of about 4000 mmd for certain combinations of modified engine tuning adjustments.

   2.3 CE for NOx ranges from a low of -75 mmd for the high altitude kits to a high of about 50 mmd for VSAD/Air Bleed retrofits.

3. With respect to idle emissions inspection and maintenance:

   3.1 The effectiveness curve for HC rose sharply from 0 to 30% rejection and continued to rise at a reduced rate to 60% rejection. HC reduction at 30% rejection is about 10%. At 60% rejection HC reduction is about 13%. CE for HC rose sharply from 0 to 30% rejection. The CE curve is relatively flat from 30 to 60% rejection at a level of about 100 mmd.

3.2 The effectiveness curve for CO rose sharply from 0% rejection and continued to rise at a reduced rate through 60% rejection. CO reduction at 30% rejection is about 5%. At 60% rejection CO reduction is about 9%. CE for CO rose sharply from 0% rejection and continued to rise at a reduced rate through 60% rejection. CE at 30% rejection is about 750 mmd. At 60% rejection CE is about 1000 mmd.

3.3 The effectiveness curve for NOx rises gradually from 0 to 60% rejection. At 60% rejection NOx reduction is about 2%. The CE curve rises sharply from 0 to 20% rejection and continues to rise at a reduced rate through 60% rejection. CE at 30% rejection is about 3 mmd. At 60% rejection CE is about 5 mmd.

3.4 The garages (licensed safety inspection stations) selected to perform idle emissions inspection represent a cross-section of the automobile repair industry.

3.5 Training provided to station personnel was adequate with respect to task objectives. However, more extensive training is required with respect to an overall emissions control program.

3.6 The idle emissions inspection, adjustment and repair procedures provided to garages was adequate. Application of these procedures resulted in substantial emissions reductions and reasonable cost effectiveness ratios. However, several problems were experienced with station personnel with respect to data transmittal and attention to inspection pass/fail limits.

3.7 Actual inspection failure rates were higher than design failure rates. The difference is attributed primarily to the performance of one station which failed all vehicles tested. One other station appears to be borderline in this respect.

3.8 Inspection charges range from an average low of $1.50 per inspection at one station to an average high of $6.00 per inspection at another station. The overall average inspection charge is $4.05 which is consistent with laboratory estimated inspection costs.

3.9 The average station cost per failed vehicle ranges from a low of $2.53 to a high of $14.25. The overall average cost per failed vehicle is $10.57.

3.10 The average station repair cost per vehicle for all vehicles ranges from a low of $0.76 to $12.26. The overall average cost per vehicle for all vehicles is $6.14.

3.11 The average combined station cost (inspection and repair) per failed vehicle ranges from a low of $4.76 to a high of $14.76 with an average cost per vehicle of $10.18.

3.12 Average overcharge per failed vehicle is estimated to range from 8 to 22% as determined from direct charges. Average overcharge per failed vehicle is estimated to be as high as 38% if direct repair charges and estimated repair charges to repair problem vehicles are combined. In terms of costs average overcharge per station is from $0.85 to $2.31 per failed vehicle or as high as $4.66 per failed vehicle.

3.13 Correlation coefficients developed between laboratory instrumentation and garage instrumentation are wide in range. Average station correlation coefficients range from a low of 0.43 to a high of 0.83 for HC emissions at curb idle. At 2500 engine rpm the correlation coefficients range from 0.26 to 0.84. For CO at curb idle the range of correlation coefficients is from 0.48 to 0.89. At 2500 engine rpm the range is from 0.26 to 0.89. In this respect the performance of two of the stations (20% of the sample) is unacceptable.

4. With respect to exhaust control retrofit:

4.1 For HC and CO reduction the catalytic system was the most effective with reductions of 75% and 85% respectively. The catalytic system was followed by LPG conversion with 40% and 55% reduction for HC and CO respectively. Catalytic system CE was about 25 mmd for HC and 450 mmd for CO. The CE ratio for LPG conversion was about 5 mmd for HC and 75 mmd for CO.

4.2 Of the remaining retrofits, EGR/Air Bleed combined, Air Bleed alone and Float Bowl Pressure Regulation (FBPR) systems are the most effective HC and CO reducing retrofits with a range from about 17% to 20% HC reduction and 20% to nearly 50% CO reduction.

4.3 For NOx reduction the VSAD/Air Bleed, VSAD/EGR, EGR/Air Bleed and EGR retrofit are the more effective systems with a range from about 25% to 45% NOx reduction.

4.4 The change in fuel economy for the various retrofits ranges from an improvement of about 21% for LPG conversion to a deterioration of about 8% for EGR only and VSAD/Air Bleed systems. Of the less costly and elaborate systems fuel economy improved about 2.5% for EGR/Air Bleed and FBPR systems.

4.5 CE for HC ranges from a low of about 5 mmd for EGR and high altitude kit retrofit to a high of about 50 to 60 mmd for EGR/Air Bleed and VSAD/Air Bleed respectively.

4.6 CE for CO ranges from a low of about 75 mmd for LPG conversion to a high of about 1150 mmd for Air Bleed and FBPR systems.

4.7 CE for NOx ranges from a low of -75 mmd for the high altitude kits to a high of about 50 mmd for VSAD/Air Bleed retrofit.

4.8 Retrofit kits are relatively easy to install except LPG systems and catalytic systems where air pumps are not currently installed. Intrinsic problems are associated with high altitude kit installation performed under typical garage-type conditions.

4.9 The application of retrofit is broad with respect to the add-on systems and the high altitude modification kits. Nearly 100% of the light-duty vehicle population can be retrofitted with one or more systems. High altitude kits supplied by Chrysler Corporation are limited to certain of the carburetor models. Other models are recommended for retrofit as a complete carburetor replacement only.

4.10 Labor and parts costs as applied to the high altitude kits is reasonable with a range from about $3.90 to $13.64 per vehicle. With respect to the add-on systems the range is from about $20 for Air Bleed systems to about $650 for LPG systems installed. Labor and parts costs for high altitude kit installations are expected to be higher if installed under more exacting conditions.

5. With respect to modified tuning specifications:

5.1 The greatest HC reductions are obtained from modified adjustment combinations of A/F ratio-idle rpm and A/F ratio-choke, both of which are on the order of 15%. Individually, the greatest HC reduction is obtained from the experimental A/F ratio setting where HC reduction is about 10%.

5.2 The greatest CO reductions are derived from modified adjustment combinations of A/F ratio-ignition timing, A/F ratio-idle rpm and A/F ratio-choke which are on the order of 25 to 30%. Individually, the greatest CO reduction is obtained from the experimental A/F ratio setting, where reduction is about 25%.

5.3 Each of the adjustments individually and in combination result in NOx increases on the order of 20 to 35%.

5.4 Modified tuning adjustments are relatively easy to perform. However, idle rpm adjustments to the experimental value pose problems relating to safety.

5.5 Adjustments can be applied to virtually all light-duty vehicles.

5.6 Adjustment cost for any two of the parameters investigated is estimated to be about $5.00 per vehicle.

5.7 Low costs and high effectiveness combine to make certain combinations of modified tuning specifications by far the most CO cost effective of the strategies investigated. The most HC cost effective strategy is shared equally by certain of the combined modified tuning specifications and idle inspection and maintenance at the higher rejection rates.

6. With respect to mandatory engine maintenance:

6.1 Mandatory engine maintenance is effective in reducing HC, CO and NOx emissions. HC reduction is in the order of 20%, CO reduction is about 10% and NOx reduction is about 8%. An overall fuel economy improvement of about 1% was obtained.

6.2 Cost effectiveness ranking is low primarily because of associated high costs for maintenance. CE for HC was about 30 mmd as opposed to CE for HC of about 100 mmd for idle inspection at 30% and higher rejection rates and modified tuning specifications. CE for CO was about 200 mmd as opposed to a CE for CO of about 4000 mmd for modified tuning specifications.

6.3 Costs are estimated to average from a low of about $33.00 per vehicle to a high of about $60.00 per vehicle.

6.4 Problems relating to parts installation and engine adjustments are not expected to be unusual.

6.5 Application to light duty vehicles is 100%.

RECOMMENDATIONS

1. Since idle emissions inspection and maintenance were found to be an effective and cost effective strategy to reduce exhaust hydrocarbon and carbon monoxide emissions without an accompanying increase in oxides of nitrogen emissions, it is recommended that idle emissions inspection of light-duty vehicles be implemented in the State of Colorado.

    1.1 Because of the various problems which developed through utilization of licensed safety inspection stations to perform idle emissions inspections, it is not recommended that idle emissions inspection be performed in the existing network of licensed safety inspection stations.

    1.2 A state owned, state operated inspection network or a privately operated, state enfranchised inspection network exist as alternatives to idle emissions inspection in the existing safety inspection network. It is recommended that these alternatives be considered.

2. Since certain of the California approved exhaust control retrofit devices were found to be both effective and cost effective in reducing exhaust hydrocarbon, carbon monoxide and oxides of nitrogen emissions, it is recommended that a program of mandatory retrofit device installation be implemented.

    2.1 For economic and other reasons it is recommended that light-duty vehicles be defined as comprising three categories of vehicles; fleet vehicles (10 or more vehicles under common ownership) pre-controlled vehicles (1967 and older model-year vehicles) and controlled vehicles (1968 through 1972 model-year vehicles.)

        2.11 It is recommended that emissions standards of retrofit performance be established for application to fleet vehicles. It is further recommended that emissions standards established for fleet vehicles be related to emissions reductions shown to be feasible by catalytic converter and LP gas conversion tests.

        2.12 It is recommended that standards of retrofit performance be established for application to pre-controlled vehicles. It is further recommended that emissions standards established for pre-controlled vehicles be related to emissions reductions shown to be feasible by EGR/Air Bleed retrofit system tests.

2.13 It is recommended that standards of retrofit performance be established for application to controlled vehicles. It is further recommended that emissions standards established for controlled vehicles be related to emissions reductions shown to be feasible by EGR/Air Bleed retrofit system tests.

3. Because of intrinsic vehicle operational problems resulting from installation of the altitude kits under typical garage-type conditions, mandatory application of the strategy is not recommended.

3.1 Since the high altitude kits were shown to have good potential for reducing carbon monoxide emissions and fuel economy benefits and further, since it is assumed that high altitude kits can be successfully installed under certain controlled conditions, it is recommended that voluntary installation of the kits under the controlled conditions be encouraged. Prior to an implementation program of voluntary installation, however, the impact on the atmosphere of higher oxides of nitrogen emissions resulting from kit installation should be assessed.

4. Certain modified engine adjustments have been shown to be both effective and cost effective in reducing exhaust hydrocarbon and carbon monoxide emissions although the modified adjustments caused an increase in emissions of nitrogen oxides. It is therefore recommended that a program of mandatory adjustment to certain of the experimental values be implemented if it can be demonstrated that adverse affects such as increased photochemical reaction, reduced visibility and adverse health affects will not result from the higher levels of nitrogen oxides discharged to the atmosphere.

5. Although engine maintenance was shown to be an effective exhaust hydrocarbon, carbon monoxide and nitrogen oxides reducing strategy, a program of mandatory engine maintenance is not recommended because of its relatively poor cost effectiveness. It is recommended, however, that voluntary engine maintenance be encouraged.

APPENDIX H

INSTRUCTIONAL OUTLINE FOR MOTOR VEHICLE EMISSIONS CONTROL INSPECTORS

NINE (9) HOURS OF INSTRUCTION

(Revised from six (6) hours)

I. Introduction

- A. Aims of statewide program
- B. Role of inspector as applied to automotive emissions control
- C. Evaluation test for proficiency

II. The General Problem of Air Pollution

- A. Types of pollutants
- B. Sources of pollutants
  1. Stationary
  2. Mobile
- C. Impact of air pollution
  1. Persons
  2. Property
  3. Plant and animal life
  4. Photochemical effects

III. Automobile Emissions

- A. Regulations, laws and ordinances
  1. Federal standards and specifications
  2. State standards and specifications
  3. Air quality regions
  4. Official handbook
- B. Inspection
  1. Safety procedures
  2. Visual areas of inspection
     a. Crank case emissions systems
     b. Evaporative emissions systems
     c. Engine modifications
     d. Air injection

e. Exhaust gas recirculation
f. Visable contaminants

3. Analytical inspection
   a. Infrared analyzer
   b. Meter reading
   c. Various types of instruments
   d. Calibration and care of test equipment

C. Data recording and procedure
   1. Pass vehicle procedure
   2. Fail vehicle procedure

IV. Laboratory Session

A. Live inspections
   1. Demonstrate safety procedures
   2. Visual inspection of all emissions related hardware
   3. Visual contaminant inspection
   4. Analyzer and meter reading
   5. Data recording
   6. Passing or failing vehicle procedure

V. Role of Inspection in Public Relations

A. Inspector's role as official arm of state program

B. Ways and means available to inspector to assist public with possible corrective action, preventative maintenance, additional knowledge

C. Owner procedures providing for cases of unjust inspections and consumer protection

VI. Review and Testing

A. Review, use, care, and calibration of equipment

B. Review use of handbook

C. Review inspector's image as an important factor affecting public opinion of the inspection program

D. Evaluation

APPENDIX I

INSTRUCTIONAL OUTLINE FOR MOTOR VEHICLE EMISSIONS CONTROL STATE INVESTIGATORS

NINE (9) HOURS OF INSTRUCTION

(Revised from six (6) hours)

I. Introduction

A. Aims of program statewide

B. Role of investigator as applied to automotive emissions controls

C. Evaluation test for proficiency

II. General Problem of Air Pollution

A. Types of pollutants

B. Sources of pollutants
1. Stationary
2. Mobile

C. Impact of air pollution
1. Persons
2. Property
3. Plant and animal life
4. Photochemical effect

III. Automobile Emissions

A. Regulations, laws, and ordinances
1. Federal standards and specifications
2. State standards and specifications
3. Air quality control regions
4. Official handbook

B. Programs present and future
1. Vehicle maintenance
2. Vehicle inspection
3. Public indoctrination

IV. Current Control Methods for Emissions

A. Crank case emissions
   1. Road draft tubes
   2. Open PCV
   3. Closed PCV

B. Engine modifications
   1. Lean carburation
   2. Heated air intake system
   3. Vacuum advance delay ignition systems
   4. Internal engine changes
   5. Air injection systems

C. Evaporative losses
   1. Vapor storage systems
   2. Tank overfill protection

V. Emissions Testing Equipment and Techniques

A. Tach-dwell meter

B. Timing light

C. Vacuum gauge

D. HC-CO analyzer

E. PCV valve tester

VI. Safety Precautions

A. Exhaust disposal

B. Personal safety

C. Calibrating gases

VII. Inspection Procedures

A. Use of handbook

B. Pass-fail techniques

C. State forms

D. Owner recourse procedures

VIII. Laboratory Session

A. Calibration and use of equipment

B. Live inspections using handbook
   1. Demonstrate safety
   2. Visual inspection
   3. HC-CO analyzer inspection on vehicle
   4. Complete necessary forms (either pass or fail)
   5. Simulate disputed HC-CO readings
   6. Inspect premises for possible station license
   7. Inspect premises for appropriate equipment

IX. Review and Testing

A. Safety precautions

B. Duties of investigator

C. Calibration checks

D. Questions and answers

E. Evaluation

APPENDIX J

INSTRUCTIONAL OUTLINE FOR MOTOR VEHICLE
EMISSIONS CONTROL REPAIRMEN

FIFTEEN (15) HOURS OF INSTRUCTION

I. Introduction

A. Aims of statewide program

B. Role of repairmen as applied to automotive emissions control

C. Evaluation test for proficiency

II. General Problem of Air Pollution

A. Types of pollutants

B. Sources of pollutants
1. Stationary
2. Mobile

C. Impact of air pollution
1. Persons
2. Property
3. Plant and animal life
4. Photochemical effects

III. Automotive Emissions

A. Regulations, laws and ordinances
1. Federal standards and specifications
2. State standards and specifications
3. Air quality control regions
4. Official handbook

B. Inspections
1. Safety procedures
2. Visual areas of inspections
a. Crank case emissions systems
b. Evaporative emissions systems
c. Engine modifications
d. Air injection
e. Exhaust gas recirculation
f. Visable contaminants

3. Analytical inspection
    a. Infrared analyzer
    b. Meter readings
    c. Various types of instrumentation
    d. Calibration and care of testing instruments

C. Data recording and procedure
    1. Pass Vehicle Procedure
    2. Fail Vehicle Procedure

IV. Emissions Reduction and Control Methods

A. Pre-combustion controls
    1. Evaporative
        a. Tank over-fill protection
        b. Fuel vapor trapping methods
            1. Charcoal canister
            2. Vapor separator
            3. Crank case storage
    2. Intake air temperature control
    3. Intake manifold temperature controls
        a. Exhaust heat riser valve
        b. Coolant temperature controls
        c. Exhaust cross-over temperature

B. Direct combustion controls
    1. Internal engine modifications and fuel distribution
        a. Compression ratio
        b. Combustion
        c. Improved intake manifold flow
        d. Valve timing overlap
        e. Redesigned pistons
    2. Carburation modification
    3. Ignition controls
    4. Exhaust gas recirculation system

C. Post-combustion controls
    1. Crank case ventilation controls
    2. Air injection system
    3. Converters and catalytic exhaust conditioning devices

D. Engine protection controls
    1. Overheating controls
    2. Overspeeding controls

V. Service of Emissions Controls (in laboratory)

A. Safety precautions to be observed (in laboratory)
    1. Fuels and fumes
    2. Equipment
    3. Running engine

B. Pre-combustion controls

1. Evaporative controls
   a. Diagnosis & service of fuel vapor trapping system
   b. Diagnosis and service of crank case storage system
2. Intake air temperature controls
3. Intake manifold temperature controls
   a. Diagnosis of temperature controlled intake manifold malfunctioning
   b. Diagnosis and service of heat riser valve
   c. Diagnosis and service of coolant temperature control
      1. Thermostat
      2. Temperature controlled fans

C. Servicing combustion controls
   1. Diagnosis of carburetor circuits
      a. Starting
      b. Low speed
      c. Cruising
      d. Wide open
      e. Deceleration
   2. Diagnosis and service of ignition controls
      a. Service during starting
      b. Service during idle cold and hot
      c. Service during acceleration
      d. Service during deceleration
      e. Service during cruising
   3. Service and diagnosis of EGR system

D. Service of post combustion controls
   1. Diagnosis and service of crank case ventilating system
   2. Diagnosis and service of air injection system
   3. Diagnosis and service of converters and catalytic exhaust conditioners

E. Engine protection controls servicing
   1. Diagnosis and service of overheat control device
   2. Diagnosis and service of engine overspeed control device

F. Demonstration on testing equipment

G. Utilization of testing equipment

VI. Review and Testing

A. Review safety procedures

B. Review question and answer period

C. Practice use of reference book

D. Evaluation

APPENDIX K

SECONDARY AND POST-SECONDARY SCHOOLS IN THE STATE OF COLORADO WITH POTENTIAL FACILITIES FOR CONDUCTING AUTOMOTIVE EMISSIONS CONTROL PROGRAM

Secondary Schools

Name of School	No. of Auto Teachers	Name of School	No. of Auto Teachers
Mapleton High 601 E. 64th Avenue Denver, CO 80229	1	East High 1525 Detroit Denver, CO 80206	1
Ranum High 2401 W. 80th Avenue Westminster, CO 80030	2	North High 3960 N. Speer Blvd. Denver, CO 80211	1
Westminster High 7300 Lowell Blvd. Westminster, CO 80030	1	West High 931 Elati Street Denver, CO 80204	2
Brighton High 270 S. 8th Avenue Brighton, CO 80601	2	Cherry Creek High 9300 E. Union Avenue Englewood, CO 80110	2
Meritt Hutton High 810 Eppinger Blvd. Thornton, CO 80229	3	SEMBCS Career Center 3897 Jason Englewood, CO 80110	1
North Glen High 601 W. 100th Place North Glen, CO 80221	3	Pagosa Springs High Box 487 Pagosa Springs, CO 81147	1
Alamosa High 401 Victoria Alamosa, CO 81101	1	Boulder Valley Voc-Tec. Center 6600 Arapahoe Boulder, CO 80303	3
Sheridan High Box 1198 Englewood, CO 80110	1	Career Development Center 1200 S. Sunset Longmont, CO 80501	3
Aurora Technical Center 500 Buckley Rd. Aurora, CO 80010	1	Salida High Box 70 Salida, CO 81201	1

Name of School	No. of Auto Teachers
Kit Carson High Box 185 Kit Carson, CO 80825	1
Centauri High Box 72 La Jara, CO 81141	1
Centennial Senior High Box 347 San Luis, CO 81152	1
Harrison High 2755 Janitell Road Colorado Springs, CO 80906	2
Widefield High 615 Widefield Security, CO 80911	1
Canon City High 1313 College Avenue Canon City, CO 81212	1
Emily Griffith Opportunity School 1 1250 Walton Street Denver, CO 80204	4
Douglas Co. Senior High Box Q Castle Rock, CO 80104	1
Coronado High 1590 W. Fillmore Colorado Springs, CO 80904	1
William Mitchell High 1205 Potter Drive Colorado Springs, CO 80909	1
Palmer High 301 North Nevada Colorado Springs, CO 80902	1
Wasson High 2115 Afton Way Colorado Springs, CO 80909	1
Bear Creek High 3490 S. Kipling Morrison, CO 80465	1
Evergreen Senior High Evergreen, CO 80439	2
Golden Senior High 701 W. 24th Golden, CO 80401	1
Jefferson Senior High 2305 Pierce Street Lakewood, CO 80215	1
Lakewood Senior High 9700 W. 8th Lakewood, CO 80215	1
Wheatridge Senior High 9505 W. 32nd Avenue Wheatridge, CO 80002	1
Warren Occupational Tech. Center 13300 W. Ellsworth Golden, CO 80401	4
Florence High 400 Washington Avenue Florence, CO 81226	1
Glenwood Springs High Box 820 Glenwood Springs, CO 81601	1
Walsenburg High Walsenburg, CO 81089	1
Alameda High 1255 S. Wadsworth Denver, CO 80226	2
Arvada Senior High 7951 W. 65th Avenue Arvada, CO 80002	1
Arvada West Senior High 11325 Allendale Drive Arvada, CO 80002	1
Durango High 201 12th Street Durango, CO 81301	1

Name of School	No. of Auto Teachers
Trinidad High 816 West Street Trinidad, CO 81082	2
Aquilar High Box 567 Aquilar, CO 81020	1
Vocational School 2115 Grand Avenue Grand Junction, CO 81501	1
Montrose High 700 S. Townsend Montrose, CO 81401	1
Brush High 206 Colorado Avenue Brush, CO 80723	1
Aspen High Box 300 Aspen, CO 81611	1
Lake County High Leadville, CO 80461	1
Revera High Sedgewick, CO 80749	1
Woodlin High Woodrow, CO 80757	1
Greeley Central High 1515 14th Avenue Greeley, CO 80631	3
Rangely High Box 928 Rangely, CO 81648	1
Larimer County Voc-Tec. Center Box 2397 Fort Collins, CO 80521	4
Wray High Wray, CO 80758	1
Adams City High 6855 Cherry Street Commerce City, CO 80022	1

Post Secondary Schools

Name of School	No. of Auto Teachers
Arapahoe Community College 5900 S. Sante Fe Drive Littleton, CO 80120	1
Community College of Denver (Auraria) 1250 Bannock Denver, CO 80204	2
Community College of Denver (North) 1001 E. 62nd Avenue Denver, CO 80216	3
Community College of Denver (Red Rocks) 2600 W. 6th Avenue Golden, CO 80401	3

Name of School	No. of Auto Teachers
El Paso Community College 2200 Bott Avenue Colorado Springs, CO 80904	7
Colorado State Reformatory Box R Buena Vista, CO 81211	1
Golden Key Vocational School Box 99 Canon City, CO 81212	1
Colorado Mountain College Glenwood Springs, CO 81601	1
Colorado Mountain College Leadville, CO 80461	2
Trinidad State Junior College Trinidad, CO 81082	3
Northeastern Junior College Sterling, CO 80751	2
Mesa Junior College Grand Junction, CO 81501	3
San Juan Basin AVTS Box 970 Cortez, CO 81321	2
Morgan County Community College 300 Main Street Fort Morgan, CO 80701	2
Otero Junior College La Junta, CO 81050	2
Lamar Community College 2400 South Main Lamar, CO 81052	2
Southern Colorado State College Area Vocational Center 900 West Orman Avenue Pueblo, CO 81004	9
S.L.A.V.S. RR2 Monte Vista, CO 81144	2
Aims College Box 69 Greeley, CO 80631	2

APPENDIX L

TEXT AND INSTRUCTIONAL MATERIALS

Textbook

Vehicle Emissions Control, 2nd edition, produced and published by Gargano Promotions Division of American Consolidated Industries.

Supplementary Materials

"The Story of Gasoline" (Ethyl Corporation)

"Positive Crankcase Ventilation" (Ethyl Corporation)

"Controlling Exhaust Emissions" (Ethyl Corporation)

"Clean-Air Tune-ups With Infrared HC-CO Emissions Analysis" (Kal-Equip Company)

All materials including text, supplementary handouts, overhead transparancies, slides and simulated state handbooks used in the program are on file at the Motor Vehicle Division of the Colorado State Department of Health, Denver, Colorado.

APPENDIX M

PRE-TEST

Circle the letter in front of the answer.

Some questions will naturally have more "right" answers than those given, circle the best choice of those given.

1. Black smoke from a vehicle tail pipe indicates the engine is burning oil.

   A. True
   B. False

2. An engine "diesels" or "runs on" after shut down. This is most often caused by:

   A. Overheated engine
   B. Too lean
   C. Idling too fast at shut down

3. A two barrel carburetor has a reasonably smooth idle. When you check the mixture adjustment, <u>using instruments</u>, you could find:

   A. One mixture needle too lean and one too rich
   B. Both needles too rich
   C. Both needles too lean
   D. All of the above

4. You have worked on both a 1962 and 1972 model car today. After both owners left you discovered the radiator caps got mixed up.

   1. If you were concerned <u>only</u> with the danger of overheating, which owner would you call back?

      A. Owner of 1962 model
      B. Owner of 1972 model
      C. Neither owner because neither car would overheat

5. You are driving in winter at 50 MPH. Suddenly the heater blows cool air and engine boils. The trouble is:

   A. Radiator froze while you drove
   B. Thermostat stuck closed while you drove
   C. Waterpump stopped pumping while you drove

6. EGR is used to:

   A. Reduce HC-CO
   B. Reduce NOx
   C. Increase gas mileage

7. Not enough "float drop" will cause trouble when:

   A. Starting a warm engine
   B. Idling a warm engine
   C. Driving at high speed with wide open throttle
   D. Cruising on level road at 25 MPH

8. Two owners with identical cars are going together on a trip. Owner A is towing a 16' travel trailer. Owner B will tow nothing. Both engines need vacuum diaphragm in their distributors but you only have one. Considering only gas mileage so less combined fuel is burned by these two cars on this trip, which owner should get the new dist. diaphragm?

   A. Owner towing trailer
   B. Makes no difference
   C. Owner not towing

9. If ignition specs are: Initial timing 0^{o}, total advance 25^{o}, mechanical advance 10^{o}, how many degrees is vacuum advance?

   A. 15^{o}
   B. 35^{o}
   C. 30^{o}

10. A "dash pot" failure will be noticed:

    A. On acceleration
    B. On starting engine
    C. On deceleration

11. You change the dwell on an engine from 30^{o} to 26^{o}. What effect does this have on timing?

    A. No change
    B. Advance it
    C. Retards it

12. An engine with this firing order: "14283675", which cylinder besides #1 will flash a timing light so you can see the marks?

    A. 8
    B. 5
    C. 3

13. CEC solenoids and idle stop solenoids both hold the throttle plates slightly open. Which one also controls distributor vacuum?

A. CEC solenoid
B. Idle stop solenoid

14. Replacing main jets with leaner ones may:

A. Raise gas mileage
B. Lower gas mileage
C. May do either of the above

15. Your cruising at 50 MPH on a level road. Your manifold vacuum gauge reads 14". Which carburetor circuit is <u>not</u> operating?

A. Float circuit
B. High speed circuit
C. Power circuit

16. All domestic engines built since 1965 time the distributor on #1 cylinder.

A. True
B. False

17. Spark plugs that miss-fire because of "Bridging" one or two days after a tune up are an indication of:

A. Owner's bad driving habits
B. Poor quality spark plugs
C. Heavy combustion chamber deposits

18. The owner knows he has: (A) one open plug wire, (B) a weak coil, (C) high float level, (D) no vacuum advance in the distributor. He will pay to fix <u>only one</u> of these troubles.

1. Which one would you fix if he only wants lower HC emissions?

A B C D

2. Which one would you fix if he only wants lower CO emissions?

A B C D

3. Which one would you fix if he can't start it cold?

A B C D

19. A running compression test is done with:

A. All the spark plugs out
B. All the spark plugs in
C. One spark plug out at a time

20. A choke vacuum brake failure will be noticed:

    A. On a fully warm engine
    B. On cold engine drive-away
    C. When trying to start flooded cold engines

21. When manifold vacuum is 16" but venturi and spark port vacuum are 0", the engine is:

    A. Stopped
    B. Running at 2500 RPM in neutral
    C. Idling

22. You suspect one flat lobe on the cam shaft. Which tests would you use?

    A. Compression test
    B. Cylinder leakage test
    C. Cylinder balance test

23. A cranking vacuum test is done with:

    A. All the spark plugs out
    B. All the spark plugs in
    C. One spark plug out at a time

24. Exhaust temperatures are hottest if:

    A. Timing is advanced more than specs
    B. Set "right on" specs
    C. Retarded less than specs

25. PCV valves are used to:

    A. Control HC emissions
    B. Ventilate the crankcase
    C. Both of the above

APPENDIX N

POST-TEST

1. The TVS (Thermostatic Vacuum Switch) when used on a General Motors engine is located in the:

   A. Exhaust manifold
   B. Engine cooling system
   C. Canister evaporation system

2. A 1970 Buick should be "failed" if it has no:

   A. EGR valve
   B. PCV valve
   C. A.I.R. Pump

3. You inspect a 1972 Rambler and find it has a 1970 engine in it. There is no Carbon Canister in the evaporation control system. You would "pass" this vehicle:

   A. True
   B. False

4. Vehicles can be "failed" with the HC-CO readings well below the state standard if:

   A. the engine is very noisy and leaks oil
   B. the glass packed mufflers are very loud
   C. the exhaust manifold is cracked

5. Operating temperature of an engine is considered to be normal when:

   A. the block thermostat opens
   B. the automatic choke opens
   C. the "cold" light goes out
   D. the air cleaner heat door opens

6. On a retest of an "emissions failed vehicle:"

   A. Inspect all emissions items
   B. Retest HC-CO
   C. Inspect only emissions items that were failed

READ METERS ON ENCLOSED SHEET AND RECORD BELOW:

	HC	(See page 78)	CO
7.	_____		_____
8.	_____		_____
9.	_____		_____
10.	_____		_____
11.	_____		_____
12.	_____		_____
13.	_____		_____

14. If the State Standard For CO is .8% circle all meters "failing." Use meter readings shown in the questions.

    A. Question #7
    B. Question #8
    C. Question #9
    D. Question #10
    E. Question #11
    F. Question #12
    G. Question #13

15. If the State Standard For HC is 120 PPM circle all meters "failing." Use meter readings shown in the questions.

    A. Question #7
    B. Question #8
    C. Question #9
    D. Question #10
    E. Question #11
    F. Question #12
    G. Question #13

16. Give the equipment required to operate an inspection station.

17. Give the requirements to become a state inspector.

18. What senate bill has caused the initiation of this project?

A. 939
B. 393
C. 353
D. 383

19. What two operating modes are checked when performing an emissions inspection?

A. _____

B. _____

20. List five safety precautions to be observed while inspecting the vehicle:

A. _____

B. _____

C. _____

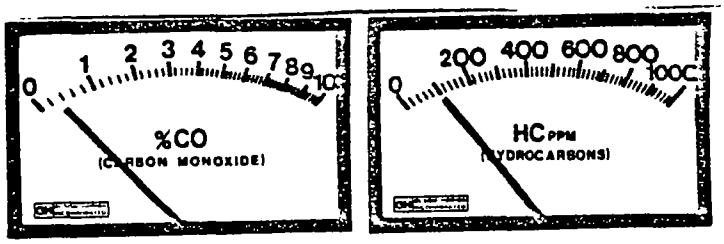
D. _____

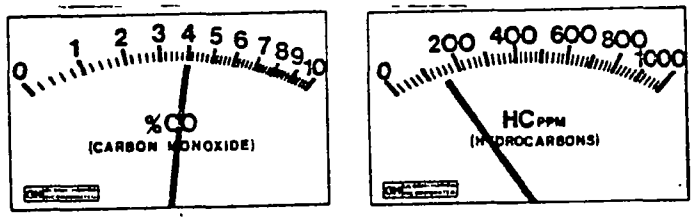
E. _____

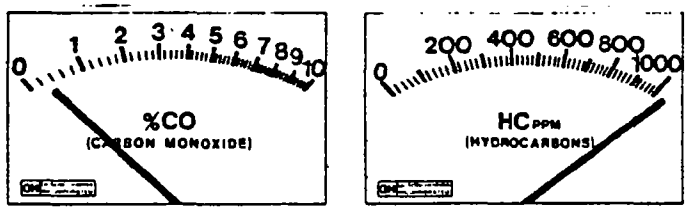
21. What could you do while the vehicle is warming up to operating temperature in preparation for emissions inspection?

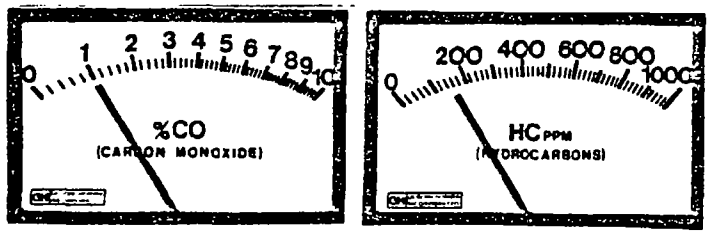
22. What adjustments or repairs may be charged for while making the emissions inspection?

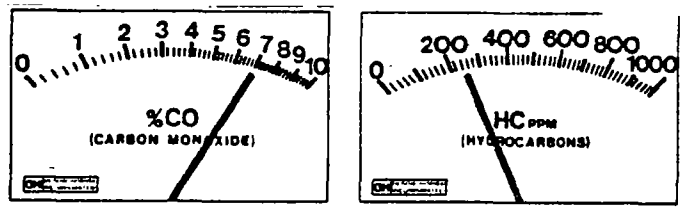
23. Using the materials at hand in your inspection station you are not able to find the answer to your problem. What would you do?

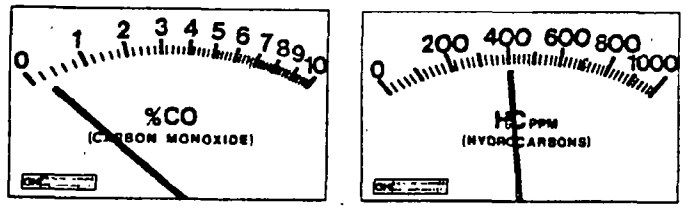
7. 

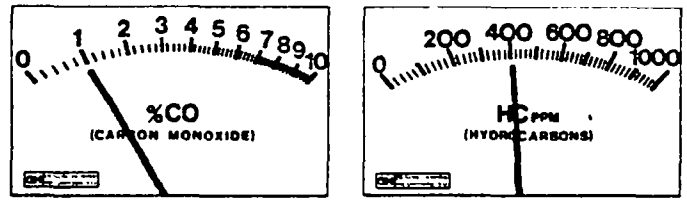
8. 

9. 

10. 

11. 

12. 

13. 

APPENDIX O

COMPONENTS USED IN PROGRAM

The following is a listing of components used in the classes for demonstration purposes. Some of these were donated by the different automotive companies and dealers while others were purchased with monies from the EPA grant. This collection is by no means complete but it presents a representative look at the components used.

8 - Vac Advance Units
3 - Air Bleeds
10 - Vac Switching Valves
5 - Temp Sensors
2 - Gear Position Sensors
6 - Speed Sensors
10 - EGR Valves
5 - PCV
4 - Air Cleaners Vac Motors
20 - Carburetors
4 - Distributors
15 - Cold and Hot Vac Switching Valves
1 - Exhaust Pipe Restrictor
3 - Heat Risers
2 - Manifold - ex. and intake
4 - Air Pumps
5 - Check Valves
2 - Gulp Valves
3 - Diverter Valves
1 - Air Pump Manifold
3 - Vac Switching Valves (foreign)
10 - Retrofit Devices
2 - Diesel Valves
2 - Modulator Valves
4 - Electronic Control Boxes
2 - Vac Amplifiers
1 - Overspeed Control
1 - Fuel Injection-Pressure Sensor
1 - Fuel Injection Regulator
1 - Injector

APPENDIX P

EQUIPMENT UTILIZED IN PROGRAM

HC-CO Analyzers

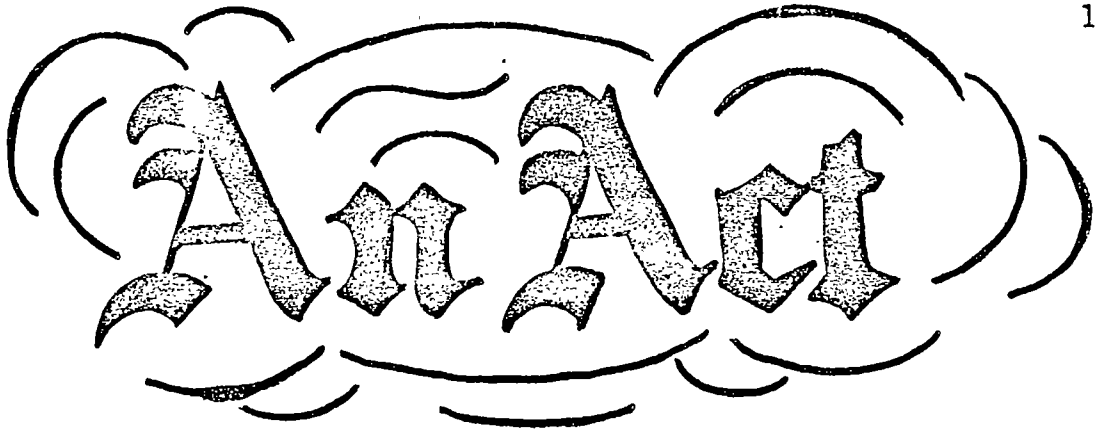
Tachometers

Dwell Meters

Various Automobiles

Various Engines

1973



SENATE BILL NO. 393. BY SENATORS Shoemaker, H. Fowler, H. Brown, Plock, Strickland, Bermingham, Anderson, Schieffelin, Enstrom, Jackson, Kogovsek, Minister, Parker, Stockton, and Darby; also REPRESENTATIVES Friedman, DeMoulin, Arnold, Bendelow, Bishop, Boley, Carroll, Eckelberry, Gallagher, Gaon, Gunn, Howe, Hybl, Kirscht, Kopel, Koster, Lamm, Miller, Ross, Sack, Sears, Showalter, Smith, Spano, Strahle, Tempest, and Webb.

CONCERNING AIR POLLUTION CONTROL, AND PROVIDING FOR THE ESTABLISHMENT OF A MOTOR VEHICLE EMISSIONS CONTROL PROGRAM, AND MAKING AN APPROPRIATION THEREFOR.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. 66-31-3, Colorado Revised Statutes 1963 (1971 Supp.), is amended BY THE ADDITION OF A NEW SUBSECTION to read:

66-31-3. Definitions. (13) "Motor vehicle" means any self-propelled vehicle which is designed primarily for travel on the public highways and which is generally and commonly used to transport persons and property over the public highways.

SECTION 2. Article 31 of chapter 66, Colorado Revised Statutes 1963 (1971 Supp.), is amended BY THE ADDITION OF THE FOLLOWING NEW SECTIONS to read:

66-31-27. Motor vehicle emissions control program. (1) The commission shall have the authority to adopt regulations concerning high altitude tuning specifications to control motor vehicle emissions in this state.

(2) The departments of revenue and health shall develop joint programs where appropriate for the control of motor vehicle emissions. Though the departments of health and revenue shall

Capital letters indicate new material added to existing statutes; dashes through words indicate deletions from existing statutes and such material not part of act.

confer and cooperate in all aspects of the motor vehicle emission control program, the primary responsibility of the commission is the adoption of rules and regulations, and the primary responsibility of the department of revenue is the enforcement of those rules and regulations as delegated pursuant to 66-31-10 (2) (g).

(3) Not later than December 1, 1973, the departments of health and revenue are directed to complete certain pilot and testing programs and studies and make joint recommendations to the governor and to the general assembly.

(4) (a) The department of health shall develop a pilot program for the purpose of testing a representative sample of motor vehicles with various vehicle emission control alternatives which may include emission testing and maintenance, air pollution control tuneup, and vehicle modification alternatives as determined by the commission.

(b) Based upon the results of the pilot program, the commission shall develop recommendations for implementing programs of emission testing or mandatory maintenance, or both; air pollution control tuneups; and vehicle modifications, including altitude modifications and retrofit control systems, for the control of motor vehicle emissions. Such recommendations shall include information on the costs and air pollution control effectiveness of alternate control measures and legislative and regulatory measures necessary to implement an effective program. Any program recommended shall be based upon establishing statewide minimum standards and shall include more stringent standards for motor vehicles registered in air quality control basins defined by the commission.

66-31-28. Training programs and studies - emission controls. (1) No later than July 1, 1974, state-employed investigators shall complete a training course and pass qualification tests as developed and approved by the commission, after conferring with the department of revenue, as related to the orientation and basic maintenance procedures on air pollution control systems installed by manufacturers. The commission may waive the requirement for completion of such a training course under such circumstances as the commission deems appropriate. Only inspectors passing said qualification tests shall perform emission inspections. The commission may require, pursuant to section 13-5-113, C.R.S. 1963, that inspection stations have on hand by July 1, 1974 any equipment necessary to complete emission inspections as provided for in this section.

(2) The departments of health and revenue shall jointly recommend, by December 1, 1973, additional training programs which may be necessary to help implement motor vehicle emission control measures.

(3) No later than February 1, 1974, pilot training programs consistent with the provisions of this section shall have been completed to determine program costs and effectiveness in meeting the training requirements of this section.

(4) (a) The departments of health and revenue jointly shall recommend a program to insure consumer protection in the implementation of the motor vehicle emission control program. The departments shall make recommendations relating to penalties and enforcement procedures that will not only be effective in the control of emissions, but also allow persons in violation reasonable time to comply with any requirements established.

(b) The commission shall consider, in promulgating rules and regulations, the adverse effect of said rules and regulations upon gasoline mileage, performance, or other factors as to any make, model, or class of motor vehicles as well as the public benefit in reducing air pollution. The commission may make recommendations to exempt from regulations any make or model of motor vehicle for which either gas mileage, performance, or other factor would be adversely affected in a significant manner by said control measures.

(c) Any make or model of motor vehicle, fueled by natural gas, or powered by electrical energy, or powered by a Rankin cycle engine, shall be exempt from the provisions of section 66-31-27.

SECTION 3. 13-5-113 (2), Colorado Revised Statutes 1963 (1969 Supp.), is REPEALED AND REENACTED, WITH AMENDMENTS, to read:

13-5-113. Periodical inspections required. (2) (a) The inspection required by this section shall include an inspection of the lights, brakes, steering assemblies, window and windshield glass, exhaust system, mufflers, fenders, and any other equipment or accessory, the proper functioning of which is found by the department of revenue to be necessary to the safe operation of the vehicle.

(b) Except as to devices found by the air pollution control commission to be ineffective pursuant to section 66-31-6 (4), C.R.S. 1963, the inspection required by this section shall include the crank case ventilating system on gasoline propelled automobiles and trucks manufactured in the United States after July 1, 1965, and on all other motor vehicles equipped with the same, connection of air pollution control devices installed by the manufacturer of any automobile of a model year of 1968 or later, and any other inspection prescribed pursuant to paragraph (c) of this subsection (2).

(c) Effective July 1, 1973, as part of the inspection required by this section, the air pollution control commission is

authorized to adopt regulations pursuant to sections 66-31-8 and 66-31-9, C.R.S. 1963, for the proper connection and operation of air pollution control devices installed by the manufacturer in any motor vehicle for the purpose of controlling vehicle emissions; the air pollution control commission may further adopt rules and regulations governing other air pollution control devices; which rules and regulations shall be enforced by the department of revenue. Such rules and regulations pertaining to inspections for the proper operation of all pollution control devices shall not become effective before July 1, 1974, and prior to that time, the air pollution control commission shall recommend to the general assembly an appropriate fee therefor.

(d) Effective with the sale of inspection certificates to be issued after July 1, 1973, there shall be a fee of fifteen cents in addition to that prescribed by section 13-5-114 (5), which fee shall be paid to the department of revenue along with the fee paid under section 13-5-114 (4), and shall be credited to the special account prescribed by section 13-5-114 (4) and may be used, subject to appropriation by the general assembly, to cover the cost of the motor vehicle emissions control activities of the departments of health and revenue.

SECTION 4. 13-5-160 (4), Colorado Revised Statutes 1963 (1969 Supp.), is REPEALED AND REENACTED, WITH AMENDMENTS, to read:

13-5-160. Automobile air pollution control devices tempering - operation of vehicle. (4) The air pollution control commission may adopt rules and regulations pursuant to sections 66-31-8 and 66-31-9, C.R.S. 1963, which permit or allow for the alteration, modification, or disconnection of manufacturer-installed air pollution control systems or manufacturer tuning specifications on motor vehicles for the purpose of controlling vehicle emissions. Nothing in this section shall prohibit the alteration or the conversion of a motor vehicle to operate on a gaseous fuel, providing that the resultant emissions are at levels complying with state and federal standards for that model year of motor vehicle.

SECTION 5. Article 13 of chapter 40, Colorado Revised Statutes 1963 (1971 Supp.), is amended BY THE ADDITION OF A NEW SECTION to read:

40-13-110. Air pollution violations. (1) (a) (i) It is a class 2 petty offense as specified in section 40-1-107 for any person to cause air pollution by any of the means:

(ii) To cause or permit, in any air pollution control region designated by the commission in which more than thirty times per year the carbon monoxide level exceeds nine parts per million averaged over an eight hour period, the emission into the atmosphere from any motor vehicle powered by gasoline, or other

fuel except diesel, of any visible air contaminant (except water vapor) for a period greater than five consecutive seconds; except that no two-cycle gasoline-powered motor vehicle shall emit into the atmosphere any air contaminant (except water vapor) of a shade or density equal to or greater than twenty percent opacity for a period greater than ten consecutive seconds;

(iii) To cause or permit the emission into the atmosphere from any diesel-powered motor vehicle operating not more than at an altitude of eight thousand feet above mean sea level any air contaminant (except water vapor) of a shade or density equal to or greater than thirty percent opacity for a period greater than ten consecutive seconds, other than as a result of a cold engine start-up;

(iv) To cause or permit the emission into the atmosphere from any diesel-powered motor vehicle operating at more than eight thousand feet above mean sea level any air contaminant (except water vapor) of a shade or density equal to or greater than forty percent opacity for a period greater than ten consecutive seconds, other than as a result of a cold engine start-up;

(b) Opacity is defined as the degree to which an air contaminant emission obscures the view of an observer, expressed in percentage of the obscuration or in the degree (percent) to which transmittance of light is reduced by an air contaminant emission.

(2) (a) The air pollution control commission shall establish training requirements for peace officers charged with the enforcement of the provisions of subsection (1) of this section.

(b) In addition to the enforcement of the provisions of subsection (1) of this section by peace officers, the air pollution enforcement officers of the department of health, including designated air pollution agents of the department, shall enforce the provisions of this section and, for such purposes only, shall have the powers of peace officers.

(3) (a) Effective January 1, 1974, the offense of causing air pollution as defined in this section is punishable by a fine of twenty-five dollars. Penalty assessment procedures provided in section 39-2-201, C.R.S. 1963, shall be utilized in the enforcement of this section and shall be subject to the additional provisions of this subsection (3). Prior to such date, peace officers may issue notices warning of conditions which appear to violate the provisions of this section.

(b) Copies of every notice issued on or after January 1, 1974, shall be forwarded by the issuing officer to the Colorado department of revenue, motor vehicle division, and to the clerk

of the county court of the appropriate county. The notice, in the form of a summons and complaint, shall provide that the person charged may pay the specified fine in person or by mail at the office of the Colorado department of revenue, motor vehicle division, Denver, Colorado, within seven days after the date of issuance of the notice, shall specify a date not less than thirty nor more than sixty days after its date of issuance for appearance to answer the charge if the fine is not paid, and shall further give notice that, in the alternative, the person may have the charge dismissed by complying with the provisions of paragraph (c) of this subsection (3).

(c) Upon presentation to the court, by mail or in person, of an affidavit by the owner of the vehicle described in the penalty assessment notice that the vehicle has been disposed of in such manner that it will no longer be operated on the highways, together with the registration card and number plates of such vehicle, the complaint shall be dismissed. Likewise, upon presentation, by mail or in person, of an affidavit of the owner that such automobile has been repaired prior to the date set for appearance upon the charge and that it is not in violation of the provisions of this section when in normal operation, the complaint shall be dismissed. Any such affidavit is subject to the penalties of perjury in the second degree if made in violation of the provisions of section 40-8-503.

SECTION 6. Appropriation. (1) In addition to any other appropriation, there is hereby appropriated out of any moneys in the state treasury not otherwise appropriated, to the department of health, for the fiscal year beginning July 1, 1973, the sum of three hundred eighty thousand nine hundred fifty-one dollars ($380,951), or so much thereof as may be necessary, for the motor vehicle emissions control program authorized by this act. These funds shall be used to develop within the department of health a motor vehicle emissions control section, to develop a pilot program for the testing of vehicle emission control alternates, to develop training programs, and to develop other measures and recommendations in line with the intent of this act.

(2) In addition to any other appropriation, there is hereby appropriated out of any moneys in the special account within the highway users tax fund prescribed by section 13-5-114 (4), C.R.S. 1963, not otherwise appropriated, to the department of revenue, for the fiscal year beginning July 1, 1973, the sum of twenty-five thousand fifty-nine dollars ($25,059), or so much thereof as may be necessary, for the performance of its duties in the implementation of this act.

SECTION 7. Safety clause. The general assembly hereby

finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

John D. Vanderhoof
PRESIDENT
OF THE SENATE

John D. Fuhr
SPEAKER OF THE HOUSE
OF REPRESENTATIVES

Comfort W. Shaw
SECRETARY OF
THE SENATE

Lorraine F. Lombardi
CHIEF CLERK OF THE HOUSE
OF REPRESENTATIVES

APPROVED _____

John A. Love
GOVERNOR OF THE STATE OF COLORADO