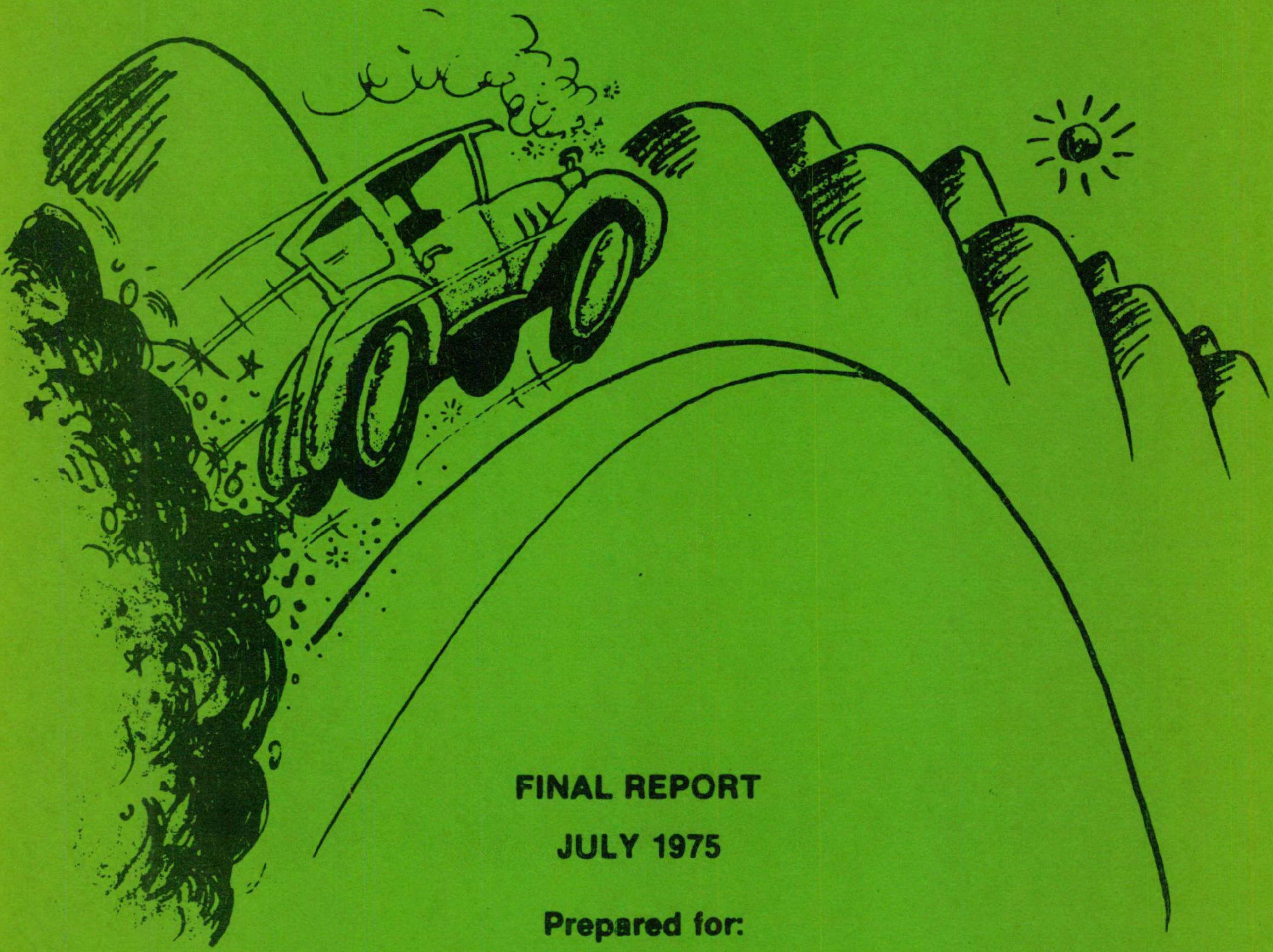
HIGH ALTITUDE VEHICULAR EMISSION CONTROL PROGRAM

VOLUME VIII. PILOT TRAINING PROGRAM

RESULTS FOR MOTOR VEHICLE

EMISSION CONTROL

SUPPLEMENT



FINAL REPORT

JULY 1975

Prepared for:

State of Colorado
Department of Health
Denver, Colorado 80220

Environmental Protection Agency
Region VIII
Denver, Colorado 80203

Colorado State University

444 High Altitude Vehicular Emission Control Program Vol VIII

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FINAL REPORT ON COLORADO MOTOR VEHICLE EMISSION CONTROL EDUCATIONAL TRAINING PROGRAM

Submitted to

State of Colorado

Department of Health

By

Department of Industrial Sciences

Colorado State University

Fort Collins, Colorado

July, 1975

DISCLAIMER

This report has been financed in part with State funds from the State of Colorado Department of Health, Denver, Colorado 80220 and prepared by the Industrial Sciences Department at Colorado State University under Contract/ Grant Number C291146.

The conclusions, opinions, and findings are those of the project team members and are not necessarily those of the Colorado State Health Department. Mention of company or commercial product names does not constitute endorsement by the project team members, the State Health Department, or Colorado State University.

The results and conclusions presented are based on data gathered by the Industrial Sciences Department of Colorado State University.

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

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1.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations presented herein are derived from the Colorado Motor Vehicle Emissions Control Educational Training Program and activities conducted by the Industrial Sciences Department at Colorado State University.

Conclusions

(1) The instructional materials and evaluation instruments developed during the project and evaluated by automotive teachers have proven to be satisfactory for use in emission control systems training.

(2) Twenty-six (26) automotive teachers in the DAQCR benefited from the forty (40)-hour emissions control training program conducted by Colorado State University.

(3) An effective vehicle emissions control training program can be disseminated by properly trained automotive instructors to the automotive service industry.

(4) Consultant services to emissions control teachers in the field was a minor aspect of the project; however, consultant services will have a greater impact on future training.

(5) The suggested certification requirements developed for inspectors and investigators will insure the integrity of an emission inspection/maintenance program.

Recommendations

(1) Revisions and additions to developed instructional materials must be continued to maintain a relevant training program.

(2) In-service, up-dated training for those DAQCR teachers who previously attended Colorado State University emission control workshops should be provided.

(3) Provide instruction to those automotive teachers desiring to become qualified to train repairmen, inspectors, and investigators.

(4) Provide training to approximately 1,000 mechanics in the DAQCR to qualify them as emission control repairmen and inspectors. Emphasis should be placed on inspection and diagnostic procedures, and the proper use of testing equipment during the training.

(5) Establish an emission control certification and training center for repairmen, inspectors, and investigators.

(6) The training center personnel should act as disseminators of public information, and as emission control consultants to teachers, repairmen, inspectors, and investigators.

2.0 PROJECT OBJECTIVES

The primary objectives of the project were to:

(1) develop educational instructional material for emissions control teachers.

(2) develop evaluation instruments for emissions control teachers.

(3) conduct a forty (40)-hour emissions control workshop for twenty-five (25) automotive teachers within the Denver Air Quality Control Region.

(4) develop Colorado Motor Vehicle Emissions Control certification requirements.

(5) provide consultant services to emissions control teachers in the field.

(6) provide and administer instruments in evaluating instructional materials used in pilot program for automotive teachers.

(7) provide course outlines on training program for motor vehicle emissions control to be used by teachers in the field.

(8) provide written recommendations on techniques to be used in implementing an effective certification and educational program on motor vehicle emissions control.

(9) provide monthly progress reports on project.

(10) provide interim report by February 15, 1975, with tentative recommendations on certification program for inspectors, investigators, repairmen and automotive teachers.

(11) provide final report with revised recommendations by June 30, 1975.

3.0 INTRODUCTION

This is the final report on the Colorado Motor Vehicle Emissions Control Educational Training Program. The project is focused toward: providing an educational program for twenty-five (25) motor vehicle emission control teacher educators; developing certification requirements for emission control inspectors and investigators; providing course outlines and evaluation instruments to be used by prospective emission control teachers; and evaluating instructional materials developed for the training of automotive teachers. This project developed 240 - 35mm slides and the same number of matching transparencies with narrations portraying five (5) vehicle emission control systems used by various automotive manufacturers. In addition to the slide series, a video tape program was produced illustrating the chemistry of the internal combustion engine and its related pollutants; namely, hydrocarbons, carbon monoxide and oxides of nitrogen.

The project provides the necessary instructional, training and evaluation materials for a delivery system to be administered to auto mechanic teachers and other people in the automotive inspection, maintenance and repair industry. In developing the vehicle emission control teacher training program, the following assumptions were considered:

(1) Instructional materials are designed for teacher use.

(2) Teachers will be familiar with carburetion, electrical, and engine theory.

(3) Teachers will be familiar with emission systems.

(4) Teachers will be familiar with electrical test equipment.

(5) Teachers will be familiar with diagnostic procedures.

(6) Teachers will be familiar with the effective use of instructional media.

(7) All teachers will have trade experience.

In fulfilling the requirements of the contract, with the Colorado State Department of Health, the Department of Industrial Sciences at Colorado State University conducted two (2) emissions control workshops for twenty-six (26) automotive teachers.

In addition to the teacher training workshops, a pilot course in automotive emissions was conducted for eleven (11) graduate and undergraduate students on campus at Colorado State University by the Department of Industrial Sciences. The course content for these students was a duplicate of that offered to the twenty-six (26) instructors.

Purpose of the Project

The overall purpose of this project was to develop instructional materials for an effective delivery system concerning the orientation and maintenance on motor vehicle emission control systems for automotive teachers, and to establish inspection certification requirements for inspectors and state investigators to effectively implement a program.

The engineering changes on automobile emission control devices are becoming more complex every day. Compounding this situation is the apparent and distinct lack of instructional materials designed to aid the automotive teacher in the task of teaching vehicle emission control systems. With the introduction of the catalytic converter, warm-up systems, electronic ignition, carburetor modifications, and emphasis on fuel economy, changes in our teaching materials and methods are needed. The situation was recognized and upheld further by the Air Pollution Control Commission's report to the Governor in 1973. The commission concluded that inadequate training opportunities and skills presently exist; one of the key elements of an effective vehicle emission inspection program is the proper training of inspectors and investigators. To comply with these recommendations of the commission, the Department of

Industrial Sciences at Colorado State University was awarded a contract by the Colorado State Department of Health for developing a training program and necessary instructional material on motor vehicle emission control systems. Under the same contract, Colorado State University developed certification requirements and procedures for emission control inspectors and state investigators.

Method and Procedure

In order to implement an effective and efficient Colorado Motor Vehicle Emission Control Educational Training Program, it was essential to develop a delivery system consisting of the appropriate components and adequate instructional materials and personnel. To fulfill 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 other supporting facilities, including the Media Center at Colorado State University, proposed the establishment of a delivery system model for an instructional program on vehicle emission controls (see appendix A). Therefore, the thrust of the project concentrated on the initiation and implementation of a vehicle emission control training program for Colorado's automotive instructors that would assist in advancing the state of the art in mobile air pollution abatement.

The project was directed toward:

(1) analyzing information, materials and results of various field tests now being performed by private, state and other agencies on vehicle emission control.

(2) selecting twenty-five (25) qualified automotive teachers in the vocational and technical institutions from the Denver Air Quality Control Region to participate in the Colorado Motor Vehicle Emission Control Educational Training Program conducted by Colorado State University.

(3) providing selected teachers in Colorado with the appropriate educational and training background on motor vehicle emission control.

(4) providing adequate instructional materials to selected automotive teachers so they may provide instruction for inspectors, investigators, repairmen, and vocational and technical students throughout the state.

(5) conducting field test classes with selected

teachers and inspectors on instructional and course materials as they were being developed.

(6) developing evaluation methods for vehicle emission training programs, follow-ups, and recommendation of the results.

(7) develop criteria and procedures for the certification of inspectors and investigators in Colorado.

Pilot Training Program

Three years ago, an emissions control training program in Colorado began with the instruction of one hundred fourteen (114) veteran mechanics on automotive emission control theory, maintenance, and service. The classes were conducted for Region VIII of the Environmental Protection Agency by the Industrial Sciences Department at Colorado State University. The program consisted of thirty-two (32) hours of classroom instruction and one hundred twenty-eight (128) hours on-the-job training in the use of exhaust analyzers and diagnostic test equipment.

Another pilot training program on motor vehicle emissions control was developed and implemented by the Industrial Sciences Department at Colorado State University for the Department of Health and Revenue. The training program was a six (6)-hour training course offered to fifteen (15) inspectors and six (6) state investigators.

The following procedures were employed 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 programs 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.

The pilot training programs conducted by Colorado State University for evaluating the training needs for automotive emission control personnel indicated the following: 1) more than six (6) hours of instruction are needed to provide adequate information for investigators and inspectors; 2) state regulatory laws and guidelines are needed to give guidance to the automotive emissions program; 3) a certification program is needed to insure the proficiency of the inspector and investigator; 4) test sites and equipment will be needed to train inspectors and investigators.

Colorado State Automotive Teachers Workshop

In June, 1974, Colorado State University instituted a one-week, forty (40)-hour automotive emissions workshop for twenty Colorado vocational automotive teachers. This instructional program was conducted on the campus of Colorado State University. The results and recommendations obtained from the mechanics and inspector/investigators pilot training program were used as the basis for developing the forty (40)-hour teacher workshop trianing course. The principle objectives of this workshop were: 1) to provide instruction on the orientation and basic maintenance procedures on vehicle emission control systems; 2) to develop and evaluate course material and laboratory activities to be administered in future emission control workshops. As a result of the Colorado State one-week workshop, existing instructional materials were gathered and evaluated. Further additions and revisions of these materials were made and implemented during the National Automotive Teachers Workshop held in July on the Colorado State University Campus (see appendix C).

4.0 SUMMARY OF VEHICLE EMISSION CONTROL TEACHER TRAINING PROGRAM AND PROJECT ACTIVITIES

In partial fulfillment of the contract with the Colorado Department of Health, Colorado State University was to provide emission control training for twenty-five (25) Colorado automotive teachers. In conjunction with this objective, instructional materials were to be developed for use by automotive teachers to conduct emission control training.

Utilizing the training materials used for previous pilot programs, revisions and new materials developed by the twenty-three (23) participants in the National Automotive Workshop, an outline was developed for the forty (40)-hour Colorado teacher training program (see appendix B). This forty (40)-hour training class was scheduled from August 19 through August 23 at the Warren Occupational Technical Center in Denver.

Letters with applications were mailed to approximately sixty (60) Colorado automotive teachers, primarily in the Denver Air Quality Control Region. Because the training program coincided so closely with the opening of many schools, only eleven (11) teachers responded; however, four (4) service personnel from industry requested and were given permission to attend the class.

The instructional materials selected for the classroom texts were: Emissions Control Manual by Gargano, Vehicle Emissions Control by Motorcraft, and Emission Control Systems Maintenance Manual by General Motors. The Mitchell Manual's Automotive Emission Control Service Manuals were used as the reference and technical books for the laboratory exercises. Additional reference materials, supplementing the classroom texts, were primarily filmstrips from Mitchell Manuals and Gargano along with video tapes from General Motors, Ethyl Corporation and Ford Motor Company (see appendix C).

The workshop activities were divided into approximately four (4) hours of class lecture and four (4) hours of laboratory experiences with hands-on exercises related to classroom instruction. Six laboratory worksheets were used for the hands-on assignments (see appendix D). The fifteen (15) participants were divided into five teams of three members each. Five vehicles were procured from local automotive dealerships allowing each team a vehicle on which to work. During the laboratory period the participants became acquainted with and more proficient in the use of diagnostic equipment and infrared analyzers. Instruction and demonstrations stressed that proper diagnostic procedures on emission controlled vehicles were more important than on pre-controlled vehicles.

At the conclusion of the training, the majority of the participants expressed a willingness to become involved in training other personnel. The automotive teachers felt that future refresher training would be necessary to maintain an effective Vehicle Emission Control training program.

Instructional Material Development

Development of a training program for automotive teachers covering five vehicle emission control systems was initiated by the National Automotive workshop participants in July, 1974. The emission control systems researched and developed were: air injection reaction, exhaust gas recirculation, fuel evaporation, positive crankcase ventilation, and thermostatic air control. From the initial assembly of the training program, incorporating the five emission systems, the project staff further developed and refined this material. The services of the Colorado State University Media Center were enlisted to provide the professional graphic expertise needed to produce the visual aids. These aids consisted of 240 - 35mm slides with matching transparencies, 2 - 3/4 inch video tape presentations on the "Nondispersive Infrared Analyzer" and "Chemistry of the Internal Combustion Engine". This collective effort by the National and State project staff and Media Center, in cooperation with workshop participants resulted in the development of an emissions instructional materials packet. This packet contains assumptions, supplementary reference materials, equipment list, curricula outline, laboratory worksheets previously discussed, emission reference materials, behavioral objectives, 35mm slide narrations, test questions pertaining to each emissions system and the narrations for the two video tapes mentioned previously (see appendixes D, E, F, G, H, I, J, K, L, M).

Evaluation of Materials

Upon the completion of the training materials eighteen (18) Colorado teachers who had previously attended emission control workshops were each given a set of these training aids. These teachers, their students, and teachers who participated in the National workshop, evaluated the materials on forms developed by the project team (see appendix N). In addition to the evaluation sheets for the slides and narrations, evaluations were requested on the objectives, test questions, and laboratory worksheets. As the evaluations were returned, the necessary changes and adjustments were made to the instructional materials and final assembly of the packet was made.

Winter and Spring Emission Classes

During the Fall Quarter, 1974, several students at Colorado State University indicated a strong interest in vehicle emission control training. To comply with an administrative decision the existing emissions training program was divided into Emissions I and Emissions II, offered Winter and Spring Quarters respectively, as part of the regular Industrial Sciences curriculum. Emissions I was primarily classroom instruction devoted to theory, purpose, diagnosis, operation of emission control systems, carburetion, and ignition systems. The Emissions II class was designed to offer the students hands-on laboratory experience directly related to emission control systems and diagnostic procedures. Each class offered approximately fifty (50) hours of instruction. This met the universities requirement regarding contact hours necessary to earn the designated college credit. Because of the low teacher enrollment in the summer workshop at the Warren Occupational Technical Center, it was decided to offer the emissions class off campus to Denver area automotive teachers. This allowed many of the automotive teachers the opportunity to take a class in vehicle emission controls they were unable to attend during the summer.

Richard Zimpel, from the State Vocational Department, offered his services by notifying the Denver area vocational automotive instructors of the class and its location.

Graduate credit was made available to those desiring it. The class enrollment at Red Rocks Campus and Colorado State University was fifteen (15) and eleven (11) respectively.

An instructor, Gary Dugan, was hired and approval to use the Community College of Denver Red Rocks auto facility was obtained for the off-campus course. The project staff and Mr. Dugan met and revised the curricula outline (see appendix O) and ordered the necessary instructional materials (see appendix J). A unit on electronic ignition was included in the course since it is standard equipment on most 1975 vehicles and is an integral part of emissions control.

With the addition of electronic ignition to the course it became imperative that components, manuals and visual aids be procured for instruction. Manufacturers, dealers and training centers were contacted to obtain the necessary aforementioned items. Pre-tests covering general mechanical knowledge, emissions, carburetion and ignition were revised and written for the students in order to establish a basis of what areas in the course needed the most concentration (see appendix P).

During the Spring Quarter classes three automotive instructors and the project staff developed an emissions test for automotive instructors. The purpose of the examination is to provide an evaluation tool in determining the knowledge an individual possesses about vehicle emission control systems. After assembly the test was administered to the automotive teachers enrolled in the Emissions II class at Red Rocks Campus. As the teachers took the test they were asked to evaluate the questions and submit written comments as to changes, additions and deletions that needed to be made. A copy of the revised examination can be found in appendix Q.

Follow-Up Visitation/Survey

In April a follow-up survey was conducted by the project director. Five days were spent making personal contact with eighteen (18) Colorado automotive teachers selected by the emissions staff. All of the teachers had attended one of the emissions training workshops conducted by Colorado State University during the Summer of 1974. Table I shows the location, type of school and the number of instructors contacted in the particular city or town.

The principal purpose of the follow-up was to gather information on the progress Colorado teachers had made on conducting emission control training classes in their particular area. In order for the delivery model (see appendix A) to be effective emission control workshop participants must disseminate

Table I

Location and Number of Colorado Teachers Surveyed

Location	Number of Instructors in location	Type of School
Grand Junction	1	College
Glenwood Springs	1	Voc. Center
Cortez	1	Voc. Center
La Jara	1	High School
Salida	1	High School
Pueblo	1	College
Colorado Springs	2	Community College
Denver	5	High School
Boulder	1	Voc. Center
Greeley	1	College
Fort Collins	1	Voc. Center
Lamar	1	Community College
Fort Morgan	1	Community College

similar information and training to teachers, students and repairmen in their local. The goal of the program was to prepare personnel that are qualified to inspect and maintain emission controlled vehicles in accordance with the development of a state emission inspection/maintenance program.

Prior to conducting the survey a questionnaire was developed (see appendix R). This form was completed on each of the instructors when they were contacted. The results from the questionnaire related to emission classes conducted are compiled in Table II. As shown in the table, most of the instructors integrated emissions training into their regular automotive curriculum. The following results are the number of students, by type, who received emissions training:

High School - - - - - - - - - - - - - - - - 584

Post Secondary- - - - - - - - - - - - - - 58

College - - - - - - - - - - - - - - - - - - 20

Mechanics - - - - - - - - - - - - - - - - - 58

Table III reveals data pertaining to future emissions training classes to be conducted by the eighteen (18) instructors. Identified in the table are the number of classes, dates, length of classes in hours, type of students and assistance requested by the individual teachers. Indicated by the last column in Table III a majority of the instructors expressed a need for assistance from the Colorado State University

Table II

Emissions Classes Conducted By Colorado Teachers

Teacher	Location	Sections or # of workshops held	Length of workshop/section (Hrs.)	# of Separate Sections	# of Integrated Sections	Type of Participants	# of participants
1	Ft. Collins	3	9	3		Post. Sec.	38
		3	20		3	Mech.	22
2	Salida	1	16		1	H.S.	26
3	Lamar	1	10		1	H.S. & P.S.	24
4	Aurora	1	8	1		P.S.	20
		4	6		4	H.S.	100
5	Colo. Springs	1	15		1	H.S.	28
6	Greeley	1	60	1		Mechanic	14
		1	20		1	H.S. & P.S.	48
7	Grand Junct.	0					
8	Colo. Springs	4	16		4	Mech. H.S.	12 50
9							
9	Ft. Morgan	1	30		1	H.S.	33
10	Denver	8	4		8	H.S.	59
11	Cortez	1	40		1	H.S.	10
12	Pueblo	1	33		1	Mech. College	10 20
13	Denver	1	20		1	H.S.	14
14	La Jara	3	15		3	H.S.	45
15	Boulder	2	20		2	H.S.	30
16	Denver	2	14		2	H.S.	32
17	Denver	2	2		2	H.S.	85
18	Glenwood	0					

Table III

Planned Emissions Classes By Colorado Teachers

Teacher	#of Projected Classes or Sections for 1975	Projected Dates for Classes	Length of Projected Classes (Hrs)	Types of Students	Requested Additional Training
1	4	Sum, F & W	9 to 18 hrs.	Mech. & P.S.	
2	None				Requested Dept.'s Assistance
3	1	Fall	20	H.S. & P.S.	Requested Dept.'s Assistance
4	1	Fall	6	H.S.	Update Training
5	1	Spring	20	H.S.	Requested Dept.'s Assistance
6	1	Fall	30	Mech. & Coll.	
7	Schedule not completed				
8	1	Spring	16	H.S.	
9	1	Winter	30	H.S.	Update Training
10	1	Fall	20	H.S.	
11	1	Spring	20	Mech. Teachers	Spark Control
12	1	Spring	20	Mech. Coll.	Ford & GM Manuals
13	1	Fall	60	H.S.	Converters
14	Schedule not completed				
15	1	Fall	25	H.S.	
16	1	Fall	14	H.S.	Analyzer & Assistance
17	None				Analyzer & Assistance
18	1	Not set	Not set	H.S.	

emission staff or the Health Department in conducting future emissions training classes.

Development of Proposed Criteria For Investigators and Inspectors

One of the objectives specified in the contract was for Colorado State University to develop a proposed criteria document for state investigator and inspector certification (see appendix T). The investigators and inspectors mentioned are those involved with the proposed vehicle emission inspection/maintenance program in Colorado.

The purpose of the document was to delineate the task descriptions and responsibilities, and to provide guidelines outlining the requirements that must be met for investigator and inspector certification. A sequence of procedures is provided for the investigator and inspector to follow when application for certification/renewal is made.

Prior to the development of the document considerable research was done in determining what criteria other states had developed regarding inspector and investigator certification. Information from New Jersey, New York and California, states with emission programs, was gathered and evaluated in trying to establish the basic format of the document. Emissions material from several other states was received but proved of little value as it did not pertain to vehicle emissions or certification. An additional effort was made to acquire data by a visitation to Olson Laboratory in California and Hamilton Test Systems in Phoenix, Arizona.

During the visit to Olson Laboratory they were conducting an actual emissions inspection for the State of California, on several state and fleet owned vehicles. The demonstration witnessed was a loaded mode using a Clayton Dynamometer, taking approximately two minutes per test. California has the inspection maintenance procedure developed satisfactorily and provided the project team with their inspection handbook that proved to be the most useful material received.

In Arizona, Hamilton Test Systems Corporation has been given a contract by the State to conduct all of the vehicle emissions inspection program in the private sector for the next five years. The inspection procedure planned is similar to California, using the dynamometer to test the vehicle at 55 MPH, 35MPH and idle.

Although Hamilton Test Systems is responsible for conducting the entire Vehicle Emissions inspection program none of the training or certification criteria had been developed that was useful to the project team.

Using the results and recommendations from the Final Report, March, 1974, on the Pilot Training Program for Motor Vehicle Emission Control and considering the responsibilities and duties of the inspector, twelve (12) hours of training are recommended for inspector certification. Indicated in Table II of the criteria document (see appendix T, page 269), the training time will vary slightly depending upon the applicant's background.

The forty (40)-hour training time for investigator certification was determined by: 1) analyzing teacher test results, 2) considering investigator's duties and responsibilities, and 3) assuming the knowledge possessed by the investigator should be comparable to that of an automotive instructor. Referring to Table VIII of the document (see appendix T, page 287) reveals that the training time varies relative to the type of applicant.

Considering the expenditure of the instructor only Tables III and VI of the criteria document reflect the estimated cost per student for training the inspector and investigator (see appendix T, pages 270 and 272).

The instructional program cost for the state investigator and inspector training can be estimated by making the following assumptions:

(1) Rent, insurance, and utilities for training facility -- $600.00 per month

(2) Equipment: infrared analyzer, scope, hand and miscellaneous tools -- $5,400.00

(3) Teaching supplies:

a. handouts and training books -- $5.00 per student

b. instructional packet -- $240.00

(4) Instructor: $15.00 per hour
Clerical: $ 4.00 per hour

Based on these assumptions, the following Table IV shows an estimated instructional cost of $1,230.00 for a forty (40)-hour state investigator and $480.00 for a twelve (12)-hour inspector training program. The investigator's training would require ten (10) four-hour sessions, whereas the inspector would attend four (4) three-hour sessions.

Table V illustrates the estimated cost of training one inspector student compared to a varied number of students in a class. An identical cost per student comparison for the investigator training is found in Table VI.

TABLE IV

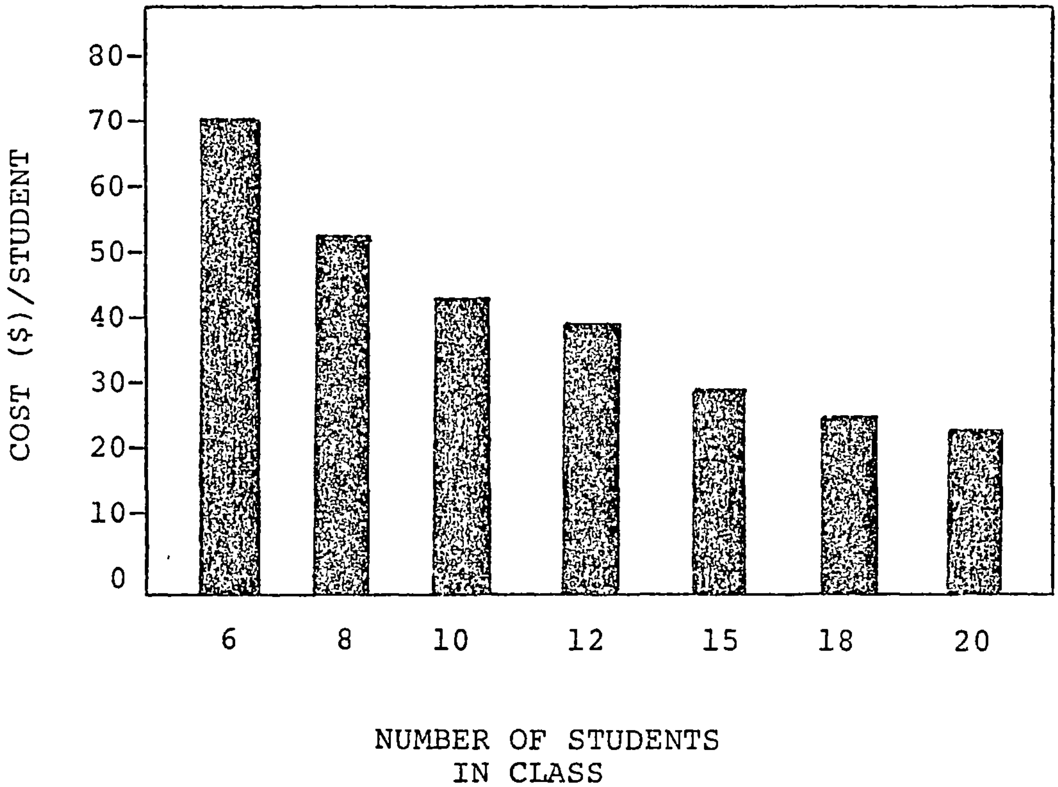
ESTIMATED INSTRUCTION COST FOR
INVESTIGATOR AND INSPECTOR TRAINING

Expenditure	Investigator 10 Session 40-Hr. Training	Inspector 4 Session 12-Hr. Training
Rent, Insurance Utilities	$ 200	$ 80
Equipment	$ 150	$ 60
Teaching Supplies *	$ 120	$ 110
Instructor	$ 600	$ 180
Clerical	$ 160	$ 50
TOTAL	$1230	$ 480

*Based on 20 students per class

TABLE V

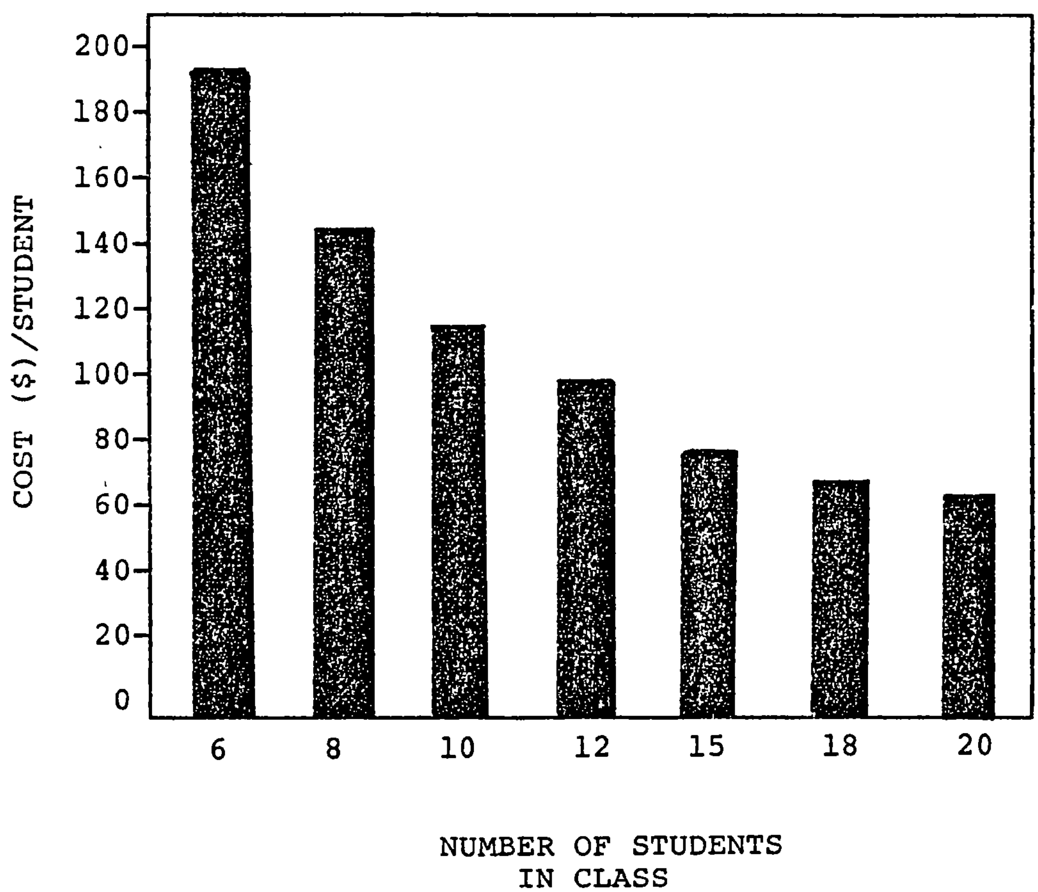
ESTIMATED INSTRUCTION COST ($) PER STUDENT FOR INSPECTOR TRAINING*



*Based on 12 hours of instruction

TABLE VI

ESTIMATED INSTRUCTION COST ($) PER STUDENT FOR INVESTIGATOR TRAINING *



* Based on 40 hours of instruction

Public Information

During the course of the project, the Project Director made three presentations in Colorado, regarding emission control training. As a guest lecturer, the Project Director gave an informative presentation to a class of automotive students at Colorado State University. Another similar presentation was delivered to a class of adult education students at Lakewood High School. Both lecture-presentations covered types of pollutants, vehicle emission systems found on todays automobiles, their purpose and basic operation.

In March, the Colorado Automotive Teachers held a meeting in Denver. The President of the Association asked the emissions staff from Colorado State University to make a presentation to the teachers on our emissions instructional material. A sample of each of the five slide series the project staff at Colorado State University had developed was shown and an explanation of our total media program on vehicle emissions systems was given.

5.0 ANALYSIS OF TEST RESULTS

This section contains the test results from the Colorado Vehicle Emission Control Educational Training Program. The emission training program was provided to twenty-six (26) automotive teachers in addition to eleven (11) graduate and undergraduate students. The automotive teachers were trained in two (2) separate classes. In August, 1974 a vehicle emissions training class was conducted for eleven (11) teachers at the Warren Technical Center in Denver. During the Winter and Spring Quarters of 1975 another emissions class was offered at the Community College of Denver Red Rocks Campus for fifteen (15) automotive teachers. An identical course during the same period was offered on campus at Colorado State University to eleven (11) college automotive students. These two courses were divided into two (2) fifty (50)-hour sections: Emissions I and II, offered Winter and Spring Quarters respectively. Emissions I was basically classroom instruction concentrating on theory, diagnosis, operation of emission control systems, carburetion and ignition systems (see appendix O). The Emissions II class offered the college students and teachers hands-on laboratory experiences related to emission control systems service and diagnostic procedures (see appendix O).

At the beginning of all emission classes, except Emissions II, a pre-test was given to each participant (see appendix S). This pre-test was divided into four (4) categories:

1) General Engine Theory
2) Emission Systems
3) Carburetion
4) Ignition

The pre-test consisted of fifty-two (52) questions and the results from the test were used as a guide in determining the instruction time to be spent in each section.

Shown in Table VII are the mean score results to questions on the pre-test in each of the four (4) categories. The table includes the results from the twenty-six (26) teachers in the class at the Warren Technical Center and the Emissions I class at Community College of Denver Red Rocks. From investigation of the table, it becomes apparent that a concentration of instruction was needed in the emission systems category.

TABLE VII

TEACHER PRE-TEST RESULTS

No. of Teachers	Mean score (%) by category			
	General	Emission Systems	Carburetion	Ignition
26	71.8	58.5	71.4	73.8

Information was gathered on the age, teaching and mechanical experience of each teacher. Table VIII shows the average results for these categories.

TABLE VIII

INFORMATION ON TEACHERS CONCERNING AGE, MECHANIC AND TEACHING EXPERIENCE

No. in class	Average age yrs.	Average mechanic experience yrs.	Average teaching experience yrs.
26	37.3	12.2	4.8

The mechanic experience of the teacher did not necessarily correlate to the number of incorrect responses. The teacher with the least amount of mechanic experience, 2 years, missed 21 questions; the teacher with 31 years of mechanic experience missed 27 questions.

The emissions control class held on campus at Colorado State University for eleven (11) college automotive students were given the same pre-test as the teachers. Table IX provides information on the mean score results in each category from the pre-test given college students.

TABLE IX

COLLEGE STUDENT PRE-TEST RESULTS

No. of Students	Mean score (%) by category			
	General	Emission Systems	Carburetion	Ignition
11	63.6	51.3	61.8	71.7

In addition to the emissions pre-test the teachers and college students that took Emissions I during the Winter Quarter were given an ignition/carburetion pre-test. As stated earlier in this report, the advent of transistorized ignition on most 1975 vehicles warranted the addition of this training to the curriculum. The test contained forty-five (45) questions related only to ignition and carburetion. Ten (10) of the forty-five (45) questions pertained to transistorized ignition systems. Table X reveals the results from this pre-test given to fifteen (15) teachers and eleven (11) college students.

TABLE X

IGNITION/CARBURETION PRE-TEST RESULTS

Type of Participants	Average Missed (45 pts. possible)	Mean Score (%)	Mean Score on Transistorized Ignition Questions (%)
Automotive Teachers	9.6	78.6	62
College Students	11.5	74.4	58

As reflected in Table X the mean score resulting from the ten (10) questions on transistorized ingition systems were considerably lower than for the entire test. It became obvious from the test scores that training was needed in the transistorized ignition area.

At the conclusion of the teacher workshop in the Summer and both Emissions I classes for teachers and students, a post-test was given to each participant. The post-test was identical to the pre-test. It was administered to obtain an evaluation on how the participants had progressed in the areas of vehicle emissions and related categories.

Table XI shows the results from the post-test taken by the twenty-six (26) teachers. The mean scores are listed for each of the four (4) categories identified earlier. Although there was a significant improvement in all the category scores the percentage gain in emission systems was the highest.

TABLE XI

TEACHER POST-TEST RESULTS

No. of Teachers	Mean Score (%) by Category			
	General	Emission Systems	Carburetion	Ignition
26	84.3	73.2	74.4	81.9

The post-test results for the eleven (11) college students are presented in Table XII. Again, as with the teachers, the percentage gain in the emissions systems category was the highest.

TABLE XII

COLLEGE STUDENTS POST-TEST RESULTS

No. of Students	Mean Score by Category			
	General	Emission Systems	Carburetion	Ignition
11	76.3	65.6	69.0	79.4

Table XIII provides a comparison of mean scores from the emissions pre- and post-tests. The teacher and student scores are both presented with the average gain shown in the last column.

TABLE XIII

COMPARISON OF PRE AND POST TEST RESULTS

Type of Participant	Category	Mean Score Pre-test	Mean Score Post-test	Average Gain (%)
Teacher	General	71.8	84.3	12.5
	Emission Systems	58.5	73.2	14.7
	Carburetion	71.4	74.4	3.0
	Ignition	73.8	81.9	8.1
College Student	General	63.6	76.3	12.7
	Emission Systems	51.3	65.6	14.3
	Carburetion	61.8	69.0	7.2
	Ignition	71.7	79.4	7.7

During the last meeting of the teachers' Emission II class, a comprehensive type emissions examination was taken by each of the fifteen (15) automotive instructors (see appendix Q). The test was developed through the efforts of several Colorado teachers and the emissions staff at Colorado State University. The examination is comprised of fifty (50) questions dealing specifically with emission components and systems. The purpose of the test is to better evaluate the knowledge an instructor possesses. Table XIV provides the results from this teacher emission test.

TABLE XIV

RESULTS OF TEACHER EMISSION TEST

No. of Teachers	Average No. Missed	Mean Score (%)
15	12.6	75

As can be seen, the average number of incorrect responses was 12.6 with the range being from 5 to 20. The test cannot be expected to be the ultimate answer in testing the knowledge of an instructor; however, some device(s) must be used and the initial thrust begun at some point. Evaluation and revisions are a necessity of any testing apparatus if it is to remain valid.

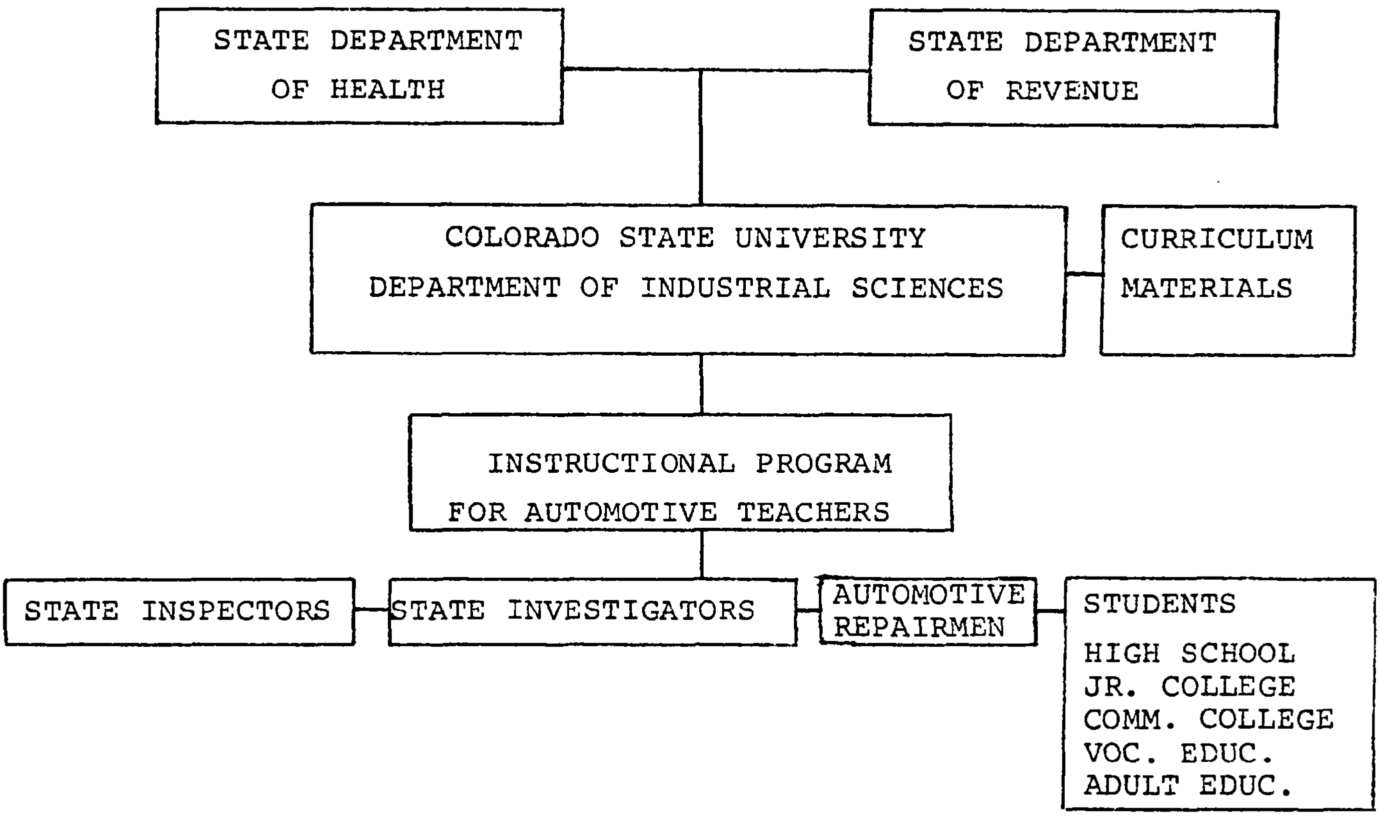
APPENDIX A

MOTOR VEHICLE EMISSION CONTROL DELIVERY SYSTEM MODEL

DELIVERY SYSTEM FOR

INSTRUCTIONAL PROGRAM ON MOTOR VEHICLE

EMISSION CONTROL FOR COLORADO



APPENDIX B

FORTY-HOUR COLORADO TEACHER TRAINING COURSE OUTLINE

COLORADO TEACHER

MOTOR VEHICLE EMISSION CONTROL WORKSHOP

I. Welcome

A. Registration

B. Introduction of participants and staff

C. Objectives and program

D. Pre-test

II. Pollution Problem, State and Local Laws

A. Mr. Don Sorrels - Colorado Department of Health

B. Film (GM, "Emissions in Perspective")

1. Discuss film

III. Basics of Combustion

A. Definition and Formation of Emissions

1. HC, CO, and NOx

B. Compression Ratios and Heat

C. Fuels

D. Film ("New Rules of the Road")

1. Discuss film

IV. Engine Modifications to Reduce Emissions

A. Carburetion

B. Camshafts and Timing

C. Combustion Chambers

D. Valves and Arrangements

E. Pistons and Heads

F. Film ("Service Up, Emissions Down")

1. Discuss film

V. Emissions Control Systems Identification and Purpose

A. Systems - General, Theory

1. PCV

2. Evaporation

3. Heated Air

4. Carburetor Controls

a. Solenoids
b. Choke

5. Air Injection

6. EGR

7. Ignition Timing Controls

a. Temperature
b. Transmission
c. Ported Vacuum
d. Speed

B. Lab Experience

1. Demonstration on Reading Exhaust Analyzer

a. HC-CO
b. Scale Increments
c. Warm-up of Vehicle

2. Emphasis of Engine Condition on Emissions

3. Hands-on Experience

a. Students Read and Record HC-CO Levels on Live Vehicles

C. Film ("Vehicle Emissions Control and Cleaner Air" and "Auto Emissions Control")

1. Discuss films

VI. Emissions Control Systems

A. PCV Controls

1. Open System

2. Closed System

B. Evaporative Controls

1. Tank Overfill

2. Tank Venting

3. Vapor Trapping Methods - Canisters

C. Heated Air Controls of the Air Cleaner

1. Thermostat Controls

2. Vacuum Motor Controls

D. Intake Manifold Heating

1. Heat Riser Valves

2. Exhaust Pipe Restrictors

3. Coolant Heated Manifolds

E. AIR System

1. Pump Design and Operation

2. Air Delivery Plumbing and Check Valves

3. Routing of Air Delivery by Use of Gulp Valve, Diverter Valve and Vacuum Signals During Driving Modes

F. Lab Experience

1. Demonstration: Meter Calibration

2. Effects of Timing and Carburetor Mixtures on HC-CO

G. EGR Controls

1. Exhaust Recycle vs. Engine Operating Modes

2. Vacuum Signal Operation of EGR

VII. Identification and Application of Emissions Controls

A. Controls Functioning During Engine Cranking

1. Distributor and/or retard circuits
2. Solenoid (advance)
3. Dual Vacuum Chamber

B. Controls Functioning at Idle

1. Idle Stop Solenoid - Gets Mixed Up with CEC Valve
2. Chrysler Type Retard Solenoid
3. Dual vacuum Diaphragm
4. 20-second Delay Relay

C. Controls Primarily Functioning in Gears Below High Gear

1. Idle Stop Solenoid
2. Dist. Vacuum Advance Denial Controls
3. Dist. Spark Delay Valves
4. Canister Purge Controls

D. Controls Primarily Functioning in High Gear

1. AIR Controls
2. Decel Valves and Solenoids
3. Idle Circuit Mixture Altering Controls
4. EGR Controls

E. Controls Functioning Above or Below Normal Engine Operating Temperature

1. Staged Choke Controls
2. Air Cleaner Controls
3. Coolant Temperature Activated Vacuum Valves
4. Ambient Air Temperature Sensors

VIII. GM Emissions Control Systems

A. AIR Induction Control

1. Vacuum Motor and Temperature Sensor

B. AIR Control

1. Pump, Pressure Relief Valve, Check Valve

2. Diverter Valve

C. Ignition Controls

1. TSC

2. CEC

3. SCS

IX. American Motors Emissions Control Systems

A. TCS

B. Decel Valves

C. CTO

D. Lab Experience

1. Worksheet #5

A. Effects of Emissions Hardware

X. Chrysler Control Systems

A. Evaporative Controls

B. Ignition Controls

1. Distributor Solenoids

2. TCS

3. OSAC

4. Decel Valve

C. EGR Controls

1. Floor Jets

2. Vacuum Controlled EGR

3. Vacuum Amplifier

XI. Ford Motor Co. Control Systems

A. Evaporative Control

1. Canister and Purge Control

B. Air Induction Control

1. Thermostatic Type

2. Vacuum Motor

C. AIR Control

1. Pump

2. Diverter Valve

D. Ignition Controls

1. Dual Diaphragm Distributor

2. TRS System

3. ESC System

4. TAV System

a. Temperature Sensor

E. EGR System

1. Valve and Control

F. Lab Experience

1. Effects of Fuel and Vacuum on Emissions

APPENDIX C

MOTOR VEHICLE EMISSION CONTROL

REFERENCE MATERIALS

REFERENCE MATERIALS

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APPENDIX D

MOTOR VEHICLE EMISSION CONTROL

LABORATORY WORKSHEETS

CARBURETOR TRANSFER & ANALYZER READINGS

Motor Vehicle Emissions Control Workshop

Lab Worksheet No. 1

Name ______________________________ Team # ________________

Record HC-CO levels from live vehicles at the engine speeds indicated.

Car #1	HC (ppm)	CO (%)
IDLE		
1100 RPM		
1200 RPM		
1300 RPM		
1400 RPM		
2500 RPM		

Car #2	HC (ppm)	CO (%)
IDLE		
1100 RPM		
1200 RPM		
1300 RPM		
1400 RPM		
2500 RPM		

Car #3	HC (ppm)	CO (%)
IDLE		
1100 RPM		
1200 RPM		
1300 RPM		
1400 RPM		
2500 RPM		

TIMING

Motor Vehicle Emissions Control Workshop

Lab Worksheet No. 2

Name ______________________________ Team # ______________

Record HC-CO levels from live vehicles at speeds and conditions listed.

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
1. Idle	Ignition timing at manufacture "specs"		
2. 1100 RPM	Same as #1		
3. 2500 RPM	Same as #1		
4. Idle	Ignition timing advanced 5 degrees over "specs"		
5. 1100 RPM	Same as #4		
6. 2500 RPM	Same as #4		
7. Idle	Full manifold vacuum applied to vacuum advance unit		
8. 1100 RPM	Same as #7		
9. 2500 RPM	Same as #7		
RESET TIMING TO MANUFACTURER'S "SPECS"			
10. Idle	One spark plug wire disconnected		
11. 1100 RPM	One spark plug wire disconnected		
12. Idle	Adjust carburetor idle mixture screws until lowest HC and CO combination is obtained		

Page 2, Lab Worksheet #2

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
13. Idle	Turn both I.M.S. one turn lean from #12 test		
RESET I.M.S. TO LEAN BEST IDLE CONDITION			
14. Idle	Turn both I.M.S. one turn rich		
RESET I.M.S. TO LEAN BEST IDLE CONDITION			
15. Idle	Turn right I.M.S. one turn lean; turn left I.M.S. one turn rich		
RESET I.M.S. TO LEAN BEST IDLE CONDITION			
16. Idle	Adjust idle mix screws until <u>lowest CO</u> reading is reached		

READJUST IDLE SCREWS AND SPEED TO "SPECS"

Page 3, Lab Worksheet #2

1. Explain the effects of advanced timing on:

   a. CO

   b. HC

2. Explain the variance between the HC and CO readings for:

   a. One plug wire disconnected at idle as compared to all connected

   b. One plug wire disconnected at 1100 RPM as compared to all connected

3. Explain variance between the HC and CO readings for:

   a. Both carb screws lean

   b. One carb screw rich, one lean

FUEL PRESSURE

Motor Vehicle Emissions Control Workshop

Lab Worksheet No. 3

Name ______________________________ Team # ______________

Record HC-CO levels from live vehicles at speeds and conditions listed.

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
1. Idle	Normal Fuel Pump Pressure ______________ Normal Fuel Pump Volume ______________		
2. Idle	Fuel Pump Pressure Two PSI less than in #1		
3. 2500 RPM	Fuel Pump Pressure Two PSI less than in #1		
4. Idle	Fuel Pump Pressure 1/2 Value of Reading in #1		
5. 2500 RPM	Fuel Pump Pressure 1/2 Value of Reading in #1		
6. 1500 RPM	Reduce Fuel Pump Pressure Gradually Until Distinct Changes in HC and/or CO Readings occur and record levels Fuel Pump Pressure ________		
7. Idle	Disconnect at Carburetor the vacuum hose for the Thermostatic Air Cleaner (Air Leak: carburetor)		
8. 2500 RPM	Same condition as #7		

Page 2, Lab Worksheet #3

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
9. Idle	Remove Vacuum Tap Plug from manifold (Localized Air Lead)		
10. Idle	Connect Vacuum Gauge to Engine: Loosen Base Nuts on carburetor and cause Vacuum Reading to drop 5" from normal reading		
11. Cranking	No leaks or disconnected hoses; record cranking vacuum Vacuum ________________	X	X
12. Cranking	Remove PCV Valve hose from vacuum source Vacuum ________________	X	X
13. Idle	Plugged PCV Valve		
14. 1100 RPM	Plugged PCV Valve		
15. 2500 RPM	Plugged PCV Valve		
16. Idle	PCV Valve Removed		
17. 1100 RPM	Same as #16		
18. 2500 RPM	Same as #16		

TRANSMISSION SWITCH & IDLE

Motor Vehicle Emissions Control Workshop

Lab Worksheet No. 4

Name ______________________________ Team # ________________

Record HC-CO levels from live vehicles at speeds and conditions listed.

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
1. Idle	Adjust idle mixture screws until lowest HC-CO combination is obtained.		
2.	Raise rear wheels up and place on stands. Shift to drive position and accelerate slowly noting at what RPM the transmission shifted into high. Maintaining this speed and RPM take readings.		
3.	Transmission in neutral and same RPM as in #2.		
4.	Manifold vacuum when transmission is in high. (Same as #2)	Vacuum __________	
5.	Transmission in neutral and RPM at same speed as in #2 and #3.	Vacuum __________	
6.	Adjust idle speed and mixture to "specs."		
7.	Idle speed 25 RPM below "specs."		

Page 2, Lab Worksheet #4

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
8.	Idle speed 50 RPM below "specs."		
9.	Idle speed 75 RPM below "specs."		
10.	Idle speed 25 RPM above "specs"		
11.	Idle speed 50 RPM above "specs."		
12.	Idle speed 75 RPM above "specs."		
13. Idle 13a. 1100 RPM 13b. 2500 RPM	None (Reference) None (Reference) None (Reference)		
14.	Heat door closed on air cleaner.		
15. 1100 RPM	Heat door closed on air cleaner.		
16. 2500 RPM	Heat door closed on air cleaner.		
	VEHICLE ON DYNO LOAD		
17. 1100 RPM	Plug air filter by wrapping tape around it until HC-CO reading changes from #13 reading.		
18. 2500 RPM	Same as #17 (use readings in #13 as reference)		

EVAPORATIVE & AIR SYSTEMS

Motor Vehicle Emissions Control Workshop

Lab Worksheet #5

Name ______________________ Team # __________

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
1. Idle	All Systems Normal (Reference)		
2. 1200 RPM	All Systems Normal (Reference)		
3. 2500 RPM	All Systems Normal (Reference)		
4. Idle	Canister Purge Line Disconnected and Plugged		
5. 1200 RPM	Canister Purge Line Disconnected and Plugged		
6. 2500 RPM	Canister Purge Line Disconnected and Plugged		
7. Idle	Disconnect Drive Belt or Delivery Hose(s) From AIR Pump to Exhaust Manifold(s)		
8. 1200 RPM	Same as #7		
9. 2500 RPM	Same as #7		

Page 2, Lab Worksheet #5

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
10. 1200 RPM	Decelerate Quickly and Note Highest HC-CO Readings		
11. 1200 RPM	Disconnect and Plug Vacuum Line To AIR By-Pass Valve; Decelerate and Note Highest HC-CO Readings		
12. Idle	Disconnect any Manifold Vacuum Hose and Pour in a Few Drops of Chem-Tool Cleaner into Line		
13. Idle	Squirt Small Amounts of Chem-Tool Around Carburetor Throttle Shaft Bushings		
14. 1000 RPM	Disconnect One Spark Plug Wire at a Time Noting HC-CO Readings. (Run Test Like a Cylinder Balance Test)	Cylinder # 1 2 3 4 5 6 7 8	

DIAGNOSTIC

Motor Vehicle Emissions Control Workshop

Lab Worksheet No. 6

Name ______________________________ Team # ______________

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
1. Idle	Do Not Calibrate or Span Analyzer After Warm-Up and Run HC-CO Test		
2. Idle	Calibrate and Span Analyzer and Repeat Test #2		
3. Engine Stopped	After Engine Has Warmed Up to Operating Temperature, Use Probe of Analyzer to Sniff Out Fuel Vapor and Liquid Leaks Around the Following: a. Fuel Pump, Fittings and Hose b. Carburetor c. Fuel Tank d. Charcoal Canister		
4. 1000 RPM	Disconnect All Plug Wires to Cylinders Fed by Right Carb. Barrel		
5. 1000 RPM	Disconnect all Plug Wires to Cylinders Fed by Left Carb. Barrel		
6. Idle	All Systems Normal Adjust to Lean Best Idle.		
7. 1200 RPM	Normal		

Page 2, Lab Worksheet #6

ENGINE SPEED	CONDITION INDUCED	HC (ppm)	CO (%)
8. 1500 RPM	Normal		
9. 2500 RPM	Normal		
10. Idle	Vacuum to EGR to Trip Open Manually		
11. Idle	Disconnect and Plug Vac. Line to EGR Valve		
12. 1200 RPM	Disconnect and Plug Vac. Line to EGR Valve		
13. 15 RPM	Disconnect and Plug Vac. Line to EGR Valve		
14. 2500 RPM	Same as #13		

APPENDIX E

PROJECT ASSUMPTIONS

ASSUMPTIONS

The motor vehicle emission control instructional materials packet is designed to be used by vocational automotive teachers. These teachers are expected to supplement this instructional packet with models, mock-ups, films, charts, and hands-on experiences. These materials cover the following motor vehicle emission control systems in depth: Air Injection Reaction, Exhaust Gas Recirculation, Fuel Evaporation, Positive Crankcase Ventilation, and Thermostatic Air Cleaner.

Utilizing tests and subjective evaluation, the teacher should be able to determine the depth of material to be presented. This depth will be dictated by the needs of the participants. The length of the instruction will depend upon the participants' ability.

The following assumptions were considered in the development of the instructional materials packet.

1. Instructional materials are designed for teacher use.
2. Teachers will be familiar with carburetion, electrical, and engine theory.
3. Teachers will be familiar with emission systems.

4. Teachers will be familiar with electrical test equipment.
5. Teachers will be familiar with diagnostic procedures.
6. Teachers will be familiar with the effective use of instructional media.
7. All teachers will have trade experience.

APPENDIX F

MOTOR VEHICLE EMISSION CONTROL

CURRICULA OUTLINE

EMISSIONS COURSE OUTLINE FOR AUTOMOTIVE INSTRUCTORS

I. Introduction

A. Air Pollution - cause and effect

1. HC, CO, NO_x - defined and explained

2. Basics of Combustion Engine Operation and Emissions.

3. Formation of Emissions in Pre-Controlled Vehicles.

a. Film: Chemistry of Combustion

4. External Controls to Reduce Emissions

a. Function and Purpose of Each

1) positive crankcase ventilation

2) heated air intake

3) transmission controlled spark

4) fuel evaporative system

5) air injection system

6) exhaust gas recirculation

7) catalytic converter

8) thermal reactor

9) high energy ignition

B. Laws and Regulations

1. State

2. Federal

3. Inspection/Maintenance

a. lab experience - visual identification on systems of cars in shop using EPA systems book.

C. Introduction to Infrared Analyzer

1. Principles of Operation

2. Pre-Testing Preparations

a. engine at normal operating temperature

b. correct calibration and span

c. correct hook-up

3. Care

a. filters

b. volume of air flow check

c. hose and fitting leaks

4. Lab Experience

a. on car testing

1) HC-CO readings from live lab cars.

II. Ignition Systems

A. Pre-Controlled Systems

1. Theory and Purpose of Ignition System

a. basic electricity

1) volts, amps, ohms

b. ignition system components; construction and operation

c. diagnostic procedure in locating problems

1) emissions vs. ignition

B. Modified Ignition Controls

1. Ignition Timing Effects on Emissions
    a. HC, CO, NO_x
    b. advance controls for reducing emissions
        1) dual diaphragms
        2) electric solenoids controlling vacuum supply
        3) modified advance curves
        4) lab experience: ignition timing changes and effects on HC-CO emissions

C. Electronic Ignition
1. Purpose and Advantages
2. Theory of Operation
    a. component identification (general to all manufacturers)
3. Specific Manufacturers Systems
    a. Chrysler
        1) component testing
    b. GM
        1) component testing
    c. Ford
        1) component testing

III. Carburetion Systems

A. Pre-Controlled
1. Carburetion Principles
    a. pressure and effects

1) purpose of vacuum

b. carburetor vacuum principles

1) types of vacuum

a) manifold

b) ported

c) venturi

c. carburetor circuits

1) jetting and power valves

a) effects, advantages, disadvantages

d. air cleaners

1) filters

e. fuel system demands

1) engine speed and load vs. fuel requirements

f. diagnostic procedure

1) locating problem area

B. Carburetor Modifications

1. Idle Mixture Limiters

a. purpose as related to HC-CO

2. Idle Stop Limiters

a. function

3. Combination Valves (C.E.C.)

a. operational checks and function

b. decel valves

4. Venting

a. internal

b. external

5. Adjustments and Service
    a. idle mixture screws
    b. float level
    c. idle and deceleration speeds
6. Chokes: Checks and Adjustments
    a. vacuum breaks
    b. water heated
    c. electric
    d. staged
    e. lab experience
        1) effects of lean and rich mixtures on HC-CO
        2) set
            a) idle mixture screws for lean-best idle
            b) check choke "specs"
            c) idle stop solenoids
7. Exhaust Restrictions and Controls
    a. heat riser
        1) service
        2) vacuum operated type
    b. restrictor pipes
    c. exhaust system problems

IV. Engine Modifications

M.M. Film: Engine Modification Systems

A. Cam Shafts

  1. Overlap Variations

    a. purpose and function

B. Valves, Ports, and Valve Arrangement

C. Intake Manifolds

  1. heat ribs

  2. water heated

  3. crossover passage

D. Exhaust Manifolds

  1. flow design

    a. with air injection

  2. scavanging

E. Combustion Chambers

  1. Reduction of Quench Area

    a. changes in contoured shape of combustion chamber

      1) reduction of quench area with improved head gaskets

    b. closer parts mating

    c. piston ring placement and alteration

    d. compression ratio modification and effects relating to HC and CO

      1) cylinder heads

      2) effects on combustion temperature-NO_x

      3) temperature effects on emissions-NO_x

F. Engine Operating Temperature

1. Operating Temperature Changes
    a. 1968-72 models
    b. 1972-75
2. Effects of Pressure Caps on System
    a. sealed systems

V. Positive Crankcase Ventilation (PCV)
  A. Principle and Purpose of Crankcase Ventilation
     C.S.U. Slides: "P.C.V."
  B. Types of Ventilation Control
    1. Type 1: Open-Valve controlled by intake manifold vacuum.
    2. Type 2: Open-Valve controlled by crankcase vacuum. (West Coast type valve)
    3. Type 3: Open-Tube to Air Cleaner
    4. Type 4: Closed-Combination System
        a. hose routing
    5. Correct P.C.V. Valve Application by Model and Year
        a. servicing and checking
  C. Lab Experience:
    1. effects of P.C.V. on emissions
    2. HC-CO readings with correct, incorrect, plugged and open P.C.V. valves

VI. Thermostatic Air Cleaners

A. Principle and Purpose of T.A.C.

Slides: C.S.U. - "T.A.C."

1. Better Cold Operation Driveability
2. Leaner Air/Fuel Mixtures
3. Reduction of Emissions HC and CO
4. Lab Experience: Check hose routing and condition, proper door operation, temperature sensor and vacuum motor.
   a. thermostatic type: check thermostat operating temperatures

VII. Air Injection Systems

Slides: C.S.U. A.I.R.

A. System Components

1. Pump Design and Operation
2. Air Delivery Plumbing and Check Valves
3. Pressure Relief Valves
4. Gulp Valves and Operation
5. Routing of Air Delivery by Use of Diverter Valve
   a. diverter valve operation
   b. vacuum signals to diverter valve generated by driving modes

      lab experience:

      1) effects of A.I.R. on HC-CO analyzer readings with A.I.R. functioning and then disconnected

c. checking and testing:

1) check hose routing

2) pump output

3) check valve operation

4) relief valve

5) diverter valve operation

VIII. Fuel Evaporative System

Slides: C.S.U. Fuel Evaporative Systems

A. Fuel Tanks

1. Tank Expansion Space

2. Filler Neck Location Limiting Overfill

3. Tank Venting

4. Caps: No Vent and Pressure Relief

a. vacuum and pressure relief valves

B. Liquid Vapor Separators

1. Tube-Type

2. Separator with Float

C. Fuel Line:

1. Routing and Construction

2. In Line Valves

a. overfill limiting valves

b. 3-way combination valves (Ford)

D. Vapor Storage

1. Crankcase

a. purging

2. Carbon Canister
    a. construction and purpose
    b. connections and location
    c. service of canister
    d. purge methods
        1) variable
        2) constant
        3) combination constant-demand
3. Carburetor Bowl Venting
    a. carburetor vent valve
    b. routing of vent vapors to canister
4. Lab Experience - Check and Test
    a. hose routing and type of evaporative system
    b. check leaks with HC and CO meter
    c. canister and filters
    d. fuel tank cap

IX. Spark Controlled Systems

A. Purpose, Similarity and Differences by Manufacturers
1. Reduction of HC, CO, NO_x
2. The Necessity of Manuals and Specifications

B. Ignition Timing Controls
1. Temperature Switches (Ambient and Coolant)
2. Transmission Switches
3. Ported Vacuum
4. Speed Sensors (In Cable)
    a. amplifier modules

5. Solenoids
6. Time Relays
7. Spark Delay Valves (Vacuum)
8. Distributor Vacuum Advance Control Valve (Deceleration)
9. Overheat Protection Devices and Switches

C. American Motors System

Slides: Mitchell Manuals

1. Spark Control Systems
    a. principles of transmission controlled spark system
        1) solenoid vacuum valve
        2) transmission switches
        3) temperature switches
        4) vacuum and electrical circuits

D. General Motors System

Slides: Mitchell Manuals

1. Principles of Spark Control Systems
    a. transmission controlled spark (TCS)
        1) vacuum advance solenoid
        2) transmission switch
        3) temperature switch
        4) delay relay
    b. combination emission control (CEC)
        1) CEC solenoid
        2) idle stop solenoid
        3) transmission switch

4) 20 second time relay

5) temperature switch

c. speed controlled spark (SCS)

1) speed control switch

2) vacuum solenoid

3) thermal vacuum switch

2. Lab Experience

E. Chrysler System

Slides: Mitchell Manual

1. Principles of Spark Control Systems

a. vacuum advance control valve (deceleration)

b. distributor advance solenoid

c. retard distributor retard solenoid

d. NO_x system (1971-72)

1) solenoid vacuum valve

2) transmission switches

3) vacuum and thermal switches

4) speed switch

e. orifice spark advance control system (1973-)

1) OSAC valve

2) temperature sensor

3) vacuum by-pass valve

2. Lab Experience

F. Ford System

Slides: Mitchell Manuals

1. Principles of Spark Control Systems

   Film: Ford ESC

   a. electronic spark control system

      1) speed sensor
      2) electronic amplifier
      3) solenoid vacuum control valve
      4) temperature switch
      5) ported vacuum switch (PVS)

   b. transmission regulated spark (TRS)

      1) vacuum control valve
      2) transmission switch
      3) ambient temperature switch
      4) ported vacuum switch (PVS)
      5) spark delay valve
      6) dual diaphragm distributor

   c. EGR/CSC system

      1) port and EGR vacuum
      2) coolant temperature PVS
      3) spark delay valve
      4) check valve
      5) EGR/PVS valve
      6) overheat protection

         a) thermal vacuum switches

2. Lab Experience

X. Exhaust Gas Recirculation (EGR)

A. Purpose and Principles

1. Reduce NO_x

2. Reduce Combustion Temperature

Slides: C.S.U. and Mitchell Manual

B. EGR Controls

1. Exhaust Recycle Requirements vs. Engine Operating Modes

2. EGR Delivery and Metering

a. floor jets

b. floor entry

1) EGR valve operation

3. Vacuum Signal Operation of EGR

a. cold override

b. control of EGR at idle

c. wide open throttle

1) vacuum and cut-off controls

d. vacuum amplifier

1) purpose and operation

e. exhaust pressure transducer

f. servicing EGR valve

C. Lab Experience: Check and Test

1. hose routing and connections

2. vacuum source valves

3. CTO switch operation

4. vacuum amplifier operation

5. vacuum reservoir
6. EGR valve

XI. Catalytic Converters

A. Construction and Chemical Principle

1. Pellet
2. Monolith
3. Precautions Due to Converter
    a. shielding
    b. insulation
    c. heat
    d. operating temperature - pellet monolith
    e. damage due to:
        1) fuel
        2) heat
        3) harmful diagnostic practices
        4) moisture
        5) road hazard
        6) output of hazardous materials
    f. HC-CO testing on converter equipped vehicles.

XII. New and Upcoming Auto Emission Devices

A. Carburetion

1. Carburetor Modifications
2. Fuel Injection

APPENDIX G

MOTOR VEHICLE EMISSION CONTROL

BEHAVIORAL OBJECTIVES

AIR INJECTION REACTION

Behavioral Objectives

Upon completion of the slide series and instructor-related teaching materials, the student will be able to:

1. Identify the process in which the Air Injection Reaction system reduces pollution from the automobile engine.

    1.1 State how the Air Injection Reaction system is effective in reducing engine emissions.

    1.2 Name the harmless gas created by the Air Injection Reaction system in the exhaust manifold.

    1.3 State how water is formed in the exhaust system by the Air Injection Reaction system.

    1.4 Name the two ways air is obtained by the air pump for delivery to the Air Injection Reaction system.

    1.5 State the two ways of routing the air to the exhaust system.

2. Identify and state the purpose of each component that comprises the Air Injection Reaction system.

    2.1 Identify and state the purpose of the air pump.

    2.2 Identify and state the purpose of the diverter valves.

    2.3 Identify and state the purpose of the gulp valve.

    2.4 Identify and state the purpose of the anti-backfire valve.

    2.5 Identify and state the purpose of the air by-pass valve.

3. Identify and state the function of each component that comprises the Air Injection Reaction system.

    3.1 State the function of the air pump in the Air Injection Reaction system.

3.2 State the function of the diverter valve in the Air Injection Reaction system.

3.3 State the function of the gulp valve in the Air Injection Reaction system.

3.4 State the function of the anti-backfire valve in the Air Injection Reaction system.

3.5 State the function of the air by-pass valve in the Air Injection Reaction system.

4. State the inspection and maintenance procedure for the Air Injection Reaction system.

4.1 State the inspection and maintenance required by the air injection inlet filtering element.

4.2 State the inspection and maintenance procedure for tightening the air pump drive belt.

4.3 State the procedure used to inspect the complete Air Injection Reaction system.

4.4 State the procedure used to inspect the check valve.

4.5 State the procedure used to inspect the air pump discharge.

5. State the testing procedures for each component of the Air Injection Reaction system.

5.1 State the procedure used to test the air pump.

5.2 State the procedure for testing the gulp valve.

5.3 State the procedure used to test the diverter valve.

5.4 State the procedure for testing the check valve.

5.5 State the procedure for testing the Air Injection Reaction system for leaks with engine operating.

EXHAUST GAS RECIRCULATION

Behavioral Objectives

Upon completion of the slide series and instructor-related teaching materials, the student will be able to:

1. Identify the process by which the exhaust gas recirculation system reduces pollution from the automotive exhaust.

    1.1 Identify the three major components of air and their respective percentage.

    1.2 State the definition of an inert gas.

    1.3 State the conditions at which nitrogen will react with other gases.

    1.4 State the date which the automobile industry first started using the exhaust gas recirculation system.

    1.5 State the amount of NO_x pollutants allowed by the current federal standards.

2. Identify and state the purpose of each component that comprises the exhaust gas recirculation system.

    2.1 Identify and state the purpose of the exhaust gas recirculation valve.

    2.2 Identify and state the source of vacuum used to control the exhaust gas recirculation valve.

    2.3 Identify and state the purpose of the pintle and pintle seat.

    2.4 Identify and state the purpose of the EGR-CTO switch.

    2.5 Identify and state the purpose of the transducer.

    2.6 Identify and state the purpose of the vacuum amplifier.

3. Identify and state the function of each component that comprises the exhaust gas recirculation system.

    3.1 State the function of the EGR valve.

    3.2 State when vacuum is made available to the EGR valve.

    3.3 State the function of the applied vacuum to the EGR valve.

    3.4 State the function of the EGR-CTO switch.

    3.5 Identify and state the function of the vacuum amplifier.

4. State the inspection and maintenance procedures for each component of the exhaust gas recirculation system.

    4.1 State intervals the EGR valve should be inspected.

    4.2 State intervals EGR valve should be cleaned and/or replaced.

    4.3 State reasons for inspecting and/or replacing vacuum lines.

    4.4 State the type of maintenance required for each component of the EGR system.

    4.5 State four reasons that can create malfunctioning of EGR valve.

5. State the testing procedures for each component of the exhaust gas recirculation system.

    5.1 State procedures used for testing EGR valve.

    5.2 State procedures used for testing EGR-CTO switch.

    5.3 State procedures used for testing EGR transducer.

    5.4 State two purposes of vacuum readings used in test procedures.

    5.5 Successfully conduct testing procedures utilizing specification manuals.

FUEL EVAPORATIVE CONTROL

Behavioral Objectives

Upon completion of the slide series and instructor-related teaching materials, the student will be able to:

1. Identify the process in which the Fuel Evaporative Control system reduces pollution from the automobile.

   1.1 Name the two areas of the automobile that hydrocarbon vapors dissipate.

   1.2 State the period during which the most evaporative losses occur from the automobile.

   1.3 State the year that all automobile manufacturers equipped their vehicles with evaporative control devices.

   1.4 State how the Fuel Evaporative Control system reduces the entrance of hydrocarbon vapors into the atmosphere.

   1.5 State the approximate percentage of the total automobile emissions that are contributed by the gasoline hydrocarbon vapors that evaporate from the carburetor and fuel tank.

2. Identify and state the purpose of each component that comprises the Fuel Evaporative Control system.

   2.1 Identify and state the purpose of the fuel tank filler cap.

   2.2 Identify and state the purpose of an external expansion tank.

   2.3 Identify and state the purpose of a liquid vapor separator.

   2.4 Identify and state the purpose of the carbon canister.

   2.5 Identify and state the purpose of the three-way overfill valve.

3. Identify and state the function of each component that comprises the Fuel Evaporative Control system.

    3.1 State the function of the fuel tank filler cap in relation to both pressure and vacuum.

    3.2 State the function of the internal and external expansion tanks.

    3.3 State the function of the liquid vapor separator.

    3.4 State the function of the carbon canister.

    3.5 State the function of the three-way overfill valve.

4. State the inspection and maintenance procedures for the Fuel Evaporative Control system.

    4.1 State the inspection procedure used to inspect the fuel tank filler cap.

    4.2 State purpose for inspecting hoses and connections of Fuel Evaporative Control system.

    4.3 State the procedure for inspecting the carbon canister.

    4.4 State the procedure for inspecting the liquid vapor separator.

    4.5 State procedure used to inspect three-way overfill valve.

5. State the testing procedures for each component of the Fuel Evaporative Control system.

    5.1 State the procedure used to test the fuel tank filler cap.

    5.2 State the procedure used to test the liquid vapor separator.

    5.3 State the method used to test the three-way overfill valve.

    5.4 State procedure to be used when inspecting carbon canister.

    5.5 State method of testing liquid check valve.

POSITIVE CRANKCASE VENTILATION

Behavioral Objectives

Upon completion of the slide series and instructor-related teaching materials, the student will be able to:

1. Identify the process in which the Positive Crankcase Ventilation system reduces pollutants from the automobile engine.

    1.1 Name the four types of Positive Crankcase Ventilation systems.

    1.2 State steps utilized by the type I Positive Crankcase Ventilation system for crankcase ventilation.

    1.3 State steps utilized by the type II Positive Crankcase Ventilation system for crankcase ventilation.

    1.4 State steps utilized by the type III Positive Crankcase Ventilation system for crankcase ventilation.

    1.5 State steps utilized by the type IV Positive Crankcase Ventilation system for crankcase ventilation.

2. Identify and state the purpose of each component that comprises the Positive Crankcase Ventilation system.

    2.1 Identify and state the purpose of the Positive Crankcase Ventilation Valve in the backfire position.

    2.2 Name the three harmful blow-by products controlled by the Positive Crankcase Ventilation system.

    2.3 Identify and state the purpose of the Positive Crankcase Ventilation Valve.

    2.4 Identify and state the purpose of the West Coast Control Valve.

    2.5 Identify and state the purpose of the two filtering elements found in the Positive Crankcase Ventilation system.

3. Identify and state the function of each component that comprises the Positive Crankcase Ventilation system.

    3.1 State the function of the backfire position of the Positive Crankcase Ventilation Valve.

    3.2 State the function of the Positive Crankcase Ventilation Valve.

    3.3 State the function of the West Coast Control Valve.

    3.4 State the function of the Positive Crankcase Ventilation Valve during the three basic modes of operation.

    3.5 State the function of the filtering elements found in the Positive Crankcase Ventilation system.

4. State the inspection and maintenance procedures for the Positive Crankcase Ventilation system.

    4.1 State the procedure used to inspect the two filtering elements found in the Positive Crankcase Ventilation system.

    4.2 State the recommended maintenance required by the two filtering elements.

    4.3 State the procedure used to inspect the Positive Crankcase Ventilation Valve.

    4.4 State the recommended maintenance required by the Positive Crankcase Ventilation Valve.

    4.5 State the recommended inspection maintenance procedure to be used for the Positive Crankcase Ventilation system.

5. State the testing procedures for each component of the Positive Crankcase Ventilation system.

    5.1 State the procedure for testing the Positive Crankcase Ventilation Valve.

    5.2 State the procedure for testing the Positive Crankcase Ventilation Valve using the "AC" tester.

    5.3 Name the steps used to conduct the RPM Drop Test.

5.4 Name the steps used to conduct the Crankcase Vacuum Draw Test.

5.5 Name the steps required for testing the total Positive Crankcase Ventilation system using the "AC" tester.

THERMOSTATIC AIR CLEANER

Behavioral Objectives

Upon completion of the slide series and instructor-related teaching materials, the student will be able to:

1. Identify the process in which the thermostatic air cleaner system reduces pollutants from the automotive exhaust.

    1.1 State how the Thermostatic Air Cleaner system helps in reducing exhaust emissions.

    1.2 Name three (3) benefits the automobile engine derived from the Thermostatic Air Cleaner system.

    1.3 Identify the process in which the thermostatic air cleaner system reduces pollutants from the automotive exhaust when the ambient temperature is below 85° F.

    1.4 Identify the process in which the thermostatic air cleaner system reduces pollutants from the automotive exhaust when ambient temperature is above 120°F.

    1.5 Identify the two types of thermostatic type air cleaners that help control exhaust pollutants.

    1.6 Identify the three operating modes of the thermostatic air cleaner system.

2. Identify and state the purpose of each component that comprises the thermostatic air cleaner system.

    2.1 Identify and state the purpose of the air valve door.

    2.2 Identify and state the purpose of the thermostat.

    2.3 Identify and state the purpose of the vacuum motor.

    2.4 Identify and state the purpose of the temperature sensor.

    2.5 Identify and state the purpose of the thermostatic air cleaner duct and shroud.

3. Identify and state the function of each component that comprises the Thermostatic Air Cleaner system.

    3.1 Identify and state the function of the spring on the thermostat of the Thermostatic Air Cleaner system.

    3.2 Identify the position of the air valve door in each of the three operating modes.

    3.3 Identify and state the function of the three positions of the air bleed valve in the temperature sensor.

    3.4 Identify and state the function of the shroud and duct work of the Thermostatic Air Cleaner system.

    3.5 State the function of the vacuum motor.

4. State the inspection and maintenance procedures for each component of the Thermostatic Air Cleaner system.

    4.1 Identify the three reasons that make inspecting the thermostat important.

    4.2 State the procedure used to inspect the vacuum motor.

    4.3 State the procedure used to inspect the temperature sensor.

    4.4 Identify the three reasons that make inspecting the air valve door important.

    4.5 State the procedure used to inspect the duct and shroud of the Thermostatic Air Cleaner system.

5. State the testing procedures for each component of the Thermostatic Air Cleaner system.

    5.1 Name the three steps to be taken when checking the thermostatic air cleaner linkage.

    5.2 State the procedure used to test for the three operating modes of the Thermostatic Air Cleaner system.

    5.3 State two procedures used to test the thermostat in the shroud of the Thermostatic Air Cleaner system.

5.4 Name the four steps used in testing the vacuum motor of the Thermostatic Air Cleaner system.

5.5 Identify the procedure for testing the temperature sensor of the Thermostatic Air Cleaner system.

APPENDIX H

MOTOR VEHICLE EMISSION CONTROL

SLIDE NARRATIONS

AIR INJECTION REACTION SYSTEM

This slide series will explain the major components and concepts that enables the engine to reduce hydrocarbons and carbon monoxides.

Upon completion of this slide series and instructor-related supplementary materials, the student will be able to:

1. Identify the process in which the Air Injection Reaction system reduces pollution from the automobile engine.
2. Identify and state the purpose of each component that comprises the Air Injection Reaction system.
3. Identify and state the function of each component that comprises the Air Injection Reaction system.
4. State the inspection and maintenance procedure for the Air Injection Reaction system.
5. State the testing procedures for each component of the Air Injection Reaction system.

AIR INJECTION REACTION

NARRATIVE

Slide

101. Title

102. Different manufacturers call the air injection system by different names but the function is the same. American Motors calls it "Air Guard". Chrysler Corporation calls it "Air Injection". Ford Motor Company calls it "Thermactor". General Motors Corporation calls it "AIR" or "Air Injection Reactor".

103. This slide shows a typical "Air Injection" equipped engine with the necessary components and air delivery plumbing to the exhaust manifold.

104. The air injection system uses an air pump as a source of air. It also has a "diverter" or air by-pass valve to prevent backfire in the exhaust system during deceleration. When the engine decelerates there is low pressure in the cylinder because the throttle valve is closed preventing air from filling the cylinder on the intake stroke. Under this condition the mixture is too rich to burn in the cylinder and a raw fuel

air mixture is pushed into the exhaust manifold. If the air injection system added air to this mixture a burn would take place in the exhaust system causing a backfire. The diverter valve shuts air injection off during the initial 1 to 3 seconds of deceleration thereby preventing a backfire.

105. After the air flows through the anti-backfire valve it flows through a hose or pipe to the check valve. The check valve is open anytime the pressure in the air injection system is higher than the pressure in the exhaust system. The check valve prevents the back flow of exhaust gas in the event of a pump failure or during times when exhaust pressure is higher than the air injection system pressure. After the check valve, the air flows into the air manifold for distribution into each exhaust port near the exhaust valve.

106. The pump, air by-pass valve, check valve and injection manifold are connected with hoses and pipes to complete the system.

107. This shows an air injection system connected to a V-8 engine. You will notice it has an air injection manifold for each bank of cylinders.

108. The air flow during operation is from the pump to the

outlet hose, through the diverter or by-pass valve and connecting hose to the check valve and into the air manifold for distribution to each exhaust valve port.

109. The air injection system reduces carbon monoxide and hydrocarbon emissions by injecting a flow of air into the hot exhaust gases. This oxygen from the air pump combines with the carbon monoxide-CO-to form CO_2 or carbon dioxide, a harmless gas. It also combines with the hydrocarbons-HC-to produce H_2O-or water, usually in vapor form. Therefore, the air injection reaction system reduces both hydrocarbons and carbon monoxide.

110. This illustration is typical of how the belt driven air pump is mounted on the front of the engine.

111. This illustration is a simplified view of the inside of the air pump. The arrows show the movement of air by the vanes through the pump. The number of vanes vary from 2 to 5.

112. Air enters the air pump in either of two ways. One is by an air intake filter shown here, or . . .

113. ...through centrifugal fan filter shown in this picture.

The centrifugal filter is by far the most popular.

114. Output air from the pump leaves the exhaust connection of the pump and flows into the connecting hose leading to the diverter valve and on to the exhaust port near the exhaust valve.

115. Maximum pressure from the pump is limited to prevent exhaust system overheating at high speeds either by a pressure relief valve on the pump or . . .

116. ...by the use of a combination pressure regulator diverter valve that "dumps" excessive pump pressure to the atmosphere.

117. Two types of diverter or anti-backfire valves are used. One type, the gulp valve, allows pump air to be sent to the intake manifold on deceleration to dilute the rich mixture preventing backfire. The by-pass type valve prevents air from entering the air injection manifold by venting the pump air to atmosphere during deceleration.

118. The gulp valve operates when intake manifold vacuum reaches about 20-22 inches of HG. This vacuum pulls the diaphragm down against spring force, opening the air valve to vent pump air to the intake manifold. This venting takes place for 1 to 3 seconds of initial

deceleration which is the critical time for backfire to occur.

119. This picture shows a cutaway view of the diverter valve. Parts shown are the diaphragm and spring, stem, valve plates and manifold vacuum entrance.

120. When the engine is operating, vacuum is applied to both sides of the diaphragm equally by means of a timing orifice in the diaphragm. The diaphragm spring raises the stem and unseats the upper valve plate.

121. The air flow under this condition flows in from the pump through the diverter valve and into the exhaust manifold or manifolds.

122. During periods of deceleration higher manifold vacuum is imposed on the lower side of the diaphragm than on the upper side. This vacuum forces the diaphragm stem and valves to be moved downward.

123. When the stem moves down the upper valve plate seats and the lower valve plate opens allowing the pump air to vent to atmosphere until the vacuum on the diaphragm becomes equal on both sides by flow through the diaphragm timing orifice.

124. When the engine is turning at a high RPM excessive pressure is produced. In the combination diverter and pressure regulator valve, the lower valve plate is forced down and excessive air flow is allowed to vent to the atmosphere.

125. This illustration shows the relationship of the check valve and air manifold.

126. This illustration shows a cutaway view of the check valve and air flow when the system has higher pressure than the exhaust system.

127. This view of the check valve shows the valve seated during the time when the exhaust back pressure is higher than the air pressure from the pump.

128. Illustrated here are the air manifolds and tubes as used on a typical 6 and 8 cylinder engine. Usually one tube is used for each exhaust port. On some vehicles the manufacturers have omitted one distribution tube, usually because of design problems.

129. In servicing the air injection system the inlet filter element, if used, should be serviced or replaced and...

130. ...the pump drive belt should be inspected and tightened

according to the manufacturer's specifications.

131. One manufacturer recommends the pump be tested using a special test tee and pressure gauge connected into the outlet hose of the pump and measuring the pump air pressure at a specified speed.

132. The gulp valve, if used, can be tested while the engine is idling by pinching the by-pass hose shut between the valve and the intake manifold. The idle speed should not change. Now the vacuum sensing line should be removed for about 5 seconds then replaced. If the valve is functioning the engine will run rough for about 1 to 3 seconds. Always check manufacturer's specifications because on certain foreign models you will damage the air pump by pinching the hose shut.

133. To test the combination diverter valve pressure regulator hold your fingers by the vent port when the engine idles. No air should be felt.

134. At high engine speed the by-pass and pressure relief valve is closed and all air pressure should be delivered to manifold.

135. Decelerating from high engine speed the throttle is closed and all the air from the pump should be vented.

for 1 to 3 seconds.

136. If the valve fails to function check the vacuum supply hose from the intake manifold. At idle there should be manifold vacuum at this point.

137. To test the check valve remove the connecting hose from the check valve.

138. Hold your hand over the check valve with the engine operating and feel for leakage. There should be no air escaping.

139. When the engine is not running make sure the check valve is not frozen shut by pushing down the check in the valve with a screw driver, or solid rod. The valve should move freely.

140. Last, to test for leaks with the engine operating, use soap and water on a brush and watch for bubbles at each connection.

141. End

EXHAUST GAS RECIRCULATION SYSTEM

This slide series will explain the major components and concepts that comprise the Exhaust Gas Recirculation System used to control automotive exhaust emission.

Upon completion of this slide series and instructor-related supplementary materials, the student will be able to:

1. Explain how the Exhaust Gas Recirculation system reduces pollution from the automotive exhaust emission.
2. Identify and state the purpose of each component that comprises the Exhaust Gas Recirculation system.
3. Identify and state the function of each component that comprises the Exhaust Gas Recirculation system.
4. State the inspection and maintenance procedures for each component of the Exhaust Gas Recirculation system.
5. State the testing procedures for each component of the Exhaust Gas Recirculation system.

EXHAUST GAS RECIRCULATION

NARRATIVE

Slide

201. Exhaust Gas Recirculation

202. EGR or the Exhaust Gas Recirculation system reduces oxides of nitrogen emissions by recirculating regulated amounts of exhaust gases with the air/fuel mixture before entering the combustion chamber. As VEC is showing us, the air/fuel mixture is diluted with exhaust gases which reduces the combustion temperature to restrict the formation of oxides of nitrogen.

203. VEC points out that air is approximately 23% oxygen, 75% nitrogen and 2% other harmless gases. Nitrogen is the gas we want to control. Under atmospheric conditions nitrogen is inert, and will not react with other gases so it passes through the combustion process unchanged.

204. However, above 2500°F or 1371°C when air is subjected to hot combustion chamber temperatures and high compression pressure, nitrogen is no longer inert. The nitrogen combines with oxygen to form a variety

of other gases called oxides of nitrogen, all grouped together under the term NO_x.

205. A function of the exhaust gas recirculation system is to reduce combustion temperatures by reducing the air/fuel mixture within the intake manifold with regulated amounts of exhaust gases. These exhaust gases will not support combustion by themselves. This exhaust gas absorbs some of the heat of combustion and lowers combustion temperatures, thus reducing the formation of NO_x. The exhaust gas recirculation system recirculates approximately 6 to 14% of the burnt exhaust gases.

206. Exhaust gas recirculation was first used by the auto industry in 1972 to help the internal combustion engine meet the clean air standards. Federal Environmental Protection Agency regulation restricts any automobile from emitting more than 3 grams of NO_x per mile.

207. The main components of the exhaust gas recirculation system are a flow control device called the EGR valve and EGR-CTO switch or Exhaust Gas Recirculation-Coolant Temperature Override switch and necessary connecting hoses. The connecting hoses route ported carburetor vacuum from the EGR valve through the

EGR-CTO switch. This allows the Coolant Temperature Override switch to block or unblock the vacuum source to the EGR valve depending upon the temperature of the engine coolant.

208. Let's take a closer look at these two components. First, the EGR valve. It is a simple vacuum opened--spring closed valve.

209. A coiled spring located above a flexible diaphragm holds the valve in a normally closed position. There's a valve vacuum nipple to accept ported vacuum from the carburetor and a pintle which is simply a metering rod, is connected to the diaphragm. With no vacuum, the valve is closed. The pintle rests on a seat at the valve bottom to prevent exhaust gas from flowing through the valve.

210. During engine operation, ported vacuum from the carburetor is supplied to the valve vacuum nipple. This vacuum shown by VEC, draws the diaphragm upwards overcoming the spring pressure and pulling the pintle off its seat to open the valve.

211. Exhaust gas is drawn by engine intake vacuum from the exhaust manifold system through the pintle opening

and valve passage and into the intake manifold to be drawn into the cylinder with the unburned gas vapors.

212. The EGR-CTO switch is the other component in the exhaust gas recirculation system. This switch is a simple temperature sensitive vacuum switch that allows the vacuum to be controlled according to the engine coolant temperature. The switch blocks vacuum to the EGR valve to keep it closed at low temperatures. This improves driveability during the warm-up period.

213. Proper routing of the vacuum hoses is very important and, of course, determines the proper operation of the system. Port 1, the upper port, is open and not used. Port D, the center port, is connected to the EGR valve and Port 2, the inner port, is connected to the carburetor exhaust gas recirculation port. Always double check for proper hose routing.

214. Some California car engines use an exhaust back pressure sensor transducer in the exhaust gas recirculation system. Together with a slightly different EGR valve, it insures maximum exhaust gas recirculation during acceleration, and some cruising conditions.

215. The back pressure sensor has a diaphragm valve that

regulates the vacuum signal to the EGR valve through a metal tube that connects the sensor valve and spacer.

216. This spacer is mounted between the EGR valve and the engine.

217. The operation of the exhaust back pressure sensor EGR valve is the same as the regular EGR valve except the back pressure sensor is hooked between the EGR-CTO switch and the EGR valve. One vacuum line connects the sensor nipple, which has a calibrated restriction, to port D of the EGR-CTO switch and another vacuum line connects the sensor to the EGR valve.

218. When exhaust back pressure is relatively high during acceleration and some cruising conditions, the exhaust back pressure traveling up the metal connecting tube overcomes the valve diaphragm spring tension and closes an air vent in the sensor. This allows the carburetor ported vacuum signal to pass through the sensor to the EGR valve resulting in exhaust gas recirculation.

219. When exhaust back pressure is too low as during idle or deceleration to overcome the diaphragm spring tension,

the vacuum signal is then vented to the atmosphere and does not pass through the sensor to the EGR valve resulting in no exhaust gas recirculation.

220. VEC is holding two different exhaust back pressure sensors that are used on cars equipped with single or dual exhaust systems to compensate for exhaust back pressure differences. Be sure to check exhaust systems and match the proper EGR valve with the right system.

221. Some California cars equipped with the back pressure sensor use a stainless steel restrictor plate between the spacer and EGR valve to limit the exhaust gas recirculation flow rate and improve driveability.

222. Many manufacturers use restrictor type orifices in their EGR valves to limit the exhaust gas recirculation flow rate.

223. These illustrations are a few of the various types of exhaust gas recirculation control valve openings.

224. Prior to March 15, 1973, many manufacturers used an ambient temperature override switch to control the EGR valve. However, on March 15, 1973, Environ-

mental Protection Agency ruling stated that the ambient temperature override switch could no longer be used at which time manufacturers changed to the CTO switch.

225. This illustration shows a typical ambient temperature switch that was used before March, 1973. Some switches do not have a filter on the vent, as shown here.

226. This illustration shows an ambient temperature control switch mounted on the firewall on a Chrysler product. These ambient temperature switches were not mounted in the same place on all automobiles.

227. Here is a CTO or coolant temperature override switch that most automotive manufacturers adopted after March, 1973, located in the radiator, which will bleed vacuum to atmosphere when not needed.

228. This CTO switch located in the radiator allows vacuum to pass to the EGR valve or be blocked off, instead of being vented to the atmosphere, dependent upon engine coolant temperature.

229. Another location for the CTO switch is in the manifold

coolant passage, again to monitor the engine coolant temperature.

230. The EGR valve may be operated by one of two sources: carburetor ported vacuum and ported venturi vacuum assisted by a vacuum amplifier.

231. The ported vacuum system picks up its EGR valve operation vacuum directly at a port in the carburetor throttle body. This port is closed when the throttle is at idle position resulting in a low vacuum supply to the EGR valve allowing the spring to hold the valve closed.

232. In the venturi vacuum amplified type system, the EGR valve operating vacuum originates at the carburetor venturi and this weak signal is then increased by the vacuum amplifier. This amplifier then provides the strong signal of intake manifold vacuum to operate the EGR valve.

The vacuum amplifier is basically a balanced diaphragm-type regulator valve. It uses the relatively low venturi vacuum signal to control a stronger intake manifold signal which operates the EGR valve.

233. The exhaust gas recirculation system does not operate at idle or at wide open throttle because of low vacuum, so VEC does not have to work. The reason the EGR valve does not function at these modes is because with the exhaust gases being added to the combustion chamber it would idle rough and would not be able to obtain maximum performance.

234. The EGR valve uses two systems to regulate the amount of exhaust gases going into the combustion chamber. One method of introducing exhaust gases into the intake manifold is the floor jet system which meters exhaust gases through two stainless steel jets in the intake manifold directly beneath the carburetor primary throttle bores. Intake manifold vacuum continually draws exhaust gases through the jets but the amount of flow depends upon the amount of vacuum, size of the floor jets and the amount of exhaust back pressure.

235. As you can see, the EGR valve allows the exhaust gases to reach the floor jets and enter the combustion chamber.

236. The other method of exhaust gas entry into the intake manifold is the floor entry method. The difference between floor jet and floor entry is the floor entry

does not meter the gases. You can see a cross-sectional area of exhaust crossover section with the EGR valve which regulates the amount of exhaust gases entering into the intake manifold.

237. Some manufacturers used a dual diaphragm type EGR valve to control exhaust gas flow. This valve has two diaphragms controlled by separate vacuum sources. One vacuum source is from the carburetor exhaust gas recirculation port and the other from the intake manifold. The amount of exhaust gas recirculation is determined by the interaction of the two diaphragms.

238. Carburetor vacuum acting on one diaphragm will open the valve. However, if high manifold vacuum is acting on the other diaphragm such as during highway cruise, the valve operation will be reduced and only a small amount of exhaust gases will be recirculated. But, during acceleration, there is little manifold vacuum to offset the increased carburetor vacuum and greater amounts of exhaust gases are recirculated to help reduce NO_x formations.

239. The vacuum bias valve is also used on some 1974 vehicles. It is located between the EGR valve and the CTO switch and is operated by its own separate

manifold vacuum source.

240. Under relatively high manifold vacuum conditions such as highway cruise the vacuum bias valve reduces the amount of vacuum to the EGR valve thus reducing exhaust gas recirculation and preventing engine surge. During low manifold vacuum, the vacuum bias valve does not reduce exhaust gas recirculation.

241. Let's see how some simple maintenance and tests can verify exhaust gas recirculation valve performance or malfunction.

242. The EGR valve should be inspected or cleaned every 10,000 to 20,000 miles.

243. Diagnosing is easy. Starting with a cold engine we will test the EGR-CTO switch.

244. After checking the vacuum lines for leaks, restrictions and correct routing, disconnect the vacuum line at the EGR valve and attach a vacuum gauge to the line.

245. Then with the still cold engine, at about 2000 rpm, the vacuum gauge should read zero. If you get a vacuum reading, the EGR-CTO switch is defective and

must be replaced.

246. Next, increase the engine rpm until the coolant temperature is above specified temperature. Carburetor ported vacuum should be indicated on the vacuum gauge. If it isn't, the exhaust gas recirculation switch must be replaced.

247. Testing of the EGR valve is just as easy. First, restart the engine and let it idle.

248. When the engine is at correct idle, using fingers, push up on the exhaust gas recirculation diaphragm, lifting the pintle off its seat. Engine rpm should decrease and then should increase when the diaphragm is released which indicates proper operation of the pintle in the EGR valve. All we are doing is dumping exhaust gas into cylinders and then blocking it off.

249. If the engine idles OK but there's no change in engine rpms, the EGR valve or the passage to the intake manifold may be blocked.

250. If the engine idles poorly and is not affected by manually opening the EGR valve, you could have constant exhaust gas being dumped into the combustion cylinder

caused by a defective EGR valve or a defective intake manifold.

251. To check the exhaust gas recirculation diaphragm with vacuum, install a tee in the vacuum signal line near the valve and connect a vacuum gauge to it.

252. Then with your fingers on the EGR valve diaphragm, slowly accelerate the engine until you feel the diaphragm move. Note the vacuum reading. It should be about two or three inches of vacuum depending upon the EGR valve being tested. Remember, do not accelerate engine to excessive rpms trying to reach a certain vacuum reading.

253. Continue acceleration until the diaphragm is deeply recessed and again note the vacuum reading. It should be between four and seven inches of vacuum depending upon the EGR valve being tested. When testing an EGR valve controlled by a vacuum amplifier, disconnect the venturi vacuum signal hose at the amplifier and connect a hand vacuum pump to the venturi hose port on the amplifier. With the engine at normal operating temperature and 1,000 rpms apply 2 1/2 inch vacuum with vacuum pump to the amplifier. With your fingers on the EGR diaphragm you should feel the diaphragm

move upward opening the EGR valve.

254. Vacuum readings should be within specifications given in your technical service manual. If they are not within specifications the EGR valve must be replaced.

255. The other exhaust gas recirculation test you might have to perform would be on the California exhaust back pressure sensor. First, inspect all exhaust gas recirculation vacuum lines for leaks, restrictions, and correct routing.

256. Then install a tee in the vacuum line between the EGR valve and exhaust back pressure sensor and attach a vacuum gauge to the tee.

257. Start the engine and let it idle. The gauge should indicate zero vacuum.

258. Accelerate the engine to 2,000 rpms and check the vacuum again. With coolant temperature below specified temperature, zero vacuum should be indicated. With coolant temperature above specified temperature, two or three inches of vacuum should be indicated.

259. Finally, if no vacuum was indicated with a warm engine,

make sure the vacuum was applied to the inlet side of the sensor. Then remove the sensor and check the exhaust tube for restrictions. Carbon or lead deposits can be removed with a spiral wire brush.

260. If the sensor connections are OK and cleaning the spacer exhaust tube doesn't help, replace the exhaust back pressure sensor. It cannot be serviced.

261. The end.

FUEL EVAPORATIVE CONTROL SYSTEM

This slide series will explain the major components and concepts that control the fuel evaporation emissions from the automobile.

Upon completion of this slide series and instructor-related supplementary materials, the student will be able to:

1. Identify the process in which the Evaporative Emission Control system reduces pollution from the automobile engine.
2. Identify and state the purpose of each component that comprises the Fuel Evaporative Control system.
3. Identify and state the function of each component that comprises the Fuel Evaporative Control system.
4. State the inspection and maintenance procedures for the Fuel Evaporative Control system.
5. State the testing procedures for each component of the Fuel Evaporative Control system.

FUEL EVAPORATIVE CONTROL

NARRATIVE

Slide

301. Title

302. It is estimated that on the pre-emission control automobile about 20 percent of all emissions consist of gasoline hydrocarbon vapors that evaporate from the carburetor and fuel tank.

303. To eliminate these evaporative losses, automobile manufacturers developed control systems beginning in 1970 for cars in California and ...

304. ... nationally in 1971, all U.S. automobile manufacturers equipped their vehicles with the following evaporative control devices.

305. A fuel tank safety filler cap which seals the system, a special fuel tank designed to allow space for fuel expansion, and a venting system to carry vapors from the fuel tank to the carburetor air cleaner.

The venting arrangement includes a liquid check valve or a liquid vapor separator to keep fuel out of the vent lines, a charcoal canister to store the vapors and connecting lines to carry the vapor from the canister to the carburetor air cleaner. Chrysler used a crankcase storage system for the first two years, instead of the canister but its function was the same.

306. The fuel evaporative emission control systems used by most U.S. automobile manufacturers are similar, sometimes almost identical. However, there are some minor differences, mainly in the name. This slide lists the names given the fuel evaporative systems by different manufacturers:

American Motors	Fuel Tank Vapor Control
Chrysler	Vapor Saver
Ford	Evaporation Control System
General Motors	Evaporative Emission Control
Foreign	Fuel Vapor Recovery System

307. Before emission control, fuel caps and fuel tanks were vented to allow raw fuel vapors, or even liquid gasoline to escape unrestricted into the atmosphere.

308. In the present fuel tank filler cap, a safety pressure relief valve will open only if pressure from one-half to one PSI builds in the tank.

309. If a vacuum of one-fourth to one-half inch mercury build-up occurs, the safety vacuum relief valve will open to let in some outside air, but normally the cap is sealed.

310. The filler neck on most fuel tanks extends below the top of the tank preventing the tank from being filled 100%. This provides an expansion space of 10 to 12% of tank capacity at the top to provide room for the gasoline to expand when temperatures increase.

311. Some models, 1970 and 1971 only, use an inner expansion tank and incorporate a fill control tube with the filler neck. If fuel continues pumping into the tank above the filler neck, a fill control tube returns it to the filler neck and this either shuts off the automatic fill-up nozzle, or tells the attendant to stop pumping.

312. With the fuel tank sealed to atmosphere, fuel vapors will collect at the top of the tank and have only one way to go--into the venting lines to be stored in the charcoal canister.

313. In those tanks without internal or separate expansion tanks, an internal expansion space must be provided into which fuel or fuel vapor can safely expand.

This volume is approximately ten to twelve percent of the fuel tank volume.

314. Some manufacturers, such as Volkswagen, use an external expansion chamber. In operation, fuel vapors rising from the tank are routed to the expansion chamber, which is designed to permit the passage of fuel vapors, but to prevent the passage of liquid fuel. From this external chamber, the fuel vapors are carried forward into a container filled with activated charcoal where they are stored when the engine is not running.

315. Because most fuel tanks are flat on top, four vents are used, one in each corner of the tank. These are connected to a liquid vapor separator by rubber hoses or metal pipes.

The liquid vapor separator consists of a length of steel tubing which is mounted at an angle ahead and slightly above the fuel tank. This tubing holds the four vent lines from the tank and a vent line which leads to the charcoal canister.

These lines are of different heights so that the tank will always be vented, regardless of vehicle attitude. This way, only the fuel vapors will be transferred to the storage area. One vent line from the tank is shorter than the others in order to provide a drain back to the tank for any liquid fuel which may get into the separator during inclined parking. The vent to the storage area or charcoal canister is at the highest point in the separator and has a small orifice to minimize liquid fuel transfer to the storage area or canister.

316. A later style liquid vapor separator is essentially the same as the stand pipe type. The chief difference is the mounting position, horizontal instead of vertical due to automobile design.

317. This shows a single loop type liquid vapor separator. The loop acts as a condenser and stand pipe, to prevent liquid from entering the charcoal canister.

318. The compound loop vapor liquid separator operates on a similar principle as the single loop system. The additional loop allows for a greater amount of vapor separation for heavy duty operation.

319. This type of separator is mounted at the top center of the fuel tank on some models so that the internal expansion area at the top of the tank provides an

adequate breathing space for the separator. It consists of a small container filled with open-cell foam. An opening at the bottom permits the entry of fuel vapors from the tank. A restrictor orifice at the top, which is connected to a vapor tube leading to the storage canister, permits the escape of fuel vapors, but minimizes the chance of liquid fuel entering the tube.

320. This system includes a three-way valve, which acts as a stopper during fueling to prevent overfilling the tank. This is done by closing the vapor line, thus maintaining an expansion volume within the fuel tank.

321. During a hot-soak period (after shutting off a hot engine) the valve opens under pressure to allow the expanded vapors to pass into the storage canister.

322. This valve also permits air to enter the fuel tank to relieve the vacuum created by fuel consumption or whenever the fuel tank air pressure is reduced by a drop in temperature.

323. The three-way valve is normally closed to retain space in the air chamber of the fuel tank and prevents overfilling. However, when pressure exceeds certain

limits, spring pressure is overcome to permit air to escape from the system.

324. On some Ford and Chrysler cars, a valve in the vent line is normally closed during filling but opens when excess vent pressure is present. On Chrysler the valve is called an Overfill Limiting valve.

325. Another method of preventing the liquid fuel from entering the vent line is the Liquid Check valve which prevents the liquid from passing to the charcoal canister. This valve is built into the tank on some models and externally mounted on others.

The vapor inlets are at the bottom of the liquid check valve and the outlet vent line which is connected to the charcoal canister is at the top. To get to the outlet, the vapors must flow past a needle valve in the cover which is linked to a float in the bowl of the valve.

326. If liquid enters the bowl, the float will rise and close the needle valve, closing the vent line to the canister. It will stay closed until the liquid drains back into the tank.

327. The next component of the evaporative systems is the

Vapor Storage Canister which uses activated charcoal granules to store the vapors until they are drawn into the carburetor. The typical canister contains about one to one and one-half pounds of charcoal which provides an exposed surface area of about one-quarter square mile, enough to store almost a cup of liquid fuel when vaporized. This storage canister has two connections, the vent line from the fuel tank and a connecting vent line to the carburetor air cleaner.

328. With the engine running, outside air is drawn through the bottom of the canister to remove fuel vapors collected by the charcoal granules. This is called the evacuation or purge cycle.

329. When the engine is running, and during the purge cycle, outside air is drawn through the fiberglass filter at the bottom of the canister, through the carbon granules, picking up fuel vapors and carrying them to the air cleaner to become a part of the air-fuel mixture to be burned.

330. This canister has 4 connections: Carburetor ported vacuum, PCV and manifold vacuum, fuel tank vapor line, and carburetor float bowl vent.

331. This shows the connections of a four-line constant and demand purge system. The purge valve controlled by ported vacuum allows the canister to be purged at two different rates according to engine speed.

332. This unit is a stamped metal canister with an open space provided at the top and bottom.

A center tube is incorporated which extends to the bottom of the canister. Air can enter at the top of the tube passing downward to the bottom of the canister. The canister purge line is externally attached (by hoses) to the carburetor air cleaner or to the PCV valve (depending on model application).

The vapor is purged out of the canister through the air outlet hose to the air cleaner (or PCV valve), then through the carburetor and into the combustion chamber--where the vapors are consumed in the normal combustion process.

333. One method of providing additional storage space for vapor is to vent the fuel tank to the engine crankcase through the engine valve cover. When the engine is started, stored vapors are drawn into the engine intake system through the PCV valve. This "purges" the

crankcase of stored vapor so they are ready for more vapor storage when the engine is turned off.

334. Now let's take a look at some methods of purging the vapor storage canister. Vapor which originated in the fuel tank and was separated by the vapor liquid separator is now stored in the canister. In this system, movement of air through the canister is caused by carburetor intake air passing over a tube which projects into the carburetor air cleaner snorkel.

335. This creates a suction that draws the vapors out of the canister and into the air stream entering the snorkel. This system is known as a Variable Purge System as it is regulated by the rate of air flow entering the air cleaner.

336. In the simplest of canister hook-ups, purging occurs through the two vent lines from the canister to the air cleaner. This provides a variable purge since the amount of purging is proportional to air flow through the air cleaner snorkel and the vacuum created inside the air cleaner can. The tube in the snorkel purges at high air velocity and the tube inside the filter of the air cleaner when the air velocity is low.

337. Another purging method ties a purge line into the PCV valve line and intake manifold vacuum. Purging air passes to the intake manifold through a small fixed orifice on the canister outlet. This is known as constant purge.

338. Still another method used by some manufacturers is called the constant and demand purge system. A purge valve at the canister allows constant purging at a restricted rate through an orifice until a certain level of vacuum occurs at the canister outlet. When ported vacuum is applied to the purge valve it allows a higher rate of purging to take place through the hose to intake manifold resulting in demand purging. Demand purging is designed to ensure that purging occurs during conditions of engine operation which will be the least affected by purge air/fuel mixture on the performance and driveability of the engine.

339. Prior to emission control regulation, hydrocarbons from the carburetor bowl were allowed to escape into the atmosphere. Advent of controls necessitated venting of the carburetor into the canister. Here we see one method of controlling vapors through the carburetor external vent or anti-perculation valve.

340. With the throttle in the off idle position, the antiperculator valve is closed. In this operational mode, no escape of fuel vapor occurs.

341. This illustration shows the connecting hoses of the antiperculator valve to the canister.

342. As a review, we will look at the components of the evaporative system again: a fuel tank filler cap which seals the system, a special fuel tank designed to allow space for fuel expansion, and a venting system to carry vapors from the fuel tank to the charcoal canister and air cleaner.

The venting arrangement includes a liquid check valve or liquid vapor separator to keep fuel out of the vent lines, a charcoal canister to store the vapors and connecting lines to carry the vapor from the canister to the carburetor air cleaner.

343. Inspecting the fuel tank vapor control system begins with checking the gasket and relief valves in the filler cap. If the gasket has deteriorated or relief valves are inoperative, replace the cap.

344. Look for fuel stains around the tank and filler neck

opening and make sure all connections are tight. Inspect liquid check valve and other parts that may be damaged and could allow fuel vapors to escape. A wet canister filter pad or strong smell of gasoline under the hood may indicate a defective check valve that could need replacing.

345. There is only one part in the system that requires scheduled replacement and that is the filter pad at the bottom of the charcoal canister. The filter pad should be replaced at every 15,000 mile interval or as recommended in the maintenance schedule.

346. Caution: On vehicles having dual fuel tanks do not remove the filler caps of both fuel tanks during re-fueling. When filling one tank, the filler cap of the other tank must be left in position on the filler neck. Removal of both filler caps during refilling could result in fuel leakage through the vapor storage canister due to overfilling of the fuel tanks.

347. This troubleshooting guide lists some of the more common problems found in the fuel evaporative system.

348. The causes and remedies associated with these problems are also shown. The End.

POSITIVE CRANKCASE VENTILATION SYSTEM

This slide series will explain the major components and concepts of crankcase ventilation which enables an engine to breathe while not contaminating the atmosphere with by-products.

Upon completion of this slide series and instructor-related supplementary materials, the student will be able to:

1. Identify the process in which the Crankcase Ventilation system reduces pollution from the automobile engine.
2. Identify and state the purpose of each component that comprises the Positive Crankcase Ventilation system.
3. Identify and state the function of each component that comprises the Positive Crankcase Ventilation system.
4. State the inspection and maintenance procedure for the Positive Crankcase Ventilation system.
5. State the testing procedures for each component of the Positive Crankcase Ventilation system.

POSITIVE CRANKCASE VENTILATION

NARRATIVE

Slide

401. The crankcase ventilation system was the first anti-pollution device installed on the automobile. This ventilation system is known by the letters PCV which stands for positive crankcase ventilation. The PCV system is very dependable and efficient and requires a minimum of maintenance.

402. The function of the positive crankcase ventilation system is to prevent the escape of blow-by products to the atmosphere.

403. During the combustion process higher pressures are developed in the combustion chamber. This high pressure results in leakage or blow-by between the piston rings and the cylinder wall. This blow-by occurs during the compression stroke...

404. ...and during the power stroke.

405. Blow-by gases contain gasoline vapor, corrosive acids, and water. To prevent these blow-by products from

reacting with the engine lubrication system they have to be removed, so the engine must be provided a means of crankcase ventilation.

406. In pre-emission control automobiles the blow-by products were allowed to escape to the atmosphere through the open road draft tube. The resulting pollution from the crankcase amounted to approximately 20% of the total pollution emitted by the automobile.

407. The earliest form of crankcase ventilation was the road draft tube. Air passing over the end of the tube created a partial vacuum drawing blow-by gases from the engine crankcase.

408. There are four types of PCV systems. We have the open system or type I which has the crankcase valve controlled by intake manifold vacuum. The next type is type II and the crankcase valve is controlled by the crankcase vacuum. We have another system, type III, that does not utilize a control valve but has a tube-to-air cleaner device. And the last type, type IV, is a closed system which is a combination of all the systems.

409. The type I system or the open system used prior to

1968 utilizes intake manifold vacuum to purge the engine crankcase. Air is drawn through the open oil filler cap, passing through the crankcase picking up blow-by gases, then traveling through the PCV valve and into the intake manifold and then into the combustion chamber to be burned. This system was approximately 75% efficient under heavy engine load because of increased blow-by gases and decreased manifold vacuum.

410. The type II system works exactly as type I except it utilizes a West Coast control valve in place of the PCV valve.

411. The West Coast control valve has a variable orifice which meters crankcase gases to the intake manifold. This variable orifice is controlled by crankcase vacuum. Ventilating air is admitted to the crankcase through a restricted opening in the oil filler cap.

412. The West Coast control valve at idle varies its orifice opening to remove the blow-by gases according to the flow rate created in the crankcase. At idle, blow-by gases are drawn through an opening called the idle groove. This groove allows constant limited ventilation for the crankcase.

413. At cruising speed the West Coast control valve modulator ball is forced off of its seat by the flow rate of the blow-by gases from the crankcase allowing these gases to pass through the valve into the intake manifold to be burned.

414. The type III system does not use a PCV valve or a metered orifice. The crankcase vapors are vented directly into the air cleaner by a slight vacuum created by the carburetor air cleaner snorkel. No provision was made for circulating fresh air into the crankcase. This system has been discontinued by American manufacturers but is still used by some foreign car makers.

415. The type IV or closed system is used on all vehicles built in the United States today. The closed system does not allow blow-by gases to be emitted to the atmosphere under any driving conditions. The blow-by gases are consumed by either entering the intake manifold through the PCV valve at the base of the carburetor or through a hose from the oil filler cap to the air cleaner and into the carburetor to be consumed.

416. This shows a typical PCV valve used in type I and

type IV systems. As you can see we have a plunger that is able to move back and forth in the valve body controlling the air flow through the valve. The plunger is moved by vacuum force and spring tension. Every time the vacuum source varies the plunger will move. This constant movement causes the plunger and its plunger seat to become worn to the point that it has to be replaced at regular intervals to assure effective operation. The PCV valve has three basic modes of operation: engine off or backfire, high speed and idle or low speed.

417. During engine off the PCV valve plunger is pushed to the crankcase end of valve body by the spring tension and the absence of vacuum. In case of back-fire, the seated plunger prevents the flame from entering the crankcase.

418. The engine operating at low speed creates a high intake manifold vacuum, overcoming the PCV valve spring pressure, drawing the plunger into the valve orifice. The PCV valve plunger position provides a maximum restriction with a minimum blow-by gas flow into the intake manifold.

419. During high speed engine operation, manifold vacuum

is low allowing the spring to move the plunger off the seat of the intake side providing maximum flow.

420. Never disconnect or plug the PCV system because every engine needs crankcase ventilation. The pressure must be relieved one way or another.

421. Testing the PCV system is relatively simple. We have the RPM Drop Test, the Vacuum Test and the Instrument Test.

422. The RPM Drop Test

1. Connect the vehicle's exhaust pipe to the shop exhaust air system.
2. Connect an engine tachometer to the engine and start the engine.
3. Allow engine to warm up to normal hot engine curb idle speed and temperature; record the engine RPM.

423. 4. Completely restrict air flow through the PCV hose by placing a finger over the PCV valve.
5. Record the engine RPM with the PCV system air flow stopped.
6. An engine RPM drop of 40-80 RPM between normal air flow and restricted air flow indicates a

properly functioning PCV system.

424. The Crankcase Vacuum Draw Test

425. In preparing to run the test, start the engine and run at idle to obtain normal operating temperature.

Remove the oil filler cap and block air flow to the crankcase from all other sources.

426. Place a sheet of thin paper over the oil filler hole. Normal operation of the PCV system will hold the paper against the oil filler opening, showing the presence of crankcase vacuum.

427. The Crankcase Vacuum Draw Test Using the Inclined Ramp and Ball Tester

1. Start engine and allow engine to run until curb hot idle RPM is achieved.
2. Block off PCV hose leading to the air cleaner on a closed PCV system.
3. Place the "Autolite tester" over the oil filler opening.
4. A satisfactory crankcase vacuum draw will cause the ball to climb into the green area.
5. Excessive crankcase pressure will force the ball

to climb into the red area.

6. A marginal performance of the PCV system will result in a yellow tester reading.

428. Another crankcase vacuum draw tester is the AC tester. It provides a quick and accurate method of testing the operation of the PCV total system and the PCV valve in separate tests.

With the engine running and the tester connected to the oil filler hole the tester body will react to both crankcase pressure and vacuum. Slots cut in the tester body allow viewing of the spring loaded, color coded drum.

429. These are the items found in the AC tester. Instructions and application chart are included but most items are self explanatory.

430. Using the AC dealer's Positive Crankcase Ventilation catalog, determine the tester dial setting for the complete system and valve testing.

431. Adjust the tester dial to the specified setting. Start engine and allow engine to achieve normal hot curb idle RPM and temperature.

432. Connect the tester assembly to the oil filler opening using appropriate adapter. Hold the tester in a vertical position with the hose fully extended. Tester hose must be free of kinks and sharp bends.

433. A green color display in the tester slots indicates a satisfactory system operation.

434. Refer to the troubleshooting chart as an aid in diagnosing other color code indications. A red color indicates excessive crankcase pressure or plugged valve ventilation. A yellow color is indicative of low vacuum possibly from a crankcase not sealed properly. A green color means system is satisfactory.

435. Testing the PCV Valve Alone

1. Adjust the tester to the specification for the engine and valve being tested.
2. Start the engine and allow it to achieve normal idle temperature and RPM.

436.

3. Connect the valve adapter to the tester hose.
4. Hold the valve adapter to the crankcase end of the PCV valve.

437.

5. Hold the tester in a vertical position and observe

the color code displayed in the tester window.

6. A green color code indicates a satisfactory valve. If the color is not completely green, replace the valve.

438. If a red color is showing in the slot this indicates a plugged PCV valve or vent. A zero flow of blow-by gases through the PCV valve will result in excessive pressure in the crankcase. This pressure in the crankcase may cause oil leakage from various gaskets and seals.

439. The PCV valve plunger may become stuck in the valve body allowing maximum air flow at idle and low speed. As a result, the engine idles rough, caused by an excessively lean air/fuel mixture. In addition, excessive oil consumption may occur due to high intake manifold vacuum and air flow impressed on the engine crankcase.

440. The PCV valve plunger may also become stuck in the idle position in the valve body, against manifold end, restricting air flow during cruise and high speed operation. This will cause excessive crankcase pressure during high speed or high engine load operation.

441. In performing maintenance or service work, always consult the automobile manufacturer's specifications. While some general service rules may be formulated, it is important that the manufacturer's maintenance and service schedules be followed.

442. Most domestic automotive manufacturers require that the system be inspected and the PCV valve be replaced at 12,000 miles or 12 month intervals.

443. In addition, Ford has specific requirements for the replacement of the inlet filter in the air cleaner...

444. ... and/or the cleaning of the filter in the oil filler cap. Again check manufacturer's specification.

445. When servicing the system, be sure to inspect and clean all hoses and parts except disposable filters and the PCV valve, which should always be replaced. Some vehicles use a spacer block under the carburetor. The drilled passageway in the spacer block must be unrestricted.

446. When replacing rubber hose used in PCV systems, be sure to use a type of hose made for the purpose, which is usually marked PCV or otherwise identified.

447. The inlet air vent or tube from the crankcase to the air filter, as found on AMC products, is equipped with a filtering element or in some cases, a metal screen and filter as indicated here. The screen serves two functions: to filter the air before entering the crankcase; and act as a flame arrester in the case of backfire.

448. Some manufacturers place this type of filter element in the oil filler cap. Such permanent type filters and screens are cleaned by washing them in cleaning solvent and allowing them to drip dry.

449. One of the most popular types of filters is the disposable type which is mounted on the inner side-wall of the air cleaner. It is replaced at recommended service intervals, usually 12,000 miles, except for Ford products. The Ford Motor Co. recommends 6,000 miles as noted previously.

450. PCV valves are no longer serviceable but are simply replaced. All valves are identified by the manufacturer's number and in some cases, by a color code.

451. When replacing the PCV valve these variations make it mandatory to <u>always</u> consult the manufacturer's

specification for the correct part application. Do not rely on the number of the old valve since it may be incorrect.

452. The PCV valve plays a vital part in maintaining proper air/fuel ratios for best emissions reduction and engine performance.

THERMOSTATIC AIR CLEANER SYSTEM

This slide series will explain the major components and concepts that provides for adjustment of intake air temperature.

Upon completion of this slide series and instructor-related supplementary materials, the student will be able to:

1. Identify the process in which the Thermostatic Air Cleaner system reduces pollution from the automotive engine.
2. Identify and state the purpose of each component that comprises the Thermostatic Air Cleaner systems.
3. Identify and state the function of each component that comprises the Thermostatic Air Cleaner systems.
4. State the inspection and maintenance procedures for each component of the Thermostatic Air Cleaner systems.
5. State the testing procedures for each component of the Thermostatic Air Cleaner systems.

THERMOSTATIC AIR CLEANER

NARRATIVE

Slide

501. The "Thermostatic Air Cleaner", also known as heated air control provides for adjustment of intake air temperature going to the carburetor. This system provides smoother engine operation plus...

502. ...Automotive manufacturers have found several benefits by preheating the air before it enters the carburetor. This heated air allows for better atomization of fuel, better cold engine operation, and elimination of carburetor icing.

503. And an overall reduction in hydrocarbons and carbon monoxide.

504. The thermostatic air cleaner is a key device in many auto emission control systems. Two types are widely used; the thermostatic type ...

505. ... and the air valve type.

506. Regardless of the type of air cleaner; air valve

or thermostatic, its job is the same. And that is to provide for adjustments of intake air temperature.

507. Each type of thermostatic air cleaner has three modes or positions of operation, which are: the cold air delivery mode, the regulating mode, and the hot air delivery mode.

508. Here is a cutaway of a thermostatic air cleaner showing the air filter, thermostat, air valve door and snorkel for outside air. It is the function of the thermostat acting on the air valve door which determines whether engine compartment air, or heated air from the shroud of the exhaust manifold is allowed to enter the carburetor.

509. During engine start and warm-up period, the air temperature is below approximately 105°F or 40.5°C (this temperature will vary from each manufacturer). The thermostat is in a retracted position, or "hot air mode." Since it is linked to the spring loaded air valve it holds the valve in a closed or "heat on position."

510. This shuts off air from the engine compartment and allows only air into the carburetor that is drawn

from the heat shroud being heated by the exhaust manifold.

511. As the manifold heated air increases to approximately 105°F or 40.5°C temperature, the thermostat begins to extend and pulls the air valve door downward allowing some cooler air from the engine compartment to enter the carburetor. It is then in the "regulating mode."

512. When the temperature reaches approximately 130°F or 54.4°C, the air valve door is fully opened to engine compartment air, and in the "cold air mode", allowing only engine compartment air to enter the carburetor.

513. Testing the thermostatic controlled air cleaner is relatively easy.

514. First check the linkage and spring, and if they are OK, remove the air cleaner top and remove the air cleaner assembly from carburetor. Place the snorkel, containing the thermostat in a pan of water with a temperature below 105°F or 40.5°C.

515. The thermostat should have the air valve door in the "heat on" or hot air delivery mode.

516. With the use of a thermometer and heat source, heat the water to approximately 130°F or 54.4°C. The thermostat should be fully extended closing the air valve door, allowing only engine compartment air to enter the air cleaner. Should this cold air delivery mode not occur, replace thermostat.

517. A vacuum override motor is used on some air cleaners. The motor is attached to the snorkel or duct and connected to the thermostat and air valve door by means of an override lever. This provides the control necessary to allow full air intake during periods of cold acceleration.

518. This is an air valve type air cleaner. It is a vacuum operated unit. Vacuum is controlled by the temperature sensor valve, which controls the amount of vacuum applied to the vacuum motor that operates the damper assembly.

519. When the temperature of the air entering the air cleaner is about 85°F or 29.4°C or less, depending upon specific application, the only air entering the carburetor, therefore, is heated air from the exhaust manifold shroud. This is the "hot air delivery mode."

520. The air valve type has an air bleed valve in the temperature sensor valve, and when fully closed it directs engine vacuum to the vacuum motor, which in turn closes the damper assembly to outside air.

521. In the regulating mode, as the temperature in the air cleaner rises between 85°F or 29.4°C and 105°F or 40.5°C the damper partially opens to mix outside air with the heated air.

522. The damper opens when the air bleed valve begins to open, bleeding off vacuum from the vacuum motor. This weakens the vacuum signal, allowing the damper door to partially open.

523. When the temperature in the air cleaner reaches approximately 130°F or 54.4°C, the vacuum motor can no longer overcome the diaphragm spring tension holding the damper door closed. The damper door closes and cooler engine compartment air enters the air cleaner and carburetor. This is the "cold air delivery mode."

524. The high temperature causes the temperature sensor spring to open the air bleed valve, bleeding off all vacuum.

525. A low vacuum condition is also obtained during full throttle operations, regardless of air cleaner temperature. This is because manifold vacuum is too weak to hold the door closed to engine compartment air, thus the necessary volume of air required by the wider throttle opening is available. During engine off, or no vacuum conditions, the damper door or valve plate blocks off the hot air duct. This is due to the lack of vacuum at the vacuum motor, regardless of the temperature at the sensor.

526. Testing and servicing of the air valve type air cleaner is relatively simple.

527. Tape a thermometer in air cleaner next to temperature sensor. Allow temperature in engine compartment to cool to $85^{\circ}F$ or $29.4^{\circ}C$ or less. Install a tee in vacuum line between vacuum motor and temperature sensor.

528. With engine off, control damper will be open allowing engine compartment air to enter carburetor (look into snorkel to be sure). Install cover on air cleaner (without wing nut) and start engine.

529. With engine at idle and ambient temperature below

85°F or 29.4°C the damper door should be closed to engine compartment air. Vacuum gauge should register full manifold vacuum.

530. If the damper door is not closed with full vacuum, shut off engine. Check for a binding air valve door, disconnected linkage, a vacuum leak, or a defective vacuum motor. A hand vacuum pump may also be used to create full vacuum on the damper door.

531. With engine at idle and ambient temperature slightly above 85°F or 29.4°C the damper should begin to open to engine compartment air and should be completely opened at approximately 130°F or 54.4°C.

532. At specified temperature the air valve door will be wide open to engine compartment air when the engine is idling, or the vacuum reading is 5"-9", and the ambient temperature is between 105°F or 40.5°C-130°F or 54.4°C.

533. When damper in snorkel begins to move toward the open position or cold air delivery mode, quickly remove cover on air cleaner and check thermometer next to sensor for appropriate specified temperature, and check vacuum gauge. Vacuum at motor should be

5" to 9" when damper assembly is open to engine compartment air. You can also use a hand vacuum pump with an attached gauge to conduct the vacuum test.

534. If temperature is within specifications and air valve door opens to engine compartment air, system is operating correctly.

535. If temperature is out of specifications, but vacuum is correct, "replace the temperature sensor."

536. If both the temperature and vacuum are within specifications and air valve door remains closed to engine compartment air, "replace vacuum motor." Remember: temperature sensor is preset at factory, do not adjust.

537. Some manufacturers use an additional air intake that is available as an option on certain automotive models. This thermostatic controlled air cleaner is basically the same as the air valve we have discussed except it has two cleaner snorkels. One snorkel contains a vacuum motor with a temperature sensor, which works the same as we have described. The other snorkel contains a vacuum motor but does not have a temperature sensor. The damper is controlled only

by intake manifold vacuum and is closed under all conditions except wide open throttle. Testing procedure is the same as for single snorkel.

538. The thermostatic and air valve air cleaners, when operating properly, play a vital role in removing hydrocarbons and carbon monoxides from the atmosphere.

AIR INJECTION REACTION

Questions

T F 1. When testing the gulp valve the bypass hose is pinched shut between the valve and intake manifold.

T F 2. When testing the air pump pressure on the left bank of a V-8 engine equipped with an AIR system, it is not necessary to plug the air outlet hose feeding the right bank.

T F 3. Air is pumped from the exhaust manifold through the diverter valve into the air pump.

T F 4. When fresh air is injected into the exhaust manifold, it creates a burn to help reduce the unburned hydrocarbons.

T F 5. The diverter valve and the gulp valve perform the same end result on the engine.

6. Under normal driving conditions the check valve in the AIR system is closed during one of the following:

   a. when exhaust pressure is higher than AIR system pressure
   b. when exhaust pressure is lower than air system pressure
   c. when the engine is decelerating
   d. a and c above

7. During deceleration the following conditions are present:

   a. lower pressure in cylinder
   b. richer fuel mixture
   c. raw fuel air mixture in exhaust manifold
   d. all of the above

8. The AIR system requires the following:

   a. air pump
   b. anti-backfire valve
   c. air injection into the carburetor
   d. a and b above
   e. all of the above

9. The main purpose of the AIR system is to:

   a. cool off the exhaust gases
   b. have oxygen combine with CO and HC to form CO_2 and H_2O
   c. improve gas mileage by increasing air/fuel ratio in the cylinder
   d. all of the above

10. If the air pump continues to deliver air to the exhaust manifold during deceleration:

    a. the exhaust gases would burn causing a backfire
    b. the exhaust gases would become too lean to burn
    c. the air pump would burn out because the diverter valve is closed
    d. a and c above

11. Which engine operation mode emits the least unburned hydrocarbons from the exhaust system?

    a. idle
    b. cruise
    c. deceleration
    d. uphill climb

12. The purpose of the pressure relief valve or the combination pressure regulator diverter valve:

    a. is to increase air pressure from the air pump to the exhaust manifold
    b. is to limit the air to the exhaust manifold to prevent exhaust system from overheating at high speed
    c. is to dump excess air pressure to the atmosphere
    d. none of the above
    e. b and c above

13. When decelerating the gulp valve is signaled to operate by:

    a. increased manifold vacuum
    b. a spring force in the gulp valve
    c. a time delay mechanism of 1 to 3 seconds
    d. a sudden drop in manifold vacuum

14. To test the diverter valve at engine idle speed which of the following should result:

    a. air pressure from the pump should be felt at the vent port
    b. no air pressure from the vent port should be noted
    c. a vacuum at the vent port should be noted

15. Back-fire upon deceleration could indicate:

    a. faulty check valves
    b. faulty air pump
    c. air pump belt slipping
    d. faulty diverter valve

16. A customer complains he replaced the diverter valve (By-pass valve) twice within 5,000 miles and needs replacing again. Upon inspecting the diverter valve you discover exhaust residue inside. A probable cause is:

    a. too low of vacuum to trigger the valve during deceleration
    b. a faulty check valve
    c. low output from the air pump
    d. a faulty relief valve

17. The AIR system supplies fresh air to reduce CO and HC emission except during:

    a. acceleration
    b. idle
    c. wide open throttle
    d. deceleration

EXHAUST GAS RECIRCULATION SYSTEM

Questions

1. What primary pollution is reduced by adding exhaust gases to air/fuel mixture, via the EGR system?

   a. NO_x
   b. CO
   c. HC
   d. smoke
   e. SA

2. Approximately in percent, what is the composition of air?

   a. oxygen 73 ppm, nitrogen 2 ppm, harmless gases 23 ppm
   b. oxygen 23%, nitrogen 75%, other 2%
   c. nitrogen 80%, other 10%, oxygen 10%
   d. lead oxides 2%, oxygen 23%, nitrogen 75%

3. Under normal atmospheric conditions nitrogen:

   a. explodes at 14.7 psi
   b. is changed to a liquid at 30,000 feet
   c. is an inert gas and will not react with other gases
   d. all of the above

4. Above 2500 degrees F. or 1371 degrees C. and at high engine compression pressure nitrogen combines with oxygen to form what compound?

   a. lead oxide
   b. variety of other gases called oxides of nitrogen - NO_x
   c. both of the above
   d. none of above

5. Define these terms:

   a. NO_x

   b. EGR

c. Air/fuel mixture

d. Inert

e. Oxides of nitrogen

f. EPA

6. The three basic components of the EGR system are:

   a. EGR, CTO, and carburetor
   b. CTO, carburetor, and connecting hoses
   c. EGR valve, CTO switch, and connecting hoses
   d. circular switch, functional valve, exhaust vent

7. The EGR valve will make it possible to:

   a. use regular gas in high compression engine
   b. use non-leaded gas in 1975 automobile
   c. meter exhaust gases to the intake manifold
   d. use two barrel carburetor thus increasing gas mileage

8. The EGR valve operates on:

   a. high temperature of gases from exhaust manifold
   b. pressure from air pump
   c. ported vacuum from carburetor
   d. high voltage from the coil

9. The main purpose of the EGR-CTO switch is:

   a. to electrically control the temp. of the engine
   b. to control vacuum from carburetor
   c. to control pressure from carburetor
   d. to control vacuum from intake manifold

10. The main function of the EGR valve is to:

    a. recirculate exhaust gases during acceleration and deceleration
    b. act as a two-way valve allowing exhaust to enter and leave the carburetor
    c. increase air fuel ratio in the carburetor
    d. increase combustion ratio in combustion chamber

11. The main function of the exhaust back pressure sensor transducer is to:

    a. insure maximum exhaust gas recirculation during acceleration and some cruising conditions
    b. overcome spring pressure to control EGR valve on California cars
    c. overcome the valve spring tension and reduce recirculation during acceleration and some cruising condition
    d. increase back pressure in California cars, thus increasing gas mileage

12. The purpose of the spacer used with exhaust back pressure sensor transducer is to:

    a. aid in controlling exhaust gas recirculation when low or high back pressure is present
    b. allow the carburetor to be mounted off the intake manifold
    c. reduce temperature of exhaust gas going to the CTO switch
    d. increase pressure of exhaust gas going to carburetor

13. The ambient temperature override switch was:

    a. used on all cars sold in California after March 15, 1973
    b. used in place of EGR valve before March 15, 1973
    c. replaced by the CTO switch after March 15, 1973
    d. used in California to increase gas mileage during energy crises

14. The purpose for understanding the chemistry of air is to:

    a. better understand where and how some of the emission problems evolve from the automobile
    b. measure the amount of natural radiation given off by the automobile
    c. tell how much air is recylable by the automobile
    d. determine if any part of the internal combustion engine exhaust is biodegradable

T F 15. The EGR system recirculates most of the exhaust gases during idle.

T F 16. The purpose of the vacuum amplifier is to bleed off excess carburetor venturi to the intake manifold.

T F 17. Exhaust gases are introduced into the intake manifold by the floor jet system, and floor entry system.

T F 18. With a cold engine at about 2000 rpm and with a defective EGR-CTO switch the vacuum reading at the EGR valve should be above 6 inch Hg.

T F 19. Testing the EGR valve with the engine at correct idle the engine rpm should not change when the pintle is off its seat.

T F 20. Exhaust emissions are greatest during periods of deceleration and idle.

FUEL EVAPORATION

Questions

1. The main purpose of the fuel evaporation system is to

   a. improve gas mileage
   b. prevent gasoline HC vapors from escaping into the atmosphere
   c. expand gas tanks so they will hold more fuel
   d. none of the above

2. In the present fuel tank filler cap the safety pressure relief valve opens only

   a. when the tank is being filled with fuel
   b. when pressure in the fuel tank exceeds one-half (1/2) pounds
   c. when the temperature in the fuel tanks reaches 87 degrees
   d. b and c above

3. The filler cap in the present fuel system

   a. allows air into the fuel tank at all times
   b. allows air into the fuel tank only when a vacuum of over one-half (1/2) inch of mercury builds up in the tank
   c. allows air pressure to be released from the fuel tank but is not designed to let air into the tank
   d. none of the above

4. The fuel tanks on most cars are prevented from being filled 100% because

   a. of the expansion space of 10% to 12% designed into the tank
   b. the design of the filler neck on the fuel tank
   c. of the high pressure developed in the tank during filling
   d. a and b above

5. The fuel vapors that come from the fuel tank that is sealed from the atmosphere are

   a. released to the atmosphere through the liquid

check valve
b. released to the atmosphere through the charcoal canister
c. stored in the charcoal canister until they become part of the air/fuel mixture to be burned
d. none of the above

6. What is the reason for having the vent lines coming from the top of the fuel tank to be of different heights?

7. What is the purpose of the single or compound loop vapor liquid separator?

8. What are the <u>three</u> purposes of the three-way valve in the fuel evaporation system?

    1.

    2.

    3.

9. What is the purpose of the float in the bowl located in the liquid check valve?

10. A storage canister has two (2) connections. What are the routings of the lines from these connections?

    1.

    2.

11. What would you look for in inspecting the filler cap on a fuel tank with a vapor control system?

    1.

2.

12. What part of the fuel evaporation system requires scheduled replacement?

13. What is the reason for not removing the filler caps of both fuel tanks on vehicles having dual fuel tanks?

14. Which meter on an infrared analyzer would register a reading in detecting a fuel vapor leak?

T F 15. Some charcoal canisters have more then two (2) connections.

T F 16. Demand purging of the canister only occurs when ported vacuum is applied in a constant and demand purge system.

T F 17. When the purge rate is controlled by the air flow entering the air cleaner the system is called the variable purge system.

T F 18. When a constant purge system is used vacuum from the intake manifold is controlled by small fixed orifice on the canister.

T F 19. When demand purging is used it will result in poor performance and driveability because of the effect it has on the air/fuel mixture.

T F 20. Because of the design of the auto perculation valve it is not necessary to vent the carburetor to the canister.

POSITIVE CRANKCASE VENTILATION SYSTEM

Questions

1. On cars sold in the United States today, what type of PCV system is used?

   a. type I or open system
   b. type II with West Coast
   c. type III with direct vent into air cleaner
   d. type IV or close system

2. What is the definition of PCV?

   a. positive crankcase vacuum
   b. potential crankcase vacuum
   c. positive crankcase ventilation
   d. none of the above

3. What percent of vehicle emission is caused by exhaust emission?

   a. 40%
   b. 60%
   c. 80%
   d. 10%

4. Crankcase emission contributes what percent of the total automotive emission output?

   a. 10%
   b. 20%
   c. 35%
   d. 60%

5. The type IV or closed PCV system uses the following combination:

   a. vented filler cap and open road draft tube
   b. non-vented filler cap and blocked road draft tube
   c. ported vacuum valve and thermostatically controlled air cleaner
   d. non-vented filler cap and hose connection from valve cover or crankcase to air cleaner

6. PCV valve is the same as:

   a. positive crankcase vacuum
   b. potential carbon valves
   c. positive crankcase ventilation
   d. all of the above

7. What was the first emission control system?

   a. air injection
   b. positive crankcase ventilation
   c. fuel vapor control

8. Identify the three (3) main parts of the PCV valve.

9. Identify the operating modes of the PCV valve.

10. During high speed engine operation what allows the spring to move the plunger off its seat?

11. Under what engine operation does the PCV valve offer the greatest restriction of blow-by gas into the intake manifold?

12. How does the PCV valve prevent flame entering the crankcase during backfire?

13. What color on the "AC" tester indicates a satisfactory PCV system?

14. What is the name of the valve in the crankcase ventilation system?

15. What are the 3 main components of blow-by gases?

16. Describe the RPM Drop Test to test the PCV system.

17. What type of filter is used in the air cleaner using the PCV system? Example: Ford Motor Co.

18. With the (type IV PCV) closed system, the only place fresh air enters is through the ___________ ___________.

T F 19. Blow-by gases are formed mainly during the exhaust stroke.

T F 20. In pre-emission control automobiles we did not have the problem of blow-by gases.

T F 21. The type III system used two PCV valves, one on each intake manifold.

T F 22. The reason the PCV valve does not need to be replaced is because there are no moving parts.

T F 23. The PCV valve is controlled by electrical current from the distributor.

T F 24. During the Crankcase Vacuum Draw Test you should feel the air moving out of the valve cover.

THERMOSTATIC AIR CLEANER

Questions

1. What causes the air door to "close off" the snorkel to cold air?

2. What causes the air door to block off heated air and allow cold air to enter the carburetor?

3. If the vacuum was never allowed to the vacuum motor in what position would the air door be in?

4. In Question 3 what parts would be at fault?

5. Explain what causes the air bleed in the temperature sensor to function.

6. Explain what happens to the air door when the temperature sensor air bleed leaks vacuum constantly.

7. Explain what happens to the air door when the air bleed in the temperature sensor does not bleed vacuum.

8. What are the three main purposes or profits of the thermostatic air cleaner system to the automobile?

   1.

   2.

   3.

9. Describe how the regulating mode functions on the vacuum motor heated air system.

10. Describe the purpose of a vacuum override motor on the thermostatic air cleaner.

T F 11. When checking the thermostat in the thermostatic air cleaner system when the temperature is above $130^{\circ}F$ or $54.4^{\circ}C$ the air valve door should be open to engine compartment air.

T F 12. The air valve door should be in the "heat on" position or Hot Air Delivery mode when the temperature is below $105^{\circ}F$ or $40.5^{\circ}C$.

T F 13. If damper door is not closed with full vacuum, it could be due to a vacuum motor being defective.

T F 14. The damper door should be completely open to engine compartment air with the engine off and the ambient temperature below $80^{\circ}F$.

T F 15. Vacuum at the motor should be 5" or less when the damper door assembly is open to engine compartment air.

T F 16. The Thermostatic Air Cleaner system's main purpose is to reduce the formation of NO_x.

T F 17. The thermostat is in a retracted position or "hot air mode" when temperature is below approximately $105^{\circ}F$.

18. The purpose of the vacuum override motor is to provide the necessary balance of air intake during

a. engine overheat
b. deceleration
c. cold engine drive-away
d. rapid cold acceleration
e. all of the above

19. The thermostatic air cleaner is in the cold air delivery mode when

a. air temperature in the air cleaner reaches about 130°
b. vehicle is in wide open throttle operation

c. the cold override motor is denied vacuum
d. vacuum is strong enough to hold the door open
e. operating under winter conditions

20. The vacuum to the vacuum motor is obtained from

a. venturi vacuum
b. ported vacuum
c. reservoir vacuum
d. manifold vacuum

APPENDIX J

MOTOR VEHICLE EMISSION CONTROL

SUPPLEMENTARY REFERENCE MATERIALS

MOTOR VEHICLE EMISSION CONTROL

WORKSHOP REFERENCE MATERIALS

Ethyl Corporation
Central Finance Department
457 Florida Boulevard
Baton Rouge, Louisiana 70801

"The Story of Gasoline"	$ .75
"Controlling Exhaust Emissions"	.25
"Positive Crankcase Ventilation"	.25

Kal-Equip Company
Otsego, Michigan 49078

"Clean-Air Tune-Ups"

Gargano Promotions
12824 West Seven Mile Road
Detroit, Michigan 48235
313/864-4011

"Vehicle Emission Control", latest edition $3.75

Delco Remy
P.O. Box 2499
Anderson, Indiana 46011

"HEI, the High Energy Ignition System" $ .50

AC Delco Division
Power Service Training Department
P.O. Box 9000
North End Station
Detroit, Michigan

"Power Service Training Emission Control Service," Part I
"Power Service Training Emission Control Service," Part II
"Power Service Training Emission Control Service," Part III

- $2.00 for all three parts

Mr. Paul A. McIntire, Jr.
14250 Plymouth Road
Detroit, Michigan 48232
313/493-2721

"What You Must Know About AMC Emission Controls", Parts I, II, and III

Mr. C. G. Palus
P.O. Box 2119
Detroit, Michigan 48231

"Electronics Ignition System", Chrysler TMJ-106P $2.00

Mr. W. W. Howes
Parklane Towers West
One Parkland Boulevard
Dearborn, Michigan 48126
313/323-4016

"Motorcraft-Vehicle Emission Control Systems" and all supplements. Form #AUD-7528-J $3.25

"Driveability-Basics-Emission Control Systems", Code 0901-017 $3.40

"Driveability-Solid State Ignition", 2A, Code 2302-006 $3.40

Service Section
General Motors Corporation
Detroit, Michigan 48202

"General Motors Emission Control Systems Maintenance Manual" and all supplements. $1.40 ea.

Environmental Protection Agency

Inspector's Guidebook, Stock #5500-00115

APPENDIX K

MOTOR VEHICLE EMISSION CONTROL

WORKSHOP EQUIPMENT

MOTOR VEHICLE EMISSION CONTROL

WORKSHOP EQUIPMENT

5	HC-CO analyzers
5	timing lights
5	dwell-tack
5	vacuum gauges
5	vacuum guns
5	pressure-volume fuel testers
1	oscilloscope
1	battery load tester (VAT 28)
5	continuity test lamps
2	volt meters ⟩ may be combined
2	ohm meters ⟩ may be combined
10	18 inch jumper leads
5	3/4 inch masking tape
5	Chem-tool carburetor cleaner (squirt can)
2	R-12 Referigant
1	hot air blower (hot air gun)
5	1/4 inch shut-off valves with 1/4 inch hose fillings
5	1/4 inch tees with 1/4 inch hose fillings
30	midget screw type hose clamps
10'	1/4 inch fuel hose
10'	5/16 inch fuel hose
10'	3/16 inch vacuum hose
10'	5/32 inch vacuum hose
10	fender covers
1	box vacuum tees assortment
1	3/4 inch video-cassette player and monitor
1	35 mm slide projector and screen
1	audio-cassette player
1	overhead projector

Necessary hand tools found in auto shop.

HAND TOOLS

1 set 7/16 thru 3/4 in. flex sockets, 3/8 drive

1 set 7/16 thru 3/4 in. 12 pt. Deepwall sockets, 3/8 drive

1 set 7/16 thru 3/4 in. 12 pt. Standard sockets, 3/8 drive

2 each ratchets, 2 in., 4 in., 6 in., 8 in., 12 in. extensions

2 each breaker bar, speed handle, universal joint

2 each 13/16 and 5/8 spark plug sockets

1 set 1/4 thru 3/4 in. comb. wrenches (open-box ends)

1 set 3/8 thru 3/4 inc. flare nut wrenches

2 each 1/2 bent dist. wrench

2 each 9/16 bent dist. wrench

1 each 4 in., 6 in., 8 in. crescent wrench

1 1/8 in. flexible dist. allen wrench

1 set allen wrenches (10 piece)

1 ignition wrench set

5 extension cord (25 ft.)

5 trouble lights

1 each 12 oz. and 16 oz. ball peen hammer

1 plastic mallet

1 each 6 in., 8 in. vise grips

1 channel locks

5 comb. pliers (6 in.)

5 needle nose pliers (6 in.)

2 Dikes (6 in.)

1 battery service kit (pliers, post cleaner terminal puller thydrometer)

5 remote starter switches

2 Ford coil primary lead adapters

2 Stubby standard blade screwdrivers

2 Stubby phillips (No. 2) screwdrivers

5 4 in. standard blade screwdrivers

5 4 in. phillips (No. 2) screwdrivers

5 6 in. standard blade screwdrivers

2 small pencil screwdrivers

2 10 in. standard blade screwdrivers

2 flexible idle misture adjusting screwdrivers

1 set flat feeler gauges (standard and nonmagnetic)

2 sets wire gaping gauge (spark plug gaping tool)

Chalk for timing marks

Rags

Golf tees (vacuum line plugs)

1 universal float gauge measuring tool

1 universal float pin gauge set or number drill index (1 thru 60)

2 insulated secondary wire pliers

1 compression tester

1 telescoping magnet (12 in. to 24 in.)

1 small pocket magnet

1 roll black electrical tape

1 assortment solderless connector kit (optional)

1 tube dist. cam lubricant

1 dist. cap tower terminal cleaner

<u>Shop Facilities</u>	Exhaust system
	Exhaust system hoses and adapters for both single and dual exhaust
	Battery charger
	Safety glasses, goggles, faceshields
	Air compressor hoses and blow guns
	Two-ton floor jack
	Car stands (5 pair)

APPENDIX L

MOTOR VEHICLE EMISSION CONTROL

NONDISPERSIVE INFRARED ANALYZER NARRATIVE

NONDISPERSIVE INFRARED ANALYZER

The infrared exhaust gas analyzer operates on the principle of absorption of specific wavelengths of infrared energy by carbon monoxide and hydrocarbon gases present in the sample of automotive exhaust gases. In general, the system compares the infrared waves that have been passed through a reference cell to the infrared waves that have been passed through a sample cell filled with automotive exhaust gases. Because the hydrocarbons and carbon monoxide molecules absorb the infrared waves in the sample cell, but not the reference cell, the difference in the amount of infrared energy absorbed is detected by an optical detector. An electrical signal from the optical detector is sent to the amplifier, modified and read out on the hydrocarbon and carbon monoxide meters.

Analyzer Components

The infrared source is a heater which emits constant infrared waves through the reference and sample cells to the filters and detectors.

The chopper is a segmented wheel, used to interrupt the infrared waves at regular intervals to create a pulsating infrared signal.

<u>A reference cell</u> is a tube containing an inert gas which the infrared waves are passed through to the detector unchanged.

<u>The sample cell</u> is a flow-through tube which receives a sample of exhaust gas through which infrared waves are passed through to the detector. The hydrocarbons and carbon monoxide molecules in the exhaust gas absorb some of the waves before reaching the detector.

<u>The filter</u> is a device used to exclude all but those infrared wavelengths that hydrocarbons and carbon monoxide molecules can absorb.

<u>The detector</u> receives the infrared waves that were allowed to pass through the filters and changes these waves to electrical signals. The signals from the detector are used to calculate the hydrocarbons and carbon monoxide content of the exhaust gas sample.

<u>The amplifier</u> receives the signal from the detectors and through electronic circuitry sends a signal to the meters which gives a visual reading.

Operation Principles

As stated before, the analyzer operates on the principle of absorption of specific wavelengths of infrared waves. The source of the infrared waves is a metal shielded heat source that emits a total spectrum of infrared, radiant energy waves through the reference and sample cells. The type of analyzer will determine if it has one or two infrared wave sources. If it has only one source the infrared waves will be reflected off a mirror and divided to provide an infrared source for both of the cells. If it has two infrared sources there will be one energy source for each cell.

The constant spectrum of infrared waves is interrupted by a rotating segmented chopper disc. This interruption of the flow of infrared waves creates a pulsating AC signal. This signal is then amplified and rectified to a DC signal which is used to activate the meters.

The reference cell is a closed tube containing an inert gas or a gas that is very low in absorption of infrared waves. This gas will be used as a reference or standard that measures the amount of energy or waves initiated by the infrared wave source.

The sample cell is a flow-through tube which receives a metered amount of exhaust gas to be analyzed. As the gas passes through the cell the hydrocarbons and carbon monoxide molecules in the exhaust gas sample will absorb a certain amount of the infrared waves. The amount of infrared waves absorbed will depend upon the concentration of hydrocarbons and carbon monoxide in the sample tube.

The infrared waves passing through the reference and sample cells pass through a filter which excludes all of the infrared waves except those which can be absorbed by hydrocarbons and carbon monoxide molecules. After the infrared waves pass through the filter they are received by the optical detectors. There are two detectors for each cell: a detector for the wavelength that measures hydrocarbons and a detector for the wavelength that measures carbon monoxide. These detectors convert the pulsating infrared waves to electrical signals. The difference between the absorption of the infrared waves in the reference cell and the sample cell is converted to electrical signals. These signals are then sent to the amplifier circuitry where they are amplified and changed into direct current used to operate the hydrocarbon and carbon monoxide meters. The meters indicate the concentration of hydrocarbons and carbon monoxide in the metered amount of exhaust gas in the sample cell. This concentration is converted to read as parts per million for hydrocarbon and percentage for carbon monoxide.

Copies of the above presentation may be obtained from the Department of Industrial Sciences, Colorado State University, in 3/4 inch videocassette form.

APPENDIX M

MOTOR VEHICLE EMISSION CONTROL

CHEMISTRY OF THE INTERNAL COMBUSTION ENGINE NARRATIVE

CHEMISTRY OF THE INTERNAL COMBUSTION ENGINE NARRATIVE

The internal combustion engine is a machine for releasing the chemical energy stored in the fuel, through the process of combustion, and converting some of that energy into motion. Unfortunately, a great deal of that energy is wasted in the form of heat, or waste gases, or worn rubber. It is important to realize that the engine is a complete system; this would include, for example, the fuel, air, lubrication, mechanical parts and all the products of combustion. What goes into the engine determines how well it operates. How well the engine operates determines, to some extent, what comes out of the engine: the emissions. Now the concern about air pollution caused by engines has led to certain restraints being placed on the kinds of things that can be wasted from an engine: the emissions. These restraints have a great influence on both the engine efficiency and on the type of fuel that must be used. The goal is to achieve the most efficiency consistent with a cheap and plentiful fuel and harmless emissions. I am going to try to explain how the chemistry of the fuel, the combustion processes that occur inside the engine, and emissions control determine how close we can come to that goal with our current technology.

A fuel gasoline contains literally hundreds of chemicals, by far the major proportion of which are called hydrocarbons.

The typical hydrocarbons in gasoline may be N-petane, 2-methyl-butane and benzene. These are long chemical names for the kinds of structures you see here, and, as you can see, these hydrocarbons are called hydrocarbons because they contain only atoms of hydrogen and atoms of carbon. These compounds can be divided into three groups for the purposes of discussion of the chemistry of the internal combustion engine. We can divide them into straight-chain hydrocarbons, branched-chain hydrocarbons and ring hydrocarbons. Sometimes these ring hydrocarbons are called aromatic hydrocarbons. It is the energy stored in the chemical bond in the hydrocarbons that is released when the hydrocarbons burn in oxygen inside the cylinder in the internal combustion engine. As you all know, the efficiency of an engine is partly dependent upon the compression ratio. For knock-free performance in a particular engine, the octane rating of a fuel must be correct. The octane rating that is needed for knock-free operation increases as the compression ratio increases, as shown here. For example, at a compression ratio of 4:1, the octane number needed is about 60. For a compression ratio which is very high such as 12:1, an octane number is 102. The octane rating is a number given to the fuel, based on the comparison of the performance of a standard engine, the so-called CFR engine (which is really only a variable compression ratio engine), running on that fuel to the performance of the engine running on a mixture of two hydrocarbons. The first one is called N-heptane and it is a straight-chain hydrocarbon and has an octane number assigned to it of 0. Also, there is another hydrocarbon called 224 trimethylpentane. Sometimes this is called iso-octane; as you can see, this is a branched-chain hydrocarbon and has an octane number of 100. In fact, generally hydrocarbons which are straight-chain hydrocarbons have low octane numbers and branched and ring hydrocarbons have fairly high octane numbers. We shall see why this is later on when we get into a discussion of the chemistry of the processes occurring inside the cylinder during each of the strokes in an auto engine. The octane number can be significantly increased by adding small amounts of certain additives to gasoline. One of these additives is called tetra-ethyl lead. This is the so-called anti-knock additive in a gasoline. The tetra-ethyl lead is called that because there are 4 ethyl groups (1, 2, 3, 4) in the chemical together with an atom of lead to which the 4 ethyl groups are attached. We can characterize the lead tetra-ethyl in this way. Usually there are about 2 to 5 grams of this material added to the gasoline in order to raise the octane number.

Lead compounds must eventually be removed from the engine; otherwise it would tend to fill up with these kinds of chemicals, and this may cause air pollution. In fact, it may lead to severe problems with some types of emissions control.

Generally speaking, there are many other additives in small amounts in gasoline for a variety of purposes. They can be added as detergents to keep the engine clean. They can be deposit modifiers, anti-icing agents, anti-rust agents and dyes, etc. Again, it is very important to understand that what goes into the engine must come out in some form or another, even if that particular chemical does not perform any useful function in the engine. For example, in gasolines there are impurities, sulphur and phosphorus compounds which are in the original crude oil and rather difficult to remove. These compounds are not useful, and they may form certain substances inside the engine which may cause alarm and may cause air pollution, which we shall see later.

Obviously, a gasoline must be mixed with air before it will burn. Air consists of approximately 20% oxygen and about 80% nitrogen. There are small amounts of other things like water vapor and carbon dioxide but those won't concern us for the moment. The hydrocarbons that we've been talking about in the fuel react only with the oxygen during the burning processes, but the nitrogen in the air is extremely important in this situation because it gives rise to air pollutants. The ratio of the amount of air to fuel, the so-called AF ratio, is very important. It plays a critical role in the miles per gallon that can be achieved and the power that can be achieved in the internal combustion engine and also in the types and the amounts of the various emissions that come out of the engine. Theoretically, about 14.5 to 15 pounds are needed to burn one pound of gasoline. This air-fuel ratio is quite close to that which gives maximum fuel economy. This correct amount, or as it is called, stoichiometric amount, is calculated from the overall chemical reaction that corresponds to the complete reaction of all the fuel hydrocarbons with just the right amount of oxygen. Unfortunately, maximum power is achieved with a richer mixture, as you can see on this diagram.

I hope you can already see that fuel and air-fuel characteristics play an important part in determining the economy, power, and the emissions that are delivered by the internal combustion engine. In a short while we will see how the chemistry of the combustion process provides an explanation of the power and the problems of the internal combustion engine.

The chemistry of the combustion processes that occur in the four-stroke or auto cycle engine may be illustrated by considering the chemical events that occur inside the cylinder during each stroke. In the intake stroke, the complex mixture consisting of all the chemicals contained in the gasoline and the air is pulled into the cylinder. We have oxygen molecules, nitrogen molecules, straight-chain hydrocarbons, branched and ring hydrocarbons, and the additives that are contained in the gasoline. You must bear in mind that the air-fuel ratio has already been determined by the carburetor. As the piston moves up during the compression stroke, the volume is rapidly decreased. As this volume decreases, the pressure increases tremendously and the temperature begins to increase greatly. This has the same effect as that produced when pumping up a bicycle tire with a hand pump. The pump barrel gets very warm. This is because the air is being compressed inside the barrel of the pump. As the temperature increases in the compression stroke, the straight-chain hydrocarbons have a tendency to begin to burn before the other types of hydrocarbons. If the anti-knock additive was not present, it would burn too fast (spontaneous ignition) and too early (pre-flame reactions). This burning without the spark having fired would result in the mixture exploding rather than burning smoothly. These explosions set up shock waves which strike the cylinders and piston and cause a characteristic knocking or pinging sound. The released energy that we have gotten from burning the hydrocarbons would be completely wasted. The anti-knock additive or the tetra-ethyl lead stops this by decomposing.

The tetra-ethyl lead breaks up and forms four ethyl groups and lead groups. The lead then combines with the decomposing straight-chain hydrocarbons and forms substances which do not burn as rapidly as the straight-chain hydrocarbons themselves. So the combustion is retarded or slowed down until the stroke reaches the top; the spark plug fires and the whole mixture begins to burn in a controlled manner.

In the power stroke the spark plug is fired and all of the hydrocarbons begin to combust or burn. The straight-chain hydrocarbons with the lead attached begin to burn. The branched-chain hydrocarbons begin to burn, and to react with the oxygen. The ring hydrocarbons begin to react with the oxygen, all three types of hydrocarbons from carbon dioxide, water, and heat. The tremendous increase in temperature results and the heat expands the gases inside the cylinder and the piston is pushed down. Unfortunately, there are several side effects which occur here that are partly due to the high temperature inside the cylinder and partly due to the nature of the fuel. The lead compounds that we talked about earlier, the anti-knock additives, have now done their job and the scavenging agents which are included in the gasoline specifically to remove the lead compounds at this point do so by reacting with the lead to form compounds which are gases, the chemical names for which are lead chloride, lead bromide, and lead bromochloride. At the high temperature the nitrogen also begins to combine with the oxygen. Now this is a reaction that does not normally occur. It only occurs in this instance because of the very high temperature generated inside the cylinder. Although not very much of the nitrogen reacts with the oxygen, enough does to cause some severe problems, as we shall see later. It forms a chemical compound called nitric oxide, the chemical formula being NO. The high temperature can also lead to some unusual chemical changes in the ring hydrocarbons that are contained in the gasoline. The ring hydrocarbons can stick together, or they can fuse to form strange-looking chemicals, one example of which is called benzopyrene. The burning of the hydrocarbons is also never quite complete for very many complex reasons. One reason is that the air fuel ratio that is normally used in engines is too rich. We talked a little about this earlier. One of the reasons for a mixture that is too rich being used is that the maximum power can be achieved with this kind of mixture, whereas for fuel economy you would use the stoichiometric amount. Because the mixture is too rich, there is not quite enough oxygen available for burning all the hydrocarbons. Therefore, we get what is called incomplete combustion, and there are some hydrocarbons left over. This incomplete combustion process also gives rise to the formation of carbon monoxide instead of carbon dioxide. Finally, there is an effect known as quenching which leaves some of the hydrocarbons unburned. This occurs because the area at the edge of the cylinder and the piston is metal and this conducts away the heat. These parts of the cylinder are a little bit cooler than the inside part. This means that the combustion process does not occur completely and it leaves unburned hydrocarbons.

In the exhaust stroke, which is the next stroke, the hot, very complex mixture of materials and waste goes out through the manifold and into the tailpipe. We are talking about things like the following: unburned hydrocarbons, used hydrocarbons, such as benzopyrene, carbon monoxide, carbon dioxide, nitric oxide, lead compounds of various types, nitrogen which has not been used, water and waste heat. In the next part, we shall see how these exhaust gases or emissions produce air pollution and what can be done to remove some of these problems.

The gases that are emitted from the tailpipe cool rapidly and are now diluted because they are present in the air and the gases are surrounded by oxygen and nitrogen which are the two major constituents of the air. Further chemical reactions can go on as the gases are exposed to more oxygen, nitrogen, and sunlight. Smog can be formed. Smog is a compound word which was originally coined in England as being smoke plus fog. The cooling allows some of the nitric oxide to react with oxygen to form something called nitrogen dioxide. Nitrogen dioxide is a brown, very highly toxic gas. The combination of NO and NO_2 is sometimes referred to as NO_x. The nitrogen dioxide is an unusual gas in that when sunlight falls on it, it can break up into nitric oxide again and an oxygen atom. The chemical formula for this is 0. Now this is very different from the normal oxygen gas that you find in air. That has a chemical formula of 0_2. The nitric oxide that is formed in this particular chemical reaction can then recycle and the whole process can come about again and we can form more oxygen atoms with the formula of 0. These 0 atoms are extremely reactive and they are looking for things to take off on; and one of the things that they can react with rather nicely is oxygen molecules; that is exactly what happens. Oxygen atoms react with oxygen molecules: $0 + 0_2$ gives 0_3 which is called ozone. This is one of the gases in smog which causes the eyes to sting. It causes also the breakdown of rubber and plastics and various other things. For example, it can attack furnishings in plastics, etc. Ozone may also attack plants and produce degradation. There are further reactions which go on. The ozone, 0_3, may react with some of the unburned hydrocarbons that we talked about in the earlier section to give some complicated chemicals given the abbreviated name of PAN. Actually, the chemical name is peroxy acetyl nitrate. These PANs are also toxic to animals and plants.

Carbon monoxide that is formed from incomplete combustion is also very dangerous to health in that when it is inhaled in sufficient quantities, it can react with the blood proteins instead of oxygen, and it can produce symptoms of sleepiness and nausea. If the concentrations of this chemical, carbon monoxide, are very high, it can even cause death.

The lead compounds which are exhausted as gases originally--remember they react with the scavengers, which were there deliberately to remove them from the engine--now cool, and instead of gases they can form particles in the atmosphere. Sometimes these are called aerosols. The lead compounds may also be dangerous to health. There are many studies now underway trying to find out if the lead compounds are indeed harmful to health. Finally, there is a great deal of concern now about the fused or rearranged hydrocarbons. These are known; in fact, many of them are known to be carcinogenic. This means they can be cancer-producing. One of the examples which I gave earlier of a fused hydrocarbon was benzopyrene and this is known to be a cancer-producing chemical. As you can see, there are some reasonable concerns about the health problems that may be encountered from automobile exhaust constituents.

It has been recognized that the automobile is responsible for the major portion of the tonnage of air pollutants, and it is now thought that the automobile is responsible for approximately 60-70% of the total air pollution tonnage. This has lead to the 1970 ammendments to the Clean Air Act. These ammendments mandate drastic reductions in the air pollutants, carbon monoxide, hydrocarbons, and NO_x emitted by automobiles and require that they be made by the 1975 and 1976 model years. You can see the drastic reduction from 10 to 0.4 in hydrocarbons, from 80 to 3.4 in carbon monoxide, and from 4 to .4 in NO_x. These 1975 standards were extended one year to 1976 models and the 1976 standards were extended to 1977. Very recently, because of problems that were being encountered in the emission control technology, they were extended to 1978.

Problems in the development of emissions control technology led to requests, as I just mentioned, to delay these standards. But for most 1975 automobiles, the manufacturers have chosen to use exhaust gas recirculation (EGR) and catalytic converters as the two main types of devices for controlling hydrocarbons, carbon monoxide and NO_x emission.

Catalytic converters will be placed before the muffler, as close as possible to the engine manifold on the exhaust pipe. These converters contain certain chemicals. For example, one is a palladium-platinum mixture which is deposited onto an inert support, sometimes alumina. This support may be in the form of pellets, approximately 3/8 inch diameter, or it may be in the form of a solid honeycomb, sometimes called a monolith. The palladium and platinum compounds are catalysts. These are chemicals which make chemical reactions go much more easily. The chemical reaction which we want to make go much more easily is the further burning of carbon monoxide and unburned hydrocarbons. The job of the catalyst is to make sure that the unburned hydrocarbons in carbon monoxide are completely burned to harmless carbon dioxide and water. Unfortunately, again, there are problems with such converters. One of the major problems is that they are poisoned by the lead compounds which we now know are included as anti-knock additives. These lead compounds which are coming out of the manifold coat the surface of the catalyst and stop the catalyst from being efficient at changing carbon monoxide and hydrocarbons into carbon dioxide and water. The ones that are included on the 1975 models are called oxidative catalysts and do not remove one of the principal sources of smog, which is the NO_x, as we said earlier. Finally, and this may turn out to be a severe problem, are any sulphur compounds which may be impurities in the original gasoline and can be nicely burned by the catalytic converter. The sulphur burns with oxygen to become sulphur dioxide. The sulphur dioxide can react further with oxygen to form sulphur trioxide. The sulphur trioxide may react with water vapor in the atmosphere to form sulphuric acid. Sulphuric acid is a rather obnoxious substance. It is very useful when it is present in the battery; that is, battery acid. When it comes out the tailpipe it can be extremely harmful. Recent tests have shown that catalytic converters do indeed extensively increase the amount of sulphuric acid coming out of the automobile. The only way in which the sulphur problem can be solved is for the gasoline itself to be made purer with respect to the sulphur. The sulphur is removed from the gasoline. Unfortunately, that route is rather expensive because that can only be done in the refinery, and the refining techniques need to be changed rather radically in order to remove the sulphur completely.

The problem of the lead may be resolved; in fact, it has been resolved for 1975 cars which have converters by using lead-free gasoline. In most 1975 autos there will be a special gas tank inlet which will only be fitted by small nozzles on pumps which are pumping lead-free gas. I mentioned previously that TEL or tetra-ethyl lead was added to increase the octane number of the fuel. If the TEL is removed, the current method of maintaining the octane number is to change refining techniques. In fact, one of the ways in which you can increase the octane rating of the gasoline without including an anti-knock additive is to increase the amount of ring or aeromatic hydrocarbons in the gasoline, as much as up to 40% of the gasoline. Remember, the ring hydrocarbons have much higher octane in general than the straight-chain or branched-chain hydrocarbons. The NO_x problem is still unsolved and much research is now underway to try to design another type of converter which will be placed probably before the oxidative converter to remove NO_x, although the technology for this is not at present economically viable. It seems that the only way to achieve clean air and more miles to the gallon may be to use other fuels. For example, one fuel is propane. There are already conversion kits available on the market for this kind of fuel. Hydrogen could be used, or even perhaps electricity in an electric car. I guess another way to try to do this is to completely redesign the power train and use stratified engines, turbines or steam engines. It certainly is going to be an interesting and a difficult challenge for the auto engineer and the mechanics of the future.

Copies of the above presentation may be obtained from the Department of Industrial Sciences, Colorado State University, in 3/4 inch videocassette form.

APPENDIX N

SLIDE AND NARRATION EVALUATION FORMS

EMISSION SYSTEM EVALUATION

Evaluator ______________________ Address ____________________________

Series A B C D E Showing Time __________________

Please evaluate each of the following categories:

1. Illustrations low 1 2 3 4 5 high
2. Narrations low 1 2 3 4 5 high
3. Clarity of content low 1 2 3 4 5 high
4. Logical progression low 1 2 3 4 5 high
5. Terminology low 1 2 3 4 5 high

Slide Key: Place an I for Illustration and an N for Narration in the appropriate box.
E = Excellent A = Acceptable P = Poor Please feel free to make comments.

Slide #	E	A	P	Comments	Slide #	E	A	P	Comments
1					32				
2					33				
3					34				
4					35				
5					36				
6					37				
7					38				
8					39				
9					40				
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30					61				
31									

AIR INJECTION REACTION SYSTEM EVALUATION

	Low 1	2	3	4	5 High
Illustrations		1	2		15
Narration		1	2	1	14
Clarity of Content		1	1	1	15
Logical Progression			4		14
Terminology			3	1	14

EXHAUST GAS RECIRCULATION SYSTEM EVALUATION

	Low 1	2	3	4	5 High
Illustrations		1	1	1	15
Narration			1	3	14
Clarity of Content		1	1	2	14
Logical Progression		1	3	1	13
Terminology			2	2	14

POSITIVE CRANKCASE VENTILATION SYSTEM EVALUATION

	Low 1	2	3	4	5 High
Illustrations			2	2	14
Narration			2	1	15
Clarity of Content		1	3	1	13
Logical Progression		1	1	2	14
Terminology		2	1	2	13

FUEL EVAPORATIVE SYSTEM EVALUATION

	Low 1	2	3	4	5 High
Illustrations		1	2	2	13
Narration		1	3	3	11
Clarity of Content		1	1	2	14
Logical Progression			4	2	12
Terminology		2	1	2	13

THERMOSTATIC AIR CLEANER SYSTEM EVALUATION

	Low 1	2	3	4	5 High
Illustrations			1	2	15
Narration			2	2	14
Clarity of Content		1	2		15
Logical Progression		1	1	2	14
Terminology		1	1	1	15

APPENDIX O

EMISSIONS I AND II COURSE OUTLINE

FOR AUTOMOTIVE INSTRUCTORS

IS 488 AUTO EMISSIONS CONTROL I

I. Introduction

  A. Pre-Test

  B. Air Pollution
    1. HC, CO, NO_x: Defined and Explained
      a. Effects on Human, Plant, and Animal Life
      b. Air Quality: Visible vs. Invisible Film: "New Rules of the Road"
      c. Discuss Film

  C. Define: Denver Air Quality Control Region - counties include Denver, Jefferson, Arapahoe, Adams, Boulder, Douglas, Gilpin and Clear Creek
    1. Progress to Date and Your Future Involvement
      a. Pilot Programs at A.T.L. Health Department Involvement and CSU Programs
        1) Federal Standards Must Be Met According to Federal Clean Air Act. An Attempt to Improve Air Quality Must Be Made
          a) Probable Involvement of Schools and Instructors
        2) Proposed Mandatory Vehicle Emissions Inspection
          a) Training - Personnel
          b) Stations - Equipment
          c) Vehicles - 1968 and Newer
            (1) Exempt Vehicles

II. Ignition: Pre-Test

  A. Film: "M.M. Introduction to Emissions"

  B. Review Formation and Causes of HC, CO, NO_x From Engines

  C. Pre-Controlled Systems
    1. Theory and Purpose of Ignition System
      a. Basic Electricity
        1. Volts, Amps, Ohms
      b. Components: Construction and Operation
      c. Diagnostic Procedure in Locating Problem

  D. Modified Ignition Controls
    1. Ignition Effects on Emissions
      a. HC, CO, NO_x

b. Advance Controls
   1) Dual Diaphragms
   2) Electric Solenoids Controlling Vacuum Supply
   3) Modified Advance Curves

E. Electronic Ignition
1. Purpose and Advantages
2. Theory of Operation
   a. Component Identification (General)
3. Specific Manufacturers
   a. Chrysler
   b. GM
   c. Ford
   Film: "Emissions In Perspective"

III. Carburetion

A. Pre-Controlled
1. Carburetion Principles
   a. Pressure and Effects
   b. Carburetor Circuits
      1. Jetting and Power Valves
   c. Air Cleaners
   d. Fuel System Demands
      1) Fuel Pressure and Delivery
   e. Diagnostic Procedure

B. Carburetor Modifications
1. Idle Mixture Limiters
2. Idle Stop Limiters
3. Combination Valves (C.E.C.)
   a. Decel Valves
4. Carburetor Vacuum Principles
   a. Manifold
   b. Ported
   c. Venturi
5. Venting
6. Adjustments and Service
   a. Idle Mixture
   b. Float
7. Chokes
   a. Vacuum Breaks
   b. Water Heated
   c. Electric
   d. Staged
8. Exhaust Restrictions and Controls
   a. Heat Riser
   b. Restrictor Pipes
   c. Exhaust System Problems

IV. Engine Modifications
M.M. Film: Engine Modification Systems

A. Cam Shafts
   1. Overlap Variations

B. Valves, Ports, and Valve Arrangement

C. Intake Manifolds
   1. Heat Ribs
   2. Water Heated
   3. Cross Over Passage

D. Exhaust Manifolds
   1. Flow Design
   2. Scavenging

E. Combustion Chambers
   1. Reduction of Quench Area
      a. Contoured Shape
      b. Closer Parts Mating
      c. Piston Ring Placement
      d. Compression Ratios
         1) Heads
         2) Effects on Combustion Temperature
         3) Temperature Effects on Emissions

F. Engine Operating Temperature
   1. Operating Temperature Changes
   2. Effects of Pressure Caps on System

V. Positive Crankcase Ventilation (PCV)

A. Principle and Purpose of Crankcase Ventilation
   M.M. Film: "O.C.V."

B. Types of Ventilation Control
   1. Type 1: Open-Valve controlled by intake manifold vacuum.
   2. Type 2: Open-Valve controlled by crankcase vacuum.
   3. Type 3: Open-Tube to Air Cleaner
   4. Type 4: Closed-Combination System
      C.S.U. Slides: "P.C.V."
   5. Correct P.C.V. Valve Application

C. Lab Experience: Effects of P.C.V. on Emissions.
   HC-CO Readings with Correct, Plugged and Open P.C.V. Valves

VI. Thermostatic Air Cleaners

A. Principle and Purpose of T.A.C.
   1. Better Cold Operation Driveability
   2. Leaner Fuel-Air Mixtures

3. Reduction of Emissions HC and CO
   Slides: C.S.U. - "T.A.C."
   M.M. - "T.A.C."

VII. Air Injection Systems
Slides: C.S.U. and M.M.

A. System Components
1. Pump Design and Operation
2. Air Delivery Plumbing and Check Valves
3. Pressure Relief Valves
4. Routing of Air Delivery by Use of Diverter Valve
   a. Diverter Valve Operation
   b. Vacuum Signals to Diverter Valve Generated by Driving Modes
   Lab Experience: Effects of A.I.R. HC-CO Analyzer Readings with A.I.R. Functioning and Then Disconnected.

VIII. Fuel Evaporative System
Slides: C.S.U. and M.M.

A. Fuel Tanks
1. Tank Expansion Space
2. Filler Neck Location Limiting Overfill
3. Tank Venting
4. Caps: No Vent and Pressure Relief

B. Liquid Vapor Separators
1. Tube-Type
2. Separator with Float

C. Fuel Lines
1. Routing and Construction
2. In Line Valves (GM Check Valve)
   a. Overfill Valves
   b. 3-way Combination Valves (Ford)

D. Vapor Storage
1. Crankcase
   a. Purging
2. Carbon Canister
   a. Construction and Purpose
   b. Connections and Location
   c. Purge Methods
      1. Variable
      2. Constant
      3. Combination Constant-Demand
3. Carburetor Bowl Venting
   a. Carburetor Vent Valve
   b. Routing of Vapors to Canister

IX. Transmission and Speed Controlled Spark (TCS and SCS)

A. Purpose, Similarity and Differences by Manufacturers
   1. Reduction of HC, CO, NO_x
   2. The Necessity of Manuals and Specifications

B. Ignition Timing Controls
   1. Temperature Switches (Ambient and Coolant)
   2. Transmission Switches
   3. Ported Vacuum
   4. Speed Sensors (In Cable)
      a. Amplifier Modules
   5. Solenoids
   6. Time Relays
   7. Spark Delay Valves (Vacuum)
   8. Distributor Vacuum Advance Control Valve (Deceleration)

C. American Motors System
   Slides: M.M.
   1. Spark Control Systems
      a. TCS

D. General Motors System
   Slides: M.M.
   1. Spark Control Systems
      a. TCS
      b. CEC
      c. SCS

E. Chrysler System
   1. Spark Control Systems
      a. CAP
      b. CAS
      c. Distributor Solenoid Retard and Advance
      d. TCS Control
         1. Solenoid Vacuum Valve

F. Ford System
   Slides: M.M.
   1. Spark Control Systems
      Film: Ford ESC
      a. ESC System
         Film: Ford TRS
      b. TRS System
         1) Dual Diaphragm Distributor
      c. Spark Delay Valves (Restrictors)
      d. PVS Valve: Distributor Vacuum Control
         1) Overheat Protection

X. Exhaust Gas Recirculation (EGR)

A. Purpose and Principles
   1. Reduce NO_x
   2. Reduce Combustion Temperature
   Slides: C.S.U. and M.M.

B. EGR Controls
   1. Exhaust Recycle Requirements vs. Engine Operating Modes
   2. Floor Jets
   3. Vacuum Signal Operation of EGR
      a. Cold Override
      b. Idle
      c. Wide Open Throttle
      d. Vacuum Amplifier

XI. Catalytic Converters

A. Construction and Chemical Principle
   1. Pellet
   2. Monolith
   3. Precautions Due to Converter
      a. Shielding
      b. Insulation
      c. Heat
      d. Damage Due To:
         1) Fuel
         2) Heat
         3) Moisture
         4) Road Hazard

Film: "Eleven Together"

XII. Exhaust Analyzer

A. Principles of Operation
   1. Infra-Red Light
   2. Optical Benches

B. Pre-Testing Preparations
   1. Engine at Normal Operating Temperature
   2. Correct Calibration and Span
   3. Proper "Hook-Up"
   4. Additional Uses

C. Care
   1. Filters
   2. Water Traps
   3. Volume of Air Flow (Vacuum Gauge)
   4. Hose and Fitting Leaks

IS 488 AUTO EMISSIONS CONTROL II

I. Orientation - set up procedures

   A. Analyzer and diagnostic equipment usage

      1. Infrared analyzer

      2. Diagnostic equipment

   B. Ignition and fuel system troubleshooting

      1. Adjustments:

         a. Check and adjust ignition to manufacturer "specs".
         b. Check and adjust fuel system to manufacturer "specs".

            1) Choke assembly and choke assists
            2) Solenoids and CEC valves
            3) Adjust air-fuel mixture and idle speed

II. Positive crankcase ventilation system checks and service

   A. Crankcase vacuum draw test

   B. Hose routing

   C. Comparison vacuum test

      1. PCV system normal vs. RCV system plugged and open

   D. Correct PCV valve application

III. Thermostatic air cleaners

   A. Thermostatic type

      1. Air door operation and proper closing and opening temperature

         a. Proper vacuum override operation

   B. Vacuum motor type

      1. Hose routing and vacuum source

      2. Proper air door operation

3. Vacuum motor check

4. Temperature sensor checks to factory "specs".

IV. Air injection systems

A. Pump drive belt tension

1. Pump output and hose connections

2. Check valve operation

3. Pressure relief valve check

4. Diverter valve operation

V. Fuel evaporative system

A. Hose routing--purge and vapor lines

B. Leak detection with infrared analyzer

C. Canister and hose damage

D. Canister filter

E. Fuel tank cap inspection

VI. Distributor advance control systems

A. Vacuum hose routing and connections

B. Vacuum control solenoids

C. Electrical circuits and components

1. Ambient temperature switches

2. Coolant temperature switches

3. Vacuum delay valve check

D. Correct operation at manufacturers specified road speed or gear

VII. Exhaust gas recirculation

A. Hose routing and connections

B. EGR valve operation within manufacturer "specs".

1. Vacuum source within "specs"
2. Proper CTO switch operation

C. Vacuum amplified system

1. Amplifier operation within manufacturer "specs".
2. Vacuum reservoir check

APPENDIX P

PRE-TEST: IGNITION AND CARBURETION

PRE-TEST IGNITION AND CARBURETION

True-False: If the statement is true circle T
If the statement is false circle F

T F 1. The drift of electrons between atoms of a conductor is referred to as current flow.

T F 2. Electron drift through a conductor is from negative to positive.

T F 3. Magnetic lines of force form a complete circuit from north to south.

T F 4. Current passing through a wire creates a magnetic field.

T F 5. The magnetic effect of an electromagnet is decreased when it becomes hot.

T F 6. Increasing the current in a coil winding will increase the magnetic strength of the coil.

T F 7. Voltage across the circuit is the difference in electrical pressure between the two sides of a circuit.

T F 8. When the voltage of a circuit is increased the resistance is also increased.

T F 9. Resistance in a circuit is effective only when current flows.

T F 10. Voltage is generated in a conductor by moving the conductor through a stationary magnetic field.

T F 11. Current is generated in a conductor when magnetic lines of force are cut by the conductor.

T F 12. The breakdown of the magnetic field in a coil causes secondary ignition operation.

T F 13. Point dwell in the distributor is a measurement of the time that the ignition points are open.

T F 14. The flow of current in the primary windings of an ignition coil depends upon the capacity of the condenser.

T F 15. Ignition spark occurs at just the instant the distributor breaker points close.

T F 16. In an ignition distributor, the condenser is connected in series with the breaker points.

T F 17. In the fuel pump the gasoline enters on one side of the diaphragm and leaves on the other.

T F 18. A hole in the float will cause the fuel mixture to become lean.

T F 19. A hole in the fuel pump diaphragm will be noticed because fuel will leak from the bottom of the fuel pump.

T F 20. A vacuum could be considered a negative air pressure.

T F 21. The fuel must move through the main discharge tube in order to reach the power valve.

T F 22. The power circuit is actuated by an increase in vacuum.

T F 23. The transfer port discharges fuel only after the throttle plate moves from the idle position.

T F 24. To replace the ignition coil on the Delco HEI, you must replace the distributor cap too.

T F 25. Gap between pickup and reluctor on Chrysler cars can be checked with ordinary feeler gauges.

Multiple Choice: Circle the letter in front of the <u>most correct</u> answer.

26. As engine speed increases under acceleration, manifold vacuum:

    a. decreases
    b. remains constant
    c. drops
    d. none of above

27. The transistor module on the Delco High Energy Ignition system is located:

    a. near the radiator to keep it cool
    b. in the distributor
    c. on firewall because it has a heat sink around it
    d. hung in open air because it does not need a ground to operate

28. Following the air flow through the venturi, the throttle plate would be located:

    a. before the venturi
    b. after the venturi
    c. in the intake manifold

29. The purpose of the accelerator pump is to:

    a. pump fuel into the float chamber
    b. aid the fuel pump at idle speeds
    c. filter out impurities from the gas tank
    d. give immediate response for throttle demands for increased power

30. An external ceramic dual resistor is used on:

    a. Chrysler cars only
    b. Ford and Chrysler products
    c. only import cars that come to U.S.A. to be sold
    d. GM cars sold in South America

31. Idle speed adjustments should be made while:

    a. engine is cold and operating
    b. engine is warm and operating
    c. engine is cold and off
    d. engine is warm and off

32. Elimination of breaker points by transistor ignition extends life:

    a. of ignition timing adjustment
    b. of ignition switch
    c. of the exhaust system because it has less of a problem of backfiring
    d. of antenna because radio problems are cut down

33. The reluctor is Chrysler's term for the part that replaces the distributor cam. Ford calls it:

    a. armature
    b. impulse trigger
    c. pole pick up unit
    d. the rotor

34. If the float was stuck in the up position, the other systems would:

    a. receive too much fuel
    b. receive no or little fuel
    c. work to compensate for the float system
    d. be too rich in fuel

35. The circuits or circuit that would be operating at part throttle would be:

    a. the idle circuit
    b. the idle and low speed circuit
    c. the low speed and power circuit

36. Oil, dirt, or oxidation on the breaker points causes poor ignition because it:

    a. increases primary current
    b. increases resistance in secondary
    c. decreases primary current

37. Condenser plates are charged as:

    a. breaker points are just opening
    b. breaker points are in contact
    c. breaker points are just closing

38. If the gap between pickup coil and reluctor is too great:

    a. ignition timing will be overadvanced
    b. pickup may not trigger the control unit, causing misfire
    c. reluctor will burn out
    d. pole pickup gets too cold

39. When you disconnect part of the transistor ignition harness, Ford recommends that you:

    a. coat terminals with electrically-conductive grease
    b. wipe terminals to remove any oil or grease
    c. any H_20 repelling oil
    d. just a good grease

40. The distributor rotor carries:

    a. battery current
    b. primary current
    c. secondary current

41. Sharp corners on the spark plug electrodes cause the plug to fire at:

    a. the lowest voltage
    b. the highest voltage
    c. the smallest gap

42. The centrifugal advance mechanism advances ignition timing by turning the:

    a. cam with rotation
    b. cam against rotation
    c. breaker points in direction of rotation
    d. breaker points against direction of rotation

43. The higher ignition voltage requirements are at:

    a. high speed full throttle acceleration
    b. low speed part throttle acceleration
    c. high speed part throttle

44. The transistor control units on most transistor ignition systems can be serviced by:

    a. installation of circuit board and transistors kit
    b. replacement of complete unit only
    c. running the alternator backwards
    d. make the internal combustion engine misfire

45. An inverted wave form on an oscilloscope screen indicates:

    a. cracked distributor cap
    b. vehicle polarity reversed
    c. coil on backwards
    d. carburetor backfiring

APPENDIX Q

AUTOMOTIVE TEACHERS' EMISSION EXAMINATION

VEHICLE EMISSION SYSTEMS CONTROL EXAMINATION

Name_________________________________ Date ______________

Directions: Select the best choice of those given for each question and circle its corresponding letter.

1. The average available secondary voltage at the coil in an electronic ignition system is:

   a. 15 KV
   b. 25 KV
   c. 35 KV
   d. 55 KV

2. In a dual diaphragm vacuum advance unit the diaphragm chamber closest to the distributor housing must have:

   a. vacuum only at wide open throttle
   b. vacuum only during deceleration
   c. vacuum only when transmission switch is closed
   d. full vacuum at idle

3. If point dwell changes from 27 degree dwell to 35 degree dwell on a V-8 engine the effect on timing and HC emissions at idle will be:

   a. timing advanced and HC increased
   b. timing advanced and HC decreased
   c. timing retarded and HC increased
   d. timing retarded and HC decreased

4. Although vacuum controlled, the early fuel evaporative valve works similar to the _______.

   a. heat riser
   b. EGR valve
   c. staged choke pull off
   d. idle speed solenoid

5. When would the EGR valve be in operation?

   a. When the engine is at normal temperature and 2,000 RPM
   b. When the engine is at normal temperature and at idle
   c. When the engine is cold and at 2,000 RPM
   d. When the engine is cold and the transmission is in 1st or 2nd gear

6. The vacuum differential valve (VDV) used on some 1975 Ford vehicles is part of the _____ system.

   a. EGR
   b. TAC
   c. Thermactor
   d. Spark control

7. The fuel evaporative system consists of four (4) major components:

   a. Fuel tank, pressure-vacuum fuel tank cap, liquid vapor separator, diverter valve.

   b. Pressure-vacuum fuel tank cap, vapor canister, liquid vapor separator, fuel tank.

   c. Liquid vapor separator, thermal vacuum valve, third speed solenoid, coolant temperature sensor.

   d. Fuel pump, carburetor, fuel tank, pressure vacuum fuel tank cap.

8. The purpose of the Chrysler OSAC valve is to:

   a. eliminate spark advance at low speeds
   b. delay spark advance during deceleration
   c. delay spark advance under all conditions
   d. delay spark advance on acceleration

9. The TIC valve on Chrysler vehicles operates to:

   a. provide full vacuum advance at low ambient temperatures
   b. provide no vacuum advance at high ambient temperatures
   c. provide vacuum advance at high coolant temperatures
   d. provide full advance during high speed operation

10. The transmission controlled spark system is used to help reduce exhaust emissions by:

    a. Advancing the spark with the transmission in low gear
    b. Providing a hotter spark with the transmission in high gear
    c. Retarding the spark with the transmission in lower gears and the engine at operating temperature

11. The speed controlled spark system serves the same purpose as the transmission controlled spark. However, unlike the TCS system the spark is controlled by a:

    a. Transmission switch
    b. Speed sensor and amplifier
    c. Temperature switch
    d. Vacuum control valve

12. If you are checking your exhaust emissions at 2,000 RPM in neutral and you get a high HC reading, one possible cause could be:

    a. Inoperative vacuum advance unit
    b. Float level too low
    c. Idle mixture screw set too rich

13. One purpose of a check valve in the AIR system is to prevent:

    a. Excess pump pressure in the system
    b. Excessive vacuum in the system
    c. Damage to system due to pump belt failure

14. If ignition timing is advanced 5 degrees over specifications you will read an increase in ____ with the infrared analyzer.

    a. Carbon monoxide
    b. Hydrocarbon
    c. Oxides of nitrogen
    d. Carbon

15. What is the purpose of the exhaust gas recirculation?

    a. Lowers peak flame temperatures during combustion
    b. Controls manifold crossover flow
    c. Controls flow of exhaust through the converter

16. The speed sensor in a spark control system is used to_____

    a. Operate tach
    b. Operate solenoid vacuum control valve
    c. Energize buzzer for over speeding
    d. Prevents premature upshift of transmission

17. The air pump introduces fresh air into the ________ to reduce hydrocarbon and carbon monoxide emissions.

    a. Engine exhaust system
    b. Intake ports
    c. EGR
    d. TCS

18. The air pump is a __________ type of pump.

    a. Gear
    b. Impeller
    c. Vane
    d. Piston

19. The charcoal canister filter should be __________ at regular intervals.

    a. Cleaned
    b. Replaced
    c. Blown out with compressed air
    d. Turned over

20. Back-fire upon deceleration could indicate:

    a. Faulty check valves
    b. Faulty air pump
    c. Air pump belt slipping
    d. Faulty diverter valve

21. On a vehicle with a heated air intake system, the air door should be in the ______________ at idle with a cold engine.

    a. Hot air delivery mode
    b. Cold air delivery mode
    c. Regulating mode

22. A defective (stuck open) E.G.R. valve will cause:

    a. Hard starting
    b. Rough idle
    c. High speed miss
    d. High NO_x emissions

23. On most vehicles equipped with an automatic transmission and transmission controlled spark (TCS), you can check operation of the TCS system by putting the transmission in:

    a. Park
    b. Reverse
    c. Neutral
    d. Any drive range

24. An engine "diesels" or "runs" after the ignition switch is turned off. This is most often caused by:

    a. Overheated engine
    b. Too lean A/F ratio
    c. Idling too fast at shut down

25. You have adjusted the idle mixture screws using a tachometer only and obtained a satisfactory smooth idle. When you check the exhaust emissions with a HC-CO meter you discover HC-CO readings above "specs". The problem could be:

a. One mixture needle too lean and one too rich
b. Both needles too rich
c. Both needles too lean
d. Either a or b of the above

26. A solenoid that holds the throttle plates slightly open and at the same time controls distributor vacuum is called the:

a. Idle stop solenoid
b. TPS solenoid
c. VCS solenoid
d. CEC solenoid

27. Replacing main metering jets with leaner ones may:

a. Raise gas mileage
b. Lower gas mileage
c. May do either of the above

28. When the diverter valve, used on air injection systems, diverts air to the atmosphere it is triggered into action by:

a. A sudden drop in manifold vacuum
b. High manifold vacuum
c. Exhaust gas pressure
d. The air pump

29. 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

30. Exhaust temperatures are hottest if:

a. Timing is advanced more than specs
b. Set right on specs
c. Timing is retarded more than specs

31. Idle CO reading too high indicate:

a. Mixture too lean
b. Mixture too rich
c. Timing too advanced
d. a and c

32. No distributor vacuum advance at 2500 RPM would:

a. Tend to lower HC readings
b. Tend to raise HC readings
c. Probably not be noticeable on HC scale

33. HC readings are highest on:

    a. Acceleration
    b. Deceleration
    c. Approximately the same in a or b

34. A cracked intake manifold causing an air leak would tend to:

    a. Lower HC readings
    b. Raise HC readings
    c. Raise CO readings
    d. Both a and c

35. 2500 RPM CO readings too high indicate:

    a. Mixture too rich
    b. Timing too advanced
    c. Both a and b
    d. None of the above

36. If the HC and CO read too high at idle but OK at 2500 RPM:

    a. The idle mixture screws are set too rich
    b. The initial timing is set too far advanced
    c. The initial timing is retarded too much
    d. Both a and c

37. When adjusting idle mixtures leaner you may lower CO too much and see:

    a. CO start climbing higher again
    b. HC start climbing higher again
    c. Both a and b
    d. None of the above

38. If the power circuit is "open" when you test at 2500 RPM the CO readings will be:

    a. Higher than normal
    b. Lower than normal
    c. Will not be shown on CO meter

39. The TCS system reduced unburned hydrocarbons and carbon monoxide in the exhaust by:

    a. Eliminating vacuum spark advance when the engine is cold
    b. Eliminating vacuum spark advance in low gear ranges at normal engine operating temperatures
    c. Filters the exhaust through a carbon canister
    c. Both b and c

40. To check the speed controlled spark (SCS) system a mechanic must do which of the following:

    a. Raise the rear wheels
    b. Shift to DRIVE
    c. Note engine timing when advancing speed from below 38 mph to above
    d. All of the above

41. The AIR system supplies fresh air to the exhaust gases except during:

    a. Acceleration
    b. Idle
    c. Wide open throttle
    d. Deceleration

42. The TCS system includes a thermal vacuum hot override switch whose function is:

    a. To allow advance in high gear only
    b. To allow unrestricted vacuum advance
    c. To recover coolant during boilover
    d. To allow for better driveability during cold operation

43. NO_x in measurable quantities is formed in the combustion chamber when temperatures reach approximately ________ degrees F. and above.

    a. 1500
    b. 1800
    c. 2500
    d. 3500

44. The purpose of Ford's vacuum override motor on the air cleaner is to provide the necessary balance of air intake during:

    a. Cold engine drive-away
    b. Rapid cold acceleration
    c. Engine overheat
    d. Ambient temperature above 150 degrees F.

Matching

Directions: Match the correct emission system name or component on the right with the description at the left. Place the letter on the line provided by the number.

45. ____ A component of the fuel evaporative emission control system that prevents liquid fuel from entering the vapor line to the canister.

46. ____ Regulates the amount of crankcase gases flowing from the engine crankcase to the carburetor as determined by intake manifold vacuum.

47. ____ A valve in the air injection system that dumps air into the atmosphere on deceleration.

48. ____ A system designed to keep air entering the carburetor at approximately 100° F. when underhood temperatures are less than 100° F.

A. CCS System

B. EGR Valve

C. Temperature Override Switch

D. Diverter Valve

E. TCS System

F. AIR System

G. Separator, Liquid/Vapor

H. PCV Valve

I. SCS System

J. Separator, Purge/Vapor

Completion

49. A system designed to prevent fuel vapors from the fuel tank and carburetor from escaping into the atmosphere is called the ____.

50. Most E.G.R. valves begin to open when ___ to ___ inches of vacuum is applied to the valve diaphragm.

APPENDIX R

COLORADO AUTOMOTIVE TEACHER QUESTIONNAIRE

COLORADO TEACHER EMISSIONS CLASS SURVEY

1. Instructor ______________________________

2. Location ______________________________

3. School ______________________________

4. Number of MVEC workshops held ______________________

5. Average length, in hours, of MVEC classes ______________

6. How was class offered: separate section __ integrated __

7. Types of participants: __students __mechanics __non-mech. __teachers

8. Number of participants in all classes: __mechanics __students __non-mech. __teachers

9. Number of planned MVEC workshops and duration: a) __Spring __hrs. b) __Summer __hrs. c) __Fall __hrs. d) __Winter __hrs.

10. Separate emissions section ____________ integrated ___________.

11. Type of participants for planned classes: __mechanics __students __teachers

12. When will class be offered: day _____ night _____

13. Do you need more training to conduct additional MVEC classes? PCV __, AIR __, Fuel Evap. __, EGR __, TAC __, Spark Control __, Conv. __, Therm. React. __.

14. What instructional materials have you used? GM __, Ford __, Chrysler __, AMC __, Echlin __, Gargano __, Mitchell Manuals __, Other ______________________

15. What type of student do you prefer to train? __mechanic __H. S. student other ______________________

16. What type of student is most receptive to the materials? __mechanic, __non-mech., __teacher, __H. S. student

APPENDIX S

MOTOR VEHICLE EMISSION CONTROL

PRE/POST-TEST

EMISSIONS PRE/POST-TEST

Name ______________________________ Date ______________

Directions: Please circle the letter in front of the correct response.

Some questions will 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" after the ignition switch is turned off. This is most often caused by:

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

3. You have adjusted the idle mixture screws using a tachometer only and obtained a satisfactory smooth idle. When you check the exhaust emissions with a HC-CO meter you discover HC-CO readings out of "specs." The problem could be:

   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
   E. None of the above

4. You have worked on both a 1962 and 1972 model cars today. After both owners left you discovered the reaiator caps got mixed up. Of you were concerned only with the danger of possible overheating which owner would you call back?

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

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

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

6. EGR is used to:

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

7. Not enough "Float Drop" will probably 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 diaphrams 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 distributor diaphram?

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

9. If ignition specs are: initial timing 0°, total advance 25°, mechanical advance 10°, how many degrees is vacuum advance?

   A. 15°
   B. 35°
   C. 30°

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 to 26. 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
   D. None of them

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

    A. CEC solenoid
    B. Idle stop solenoid

14. Replacing main metering jets with leaner ones may:

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

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

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

16. When the divertor valve, used on air injection systems, diverts air to the atmosphere it is triggered into action by:

    A. A sudden drop in manifold vacuum
    B. High manifold vacuum
    C. Exhaust gas pressure
    D. The air pump

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

    A. Owner's bad driving habits
    B. Poor qulaity 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 only one of these problems.

    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. To perform a cylinder compression test you:

    A. Remove all spark plugs and test
    B. Leave all spark plugs in and test
    C. Remove one spark plug at a time and test
    D. On a V-8 remove one bank at a time and test

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 diagnosis test would you use to further support your suspicion?

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

23. A cranking vacuum test is done with:

    A. All spark plugs in
    B. All spark plugs out
    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
    D. None of the above

26. Idle CO reading too high indicate:

    A. Mixture too lean
    B. Mixture too rich
    C. Timing too advanced
    D. A and C

27. Power valve circuits are normally:

    A. Closed at idle
    B. Open at idle
    C. Neither of the above

28. No distributor vacuum advance at 2500 RPM would:

    A. Tend to lower HC readings
    B. Tend to raise HC readings
    C. Probably not be noticeable on HC scale

29. The "fuel level" setting and the "float level" setting are the same measurement.

    A. True
    B. False

30. HC readings are highest on:

    A. Acceleration
    B. Deceleration
    C. Approximately the same in A or B

31. NO_x emissions are reduced by:

    A. Evaporative control systems
    B. EGR control systems
    C. Carbon canisters
    D. Spark delay valve

32. Crankcase fumes are 100% controlled by:

    A. Open PCV systems
    B. Closed PCV systems
    C. Road draft tube

33. A.I.R. control, thermal reactor and catalytic convertor systems all reduce HC and CO after the exhaust leaves the engine cylinder.

    A. True
    B. False

34. A cracked intake manifold causing an air leak would tend to:

    A. Lower HC readings
    B. Raise HC readings
    C. Raise CO readings
    D. Both A and C

35. 2500 RPM CO readings too high indicate:

    A. Mixture too rich
    B. Timing too advanced
    C. Both A and B
    D. None of the above

36. Vapor lock is caused by:

    A. Using gasoline of the wrong octane number
    B. Too much heat on the fuel pump and lines
    C. Too much fuel pump pressure

37. If the HC and CO read too high at idle but OK at 2500 RPM:

    A. The idle mixture screws are set too rich
    B. The initial timing is set too far advanced
    C. The initial timing is retarded too much
    D. Both A and C

38. The fuel vapors stored in a carbon canister:

    A. Are returned to the gas tank when the engine is started
    B. Are burned in the engine when it is started
    C. Stored in canister until saturated and then replaced

39. On an engine that is normally denied vacuum advance at idle you discover full manifold vacuum at the advance unit. With this condition you would:

    A. See higher HC readings than normal
    B. See higher CO readings than normal
    C. See lower HC readings than normal
    D. Both A and B

40. When an engine missfires you would expect:

    A. To see very high CO and HC readings
    B. To see only very high HC readings
    C. To see only very high CO readings
    D. No appreciable change in either reading

41. Air leaks in the muffler or tail pipe will:

    A. Make idle HC-CO read lower than it should
    B. Make idle HC-CO read higher than it should
    C. Affect only HC reading
    D. Affect only CO reading

42. Heated carburetor air is necessary on emissions controlled engines because:

    A. Of the altered advance curve
    B. Of the retarded timing used
    C. Of the leaner carburetor mixture used
    D. None of the above

43. When adjusting idle mixtures leaner, you may lower CO too much and see:

    A. CO start climbing higher again
    B. HC start climbing higher again
    C. Both A and B
    D. None of the above

44. If you advance initial timing it will:

    A. Increase idle RPM
    B. Decrease idle RPM
    C. Have no effect on RPM

45. If the power circuit is "open" when you test at 2500 RPM the CO readings will be:

    A. Higher than normal
    B. Lower than normal
    C. Will not be shown on CO meter

46. What causes photochemical smog:

    A. Unburned hydrocarbons and oxides of nitrogen mixed with vapor and air
    B. Unburned hydrocarbons and oxides of nitrogen mixed with air in the presence of sunlight

47. The thermostatic air cleaner (heated air intake system) aids the:

    A. Control of blow-by gases
    B. Vacuum spark control
    C. Atomization of fuel
    D. Evaporative control system

48. When intake manifold vacuum is applied at idle to the retard diaphragm on an engine equipped with a dual diaphragm distributor the breaker plate:

    A. Moves opposite to distributor rotation
    B. Moves in the same direction as distributor rotation
    C. Does not move
    D. May move in either direction depending on amount of vacuum

49. On what two strokes do most of the hydrocarbons reach the crankcase:

    A. Intake and exhaust
    B. Compression and combustion
    C. Exhaust and power
    D. Power and intake

50. Comparing pre-1961 against 1974-75 models with factory installed emission devices, what percentage of exhaust hydrocarbons are reduced?

    A. 50%
    B. 30%
    C. 70%
    D. 85%

APPENDIX T

PROPOSED CRITERIA, QUALIFICATIONS, AND PROCEDURES FOR INSPECTORS AND STATE INVESTIGATORS CERTIFICATION

PROPOSED
CRITERIA, QUALIFICATIONS, AND PROCEDURES
FOR
INSPECTORS AND STATE INVESTIGATORS
CERTIFICATION

Submitted to

State of Colorado

Department of Health

Air Pollution Control Commission

Prepared by

Colorado State University

Industrial Sciences Department

Fort Collins, Colorado 80523

PROPOSED CRITERIA, QUALIFICATIONS, AND PROCEDURES

FOR

INSPECTORS AND STATE INVESTIGATORS CERTIFICATION

FORWARD

Through legislation in 1955 the United States Congress authorized a Federal program (PL 84-159) of air pollution research and technical assistance to state and local governments. This legislation established a policy, retained in all subsequent legislation, of giving state and local governments the fundamental responsibility for controlling local air pollution with the Federal government providing leadership and support. Although the establishment of motor vehicle emissions standards are a Federal responsibility, the states are responsible for controlling, regulating, or restricting the use, operation, or movement of licensed motor vehicles.

The General Assembly of the State of Colorado enacted Senate Bill #393 directing the Colorado Air Pollution Control Commission to establish a Motor Vehicle Emission Control Program. This document delineates the qualifications and requirements of the state inspector and investigator pursuant to Section 66-31-28 of the Act. Section 66-31-28 of the Act authorized by the Commission pursuant to Section 13-5-113 of the Colorado Revised Statutes, requires all state employed investigators shall complete a training course and pass qualification test as developed and approved by the Commission as related to the orientation and basic maintenance procedures on air pollution controls systems installed by manufacturers. Only inspectors passing said qualification test shall perform emission inspection. Pursuant to Section 66-31-28 (4) (a) of the Act, said qualification test will be used by the Departments of Health and Revenue to insure competency for consumer protection in the implementation of the motor vehicle emissions control program. Paragraph two of Section 66-31-28 states the Departments of Health and Revenue shall jointly recommend additional training programs necessary to help implement motor vehicle emission control measures.

The need for trained personnel in the automotive industry, whether it be repairman, investigator, or inspector, has been borne out by many studies. Before an inspection and maintenance program can sucessfully become operational it is imperative an adequate supply of trained inspectors, investigators and maintenance mechanics be available.

CONTENTS

1.0 GENERAL PROVISIONS

This document specifies the tasks, responsibilities, qualifications, application and renewal procedures which inspectors and investigators must follow in obtaining state certification. The above mentioned certification will be necessary for state investigators and inspectors involved with the Colorado Motor Vehicle Emissions Inspection of light-duty motor vehicles. The inspector being any person certified by the A.P.C.C. and employed by an approved inspection station who inspects motor vehicles on a pass/fail basis for emissions levels, proper connection and operation of emission components for vehicle emissions compliance. This document states the responsibility of the state investigator will be to inspect motor vehicle inspection stations and inspectors for proper inspection equipment, correct inspection procedures, proper certification, and conduct all other supervisory duties delegated to each investigator under task description and responsibilities in Section four.

1.1 Purpose

The purpose of this report is to delineate criteria for the certification of inspectors and state investigators in the state's motor vehicle emissions inspection program. This report sets forth the task descriptions, responsibilities and provides guidelines outlining the requirements and qualifications that must be met and procedures to be followed in applying for certification by inspectors and state investigators. A sequence of procedures is outlined for inspectors and state investigators that do not qualify upon application and/or renewal for certification.

1.2 Accrediting Agency

The Air Pollution Control Commission of the Colorado Department of Health, Denver, Colorado, is the accrediting agency for certification of inspectors and state investigators. Assisting the commission in certifying the above named applicants will be Colorado State University Industrial Sciences Department and/or an agency acceptable to the commission.

1.3 Definitions

Unless otherwise specified in the context, the definitions of this report are:

1.3.1 Motor Vehicle: every self-propelled vehicle intended primarily for use and operation on the public highway.

1.3.2 Light Duty Vehicle: any motor vehicle either designed primarily for transportation of property and rated at 6001 pounds GVW or less or designed primarily for transporting persons and having capacity of 12 persons or less. The engine displacement must be greater than 97 cubic inches but vehicle cannot exceed aforementioned limitations.

1.3.3 Inspector: any individual who has met all criteria required by the Air Pollution Control Commission and is employed by an approved inspection station to inspect motor vehicles for vehicle emissions compliance.

1.3.4 Investigator: an individual appointed by the Colorado State Department of Revenue, who has met all the criteria required by the Air Pollution Control Commission, responsible for inspecting approved Motor Vehicle Inspection Stations and inspectors for correct inspection equipment, procedure and proper certification.

1.3.5 Customer: the owner or family member, employee, or any other person whose use of the vehicle is authorized by the owner or agent of owner.

1.3.6 Commission: Air Pollution Control Commission.

1.3.7 APCC: Air Pollution Control Commission

1.3.8 Denver Air Quality Control Region: the area enclosed within the boundaries of the following counties: Denver, Jefferson, Arapahoe, Adams, Boulder, Douglas, Gilpin and Clear Creek.

2.0 INTRODUCTION

The proposed criteria, qualifications, and procedures in this report were established to provide uniformity in the certification of inspectors and state investigators involved in the Colorado Motor Emissions Inspection Program. The implementation of this program is expected to achieve a reduction in carbon monoxide, hydrocarbon and oxides of nitrogen emissions from light-duty vehicles operating in the Denver Air Quality Control Region. Execution of the program is to be through a network of private, state owned or franchised inspection stations licensed and regulated by the State of Colorado (Departments of Health and Revenue). The commission recognizes the fact that applicants for the positions of inspectors and state investigators must demonstrate a high level of competence in the performance of their duties if the Colorado Motor Emissions Inspection Program is to maintain its effectiveness and integrity.

In the appendix of this document are examples of the tests and evaluation instruments to be used in determining the competence and qualifications of inspectors and state investigators for certification (see appendix C and E). Outlines of the required courses for inspectors and state investigators training are included in appendixes A and D respectively. These outlines are intended specifically for those inspectors and state investigators applying for initial certification. Any applicant for an inspector's certificate who fails to pass the competency or certificate renewal examination will be required to satisfactorily complete a refresher course as stated in appendix B. Each state investigator will be required to attend a refresher course yearly (see appendix F) before an appointment to that position is approved.

In addition to attending refresher courses as required, each inspector will be required to successfully pass an updated examination related to emission control devices and modifications on new vehicle models.

Included in this document are three manuals related to automotive emissions and air pollution control systems, prepared by Delco-Remy Corporation (see appendix H). These manuals may be used by the inspectors/investigators while performing their duties. In addition to these manuals there are many other supplementary materials available.

The bibliography (see appendix I) includes a list of books and manuals containing pertinent information and specifications relating to vehicle emission controls. These reference books will provide each applicant with helpful, self-study material, update and refresher information, before taking a test when applying for a certificate.

2.1 SAFETY CLAUSE

The commission hereby finds, determines, and declares that the following criteria and procedures are necessary for the immediate preservation of the public peace, health and safety.

The instructional program cost for the state investigator and inspector training can be estimated by making the following assumptions:

(1) Rent, insurance, and utilities for training facility -- $600.00 per month

(2) Equipment: infrared analyzer, scope, hand and miscellaneous tools -- $5,400.00

(3) Teaching supplies:

a. handouts and training books -- $5.00 per student

b. instructional packet -- $240.00

(4) Instructor: $15.00 per hour

Clerical: $ 4.00 per hour

Based on these assumptions, Table I shows an estimated instructional cost of $1,230.00 for a forty (40)-hour state investigator and $480.00 for a twelve (12)-hour inspector training program. The investigator's training would require ten (10) four-hour sessions, whereas the inspector would attend four (4) three-hour sessions.

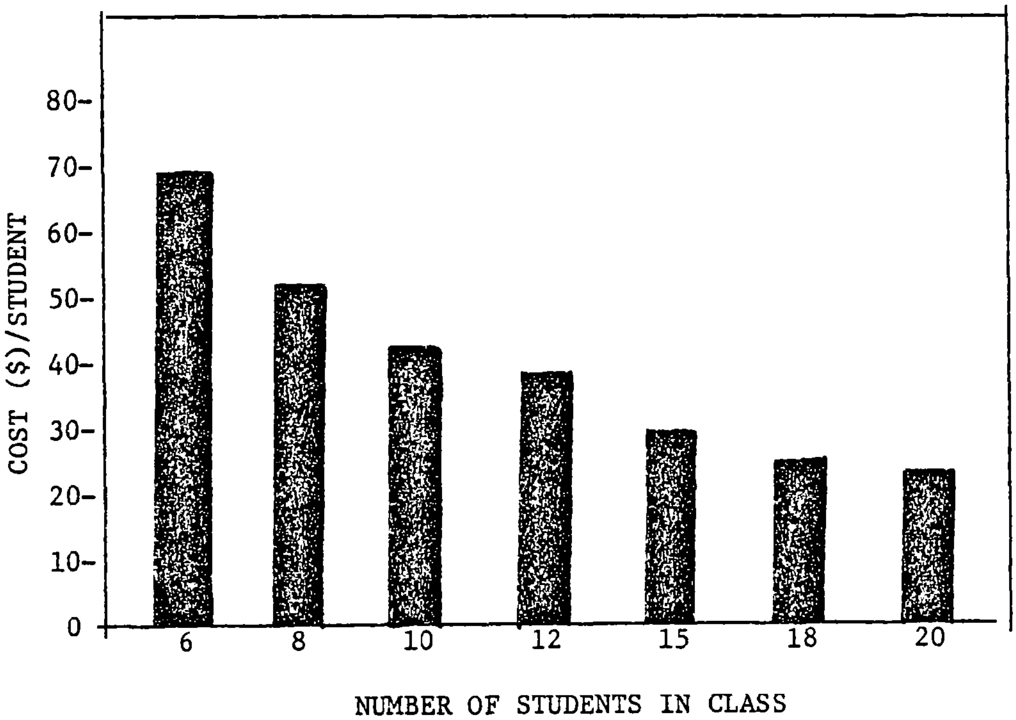
Table II compares the estimated cost of an inspector training student and the number of students in a class. An identical cost per student comparison for the investigator training is found in Table III.

TABLE I
ESTIMATED INSTRUCTION COST FOR
INVESTIGATOR AND INSPECTOR TRAINING

Expenditure	Investigator 10 Session 40-Hr. Training	Inspector 4 Session 12-Hr. Training
Rent, Insurance, Utilities	$ 200	$ 80
Equipment	$ 150	$ 60
Teaching Supplies *	$ 120	$110
Instructor	$ 600	$180
Clerical	$ 160	$ 50
TOTAL	$1230	$480

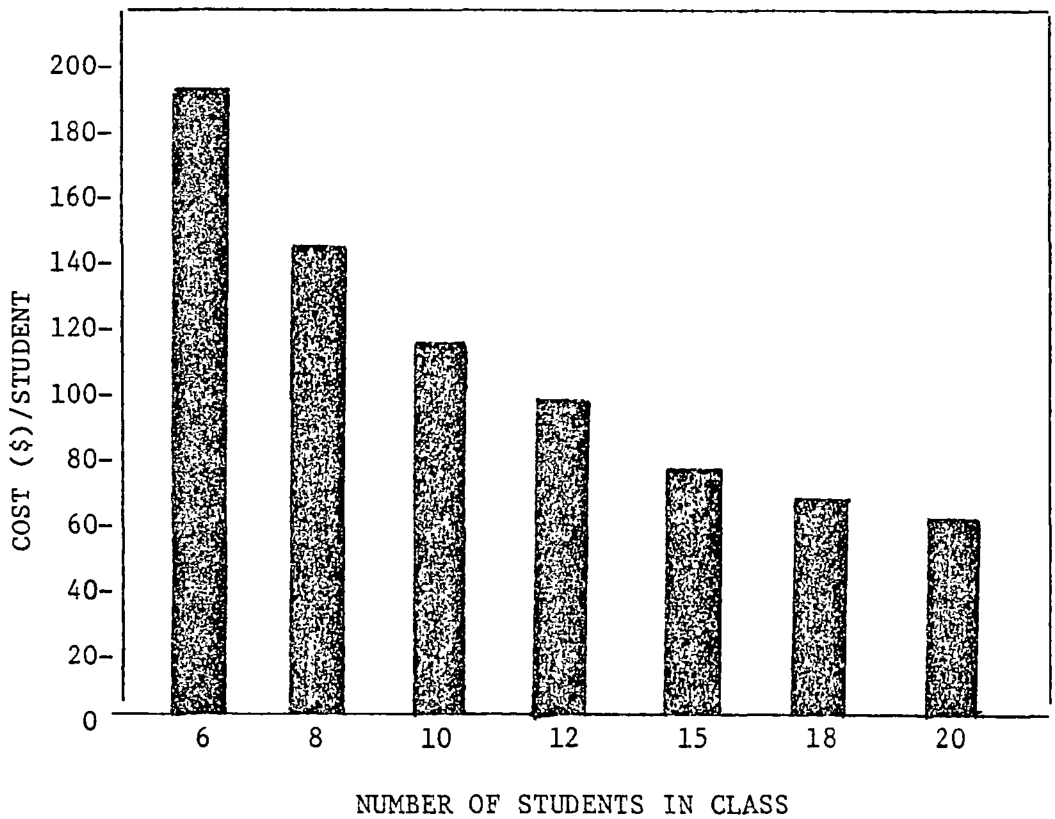
*Based on 20 students per class

TABLE II
ESTIMATED INSTRUCTION COST ($) PER STUDENT FOR
INSPECTOR TRAINING*



*Based on 12 hours of instruction

TABLE III
ESTIMATED INSTRUCTION COST ($) PER STUDENT FOR INVESTIGATOR TRAINING*



*Based on 40 hours of instruction

3.0 CRITERIA FOR CERTIFICATION OF INSPECTORS

As stated in Senate Bill 393, Section 66-13-28, only inspectors having the qualifications and passing evaluation tests deemed appropriate by the commission shall perform emissions inspections. The contents of this section describe the training criteria and procedures to be used for certification of inspectors in the Colorado Motor Vehicle Emissions Inspection Program. The success of any emission inspection program depends upon adequately trained inspectors. Table IV shows the training required by applicants with various backgrounds. This training must be completed by each applicant before initial certification is granted. As shown in Table V , the training time required in specified areas will be dependent upon past experience. It cannot be assumed that just because a person has mechanical experience he knows emission control systems or inspection procedures. Considering only the cost of the instructor in the training class and based on twelve (12) hours of instruction for every inspector, Table VI reflects the cost per student compared to various class sizes. It can be seen that as class size increases, the cost per student decreases. The twelve (12) hours of inspector training must not be conjectured to be the conclusive number of training hours for all students; it is, however, the average training time of all applicant types compared in Table V. Adjustment of training time will have to be made according to the ability, need, and experience of each class.

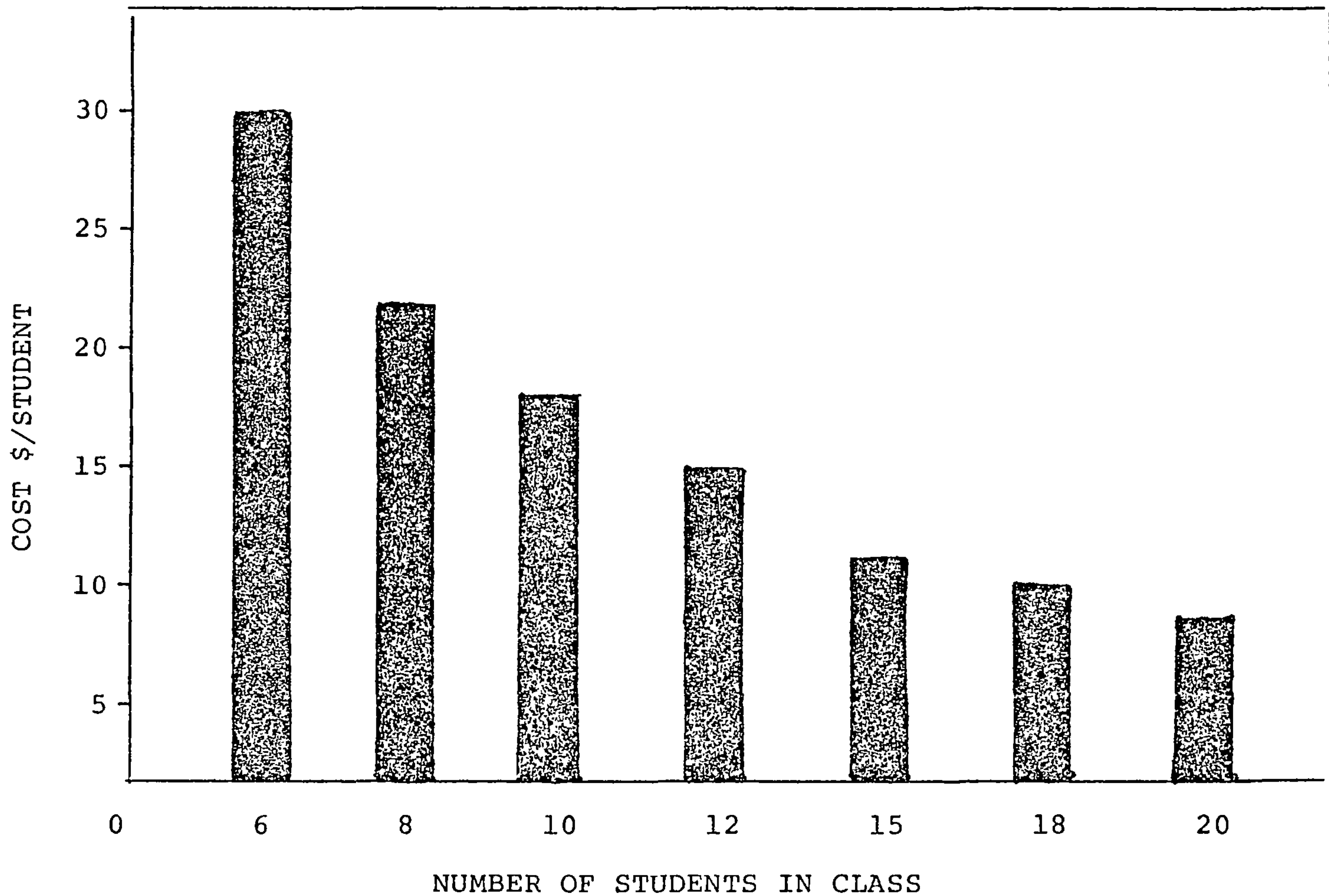
TABLE IV
REQUIRED TRAINING AREAS ON ENGINES AND EMISSIONS
SYSTEMS FOR INSPECTOR CERTIFICATION

Type of Applicant	Rules and Regulations	Inspection Procedure	Data and records Procedure	Types of Pollutants	Customer Relations	PCV System	TAC System	AIR System	Fuel Evap. System	EGR System	Spark control System	Infrared analyzer use and care
Tune-Up Mechanic	X	X	X	X	X	X	X	X	X	X	X	X
General Mechanic	X	X	X	X	X	X	X	X	X	X	X	X
Service Station Mechanic	X	X	X	X	X	X	X	X	X	X	X	X
Automotive Instructor	X	X	X	X	X	X	X	X	X	X	X	X
Existing state safety Inspector	X	X	X	X	X	X	X	X	X	X	X	X
Lay person	X	X	X	X	X	X	X	X	X	X	X	X
Automotive student	X	X	X	X	X	X	X	X	X	X	X	X

TABLE V
TRAINING HOURS REQUIRED IN EMISSIONS SYSTEMS
FOR INSPECTOR CERTIFICATION

Type of Applicant	Rules and Regulations	Inspection Procedure	Data and records Procedure	Types of Pollutants	Customer Relations	PCV System	TAC System	AIR System	Fuel Evap. System	EGR System	Spark control System	Infrared analyzer use and care
Tune-Up Mechanic	1.0	1.5	1.0	.5	1.5	.5	.5	.5	.5	1.0	2.0	1.0
General Mechanic	1.0	1.5	1.0	.5	1.5	.5	.5	.5	.5	1.0	2.0	1.5
Service Station Mechanic	1.0	1.5	1.0	.5	1.0	.5	.5	.5	.5	1.5	2.5	1.5
Automotive instructor	1.0	1.5	1.0	.5	1.0	.25	.25	.5	.5	.5	2.0	1.0
Existing state safety Inspector	1.0	1.0	.5	.5	.5	.5	1.0	1.0	.5	1.0	3.0	1.5
Lay person	1.0	1.5	1.0	.5	1.5	1.0	1.0	1.0	1.0	1.0	3.0	1.5
Automotive student	1.0	1.0	1.0	.5	1.5	.5	1.0	1.0	1.0	1.0	3.0	1.5

TABLE VI
INSTRUCTOR COST OF INSPECTOR TRAINING*/STUDENT VS. CLASS SIZE



*Based on 12 hours of instruction

This section further delineates the inspector's responsibilities, experience and education requirements, examinations, place of application, certificate term, certificate renewal procedures and reasons for revocation of certificate. The requirements that are to be fulfilled by each inspector applicant for certification are as follows.

3.1 INSPECTOR CERTIFICATION

3.1.1 Tasks and Duties Necessary to Conduct Ongoing Program:

3.1.1.1 Inspection: The inspector will conduct a motor vehicle emissions inspection on all light-duty vehicles, except those vehicles exempted in the state emissions handbook, as required by the commission in accordance with the Colorado Idle Emissions Test Procedure. The inspection will consist of a hydrocarbon and carbon monoxide measurement at the exhaust pipe at idle and 2500 revolutions per minute. He will also check under the hood and at other appropriate locations for proper connection and operation of all emissions control hardware as installed by manufacturer. He will also check for any retrofit devices and their proper operation as required by the commission.

3.1.1.2 Equipment Surveillance:

(a) HC-CO Analyzer - The inspector will be required to understand the principles of operation of the analyzer. The inspector must be able to evaluate analyzer performance via use of span gas or electronic span, check analyzer and sample hose for vacuum leak(s) and perform normal maintenance on analyzer.

(b) Tachometer - The inspector must have knowledge in normal maintenance, use and care of the meter. He must also possess skill in checking and setting calibration.

3.1.1.3 Reports: Any individual performing emissions inspection will know the flow of reports for passed and failed vehicles. The inspector will also know the various required reports and information that he must furnish to the commission.

3.1.1.4 Records: The inspector will retain and keep in an organized manner all records pertaining to vehicle inspection. Records will be available for review by investigators, members of commission, Air Pollution Board or other duly authorized individuals at any time.

3.2 APPLICATION FOR INSPECTOR CERTIFICATION

3.2.1 Competency, Experience: No person will be certified as an inspector unless he has successfully completed the required training, demonstrated his competence, ability, and shown proof of experience to Colorado State University (training agency) by such tests, examinations or other standards prescribed.

3.2.1.1 Proof of Experience: Applicants for an inspector's certificate must furnish to Colorado State University (training agency) personal references, or certificate (s) showing evidence that the applicant possess the necessary experience in emissions systems.

(a) In lieu of Experience - At its option, the training agency may accept in lieu of experience, evidence that the applicant attended and satisfactorily completed a course of instruction in motor vehicle emission control systems conducted by one or more of the following:

1) Public high school, vocational school or Junior College*

2) Industrial or trade school*

3) Vehicle manufacturer

* Accredited by Commission

3.2.2 <u>Inspector Examination</u>: Applicants for an inspector certificate must successfully complete a test or examination prescribed by Colorado State University (training agency) with a grade score of not less than 80 percent.

3.2.2.1 <u>Examination Content</u>: The examination(s) will consist of questions encompassing mathematical problems showing level of competancy (5th grade), pre-inspection procedures, inspection procedures, instrument care and use, knowledge of devices and systems of emissions control.

The questions will be of the true-false, multiple-choice and short answer type. A sample of the test may be found in appendix C.

(a) If the training agency deems it necessary, the applicant will also be required to identify displayed emissions parts and hardware and perform a check for proper connection and operation of components on a bench simulated emission system. <u>Example</u>: Identify all emission hardware displayed on a bench system that would be found on a 1974 Ford 351W engine, 2 barrel, air conditioning and automatic transmission. In addition, with an auxillary vacuum and battery source check for proper operation of a solenoid vacuum switch, coolant vacuum control valve, vacuum delay valve, and idle stop solenoid.

3.2.2.2 Failure of Inspector Examination: Any person failing the inspector's examination prescribed by the training agency may reapply for certification after satisfactorily completing the following:

(a) A refresher course in motor vehicle emissions control and retake the written test a second time. An outline of refresher course will be found in appendix B.

(b) Any applicant failing the test a second time may,at his discretion, ask for a practical test on a bench simulated model or a third retest after completing a second refresher course in motor vehicle emissions control.

3.2.3 Education: Applicants must demonstrate ability to read, write and perform 5th grade level mathematical computations included in competency test as required by Colorado State University (training agency).

3.2.4 Where to Apply: Persons wishing to become certified inspectors may apply to the training agency. Applications must be completed, signed and postmarked not less than 30 days prior to date of the test. A list of testing dates for the fiscal year will appear publicly at the State Employment Office and other places deemed necessary by the commission.

3.3 CERTIFICATION TERM AND FEE

3.3.1 Certification Term: Certification issued to motor vehicle emissions inspectors shall expire two years from date of issue unless other action is taken as stated in section 3.5 at which time the certificate becomes void immediately.

3.2.2 Certification Fee: The fee for certification issued to official motor vehicle emissions inspectors will be established by legislature and will accompany the application sent to Colorado State University, Industrial Science Department, Fort Collins, Colorado 80523. Regardless of certification results the appropriate fee will remain with the training agency.

3.4 RENEWAL OF INSPECTOR'S CERTIFICATION

3.4.1 Examination: Application for certificate renewal must be made within 90 days prior to the expiration date of current certificate. Each applicant will be required to successfully pass an examination(s) prescribed by the training agency. Tests for certificate renewal will be given monthly and applications must be completed, signed and postmarked not less than 25 days prior to date of the test. Application forms will be available from Colorado State University and the commission. If application for renewal is not completed and received within the 90 days period, the applicant must follow the procedure as specified for initial certification set forth in section 3.2.

3.4.1.1 The examination will consist of multiple choice, true-false, and short answer questions testing the updated knowledge of the inspector over new and/or modified emissions devices on new model vehicles. In addition, a time limit test containing questions requiring the use of an emissions manual covering the identification of new emissions hardware may be asked. The examination will be updated July 1 of each year. Modification of the test will correspond to changes and/or additions of new model emissions devices (see appendix G).

3.4.2 Where to Apply: Applications for renewal of inspector's certificate will be accepted by Colorado State University, Industrial Science Department, Fort Collins, Colorado 80523 that satisfy the time limits as stated in section 3.4.1.

3.4.3 Renewal Fee: The certificate renewal fee for motor vehicle emissions inspectors will be established by legislature. The fee must accompany the application for renewal and regardless of test outcome the appropriate fee will remain with Colorado State University (training agency).

3.5 DENIAL, SUSPENSION OR REVOCATION OF CERTIFICATE

3.5.1 Proof of Unfitness: The commission may deny, suspend, revoke or refuse to renew the certificate issued to an inspector upon determining that the inspector or applicant is unfit or not lawfully entitled thereto.

3.5.1.1 Fictitious Name: The commission may suspend, revoke, or refuse to renew the certificate if it is determined that an applicant or holder of certificate used a false or fictitious name on records, reports or application pertaining to the emissions inspection program.

3.5.1.2 False Statements: The commission may suspend, revoke, or refuse to renew the certificate if the applicant has knowingly made any false statements or concealed any material fact in any application for such certificate.

3.5.1.3 Violated Department Regulations: The commission may suspend, revoke, or refuse to renew the certificate if an applicant has violated one or more of the regulations developed by the commission.

3.5.1.4 Improper Service: The commission may suspend, revoke, or refuse to renew the license issued to an inspector when he has failed to properly inspect a vehicle in compliance with regulations adopted by the commission.

3.5.2 Fails Examination: The commission may refuse to issue or renew a certificate to an applicant who fails to satisfactorily pass an examination.

3.5.3 Evidence of Competence: The commission may refuse to issue a certificate to an applicant who fails to provide satisfactory evidence of abilities and competence as specified in section 3.2.1.

3.5.4 Negligence and/or Incompetency: The commission may deny, suspend, revoke or refuse to renew the certificate if the inspector is guilty of gross negligence or repeated gross incompetent conduct of duties.

3.5.4.1 Incompetency: The commission may deny, suspend, revoke or refuse to renew the certificate if the inspector is guilty of willful and repeated incompetent performance of inspections and/or related customer services.

3.5.4.2 Negligence: The commission may deny, suspend, revoke or refuse to renew the certificate if the inspector is guilty of intentional and repeated negligence of safety procedures and workmanship in conducting inspections.

3.5.5 Failure to Comply: The commission may deny, suspend, revoke or refuse to renew the certificate of an inspector upon intentional failure to comply with any provisions, rules, inspection procedures or regulations promulgated by the commission and training agency.

3.5.6 Aiding and Abetting: The commission may deny, suspend, revoke or refuse to renew a certificate to an inspector who intentionally aids and abets a person who willfully modifies hardware or informs any person of sub-standard inspection procedures.

3.6 CERTIFICATE VOID

3.6.1 When Not Employed: An inspector's certificate is void when not employed by a licensed inspection station.

3.6.2 Retention of Inspector's Certificate: An unemployed inspector may retain his/her inspector's certificate and upon re-employment in an official emissions inspection station the certificate again becomes valid for remaining period of two year term.

4.0 CRITERIA FOR CERTIFICATION OF INVESTIGATORS

This section of the document delineates the tasks and duties required of each state investigator. Described in this section is the criteria and procedures to be used for certification of investigators in the Colorado Motor Vehicle Emissions Inspection Program. The necessity of the state investigator's expertise, competence, and training cannot be overemphasized. The state investigator's ability to fulfill his responsibilities will be a major contribution to a successful and ongoing emissions inspection program. As shown in Table VII, all applicants must complete training in all of the thirteen (13) areas regardless of background or experience. Although training in each area is required, the length of instruction in hours varies according to the type of applicant. Table VIII exhibits the varying amounts of training time required according to the applicant's background. The training course is based on a forty (40) hour curriculum which corresponds to the average length of instruction for the applicants listed. Shown in Table IX is the cost per student compared to the number of students in a class. This cost is only that of the instructor for each training class. As can be expected, the cost per student decreases from $100 to $30 per student as class size increases from six (6) to twenty (20), respectively.

TABLE VII
REQUIRED TRAINING AREAS ON ENGINES AND EMISSIONS SYSTEMS
FOR INVESTIGATOR * CERTIFICATION

Type of Applicant	Rules and Regulations	Inspection Procedure	Data and records Procedure	Types of Pollutants	Customer Relations	PCV System	TAC System	AIR System	Fuel Evap. System	EGR System	Spark control System	Infrared analyzer use and care	Diagnosis Procedure
Tune-Up Mechanic	X	X	X	X	X	X	X	X	X	X	X	X	X
General Mechanic	X	X	X	X	X	X	X	X	X	X	X	X	X
Service Station Mechanic	X	X	X	X	X	X	X	X	X	X	X	X	X
Automotive Instructor	X	X	X	X	X	X	X	X	X	X	X	X	X
Existing state safety Inspector	X	X	X	X	X	X	X	X	X	X	X	X	X
Automotive Student	X	X	X	X	X	X	X	X	X	X	X	X	X

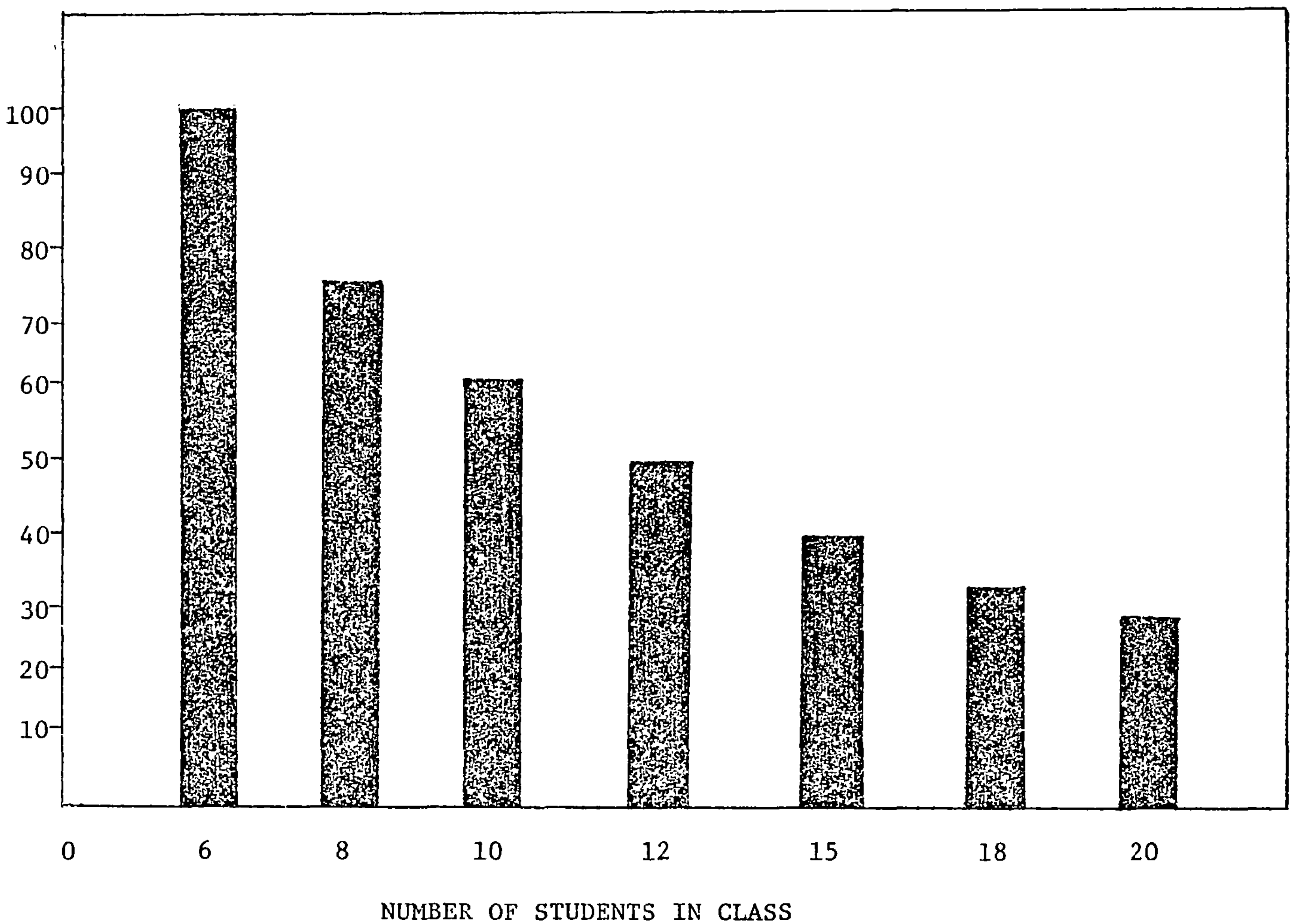
*Must meet civil service requirements

TABLE VIII
TRAINING HOURS REQUIRED ON EMISSION SYSTEMS
FOR INVESTIGATOR* CERTIFICATION

Type of Applicant	Rules and Regulations	Inspection Procedure	Types of Pollutants	Data and records Procedure	Customer Relations	PCV System	TAC System	AIR System	Fuel Evap. System	EGR System	Spark control System	Infrared analyzer use and care	Diagnosis Procedure
Tune-Up Mechanic	3.0	4.0	1.0	2.0	2.0	1.5	2.0	2.5	2.5	3.0	8.0	4.0	2.0
General Mechanic	3.0	4.0	1.0	2.0	2.0	1.5	2.0	2.5	2.5	3.0	8.0	4.0	2.0
Service Station Mechanic	3.0	4.0	1.0	2.0	2.0	1.5	2.0	2.5	3.0	3.0	8.0	4.0	4.0
Automotive Instructor	3.0	4.0	1.0	2.0	2.0	1.0	1.5	2.0	3.0	3.0	6.0	4.0	2.0
Certified safety Inspector	2.0	3.0	1.0	1.0	1.5	1.5	2.0	2.5	2.5	3.0	8.0	5.0	4.0
Automotive Student	3.0	5.0	2.0	2.5	3.0	2.0	2.0	3.0	3.0	4.0	8.0	5.0	4.0

*Must meet civil service requirements

TABLE IX
INSTRUCTOR COST OF INVESTIGATOR TRAINING*/STUDENT VS. CLASS SIZE



*Based on 40 hours of instruction

Delineated in this portion of the report are the state investigator's responsibilities, competency, experience and education requirements, examinations, place of application, appointment procedure and term, methods of renewal and requisites for certificate retention. The following criteria will assist in fulfilling the requirements established by section 66-31-28 of Senate Bill 393, stating state-employed investigators shall pass qualification tests as developed and approved by the commission.

4.1 INVESTIGATOR CERTIFICATION

4.1.1 Task and Duties Necessary to Conduct Ongoing Program:

Each state-employed investigator will be required to complete the specified investigator's emission control training course (see appendix D) and to perform the following:

4.1.1.1 Equipment Surveillance: In order that a satisfactory degree of quality control can be maintained in the inspection program the state investigator will be required to understand the operating principles and use of inspection equipment.

(a) HC-CO Analyzer - The investigator will be required to understand the principles of operation of the analyzer. The investigator must be able to evaluate analyzer performance via use of span gas or electronic span, check analyzer and sample hose for vacuum leak(s) and check if proper care and maintenance has been performed on analyzer by the inspector.

(b) Tachometer - The investigator must know normal maintenance use and care of meter and possess skill in checking and setting calibration.

4.1.1.2 Inspection Procedures: The investigator will be required to demonstrate correct inspection procedures and observe inspector for proper performance of inspection.

4.1.1.3 Enforcement: The investigator will be responsible to enforce all state emissions inspection policies as stated in Colorado Motor Vehicle Emissions Handbook. In the event an inspector or station violates any inspection policy, the state investigator with authority from the Executive Director of Revenue will have the prerogative to remove the certificate(s), impound stickers and terminate any further inspections.

4.1.1.4 Inspection of Stations: Investigator will inspect fleet and private inspection stations for proper equipment, stock of parts and area of inspection for compliance with regulations. Investigator will review records for correct order, form and proper storage.

4.1.1.5 Complaints: The investigator will investigate and act as a mediator where complaints arise between customer and inspector or inspection station. If situation can not be resolved by investigator, it will be brought before the the Board for satisfaction of all concerned.

(a) Complaint flow chart:

Customer ---- Investigator ---- Board for motor vehicle safety inspections

4.1.1.6 Discipline: The investigator will be required to take appropriate action on disciplinary problems of inspectors as stated in Colorado Motor Vehicle Emissions Handbook. A case involving suing action between customer, station, inspector or investigator will be entered and settled in a court of law.

4.1.1.7 Mechanical Skills: The investigator will be required to perform normal mechanical skills as related to the emissions test procedure.

4.2 APPLICATION FOR INVESTIGATOR CERTIFICATION

4.2.1 Competency: Proof of competency will be shown by passing the National Institute for Automotive Service Excellence Test, covering tune-up and fuel, or equivalent in addition to a test in the area of emissions devised by Colorado State University (training agency) with a grade score of not less than 80 percent.

4.2.2 Investigator Examination: Applicants for an investigator certificate must successfully complete a motor vehicle emissions test or examination prescribed by the training agency with a grade score of not less than 80 percent.

4.2.2.1 Examination Content: The examination(s) will consist of questions covering pre-inspection procedures, inspection procedures, instrument care and use, knowledge of devices and emissions systems; all of which are imperative to the program in maintaining quality control. It will also consist of an emission related situation requiring an essay response of one page or less demonstrating competency in written communication. The questions will be true-false, multiple-choice, short answer, and essay (see appendix E).

Every investigator must be thoroughly familiar with emissions systems and parts to maintain integrity of the inspection program, therefore, the applicant will also be required to identify displayed emissions parts and hardware and check for proper operation of emission components on a bench simulated system using a test light, voltmeter and ohmmeter in conjunction with an auxillary battery and vacuum source.

4.2.3 Education: The investigator must have a high school education or G.E.D. and demonstrate verbal and written competencies for effective communication.

4.2.3.1 Demonstration of Competencies: Each applicant will demonstrate his written competency by successfully completing the test; verbal competency will be demonstrated by a personal interview.

4.2.4 Where to Apply: Application for investigator certification will be submitted to the Department of Revenue, Motor Vehicle Department, 1140 West 6th Avenue, Denver, Colorado 80204.

4.3 CERTIFICATION PROCEDURE AND TERM

4.3.1 Process in Attaining Certification:

a) application

b) meet Civil Service regulations

c) provisional appointment

d) meet additional job requirements and proficiency

e) certification

4.3.2 Appointment: Upon meeting Civil Service requirements the applicant will be appointed by the Department of Revenue on a provisional basis until additional job requirements identified in Sections 4.2.1 and 4.2.2 are met, except as amended in Section 4.3.3.

4.3.3 Failure to Meet Requirements for Certification: Within ninety (90) days of provisional appointment the investigator will meet and pass requirements identified in sections 4.2.1

and 4.2.2. If these requirements are not met, certification will be denied.

4.3.4 Test Application: Investigators' application for the test will be submitted to Colorado State University, Department of Industrial Sciences, Fort Collins, Colorado 80523 (training agency) and must be completed and postmarked not less than two weeks (14 days) prior to test date.

4.4 CERTIFICATION FEE AND RETENTION

4.4.1 Fee: The fee for an investigator's certificate will be only those costs incurred by taking the appropriate tests and to cover administrative expenses.

4.4.2 Retention of Investigator's Certificate: Retention of investigator's certificate will be subject to fulfilling updated requirements established by the Department of Revenue and the Commission (see appendixes F and G).

4.4.2.1 Retention Requirements: Each investigator upon application for retention of certificate shall be required to attend 16 hours of update training before June 1 of each year, as deemed necessary by the Commission, relating to modification and changes of emission control hardware.

4.4.2.2 Proof of Maintenance of Knowledge: The investigator will demonstrate his knowledge by passing a test with a score of not less than 80 percent. The examination will be updated each year by June 1 as changes, modifications and additions of emission control devices by vehicle manufacturers dictate.

4.5 CERTIFICATE VOID

4.5.1 When Not Employed: An investigator's certificate will be void when not employed by the Colorado Department of Revenue.

4.5.1.1 While on Leave: During leave of absence, sick leave, vacation, or any other form of time off, the investigator's certificate will be void and no investigation may be performed. Upon return from investigator's absence, his certificate will be reinstated.

APPENDIX A

INSPECTOR'S COURSE OUTLINE

(Sample Outline)

INSPECTOR'S COURSE OUTLINE FOR EMISSIONS INSPECTION PROGRAM

I. POLLUTANTS AND EXHAUST ANALYZERS

A. Air Pollution

1. HC, CO, NO_x: Defined and explained

B. HC/CO Analyzers and Use

1. Operation

2. Gas and Electronic Span

3. Maintenance

4. Pre-test preparation

a. Engine temperature

b. Calibration

c. Connections

d. Conducting test

e. Additional uses

II. TEST LANE PROCEDURE

A. Safety

1. Fire

2. Personal injury

(Sample Outline)

B. Testing the Vehicle

C. Customer Relations

1. Failed Vehicles

D. Inspection Forms

1. Fees
2. Completing of forms and filing
3. Security

III. ENGINE AND IGNITION THEORY

A. Engine Requirements

B. Ignition Theory and Components

1. Standard Ignition Systems
2. Solid State Ignition Systems
3. Ignition Effects on Emissions

IV CARBURETION

A. Principles of Pressure

B. Vacuum Principles

1. Ported
2. Manifold
3. Venturi

C. Bowl venting

(Sample Outline)

D. Idle Mixture Limiters

E. Throttle Positioners and Idle Stop Solenoids

1. Checking and testing

V. THEORY OF EMISSION CONTROLS (GENERAL)

A. Systems and Similarity Between Manufacturers

1. Positive Crankcase ventilation
2. Heated Intake Air System
3. Air Injection System
4. Fuel Evaporative Systems
5. Ignition Spark Controls
6. Exhaust Gas Recirculation

B. Use of Exhaust Emission Manuals

VI. Specific Emission Controls

A. Positive Crankcase Ventilation

1. Types of PCV Systems
2. Testing and Checking of Components

B. Heated Intake Air Systems

1. Types
2. Control devices
3. Testing and checking of components

(Sample Outline)

C. Air Injection Systems

1. System Components

2. Hoses and Plumbing

3. Vacuum Signals

4. Testing and Checking of Components

D. Fuel Evaporative Systems

1. Fuel Tank Caps

2. Vapor Storage

3. Fuel and vacuum lines (connection)

4. Purging controls

5. Carburetor venting

6. Testing and checking components

E. Ignition Spark Controls

1. Ignition Timing Controls

a. Solenoids

b. Time relays

c. Vacuum delay valves

d. Transmission switches

e. Temperature override and thermal switches

f. Deceleration vacuum control valves

g. Speed sensors and amplifier modules

h. Testing of systems and components

(Sample Outline)

F. Exhaust Gas Recirculation Systems

1. EGR Controls

a. Floor jets

b. EGR valves

c. Vacuum hose routing

d. Temperature override switches

e. Deceleration vacuum control valves

f. Speed sensors and amplifier modules

g. Testing of systems and components

VII. NEW MODEL EMISSION SYSTEMS AND MODIFICATIONS

A. Systems and Testing

APPENDIX B

REFRESHER COURSE REQUIREMENT AND CONTENT FOR APPLICANT CERTIFICATION AND INSPECTOR CERTIFICATE RENEWAL

(SAMPLE ONLY)

REFRESHER COURSE REQUIREMENT AND CONTENT FOR APPLICANT CERTIFICATION AND INSPECTOR CERTIFICATE RENEWAL

Any applicant/inspector who fails to pass the competency or certificate renewal examination with the required 80% score will be required to take a refresher course in emissions systems. As indicated by the test questions missed it can be determined what area(s) the applicant lacks knowledge. If the applicant so desires he may take the entire inspector's emission course as outlined but will only be required to enroll in the section(s) of the course he needs additional training. For example, the applicant shows a deficiency in Exhaust Gas Recirculation; therefore the only section of the course requiring attendence by the applicant would be the EGR unit.

APPENDIX C

INSPECTOR COMPETENCY EXAMINATION

INSPECTOR EXAMINATION

The following inspectors' examination is an example only of the Type of test that will be used to certify an inspector to conduct a tail pipe and under hood vehicle emissions inspection. The examination consists of questions showing level of compentency in mathematical problem solving (5th grade), inspection procedures, instrument use, knowledge of devices and systems of emissions control.

The inspector's application procedures incompassing the examination requirements are stated in section 3.2 of this document.

(Sample Only)

INSPECTOR COMPETENCY EXAMINATION

Multiple-Choice: Place the letter corresponding to the best answer in the space provided.

____ 1. HC is the symbol for

a. nitrogen
b. sulfur
c. oxygen
d. hydrocarbons

____ 2. CO is the symbol for

a. hydrocarbons
b. carbon monoxide
c. chlorine
d. calcium

____ 3. An engine is equipped with a throttle stop solenoid (anti-dieseling solenoid). At what time(s) should the plunger be in the extended position (solenoid energized)?

a. only above 30 M.P.H.
b. only below 30 M.P.H.
c. any time ignition switch is "on"
d. none of the above

____ 4. On an engine with an air injection system with a diverter valve air <u>should be</u> "dumped" momentarily to the atmosphere when

a. the engine is decelerating
b. the engine is accelerating
c. the engine speed is below 2,000 R.P.M.

____ 5. When checking for a fuel vapor leak with the HC-CO analyzer probe and a leak is present you would most likely see what meter reading?

a. High HC and CO
b. only high CO
c. only high HC
d. would not be detected

True-False: Circle T if statement is true, F if the statement is false.

T F 1. A vehicle is equipped with a heated air intake system with a vacuum motor controlled air door; regardless of underhood temperature, when the engine is off, the air door will be in the cold air mode (position).

T F 2. On a GM vehicle with a CEC solenoid the idle speed is controlled and set by the solenoid plunger.

T F 3. It is not necessary to allow the engine to reach normal operating temperature to perform an HC-CO emissions test with an infra-red analyzer.

T F 4. Some vehicles with spark control systems allow vacuum advance to the distributor regardless of gear selection when the engine coolant is below a specified temperature.

T F 5. You inspect a 1972 vehicle with the air cleaner lid turned upside down. This is O.K. because this does not affect any of the emission systems.

Short Answer: Fill in the blank with the correct missing word or phrase.

1. The vacuum motor on a heated air induction system must be operated by ________________ vacuum.
(source)

2. The infrared analyzer test probe must be inserted into the tail pipe at least ______________ inches to obtain an accurate emission sample.

3. Explain briefly how a simple test (without gauges) can be performed to check if an air injection pump has any air output.

4. What, if any, are the visible differences between a distributor with a retard solenoid and one with an advance solenoid on a Chrysler Corporation engine?

5. A Ford Motor Company engine is equipped with a dual diaphragm vacuum advance mechanism. Which diaphragm should be connected to manifold vacuum?

Math Problems: Solve the following

1. Add 43 + 21 + 19 = 21.3 + 15.9 = 13.02 + 67.5 =

2. Subtract 43 - 29 = 89.1 - 74.8 =

41.165 - 3.09 =

3. Multiply 107 X 39 = 51.3 X 6.2 =

442 X 65% =

4. Divide 192 ÷ 4 = 56.23 ÷ 21 =

Practical Test:

Upon completion of this written examination you will be required to perform an actual emissions test on a vehicle according to the State of Colorado's Inspection Handbook in the presence of a trained supervisor.

APPENDIX D

INVESTIGATOR COURSE OUTLINE

(Sample Outline)

INVESTIGATOR COURSE OUTLINE FOR EMISSION CONTROL AND INSPECTION PROGRAM

I. POLLUTANTS AND EXHAUST ANALYZERS

A. Air Pollution

1. HC, CO, NO_x: Defined and explained

a. Formation of HC, CO, NO_x in engine

2. Effects on human, plant, and animal life

B. Exhaust Analyzers

1. Principles of Operation

a. Electronic and span gas

2. Pre-testing Preparations

a. Engine temperature

b. Calibration and span

c. Proper "hook-up"

d. Additional uses

3. Maintenance of analyzer

a. Filters

b. Water traps

c. Checking air flow rate

d. Hose and fitting leaks

4. Test lane procedure

a. Safety

b. Customer relations

1) Failed vehicles

c. Forms

d. Exempted vehicles

(Sample Outline)

II. ENGINE AND IGNITION THEORY

A. Engine Requirements

1. Fuel - air - ignition

a. Heat and power

B. Ignition Theory

1. Purpose

2. Components

a. Standard ignition

b. Solid state types

c. Diagnosis

3. Ignition effects on emissions

a. HC, CO, NO_x

b. Advance controls

1) Testing and checking of components

III. CARBURETION

A. Carburetion Principles

1. Pressure and effects

2. Air cleaners

3. Carburetor vacuum principles

a. Manifold

b. Ported

c. Venturi

4. Venting

5. Idle mixture limiters

6. Chokes

7. Exhaust restrictors and heat valves

B. Throttle Positioners

1. Idle stop solenoids

IV. THEORY OF EMISSION CONTROLS (GENERAL)

A. Relation of Controls to Emission Reduction

1. Positive crankcase ventilation
2. Heated intake air system
3. Air injection system
4. Fuel evaporative system
5. Ignition spark controls
6. Exhaust gas recirculation

V. SPECIFIC EMISSION CONTROLS

A. Positive Crankcase Ventilation

1. Operation and purpose
2. Types of PCU systems
3. Testing and checking system

B. Heated Intake Air Systems

1. Types
   a. Thermostatic
   b. Vacuum motor
      1) Controls and operation
      2) Testing and operation of components

(Sample Outline)

C. Air Injection Systems

1. Components and checks

   a. Pump

   b. Relief valves

   c. Diverter and check valves

   d. Hoses and vacuum signals

   e. Testing of components

D. Fuel Evaporative Systems

1. Fuel tanks

   a. Caps and vents

2. Vapor storage

   a. Crankcase

   b. Canisters

      1) Purging methods

3. Carburetor venting

4. Methods of checking and testing components

E. Ignition Spark Controls

1. Ignition timing controls

   a. Solenoids

   b. Time relays

   c. Vacuum delay valves

   d. Transmission switches

   e. Temperature override and thermal switches

   f. Deceleration vacuum advance control valves

   g. Speed sensors

      1) Amplifier modules

   h. Methods of checking and testing components

(Sample Outline)

F. Exhaust Gas Recirculation

1. Principle of operation

a. Purpose

b. Combustion temperatures

2. EGR Controls

a. Exhaust recycle requirements vs. engine operating modes

b. Flood jets

c. EGR valves

d. Vacuum operated EGR

1) Override switches

2) Ported vacuum signals

3) Venturi vacuum signals

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4) Hoses and routing

5) Testing and checking

VI. INSPECTION POLICIES

A. Inspector Surveillance

B. Fee Collection and Security

C. Complaints and procedures

VII. NEW MODEL EMISSION SYSTEMS AND MODIFICATIONS

A. Systems and Testing

APPENDIX E

INVESTIGATOR COMPETENCY EXAMINATION

(SAMPLE ONLY)

INVESTIGATOR COMPETENCY EXAMINATION

Multiple-Choice: Place the letter corresponding to the best answer in the space provided.

____ 1. Evaporation Emission control systems on 1970-71 American Motors, Chrysler and some Ford cars

a. store fuel vapors in the engine crankcase, drawing them through the PCV system when wngine is started and running
b. store fuel vapors in twin charcoal canisters
c. store fuel vapors in the intake manifold when engine is not running

____ 2. Since 1968, all U.S.--built passenger cars and light trucks have been equipped with

a. a recirculating PCV system
b. an open PCV system
c. a closed PCV system

____ 3. The Exhaust Gas Recirculation system is designed primarily to

a. reduce hydrocarbon emissions
b. reduce carbon monoxide emissions
c. reduce nitrogen oxide emissions

____ 4. On an engine with an air injection system with a diverter valve air <u>should be</u> "dumped" momentarily to the atmosphere when

a. the engine is decelerating
b. the engine is accelerating
c. the engine speed is below 2,000 R.P.M.

____ 5. A distributor advance mechanism that provides improper timing may cause

a. poor M.P.G.
b. possible high speed miss
c. ineffective emission control
d. all of the above

____ 6. Which instrument can be used to test for high HC when an engine tuneup has been performed using manufacturers specifications?

a. timing light
b. tach dwell
c. vacuum gauge
d. all of the above
e. none of the above

True-False: Circle T if statement is true, F if the statement is false.

T F 1. Exhaust emissions are greatest during periods of deceleration and idle.

T F 2. A mechanic cannot disconnect pollution control devices but it is O.K. (legal) for a person to do it on his own car.

T F 3. An automatic transmission switch used on a TCS system that is identified in the diagram as normally open should not have continuity if checked when engine is running and selector is in neutral.

T F 4. Extremely high HC and CO readings are indications of a flooding carburetor when testing from idle to 1,000 R.P.M.

T F 5. When both HC and CO are high during idle R.P.M. the key to an overrich diagnosis is an excessively high CO reading.

Short Answer: Fill in the blank with the correct missing work or phrase.

1. A type 4 (closed) crankcase ventilation system has a ________________________(vented/non-vented) oil filler cap.

2. On a vehicle with a V-8 engine and air injection there are _______________check valves in the distribution lines.

3. Explain briefly but thoroughly how a vehicle with a transmission controlled spark system could be checked for allowing proper spark advance in 3rd gear in the shop. Car has automatic transmission.

Essay Question: As an investigator you are faced with the following situation. Write out a solution to this situation in one page or less as how you would try and resolve the problem.

Problem: A customer had an emissions inspection performed on his vehicle which has a drain hole in the muffler. The inspector would not pass the vehicle because he contends the hole is of sufficient size to dilute the sample. The customer claims it is of little significance. What would you suggest?

Practical Test: You will be required to watch an emissions inspection on a live vehicle and note any malpractices that may be performed by the inspector.

APPENDIX F

REFRESHER COURSE REQUIREMENT AND CONTENT

(SAMPLE ONLY)

REFRESHER COURSE REQUIREMENT AND CONTENT

FOR INVESTIGATOR REAPPOINTMENT

As stated in Section 4.4.2.1 of this document each investigator, in order to retain certification will be required to attend update training before June 1 of each year, as deemed necessary by the commission, relating to modification and changes of emission control devices. Unit VII of the regular inspectors training course encompasses new model and modified emission systems by vehicle manufacturers. Enrollment in this unit will be required of each investigator, annually, or as deemed necessary by the commission, for retention of certification.

APPENDIX G

INVESTIGATOR'S AND INSPECTOR'S

UPDATE EXAMINATION

(SAMPLE ONLY)

INVESTIGATOR'S AND INSPECTOR'S UPDATE EXAMINATION

The following example is part of a typical examination that will be given each investigator and inspector when application for certification renewal is made. The applicants will be allowed an emissions manual to answer problem #1. There will be a time limit to complete the examination. Because of the numerous changes and modifications in vehicle emission controls from year to year, the need for an update test is imperative.

PROBLEM #1: List all the emission controls that are used on the following engines and in their respective model year. Where modifications or new additions occur, identify component and/or system location (all must be correct).

1974-1975 Chevrolet Impala with: 350 engine, 2 barrel carburetor, air conditioner, automatic transmission.

PROBLEM # 2: Identify six (6) displayed vehicle emission control devices that are found on 1975 automobiles (all must be correct).

QUESTIONS: T F

On some 1975 Chrysler products a carburetor solenoid is used to prevent the catalyst from overheating.

The EGR modulator on 1975 General Motors products regulates vacuum to the EGR valve according to: (circle correct response letter)

a) road speed

b) transmission gear

c) exhaust back-pressure

PRACTICAL TEST:

Conduct an inspection of a current model year vehicle under the supervision of a member from the training agency.

APPENDIX H

EMISSION CONTROL TRAINING REFERENCE MANUALS

TABLE OF CONTENTS

INTRODUCTION

The purpose of The Power Service Manuals (Vol. No. 1 and Vol. No. 2) is to help you become familiar with the crankcase and exhaust emission control systems now required on all cars, according to Federal law. The No. 1 Manual contains an explanation of the PCV or Positive Crankcase Ventilation system, and the General Motors CCS or Controlled Combustion System. At a later date, a No. 2 Power Service Manual will be available. It will contain an explanation of the General Motors AIR or Air Injector Reactor system and the Chrysler CAP system.

The required service on emission systems is quite limited. The major control of emissions is accomplished by performing periodic engine tune-ups that maintain optimum engine performance at all times. For that reason, this No. 1 Manual contains a brief description of the procedures performed during the first half of a complete engine tune-up. The remaining half of the engine tune-up procedures will be covered in the No. 2 Manual.

Crankcase emission control systems function in much the same manner on all makes of cars. This Manual will describe a typical system. When you understand the basic system, you should have no trouble in identifying the components and servicing the system on any car.

The various exhaust emission control systems have certain common characteristics, too. Generally speaking, all engines equipped with an exhaust emission control system have these modifications . . .

1. Specifically calibrated carburetor
2. Specifically calibrated distributor
3. Retarded timing
4. Higher idle speed
5. Higher operating temperatures

In addition, they will incorporate control units of the type used in either the CCS or AIR systems. Again with a basic understanding of system components, you should have no trouble in servicing similar systems on any car.

Along with this First Manual, you received an examination that will test your understanding of the material in the booklet. To complete the exam, select the correct answer from the three suggestions. Indicate your choice, and mark down the page number where you located the answer.

You're on your own, so you can proceed as you choose. You can read the examination questions, and then watch for the answers as you review the text and study the illustrations. Or you can study the explanations and the drawings, and then undertake to answer the questions. You will receive a diploma after you successfully complete this examination, and the one that will come to you with the Second Manual.

AUTOMOTIVE EMISSIONS IN RELATION TO AIR POLLUTION

The automobile is just one of many contributors to air pollution. However, it's the one that interests us ... because it's a part of our job to help individual car owners and automotive service personnel live up to the rules and regulations that now govern automotive emissions.

The automobile contributes to air pollution simply because it uses gasoline, a fuel made up of hydrocarbons. When unburned hydrocarbons escape into the air, they contribute to its contamination ... and that's the definition of air pollution.

The automobile has four sources (Fig. 1) for the release of unburned hydrocarbons into the atmosphere. The first is the crankcase, where blowby gases account for about 20% of the total. The second source is the exhaust, responsible for approximately 60% of the total. In addition to unburned hydrocarbons, exhaust emissions also include carbon monoxide and nitrogen oxides.

The remaining 20% comes from the third and fourth sources . . . the fuel tank and the carburetor . . . where evaporation goes on all the time.

A single car doesn't add much to air pollution. Only about one-tenth of one percent of the engine exhaust is unburned hydrocarbons. But when hundreds of thousands of cars are operating in a congested area, it all adds up.

The automobile manufacturers undertook to solve their own part of the air pollution problem, and many scientists and engineers have put in much time and effort to lower the level of hydrocarbon emissions.

Crankcase emissions have been virtually eliminated by the development of the PCV, or Positive Crankcase Ventilation system.

To reduce exhaust emissions, General Motors has developed the CCS, or Controlled Combustion System . . . and the AIR, or Air Injector Reactor system. Other manufacturers have similar systems with different names. These systems reduce exhaust emissions to below the required standards . . . 275 parts per million by volume for hydrocarbons, and 1.5% by volume for carbon monoxide.

To control evaporation from the fuel tank and the carburetor is not easy, and the automotive engineers continue to work on the problem.

In the future, the emission control standards will continue to change, and the automotive engineers will continue to improve their emission control systems to meet the new requirements.

Our job is to make sure the present systems continue to do the work they were designed to do.

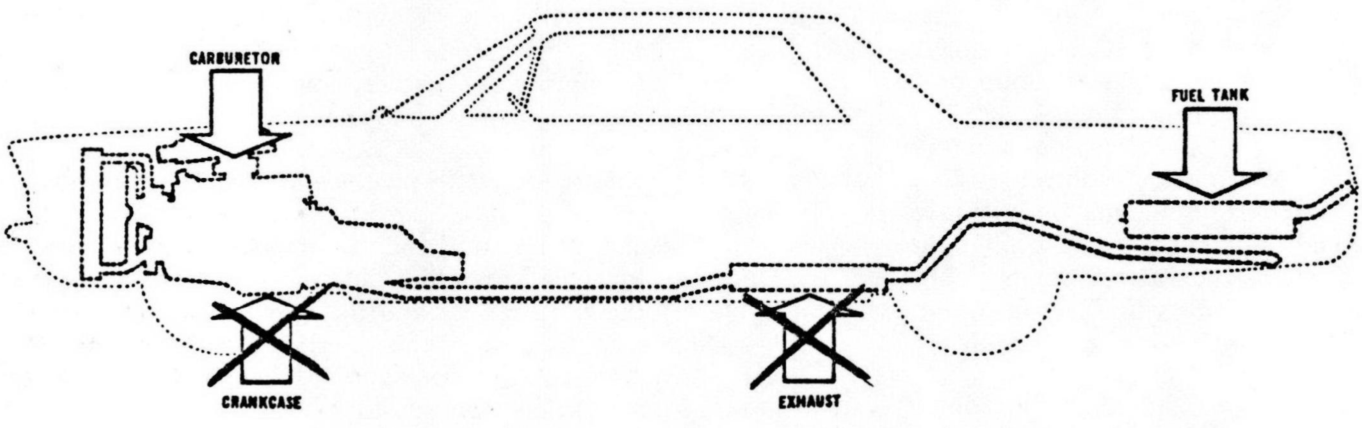


Figure 1

There are four reasons why some of the burned and unburned gases from the combustion chamber enter into the crankcase (Fig. 2):

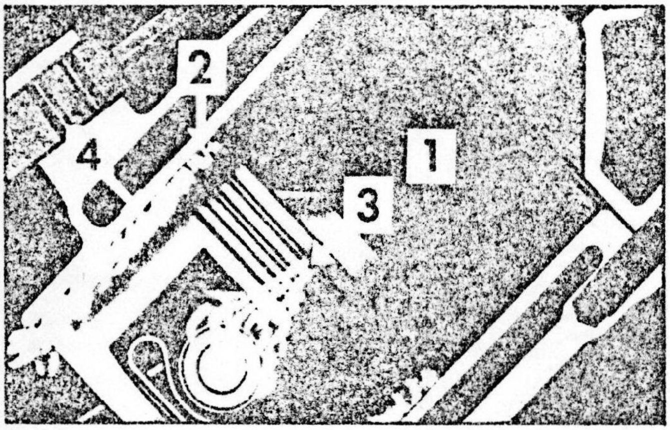


Figure 2

1. High combustion chamber pressures.
2. Necessary working clearance of piston rings in their grooves.
3. Normal ring shifting that sometimes lines up clearance gaps of two or more rings.
4. Reduction in ring sealing contact area with change in direction of piston travel.

There are two reasons why these blow-by gases of combustion must be removed from the crankcase:

1. To prevent oil dilution.
2. To prevent the formation of sludge.

For many years a road draft tube system (Fig. 3) was used to eliminate blow-by fumes from the engine crankcase. In this system, the vacuum created at the outlet of the road draft tube would simply suck out the undesirable crankcase fumes into the atmosphere. Outside air entered the crankcase through a vented oil filler cap.

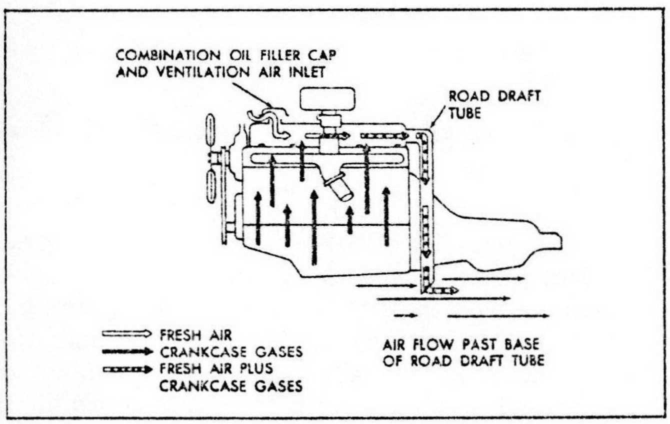


Figure 3

The road draft tube system left much to be desired. It was ineffective for crankcase ventilation purposes at low speed, and also contributed to air pollution.

OPEN PCV SYSTEMS

Various types of controlled crankcase ventilation systems were installed on some cars as early as 1961, and they became common on the majority of cars in 1963. Although there were basic differences in these early systems, they all essentially used manifold or induction system vacuum to withdraw blow-by fumes from the crankcase and recirculate them into the combustion chamber, along with the air fuel mixture delivered by the carburetor.

Between 1963 and 1967, the most common method used to control crankcase emissions was an open positive crankcase ventilation system (Fig. 4). In a typical installation, this system utilizes a PCV or control valve in the engine valve cover, and a hose that connects the PCV valve to an intake manifold vacuum opening. With some applications, the PCV valve may be in a crankcase opening at the top of the engine block, or at the intake manifold end of the connecting hose. Other applications use only a fixed orifice in place of a PCV valve.

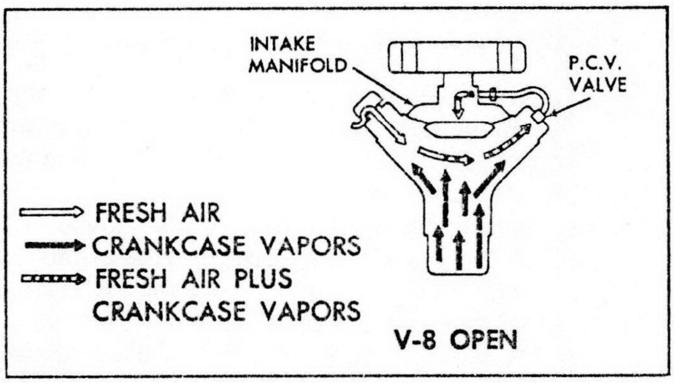


Figure 4

Vented oil filler caps are characteristic of open PCV systems. Under normal engine operating conditions with an open PCV system, outside air which has entered through the vented cap, plus crankcase fumes, are drawn into the intake manifold and burned in the combustion chamber. Under heavy acceleration, manifold vacuum decreases and crankcase pressures build up. With these circumstances, a portion of the crankcase fumes are forced back out through the vented oil filler cap. For this reason, an open PCV system only partially controls crankcase emissions.

CLOSED PCV SYSTEMS

All 1968 and later model cars are equipped with a closed positive crankcase ventilation system. Generally, it utilizes the same components as the open system, with the following exceptions (Fig. 5):

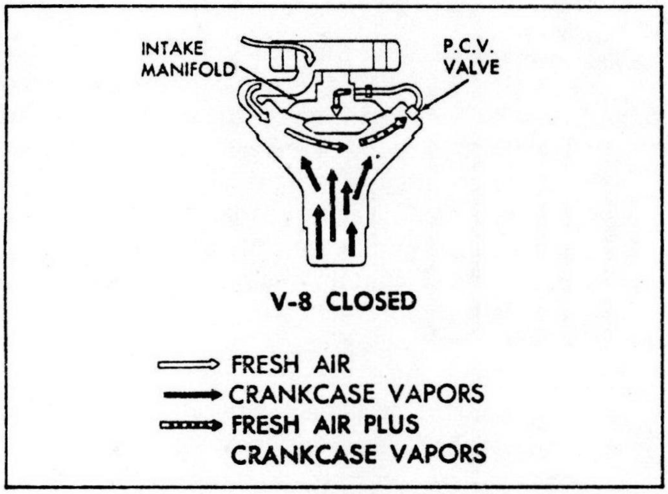


Figure 5

1. In place of a vented oil filler cap, an air intake hose is connected between the carburetor air filter and a crankcase opening in the valve cover.
2. Sealed oil filler and dip stick caps are used.
3. A flame arrester is used in those installations where air is supplied from the clean air side of the carburetor air filter.
4. A separate PCV air filter is used when the inlet air hose is connected to the unfiltered side of the carburetor air cleaner. This filter is either in the periphery of the carburetor air filter, or at the point where the inlet air hose connects to the valve cover.

Under normal engine operating conditions, the closed PCV system functions in the same manner as the open system, except that air enters the crankcase through the inlet hose connected to the carburetor air filter. However, under heavy acceleration conditions, any excess vapors from the crankcase flow back up through the air inlet hose to the carburetor air cleaner. At this point, they mix with incoming air, flow through the carburetor, and are reburned in the combustion chamber. Backup fumes cannot escape from the system.

In effect, the closed positive crankcase ventilatio system provides almost 100% control of crankcas emissions.

PCV VALVE OPERATION

The PCV valve assembly consists of a valve spring, valve plunger, and a two-piece, crimped outer valv body (Fig. 6). The function of the valve assembly

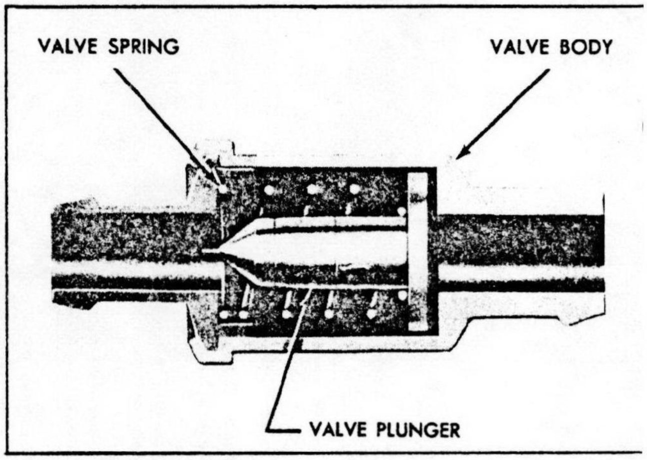


Figure 6

to meter the flow through the system according t the various modes of operation . . . idle, acceler tion, cruise.

The action of the valve plunger is governed by th intake manifold vacuum, and by the valve spring.

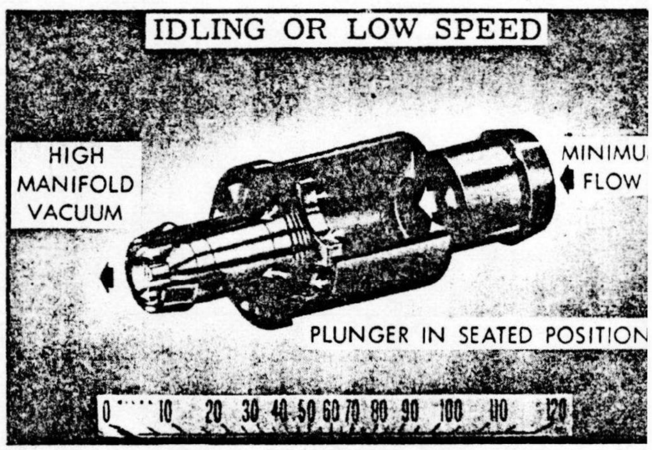


Figure 7

During periods of deceleration and idle or lc speed, manifold vacuum is high (Fig. 7). This hi vacuum overcomes the force of the valve spring, a the plunger bottoms in the manifold end of t valve housing. Because of the valve constructio this restricts, but does not completely stop the flc of crankcase vapors to the intake manifold.

When the engine is lightly accelerated or operated at constant speed, intake manifold vacuum is less than at idle. During this mode, the spring force equals the vacuum pull, and the plunger assumes a mid-position in the valve body. More crankcase vapors now flow into the intake manifold (Fig. 8).

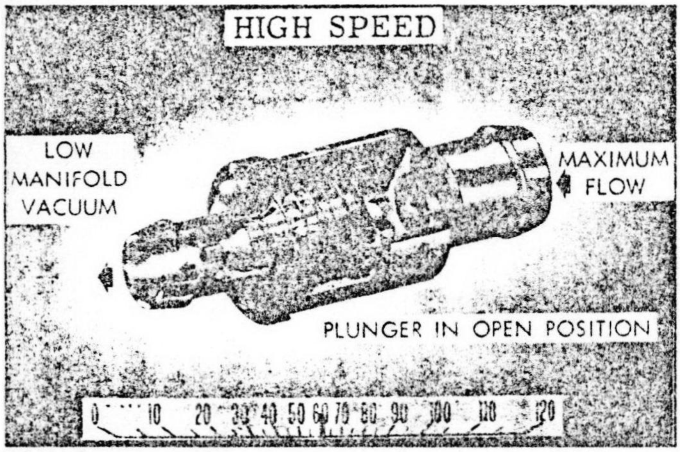


Figure 8

In the event of a backfire, Fig. 9, the valve plunger is forced back and seated against the inlet of the valve body. This prevents the backfire from traveling through the valve assembly into the crankcase. If the backfire were allowed to enter the crankcase, it could ignite the volatile blow-by gases. The plunger

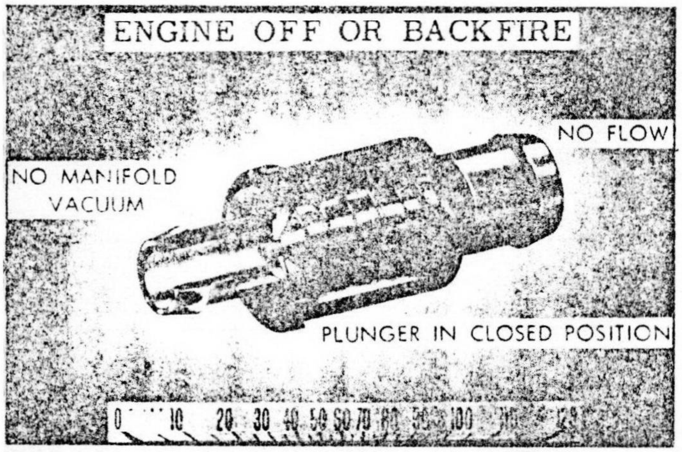


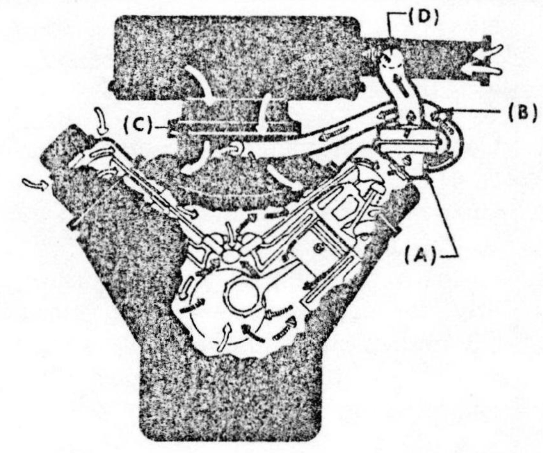
Figure 9

is also seated when the engine is off and there is no manifold vacuum.

It should be noted that additional air is permitted to enter the intake manifold when PCV is used. However, the carburetor used with this system is calibrated to compensate for the air plus the blow-by gas that enters the intake manifold from the crankcase. For this reason, it should be remembered that PCV valves are carefully sized for each engine.

DUAL ACTION VALVE

There is one additional type of valve unlike the plunger type that is referred to as the dual action valve. It was used on several years production of Oldsmobile. It functions as follows (See Figure 10).



DUAL ACTION VALVE SYSTEM

Figure 10

At low rpm operation, unburned hydrocarbons are drawn into the intake manifold via valve opening (a) connecting tube (b), and orifice (c), at the carburetor base plate.

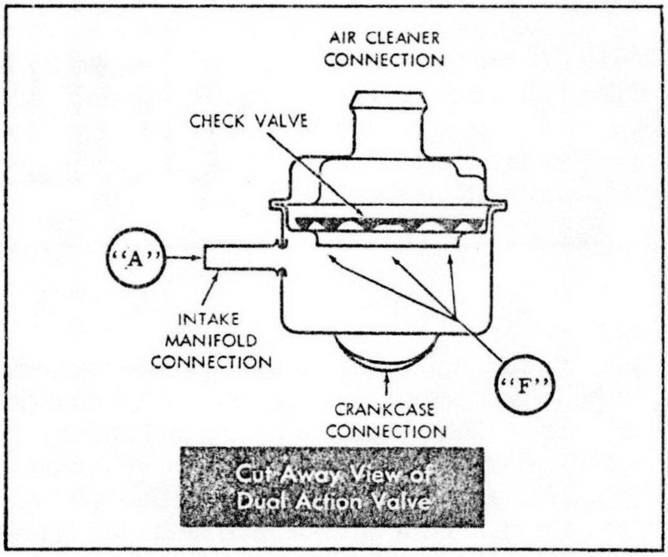


Figure 11

At high engine rpm, a slight vacuum occurs at (d), a slight blow-by pressure occurs at underside of check valve (f) (See Figure 11). This combination of vacuum and pressure, raises the check valve off seat, allowing the additional blow-by to flow into the air cleaner. At this time both the fixed orifice and check valve are in operation.

PRACTICAL CHECK OF PCV SYSTEMS

If excessive sludging of the valve occurs, it will not operate, and the valve passage may be closed. This will cause high crankcase pressure at highway speeds. This pressure can cause the engine to blow out oil through the air intake or the engine seals and gaskets.

A plugged system will definitely cause a rough idle. A quick check to see if rough idle is caused by the PCV valve is to:

1. Connect tachometer to the engine.
2. Start the engine and adjust idle.
3. Clamp off the hose that goes from the valve to the carburetor base.
4. If the ventilation system is working properly, the engine rpm will drop about 30 to 50 rpm. You should be able to hear the valve click shut when clamping off the line and releasing it several times.

There will be no change in engine rpm if the valve or hoses are sludged up and restricted.

TESTING PCV SYSTEMS

It is generally recommended that PCV systems (Fig. 12), be tested during the first four months or 6,000 miles of operation. Thereafter, a system should be checked during engine tune-up, or whenever rough engine performance warrants it.

It is best to check a PCV system with a tester designed for the purpose. The AC CT-3 is a typical tester. It reports the condition of the system by color . . . red for danger, orange for caution, green for okay. The valve can be tested separately. Complete testing procedures and specifications are a part of the instructions packaged with the tester.

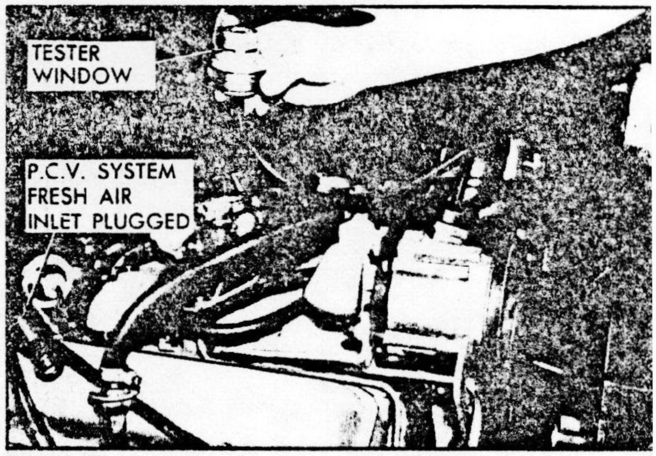


Figure 12

SERVICING PCV SYSTEMS

PCV systems must be maintained in proper workin order to insure minimum crankcase emission, as we as good engine performance. Generally, manufactu ers recommend the following procedures at periodi tune-up intervals, or every twelve months or 12,00 miles of operation:

1. Replace the PCV valve assembly ever twelve months or 12,000 miles.
2. Replace any replaceable type filters. Clea and re-oil the cleanable type filters.
3. Inspect, clean, and . . . if necessary . . replace all hoses, tubes, and fittings in th PCV system.

Disassemble and wash all components in a suitabl solvent, and blow out gently with compressed air. I the system is not excessively dirty, cleaning with spray type solvent is acceptable. Extremely dirty o deteriorated hoses should be replaced. Use only th recommended oil and gas resistant hose.

EXHAUST EMISSION SYSTEMS

One of the approved exhaust emission control methods gets results through the use of modified carburetion, revised ignition timing, and hotter thermostats (Fig. 13). The carburetor calibration is changed to provide a leaner mixture, the spark calibration is changed to provide retarded initial timing, and the hotter thermostats permit higher coolant temperatures. These factors . . . along with a thermostatically controlled air cleaner . . . cause more complete combustion and a reduction in the amount of unburned hydrocarbons and carbon monoxide.

The General Motors name for this control method is Controlled Combustion System (CCS). Other manufacturers have different names.

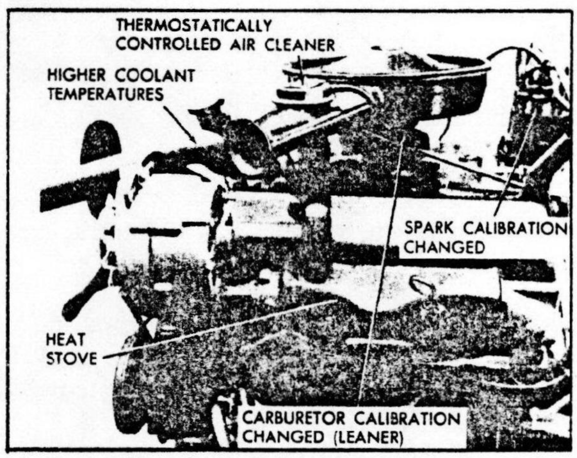


Figure 13

For purposes of explanation and understanding, we will describe the CCS and its various components. They are typical of units found on other installations, and even though they may vary in appearance, they function in a very comparable manner.

Many different components will be found on various CCS installations. Basically, each engine and transmission combination has different control requirements.

Manufacturers use whatever unit or combination of units is required to control their various engine applications. Generally speaking, engines used with standard transmissions require more control components than engines used with automatic transmissions. Also . . . for any given engine application, the use of control components may vary from one model year to another.

When you are familiar with the function of each individual type of control component, you will know how to relate its use to the different cars that may come to your attention. Here are the principal components that you should know.

VACUUM SPARK ADVANCE

For many years, two sources of vacuum have been utilized to control the vacuum operated advance unit on the distributor, and thereby vary spark timing in relation to engine load (Fig. 14).

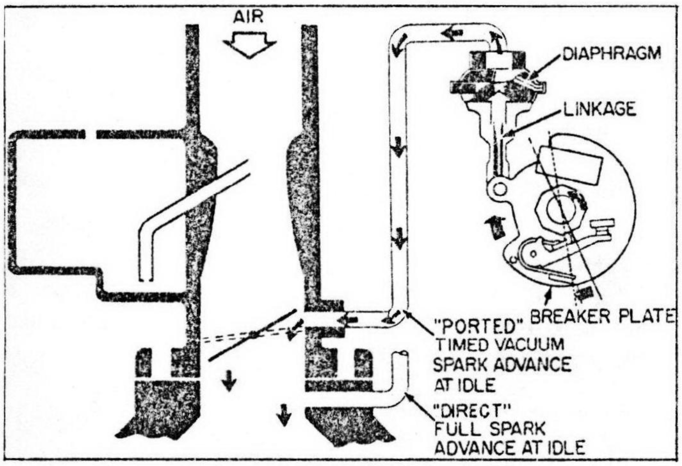


Figure 14

1. "PORTED" vacuum provides timed vacuum spark advance at idle. In this case, a calibrated port is located in the throttle bore just above the throttle valve. It is connected by a vacuum line directly to the distributor vacuum advance unit. In the curb idle position, the throttle valve is below the spark port. Consequently, no vacuum is applied to the advance unit, and the spark advance remains in the retarded position.

   As the throttle valve is opened and engine speed increases, the resulting vacuum is applied to the vacuum advance unit, causing the spark to advance for normal operation.

2. "DIRECT" manifold vacuum provides full vacuum spark advance at idle because the vacuum advance line is connected to a port either in the throttle bore below the throttle valve or in the intake manifold.

Some emission controlled engines use only "ported" vacuum advance. Others use both "ported" and "direct" manifold vacuum for more effective emission control under various engine operating conditons.

TYPICAL VACUUM CONTROL CIRCUIT

A typical vacuum control circuit (Fig. 15) includes a combination of the different types of control units that might be found on different engine applications. Remember that not all control units will be found on all engine applications. However, when you are familiar with the basic function of each unit, you will have no problem in adapting your knowledge to any particular car.

Following are descriptions of different units that are utilized to control vacuum spark advance for various engine-transmission combinations.

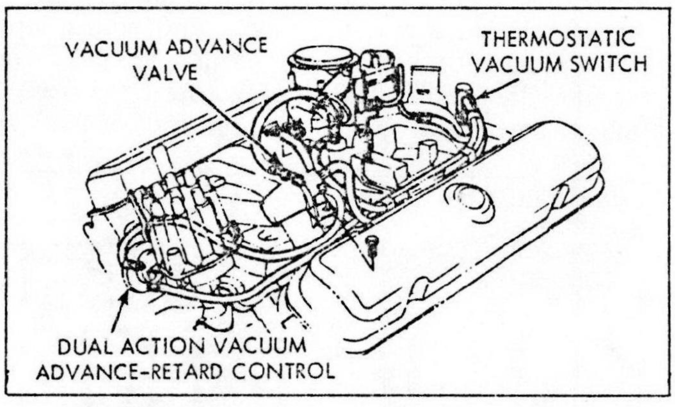


Figure 15

DUAL ACTION VACUUM ADVANCE – RETARD CONTROL

Some distributors used with emission controlled engines have a dual acting vacuum advance-retard mechanism. Its purpose is to provide retarded timing during idle and coast down or deceleration conditions. With full manifold vacuum applied to the retard side, the timing is approximately 5 degrees to 10 degrees below the initial timing setting.

Under part-throttle conditions, the advance side of the dual action mechanism functions to provide normal vacuum advance. Fig. 16 is used only to illustrate the basic principles involved. In actual installations, both thermostatic and vacuum advance valves may be used as part of the total vacuum control circuit. These units make it possible to route direct manifold vacuum to the retard port and either ported or direct manifold vacuum to the advance port.

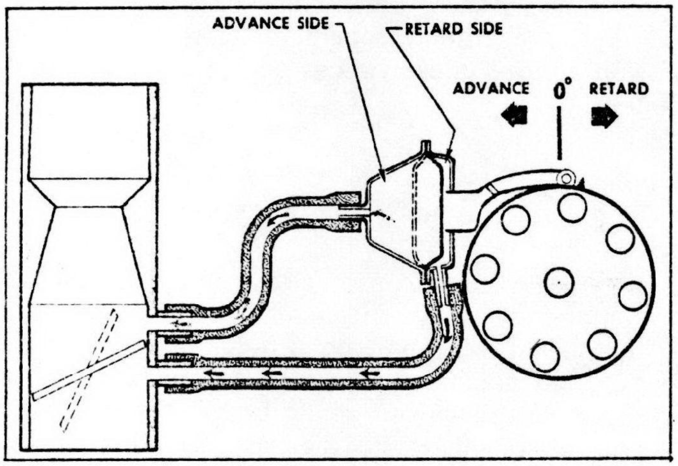


Figure 16

THERMOSTATIC VACUUM SWITCH

In most emission controlled engines, initial ignition timing is slightly retarded, compared to previous years. Engines with retarded initial timing tend to run hotter at idle . . . if allowed to idle for lengthy periods. For that reason, many engines are equipped with a thermostatic vacuum switch (Fig. 17), located in the engine coolant jacket near the front of the engine. Valves may have either three or five hose

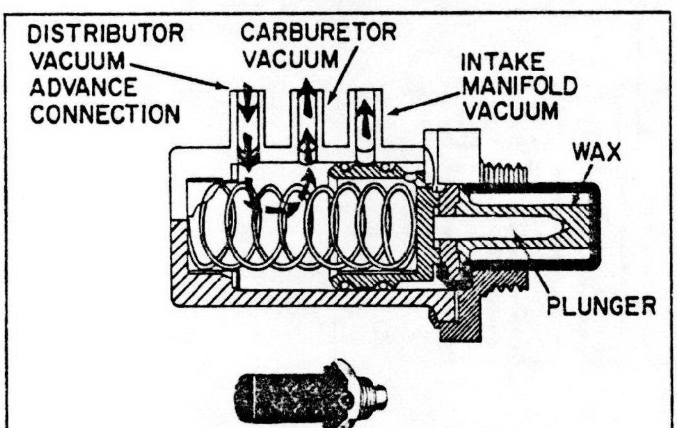


Figure 17

connections, depending on the vacuum contro circuit in which it is used.

When the coolant temperature reaches approximately 220 degrees F, the valve switches the vacuum source from ported to direct manifold vacuum . . and the distributor vacuum control advances the spark timing to speed up the engine. This results in lower combustion chamber temperature, and along with higher fan speed, cools down the engine. After the engine has cooled down, the thermostatic switch returns to ported vacuum, and the timing returns to the normal retarded position.

VACUUM ADVANCE VALVE

Some engine applications use a vacuum advance valve to provide better combustion during "coasting" conditions, when the throttle is closed and direct manifold vacuum is high. In operation, the valve switches from ported vacuum, and applies direct manifold vacuum to the distributor to advance the ignition timing. This results in more complete combustion of the fuel charge (Fig. 18).

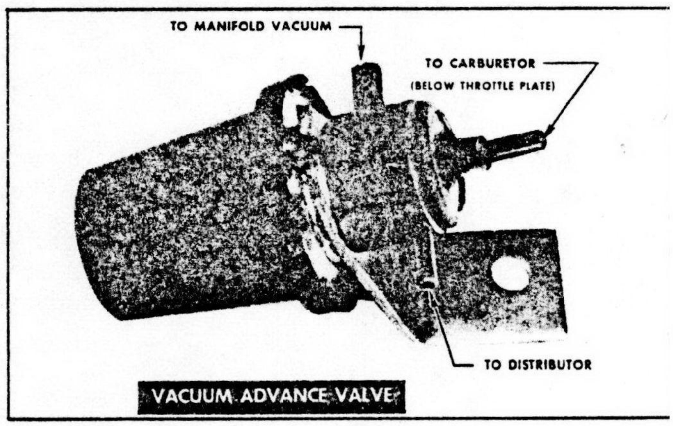


Figure 18

IDLE STOP SOLENOID

Because of the higher idle speeds used with emission control systems, the possibility of dieseling exists after turning off the ignition on certain vehicles. To alleviate this condition, an idle stop solenoid is used on some cars (Fig. 19).

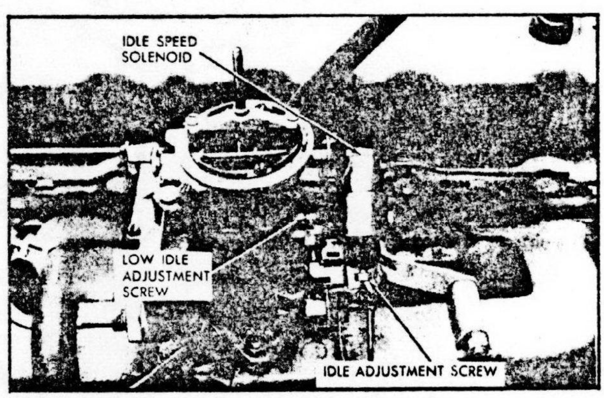


Figure 19

The solenoid eliminates dieseling tendencies by allowing the throttle valve to close beyond the normal curb idle position when the ignition switch is turned off.

In operation, the solenoid is energized whenever the ignition switch is turned on. The plunger of the solenoid serves as a stop for the carburetor throttle lever. As a result, normal idle speed adjustment is obtained by turning the solenoid plunger screw "in" or "out".

When the ignition switch is turned off, the solenoid plunger retracts and allows the throttle lever to move toward the closed position until it strikes the carburetor throttle stop screw. On these applications, two idle speed adjustments must be made . . . one with the solenoid energized, and another with the solenoid de-energized. Refer to the United Delco 60A100-1 tune-up specifications for the correct idle speed adjustment procedures.

THERMOSTATICALLY CONTROLLED AIR CLEANER

General Motors cars equipped with CCS incorporate a thermostatically controlled air cleaner, designed to keep air entering the carburetor at approximately 100 degrees F when underhood temperatures are less than 100 degrees F. By keeping the air at this temperature, carburetor icing can be minimized, engine warm-up can be improved, and . . . finally . . . the carburetor can be calibrated for leaner fuel air ratios that will reduce hydrocarbon emission. This system is known as the AC Auto Thermac (Fig. 20).

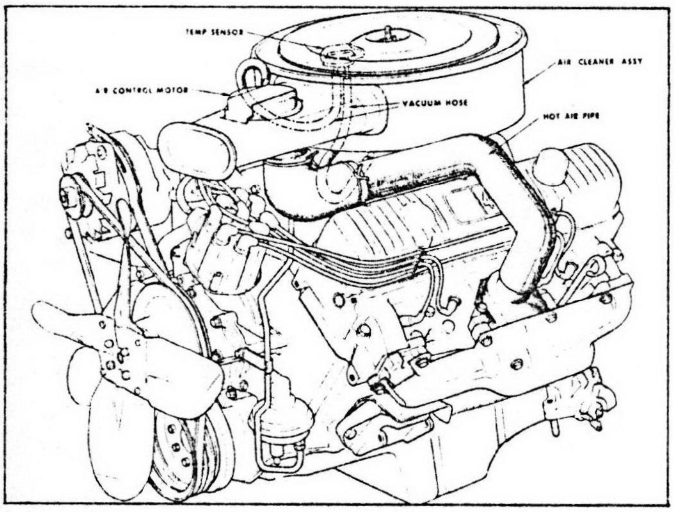


Figure 20

The system basically consists of a temperature sensor, vacuum operated air control motor, hoses, and pipes. Also included is the necessary shrouding around the exhaust manifold . . . a heat stove that supplies heated air to the carburetor. The sensor is located in the cleaner body, on the clean air side of the air filter.

In operation, the sensor bleeds varying amounts of air . . . depending on the temperature . . . to the vacuum motor. The motor, through its linkage, provides for four modes of operation.

1. Static mode (Fig. 21). When the engine is

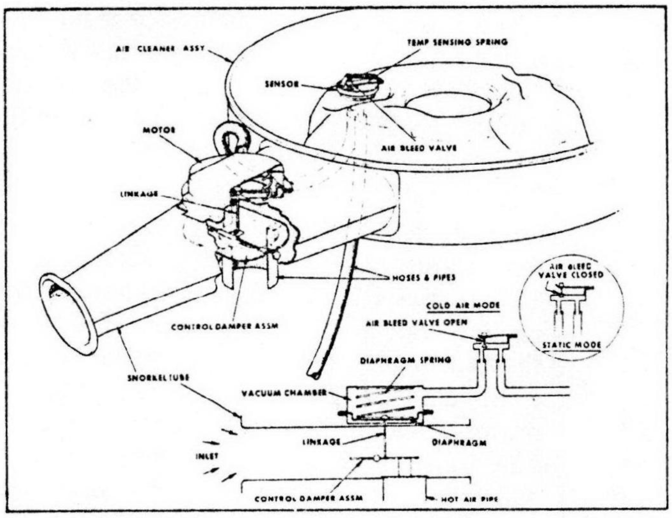


Figure 21

not in operation, the control damper assembly will be so positioned that the snorkel tube passageway will be open, and the hot air pipe will be closed. This is the result of the absence of vacuum in the diaphragm chamber of the vacuum unit, and the effect of the diaphragm spring which pushes the diaphragm and its linkage downward.

2. Hot air delivery mode (Fig. 22). When the

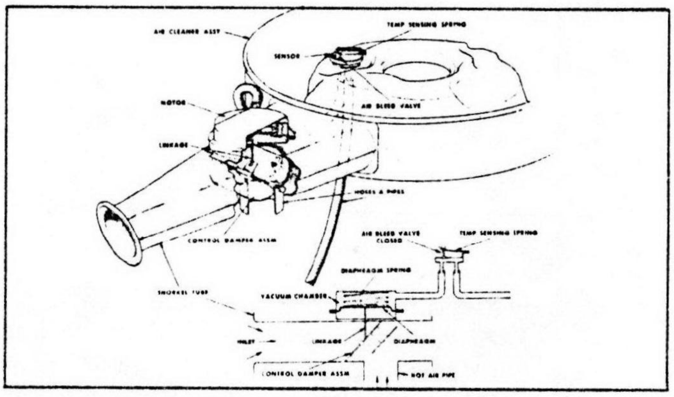


Figure 22

engine is started, and underhood temperature is less than 85 degrees F*, engine vacuum is applied to the vacuum chamber in the motor, via the connecting hoses and the sensor. The sensor air bleed valve at this time is closed. The vacuum overcomes the force of the diaphragm spring, and the diaphragm and linkage are pulled upward. In turn, the control damper assembly is positioned to shut off the flow of cold air, and permit hot air to enter the air cleaner through the hot air pipe.

Should the engine suddenly be heavily accelerated while in the hot air mode, the vacuum level in the system will drop to a very low level. In turn, the motor diaphragm spring will push the diaphragm and linkage downward, thus positioning the control damper assembly to permit air to enter the air cleaner through the snorkel tube.

3. Cold air delivery mode (Fig. 21). When the temperature of the air at the sensor is above 128 degrees F**, the sensor bi-metal spring relaxes and moves downward. This allows the sensor air bleed valve to open. A sufficient amount of air will bleed into the motor vacuum diaphragm chamber, dropping its vacuum level. The diaphragm spring will force the diaphragm and its connecting link downward, placing the control damper assembly so as to open the cold air passage, and close the hot air pipe, permitting cold air to enter the air cleaner.

4. Regulating mode (Fig. 23). At temperatures

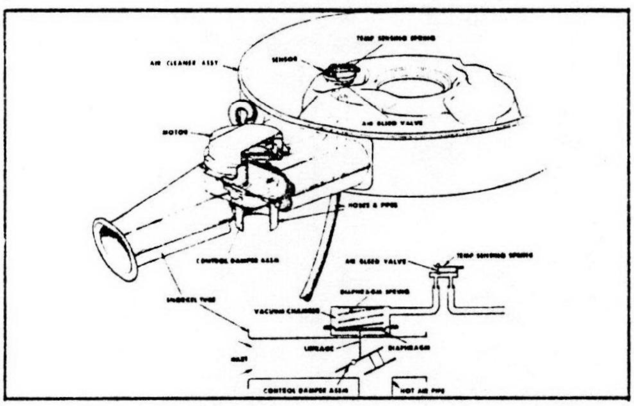


Figure 23

between 85 degrees F* and 128 degrees F**, varying amounts of air are bled into the system, depending on the exact temperature at the sensor unit. This results in a vacuum level and control damper assembly position required to maintain carburetor air temperature at from 85 degrees F* to 128 degrees F** when underhood temperatures are below this range.

CHECKOUT AND SYSTEM SERVICING

Make a visual inspection of the system, checking foı loose, kinked, or deteriorated hoses. Repair or re- place as required.

QUICK CHECK

1. Start test with engine cold, with air cleane: at a temperature below 85 degrees F*. If th(engine has been in recent use, allow it t(cool.
2. Observe the damper position before startin; the engine. If the position of the snorke tube requires it, use a mirror. The dampe should be in the cold air delivery mode.
3. Start the engine and allow it to idle. Imme diately after starting the engine, the dampe should be in the hot air delivery mode.
4. As the engine warms up, the damper wi! move toward the cold air delivery mode while the air cleaner becomes warm to th hand.
5. The system is operating normally as de scribed above. If the air cleaner fails t(operate as above . . . or investigations of th reported complaint fail to establish a cause or the correct operation of the air cleaner i still in doubt . . . proceed to the system operational test.

OPERATIONAL TEST

1. Start test with the air cleaner at a tempera ture below 85 degrees F*. If the engine ha been in recent use, allow it to cool down. NOTE: At temperatures above that specif ed, this test cannot be performed. Howevei make certain the damper assembly is in th cold air delivery mode. With the air cleane in position, secure a temperature gauge nex to the sensor a half-hour before proceedin to Step 2. Install air filter cover. Do nc install wing nut.
2. Start engine. When the control dampe assembly begins to open the snorkel tub passageway, observe test gauge temperatur(It must read between 85 degrees F and 11 degrees F***.
3. If the system fails to operate the dampe assembly at the temperature indicated, pr(ceed to the vacuum motor check.

VACUUM MOTOR CHECK

1. With the engine shut off, the position of the control damper assembly should be in the cold air delivery mode.
2. To determine if the motor is operable, apply at least nine inches of vacuum . . . either from the engine or an independent source . . . to the vacuum fitting on the motor.
3. The control damper assembly should close the cold air passage as long as vacuum is applied. The hot air pipe will be open.
4. If the vacuum motor fails to operate the control damper assembly with the direct application of vacuum, first check to determine if the motor linkage is properly connected to the door, or if a bind is present. If the linkage is found satisfactory, then motor replacement is indicated.
5. If the motor check is found to be satisfactory, then sensor replacement is indicated.

Sensor and vacuum motor assembly replacement packages contain detailed instructions and replacement procedures. The damper door is not serviceable. The air cleaner assembly must be replaced if the damper door is defective.

FOOTNOTES

* Except for Buick V-8 (95 degrees) and GMC V-6 (66 degrees).
** Except for Buick V-8 (138 degrees) and GMC V-6 (108 degrees).
*** Except for Buick V-8 (95 degrees to 125 degrees) and GMC V-6 (66 degrees to 100 degrees).

FORD IMPROVED COMBUSTION SYSTEM (IMCO)

The IMCO system is similar to the GM CCS system previously discussed. The following additional special notes apply.

1. Some carburetors use special external limiter caps on the idle mixture screws which limit the idle adjustment range, prohibiting rich idle mixture adjustments. Others use fixed internal orifice limiters at the base of the idle mixture screws.

2. Both "IMCO" and "Thermactor" use a temperature controlled carburetor air intake system, as shown in Ford Motor Company's views (Figures 24 thru 27). It is similar to the AC Auto Thermac. Basically the system consists of a valve plate and spring assembly (air door) thermostatic bulb and vacuum override motor. (See Figure 24).

The system operates on the principle of expansion and contraction (according to temperature) of the thermostat which in turn operates the valve plate (door) through its range of control. Generally a vacuum override motor is connected to engine vacuum. Its function is to overcontrol the thermostat providing a mixture of hot and cold air during heavy acceleration periods. The three modes of operation are shown in Figures 25-26-27.

Warm up. Duct and valve assembly in Heat-on position (Fig. 25).

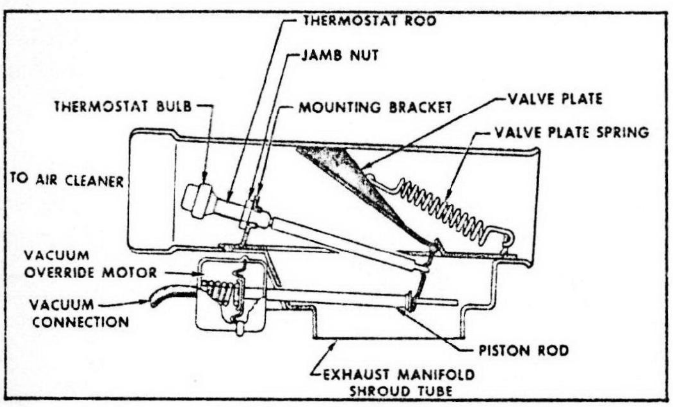


Figure 24

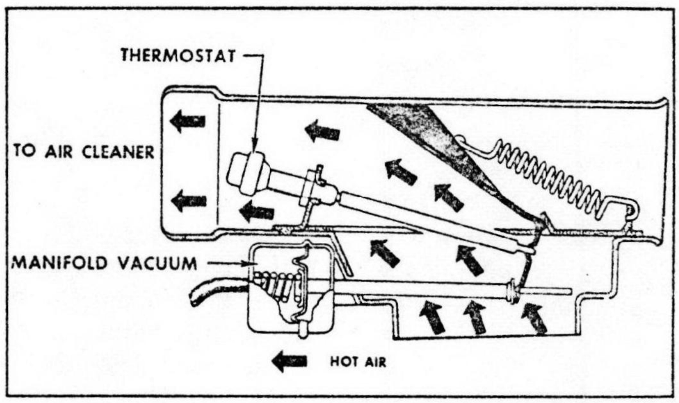


Figure 25

QUICK CHECK OF THE DUCT AND VALVE ASSEMBLY WITHOUT OVERRIDE:

With the duct assembly installed on vehicle, cold engine and not running and a temperature of less than 100° in engine compartment, the valve plate should be in the "heat-on" position.

WITH OVERRIDE:

With the duct assembly installed on vehicle, cold engine and not running and the temperature of less than 100° in engine compartment, the valve plate assembly should be in the one half heat-on position.

Cold acceleration.	Duct and valve assembly in Partial Heat-on position (Fig. 26).

Start engine - it should go to the "heat-on" position. (For both with or without vacuum override.)

As the engine warms up and the engine compartment temperature exceeds 100° the duct and valve assembly should move to the "heat-off" position.

If the duct and valve assembly does not meet these requirements, check the assembly for binds, poor vacuum connections and defective vacuum motor. For detached check out of the thermostatic temperature bulb, refer to the Ford Motor Service Manual.

Warm engine.	Duct and valve assembly in Heat-off position (Fig. 27).

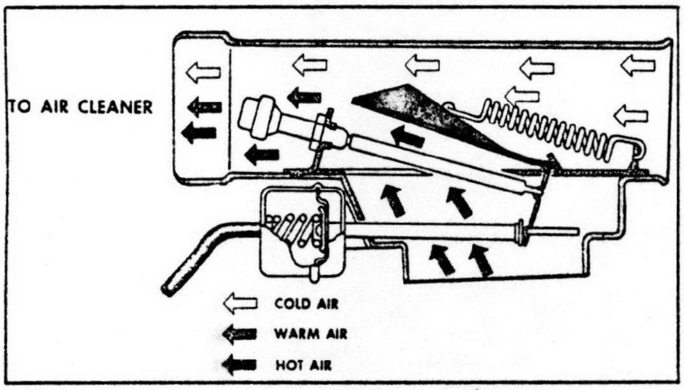


Figure 26

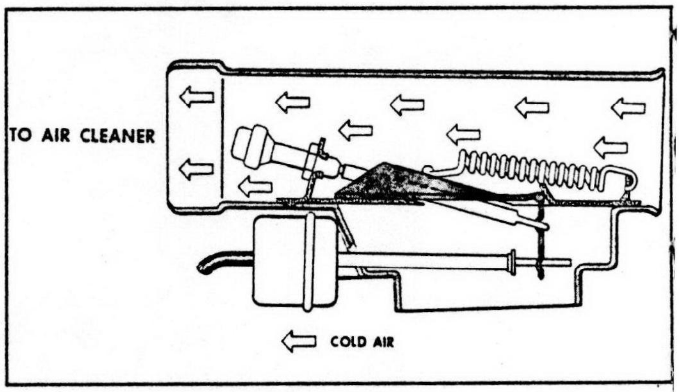


Figure 27

SERVICE REQUIREMENTS

Emission control systems are relatively simple, and should require no special care other than recommended service. In general, here are the service intervals . . .

At first 4 months or 6,000 miles	Check operation of PCV system. Visually check CCS system components and operation.
	Check engine idle speed, idle mixture, and timing setting.
At each 12 month or 12,000 mile interval	Perform a quality tune up, which also includes a check of the PCV and CCS systems, and an adjustment of the idle speed, idle mixture, and timing setting.
	Replace PCV valve.
At each 24 month or 24,000 mile interval	Perform checks and adjustments noted under 12 month or 12,000 mile interval.
	Replace or clean PCV breather filter (on units so equipped) or clean flame arrester (on units so equipped).

Proper adjustment of the idle speed, idle mixture, and timing setting is deemed so important that the manufacturers have installed a decal (Fig. 42 see Page 19) in the engine compartment of every vehicle equipped with emission control systems, giving exact instructions and specifications for these adjustments. Follow the directions carefully, and in the correct sequence.

Delco GM

POWER SERVICE

PROCEDURE CHECK SHEET

Name________________________ Make of Vehicle________________ Year__________

Address________________________ Model:________________________

Telephone No.________________________ 4 cyl. ☐ 6 cyl. ☐ 8 cyl. ☐

CUSTOMER'S STORY

Mileage since last tune-up________________

Mileage since last carburetor overhaul________________

Customer Performance Complaints:

Poor Acceleration__________ Rough Idle__________

Engine Knocks or Pings__________ Stalls__________

Hard Starting Hot______ Cold______ High Speed Miss______

Preventive maintenance tune-up desired

(No specific performance complaints)________________

I. BATTERY AND CABLES

1. Clean battery, battery and cable terminals, battery carrier and hold downs. ☐
2. Check battery condition and state of charge.

Defective ☐ Satisfactory ☐

Discharged ☐

II. CRANKING MOTOR AND CIRCUIT

1. Clean and tighten terminal connections. ☐
2. Operates at satisfactory speed and sound. ☐
3. Electrical check—Unsatisfactory ☐ Satisfactory ☐

III. ENGINE MECHANICAL CONDITION

(Determined by compression or cylinder balance test, etc.)

Cylinder Check								
	1	2	3	4	5	6	7	8

Questionable ☐ Satisfactory ☐

If questionable, call owner before proceeding with tune-up. Suggest use of carburetor and combustion chamber conditioner as partial corrective measure.

IV. SPARK PLUGS

1. Replace. ☐
2. Clean and regap—Gap Specifications__________ ☐

V. DISTRIBUTOR AND IGNITION CIRCUIT CHECKS

1. Inspect cap and rotor. ☐
2. Check centrifugal and vacuum advance units. ☐
3. Check condition of primary and secondary wiring. ☐
4. Replace contact points and condenser as required. ☐
5. Lubricate as required. ☐

VI. IGNITION CIRCUIT TESTS AND ADJUSTMENTS

1. Electrical check for high resistance, grounds, shorts, etc.

Unsatisfactory ☐ Satisfactory ☐

2. Adjust cam dwell—Specification__________ ☐
3. Adjust timing—Specification__________ ☐

VII. FUEL, MANIFOLD AND EXHAUST EMISSION SYSTEM SERVICE

1. Free heat riser valve with cleaner and lubricant. ☐
2. Service P.C.V. and exhaust emission system. ☐
3. Use carburetor and combustion chamber conditioner. ☐

VIII. CARBURETOR AND FUEL SYSTEM SERVICE

1. Test fuel pump pressure. ☐
2. Test fuel pump volume—approximately one pint in one minute. ☐
3. Simplified carburetor tune up as required. ☐
4. Fuel filter service. ☐
5. Air cleaner service. ☐
6. Check choke linkage—unloader operation. ☐
7. Adjust idle mixture. ☐
8. Adjust idle speed. ☐

IX. CHARGING SYSTEM

1. Check charging voltage—Specification__________ ☐
2. Charge battery as required. ☐

X. GENERAL VEHICLE INSPECTION

2. [illegible] ☐

WE USE GENUINE UNITED DELCO PARTS

MI-226 Printed in U.S.A.

Figure 28

ENGINE TUNE-UP

PROCEDURE

Engine tune-up means different things to many people. To the car owner it is a term that indicates good overall vehicle performance. To the engineer it infers the technical aspect; supplying the required electrical voltage and fuel-air ratio so that the engine will run smoothly at all speeds and loads. To the practical tune-up specialist, tune-up means performing a series of checks, tests and adjustments that will restore original standards of performance to the engine. Finally engine tune-up, properly performed, means optimum automotive emission control.

A definite relationship exists between emission controls and engine tune-up. An engine that is out-of-tune after many miles of operation can result in failure of the emission controls to properly perform their job. Malfunctioning emission controls can cause poor engine performance. Thus, car owner satisfaction is dependent on thorough testing and service of all components related to both performance and emission control.

The purpose of this section is to provide a complete step-by-step pictorial tune-up procedure as a guide for the practical tune-up specialist. Each step is related to the "Power Service" Procedure Check Sheet (Fig. 28) that is available for use in your daily tune-up work. In this No. 1 manual we will be concerned with only the first half of the tune-up procedures normally performed. You will find the remaining half in the No. 2 Power Service Manual.

Knowledge - Recognition - Understanding

It is not within the scope of the "Power Service Manuals" to provide you with a complete background in basic principles of carburetor, electrical and engine components that are essential to engine tune-up. However, there are certain fundamentals with which you should be familiar:

A. Tune-up cannot be performed without an adequate understanding of the basic engine as well as the various units and systems that feed the engine. In contrast to what the term implies, most operations in engine tune-up are performed on carburetor and electrical components (Fig. 29).

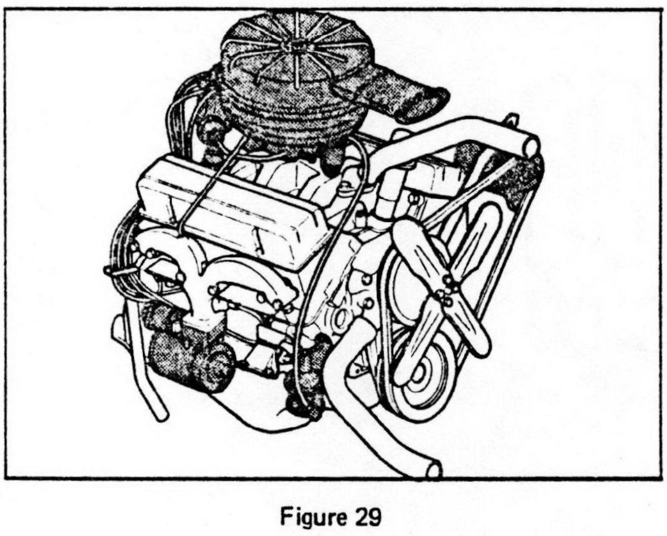


Figure 29

B. Compression, ignition and carburetion are often referred to as the basic requirements of tune-up.

A knowledge of how these three ingredients are coordinated through the action of the crankshaft, camshaft, cylinder, carburetor and distributor are essential for anyone interested in tune-up (Fig. 30).

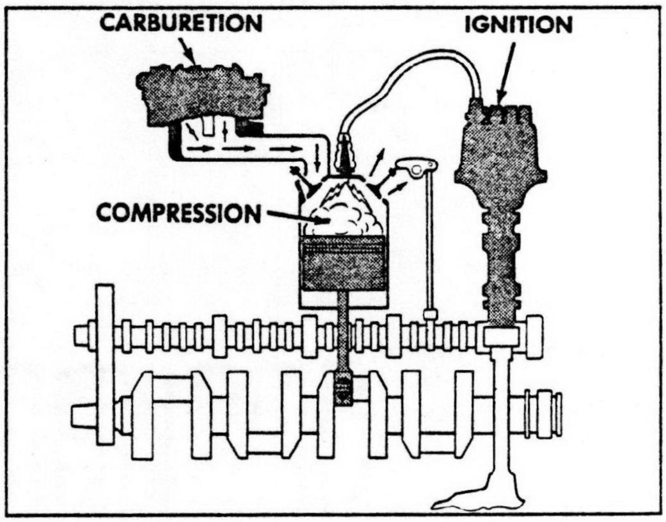


Figure 30

C. Five important areas have to be considered in tune-up. Good engine mechanical condition is a prerequisite without which tune-up is impractical. If engine is tunable, all recommended operations have to be performed in the cranking, ignition, fuel and charging systems for complete tune-up.

D. Each major area in tune-up requires (Fig. 31):

1. VISUAL INSPECTION for deterioration and wear.
2. CLEANING of corrosion, oii and dirt at critical points.
3. REPAIR OR REPLACEMENT of needed parts.
4. TESTING each circuit or system for hidden defects.
5. ADJUSTING accurately to all tune-up specifications.

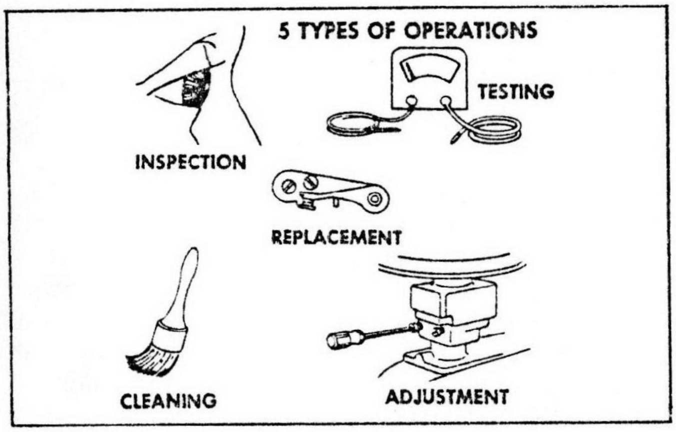


Figure 31

LISTEN TO THE CUSTOMER'S STORY

Before proceeding with an engine tune-up, it is important to obtain factual information from an owner regarding the past service history of his car and any performance problems he might have encountered. Record this information in a Power Service Procedure Check Sheet. Although an owner may not know what is wrong with his car, the information he provides will be invaluable to you in correcting a specific complaint which may or may not be related to engine tune-up. Remember that any specified problem has to be diagnosed and corrected. The owner may judge the quality of your tune-up on this one point (Fig. 32).

Many owners will want only a preventive maintenance tune-up and will specify no particular problems. In either case following the complete Power Service Procedure will be your insurance that your tune-up will be done right the first time and therefore no costly come back or repeat work.

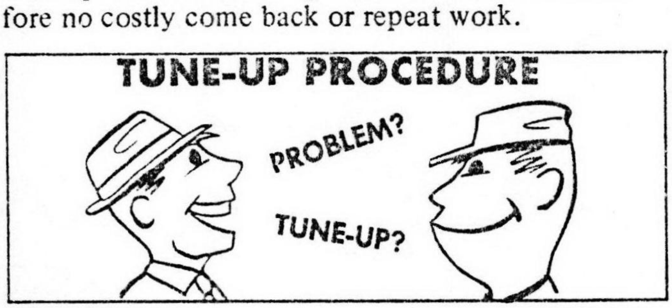


Figure 32

I. Battery and Cables

1. Clean and Visually Inspect Battery and Cables - The external condition of a battery plus good cables and tight corrosion free connections all contribute to battery performance. Additionally, its appearance is a factor in customer judgment of a quality tune-up (Fig. 33).

   Make a visual inspection of the battery for cracked case and covers. Check cables for corroded terminals and frayed or damaged insulation. If the battery or cables show serious signs of deterioration, they should be replaced.

   Remove cable terminals from battery and clean battery and terminals with a solution of baking soda and water. Remove oxidation from cable terminals and battery posts with a wire brush. After cables are replaced on battery, apply a film of grease to terminals to retard corrosion. Check battery hold-down for correct tightness. Check and adjust electrolyte level.

   Caution - When connecting battery cables, always connect the ground cable last.

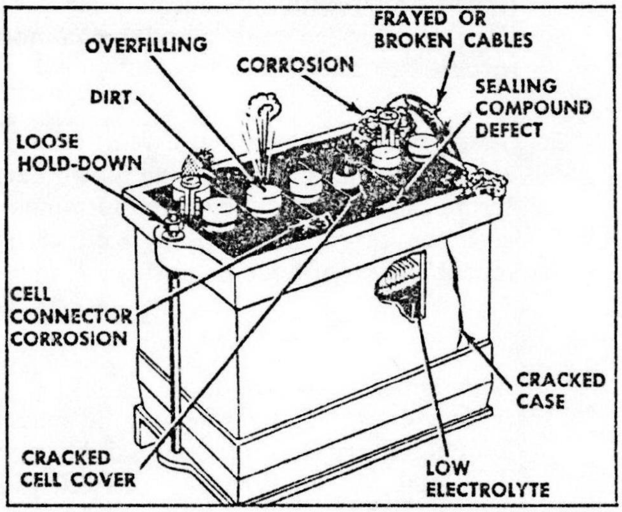


Figure 33

2. Test Battery - The accuracy of many checks and electrical tests in tune-ups depends upon the condition and state of charge of the battery. It should be thoroughly tested early in the tune-up procedure. The ability of the battery to render trouble-free service can best be checked with a 421 tester and a hydrometer (Fig. 34).

   Caution - Never deliver a tuned-up car with a battery in a low state of charge.

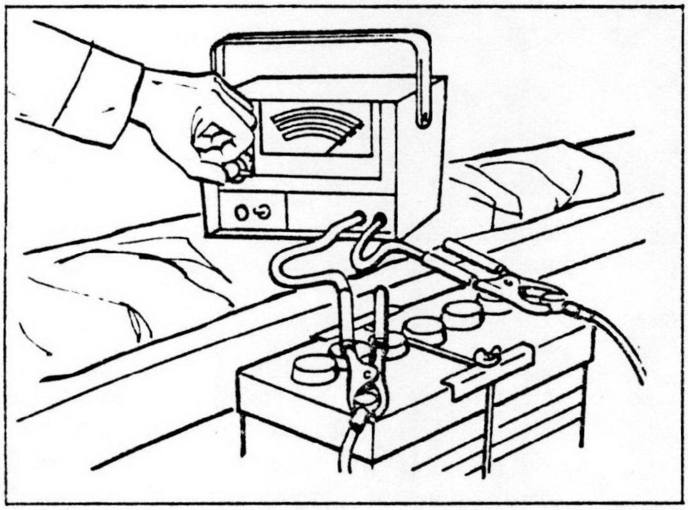


Figure 34

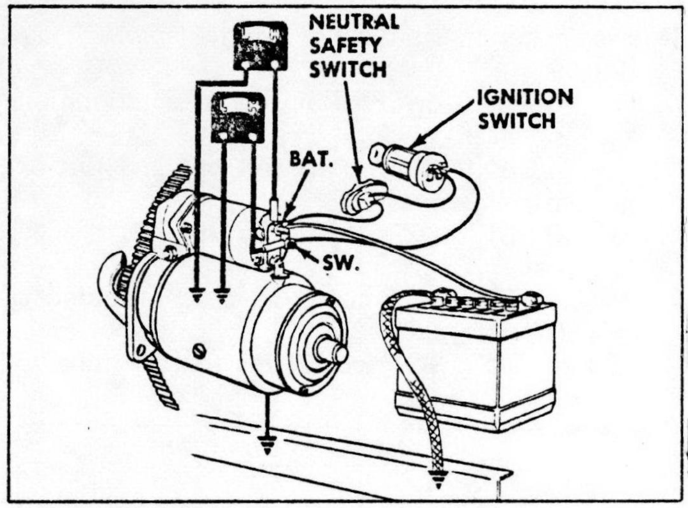


Figure 35

II. Cranking Motor and Circuit (Fig. 35)

1. Check all circuit connections at cranking motor solenoid or magnetic switch. Clean and tighten if necessary.

2. Ground coil distributor terminal with a jumper wire and crank engine through 8 - 10 revolutions, observing the cranking speed and sound of the cranking motor. If the speed and sound are normal, omit Check No. 3. If speed and sound are abnormal, proceed to Check No. 3.

3. Test Cranking Motor and Circuit - Two voltage tests, one at the cranking motor battery terminal and one at the switch terminal, will give the best indication of both cranking motor and circuit conditions.

With ignition switch in the cranking position, voltage at the solenoid or magnetic switch battery terminal should be no less than 8.6 volts. (Where accessibility is a factor, a voltage test at the battery terminals will suffice). Voltage at the solenoid or magnetic switch terminal should be no less than 7.7 volts.

Remember that you have checked the battery condition and cleaned the battery post cable connection earlier in the tune-up procedure. These actions will have eliminated the major sources of trouble in the cranking motor circuit.

III. Engine Mechanical Condition (Fig. 36)

A compression test gives a good indication of engine mechanical condition. The compression of the lowest cylinder should be at least 75% of the highest cylinder. Low compression on one or more cylinders indicates defective rings, gaskets or valves. Excessive carbon build up on valves and in the combustion chamber may also cause uneven compression readings. X66 combustion chamber conditioner is recommended for carbon removal.

A cylinder balance test will also give a good indication of engine mechanical condition. Irrespective of the type of test used the engine mechanical condition should be determined early in the tune-up procedure.

If serious engine mechanical defects are noted, advise the owner before proceeding with the tune-up.

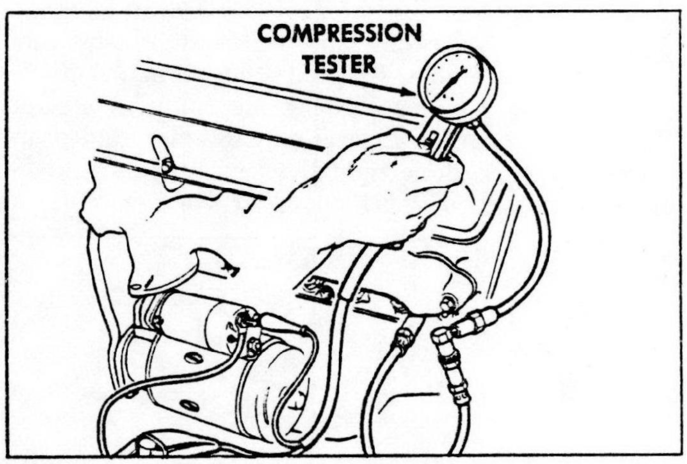


Figure 36

IV.Spark Plugs (Fig. 37)

1. Visually inspect spark plugs for cracked insulation, damaged threads and eroded electrodes. Replace as required. Use manufacturers specified part numbers, heat range and gap setting.
2. If spark plugs are in condition for re-use, clean, file end of center electrode flat to restore sharp corners and re-gap to specifications. Use a new gasket.

   Make sure spark plug holes and gasket seat are free of carbon and rust.

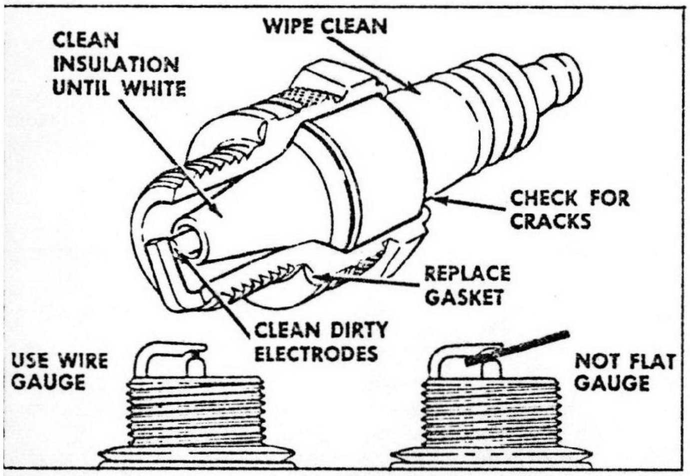


Figure 37

V. Distributor and Ignition Circuit Checks (Fig. 38)

1. Check distributor cap and rotor for cracks, chips and carbonized paths which will allow high voltage leaks to ground. Such defects require replacement. Wipe cap inside and outside with clean solvent-dampened cloth. Inspect towers and electrodes for corrosion and oxidation. Remove same with special wire brush. Check carbon button in center of cap for wear or electrical arcing deterioration.

   Check rotor spring for proper tension and contact with carbon button in distributor cap.

   Replace contact set and condenser as required. New contacts should be properly aligned and leads should be positioned to avoid interference with cam, contact points or rotor. Any frayed leaks should be replaced. Place a small amount of high temperature cam lubricant on the breaker cam surface or replace cam lubricator if so equipped. On internal adjustment distributors, apply two or three drops of oil to felt wick under rotor.

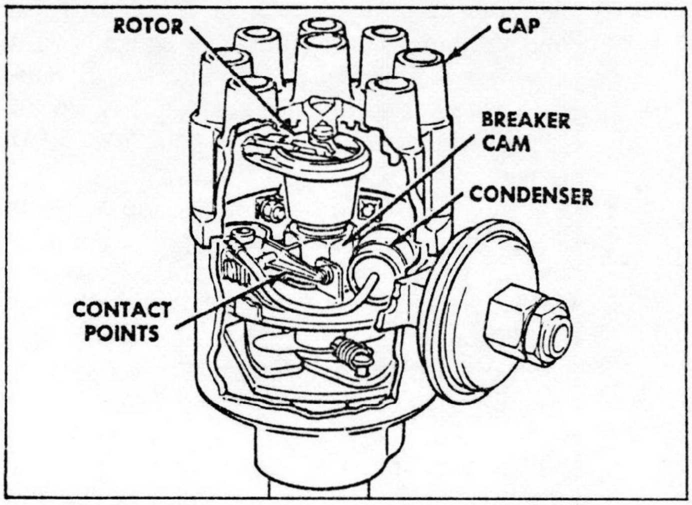


Figure 38

2. The mechanical action of centrifugal advance mechanisms can be checked by turning rotor in direction of normal rotation. The action of the weight springs should enable it to snap back quickly and freely to normal position (Fig. 39).

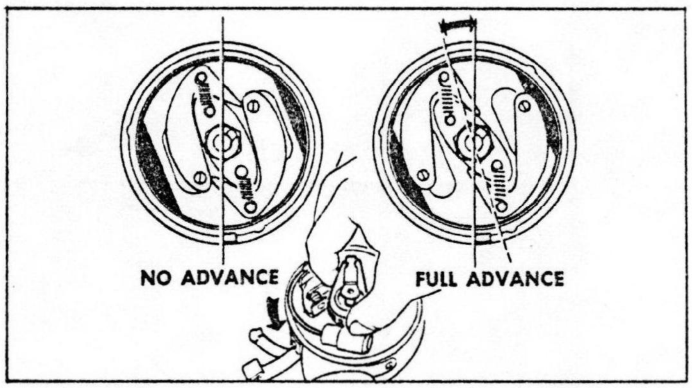


Figure 39

Mechanical action of vacuum advance mechanisms can be checked by turning distributor plate or complete distributor in opposite direction to normal shaft rotation. They should return to normal position freely and quickly (See Fig. 40).

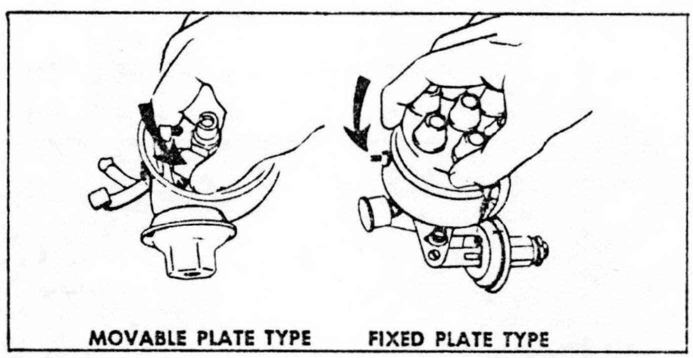


Figure 40

A more complete check of the centrifugal and vacuum advance units can be made with a power timing light. This check will indicate whether total timing advance is within specification at the 2000 to 2500 RPM range.

3. The physical condition and connections of all primary and secondary ignition cables should be checked. Make sure all primary connections are clean and tight and that insulation on both primary and secondary cables is not frayed, damaged or oil soaked (See Fig. 41).

When removing secondary cables from coil tower, distributor cap or spark plugs, the insulating boots should be loosened with a slight rotating action. Then pull out cable while holding base of insulating boot. After replacement all cables should be firmly seated in cap and coil towers.

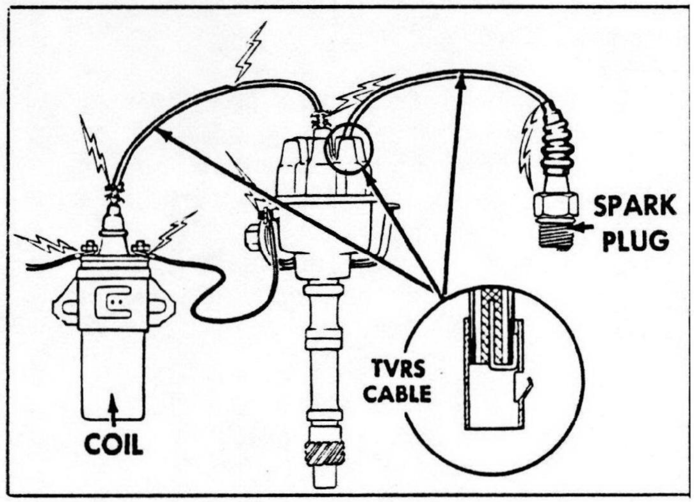


Figure 41

Use of cable part numbers specified by manufacturer will insure proper ignition performance and radio frequency suppression.

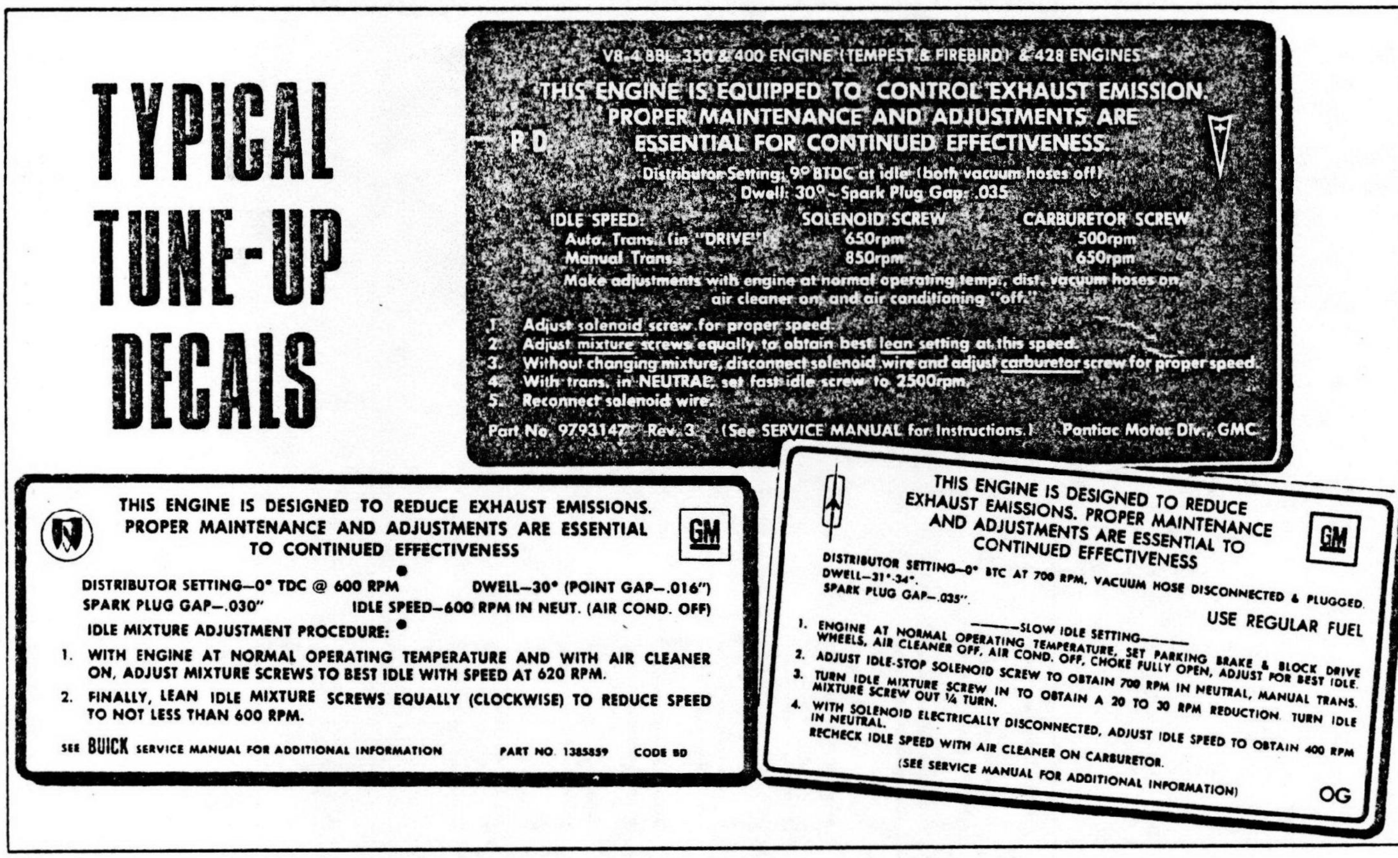


Figure 42

POWER SERVICE
MANUAL NO. 2
WILL CONTAIN THE SECOND HALF
OF THE COMPLETE ENGINE TUNE-UP
PROCEDURES

TABLE OF CONTENTS

INTRODUCTION

UMS Power Service Training Manual No. II, is an extension of the information contained in Manual No. I.

Power Service Manual No. I made you familiar with typical crankcase and exhaust emission control systems now required on all cars, according to Federal law. It contains an explanation of the PCV (Positive Crankcase Ventilation) system and the CCS (Controlled Combustion System). Also included is a description of the procedures performed during the first half of a complete engine tune-up.

This Power Service Manual No. II goes forward from that point. It includes a description of the basic operating principles and the components for both the AIR (Air Injector Reactor) and (CAP) Chrysler systems, and includes the second half of the Power Service tune-up procedures.

Manual No. I points out that crankcase emission control systems function in much the same manner on all makes of cars. When you understand a typical system, you are prepared to service any similar system. The GM CCS (Controlled Combustion System) is also presented as typical of one type of exhaust emission control system.

Manual No. II explains a typical GM Air Injector Reactor (AIR) system, Ford and American Motors have similar systems called the Thermactor and Air Guard systems, respectively. Other manufacturers also use basic Air Injection systems. All the systems utilize the same type of components, even though they have different external appearances. When you understand the AIR system and its components, you will easily recognize how the comparable systems function.

Also included in this Manual is an explanation of the Chrysler Cleaner Air System (CAS) or Cleaner Air Package (CAP). These systems have many similarities to the CCS system except that no hot air cleaner is used.

Power Service Manual No. I told you that, all engines equipped with a CCS-type exhaust emission control system have these modifications:

1. Specifically calibrated carburetor
2. Specifically calibrated distributor
3. Generally retarded timing
4. Higher idle speed
5. Higher operating temperatures

This is true of engines equipped with an AIR–type system, too.

Like the CCS, the AIR system requires only limited service. In most cases, a Power Service tune-up will assure satisfactory exhaust emission control. That's why the First Manual included the first half of the regular tune-up procedures and why this Manual presents the second half.

To test your understanding of the material presented, an examination paper is included with this Manual. You are already familiar with the form, if you have completed the First Manual examination. From each of the three possible answers, select the one that you believe to be correct. Mark down your choice and the page number where you located the answer.

When you have successfully completed both examinations, you will receive a diploma which will assure your customers that you can perform United Delco Power Service Tune-Up.

AIR INJECTOR REACTOR SYSTEM

Combustion in the modern automotive engine has been improved by use of the specifically calibrated carburetor and distributor, by generally retarded timing, higher idle speed, and higher operating temperatures. However, it is still necessary to have a supplementary method of reducing the amounts of carbon monoxide and unburned hydrocarbons to the low levels established by law.

The Air Injector Reactor system (Fig. 1) accomplishes that reduction by adding oxygen, in the form of compressed air, to the very hot and highly flammable gases released by the exhaust valves. That's much like fanning dying embers, and the result is the same. The added oxygen causes the unburned hydrocarbons to ignite immediately, and the reaction changes the exhaust emissions to harmless gases, the by-products of nearly-complete combustion.

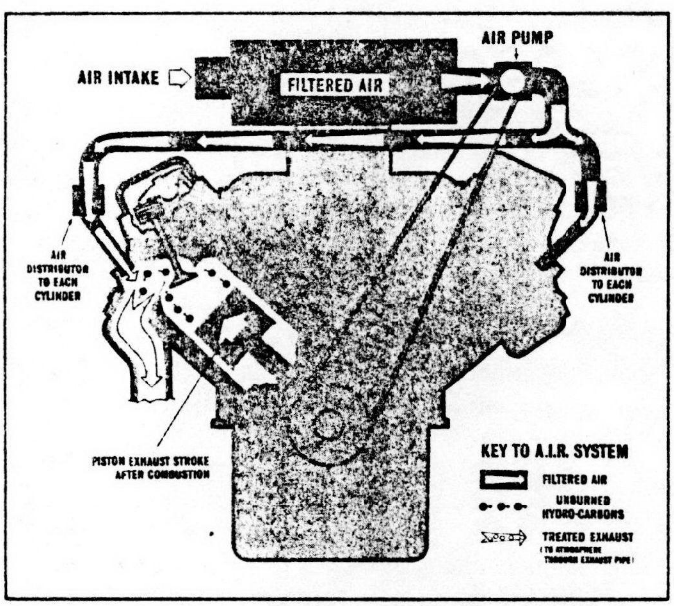


Figure 1

AIR SYSTEM COMPONENTS AND TYPICAL INSTALLATION

The Air Injector Reactor (AIR) system is primarily composed of an air pump, diverter valve, check valve, air manifold or combustion pipe assemblies, and connecting hoses and fittings. In a typical V-8 engine installation (Fig. 2), the air manifolds or combustion pipes route the compressed air into the exhaust manifolds.

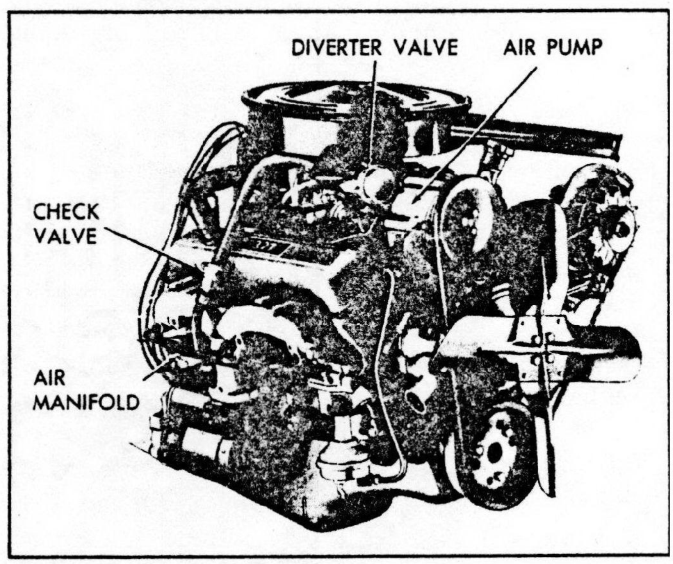


Figure 2

With some engine applications, the air is carried to the exhaust ports through a drilled passage in the cylinder head. This eliminates the need for an external air manifold.

BASIC AIR SYSTEM OPERATION

In normal vehicle operation, the AIR system draws iltered air into the air pump, where it is com- ıressed. The compressed air is fed out of the pump hrough the diverter valve, through the check valve, nto the combustion pipe assemblies, and delivered o the exhaust valve areas (Fig. 3).

'he compressed air mixes with the hot exhaust gases n the cylinder head or exhaust manifold, and burns nost of the carbon monoxide and hydrocarbons be- ɔre the gases leave the engine through the exhaust ystem. Thus, the exhaust emitted at the tail pipe is ɔw in harmful ingredients that cause air pollution.

'he oxygen in the compressed air must be added at he exhaust valve areas, because the gases cool down o a non-flammable mixture by the time they enter he exhaust system. There is a slight increase in perating temperatures at the cylinder head or ex- aust manifold, but it is not sufficient to cause con- ern.

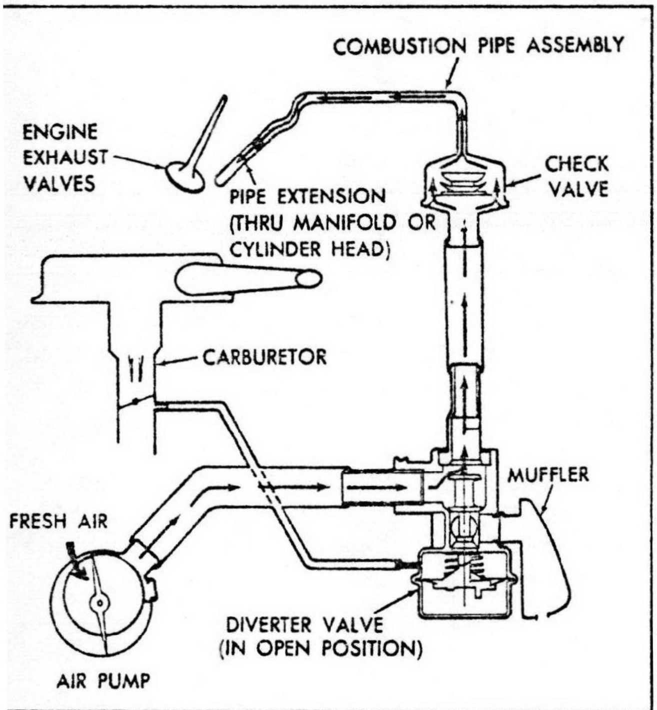


Figure 3

IR PUMPS

wo different types of pumps have been used with r injection systems. A 3-vane pump was used ·imarily on 1966 and 1967 California cars. A vane pump was used in the majority of 1968 and ›69 AIR applications.

ɔth types perform the same basic function, com- pressing clean air for injection into the exhaust manifold or cylinder head.

The only major differences between the two pumps are that one has two (2) vanes and its own centri- fugal air cleaner, while the other pump has three (3) vanes and draws its fresh air supply either from the clean air side of the carburetor air cleaner or from a separate air intake filter.

2-VANE PUMP

Component parts of the 2-vane pump include (Fig. 4):

1. Pump housing
2. Centrifugal filter.
3. Set of two vanes, which rotate about the centerline of the pump housing bore.
4. Rotor, which rotates on an axis different from the axis of vane rotation. The rotor drives the vanes, and is driven by the pump's pulley.
5. Set of seals, two per vane, which provides sealing between the vanes and rotor.
6. Relief valve, on some models.

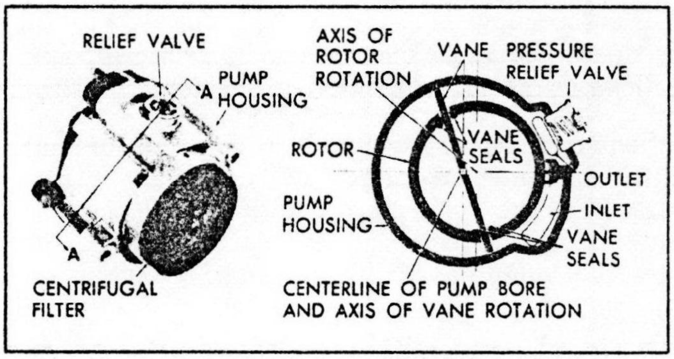


Figure 4

The pump vanes are located 180° apart and are in constant near-contact with the pump housing bore. The vanes are driven by the rotor, and slide through the slits in the rotor.

The three phases of 2-vane pump operation are shown in Fig. 5.

Left view. As the vane rotates past the inlet port, it provides an increasing volume. This has the effect of producing a vacuum, which draws air into the pump.

Center view. When the second vane has passed the inlet port, the air that was drawn into the pump is trapped between the two vanes. As the vanes continue to rotate, the trapped air is forced into a smaller volume and thus compressed.

Right view. When the first vane has passed the outlet port, the compressed air is expelled out of the port and into the remainder of the system. It should be noted that each full revolution completes two cycles of intake, compression, and exhaust.

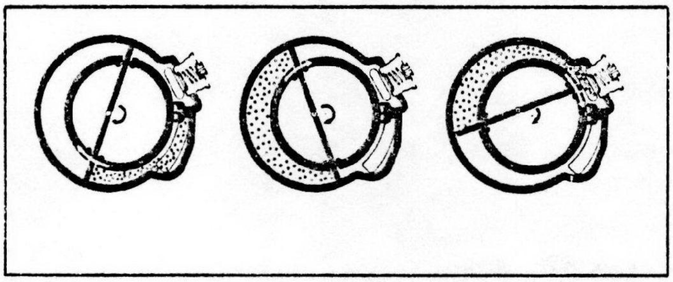


Figure 5

The 2-vane pump is unserviceable, except for the pressure relief valve on units so equipped and the centrifugal filter. When the pump is defective internally, it should be replaced as a complete assembly.

CENTRIFUGAL FILTER

The 2-vane pump uses a centrifugal filter to clean the air as it enters the inlet port and prevents foreign particles in the air from entering the pump (Fig. 6).

Air enters the pump by passing the vanes of the centrifugal filter. Because the vanes are being rotated at high rpm, and because of their special contour, any foreign particles in the air trying to enter the pump are hit by the rotating vanes and bounced out and away from the pump.

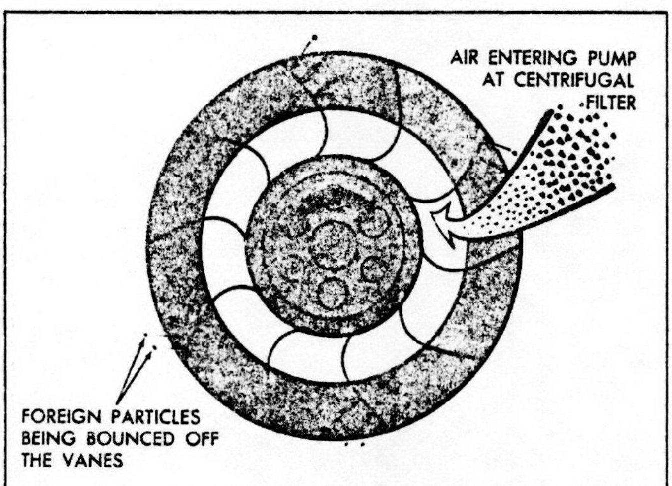


Figure 6

PRESSURE RELIEF VALVE

Some pumps incorporate a pressure relief valve in the outlet port cavity (Fig. 7). The purpose of this valve is to relieve pressure in the pump when it exceeds a predetermined value.

The valve body encloses a preloaded spring, a seat, and a pressure setting plug. When air pressure in the pump builds up to the predetermined value, it forces the valve seat up against the spring force, opens the orifice, and relieves the pressure by exhausting it into the atmosphere. This usually occurs at speeds over 45 mph.

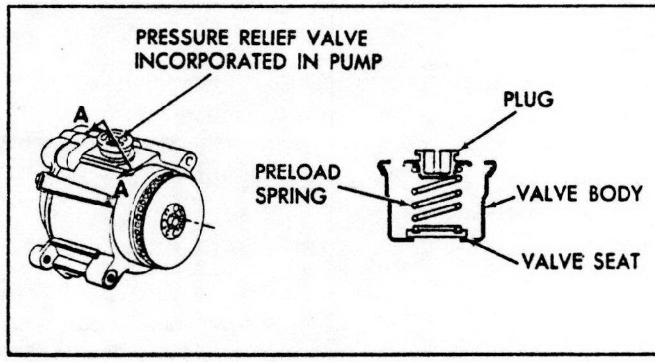


Figure 7

The pressure at which the valve opens is determined by the length of the pressure setting plug. Longer plugs raise the value at which the relief valve will exhaust the pump's air pressure. Shorter plugs lower this value.

It should be noted that each engine application requires a specific relief valve setting with a designated pressure setting plug. For this reason, they are not interchangeable.

In some installations, the pressure relief valve is incorporated as part of the diverter valve assembly (Fig. 8). In either location, the function of the relief valve is the same.

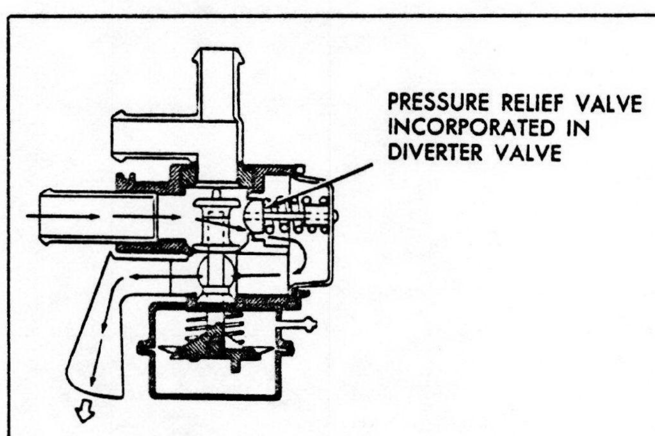


Figure 8

3-VANE PUMP

Externally, the appearance of the 3-vane pump (Fig. 9) is similar to that of the 2-vane pump. Functionally, the intake, compression, and exhaust cycle is exactly the same, but in this case the cycle is completed three times per revolution instead of twice (Fig. 10).

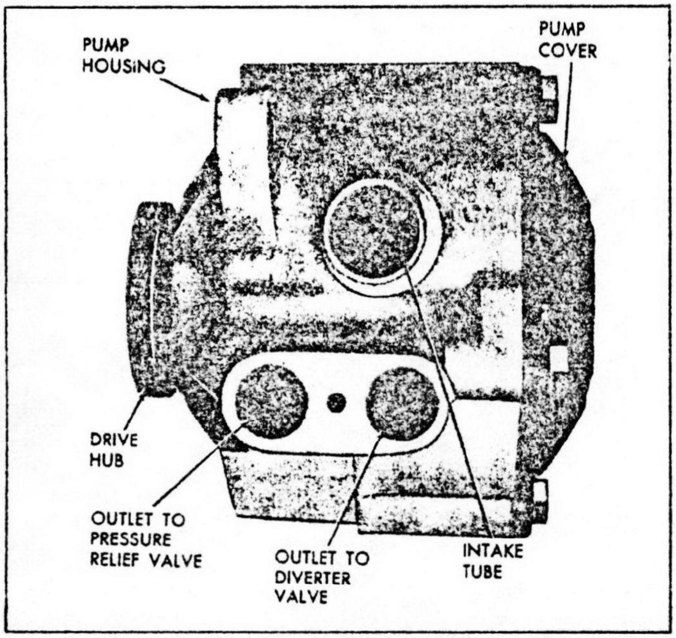
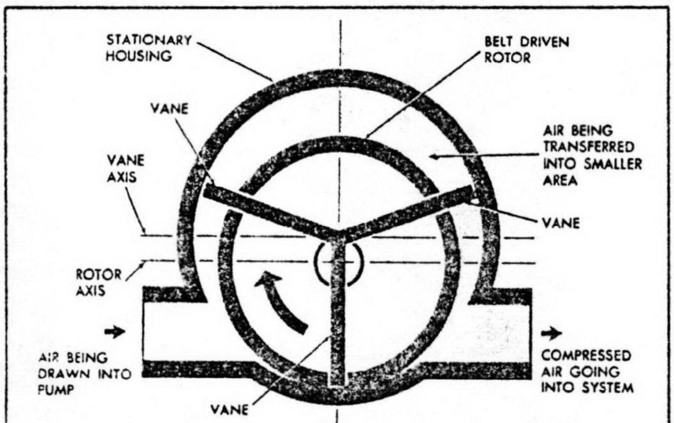


Figure 9.



THE VANES ROTATE ABOUT THE UPPER AXIS. THE ROTOR, WHICH IS BELT DRIVEN, ROTATES ABOUT THE LOWER AXIS. FRESH AIR IS TRAPPED BETWEEN THE VANES AND TRANSFERRED INTO A SMALLER VOLUME. THUS THE TRAPPED AIR IS COMPRESSED BEFORE IT IS EXHAUSTED INTO THE SYSTEM.

Figure 10

The 3-vane pump is serviceable, and any internal troubles can be corrected by following appropriate overhaul procedures.

DIVERTER VALVE

The majority of AIR installations incorporate a diverter valve. The purpose is to momentarily exhaust the air pump's output by diverting it into the atmosphere, so that it cannot reach the exhaust valve area during the initial stages of engine overrun or deceleration.

Closing of the carburetor throttle valve during deceleration causes a high manifold vacuum which draws a rich mixture of fuel into the cylinders. This rich mixture cannot be completely burned in the power stroke, so much of it is released through the exhaust valves. If air from the pump were allowed to combine with this hot and volatile mixture, backfire would occur. It is the function of the diverter valve to prevent that backfire.

During normal operation, air pump output is simply routed through the diverter valve into the remainder of the system.

However, during engine overrun, a strong vacuum signal, taken from just below the carburetor throttle plate, is sent to the diverter valve diaphragm. This vacuum signal is strong enough at this point to overcome the spring force opposing the diaphragm action. Consequently, the diaphragm is pulled up against the spring (Fig. 11).

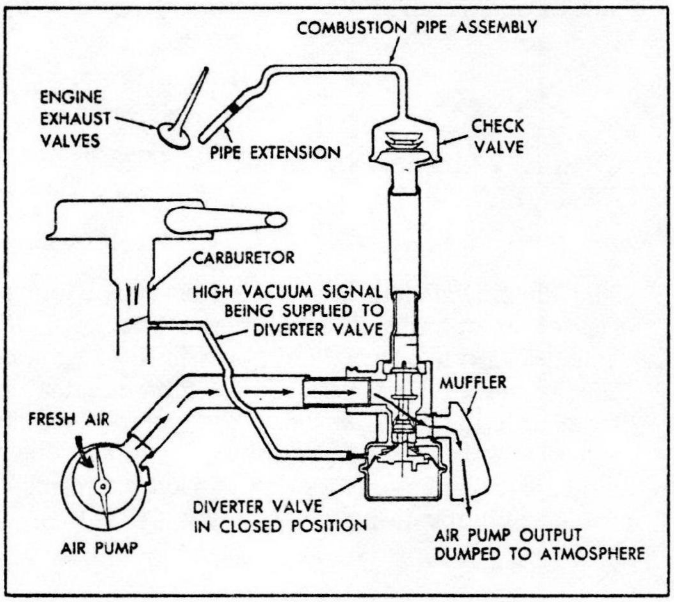


Figure 11

The spool valve of the diverter valve is connected directly to the diaphragm, so it also moves up and seats in the upper position. The action of the spool valve shuts off the passage into the remainder of the system, and simultaneously opens a path that exhausts the air pump output through the muffler to the atmosphere. This condition exists only momentarily. A calibrated bleed hole in the diaphragm assembly allows pressure to equalize on both sides of the diaphragm, this allows the spool valve to revert to its normal position after a very brief interval of time.

Diverter valves are calibrated to function in accordance with the needs of each engine installation. For this reason, they are not interchangeable.

NOTE: Some of the 1966 and 1967 California cars used an "intake air bleed valve." This valve functioned in a manner similar to that of the diverter valve, except that during deceleration, pump output air was routed to the intake manifold rather than exhausted to the atmosphere.

It has been mentioned that some diverter valves incorporate a pressure relief valve within them (Fig. 8). In this combined valve assembly, the diverter valve action remains the same as just described, and the action of the pressure relief valve is the same as when it is incorporated in the pump assembly.

In some instances where replacement pumps have been used, there might be a pressure relief valve in both the pump and the diverter valve assembly. With these installations, the relief valve in the pump has a pressure setting plug which functionally blocks it out of operation.

CHECK VALVE AND COMBUSTION PIPE ASSEMBLY

The check valve in the AIR system is a one-way valve that permits air flow in the direction of the exhaust valves, but prevents flow in the direction of the air pump (Fig. 12). This keeps exhaust gases from entering and damaging the pump. One check valve is used with 4, 6, and some 8-cylinder engines. Other 8-cylinder engines use two check valves, one for each combustion pipe assembly.

The air manifold or combustion pipe assembly routes the air pump output to individual injection tubes. These tubes are inserted into the cylinder head or exhaust manifold, and direct air to the area of the exhaust valves, where the exhaust gases are dispelled from the cylinders. Fig. 13 shows typical In Line and V-8 air manifold and injection tubes.

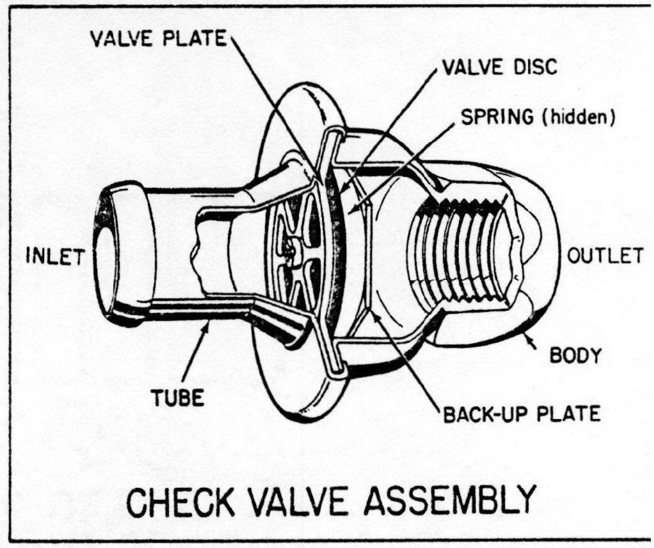


Figure 12

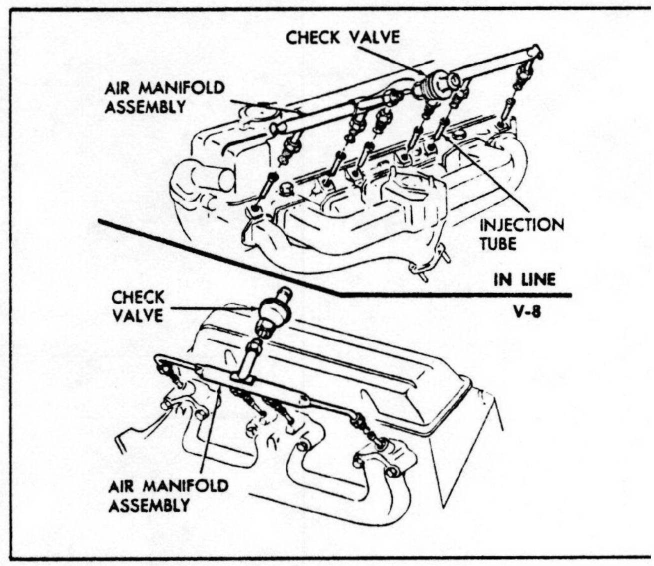


Figure 13

SYSTEM VARIATIONS

To avoid confusion, it should be noted that a though some GM truck engines use the AIR systen they also use a modified warm air system in co junction with the air cleaner (Fig. 14). However, tl thermostatic control system is not used.

Warm air is furnished to the carburetor at all time with no provisions to regulate the supply. The he stove used is less than fully efficient, and does nc require precise regulation.

NOTE: Other Manufacturers may use air inje tion systems together with a temperatur controlled hot air cleaner, as explained in Manu No. I.

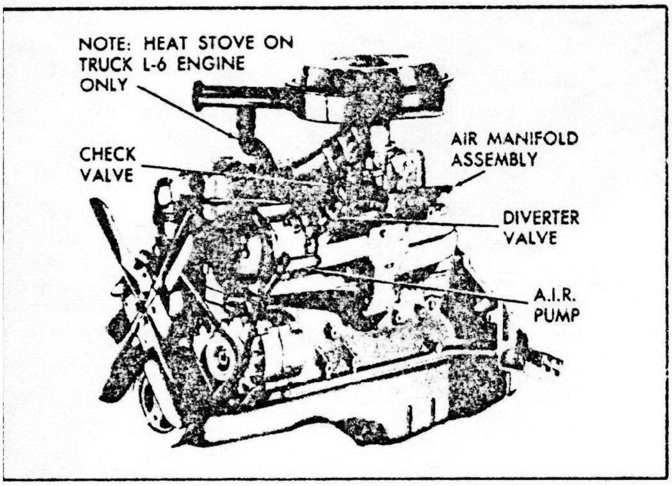


Figure 14

SERVICING THE AIR SYSTEM

Only a properly tuned engine can provide full power and performance, and full value from the AIR system for the control of exhaust emissions.

Here is the basic recommendation for vehicles equipped with the AIR system . . .

A check of system operation should be made at 4 months or 6,000 miles, whichever occurs first, and at each tune-up interval, every 12 months or 12,000 miles. The initial check and each tune-up should include adjustment of carburetor idle speed, idle mixture, and engine timing.

The initial check at 4 months or 6,000 miles is desirable. After this break-in period, the engine operation is more stabilized, and tune up settings will be less subject to change.

CHECKING THE AIR SYSTEM

Checking the AIR system is relatively easy and requires little time. Following is a list of the components that should be checked and information on how to check them.

DRIVE BELT

1. Inspect belt for wear, cracks, or deterioration. Replace if necessary.
2. Check belt tension (Fig. 15), using strain tension gauge, and adjust if necessary. Belt settings will vary slightly with different applications. A typical setting for a used belt is 55 lbs., and for a new belt 75 lbs.

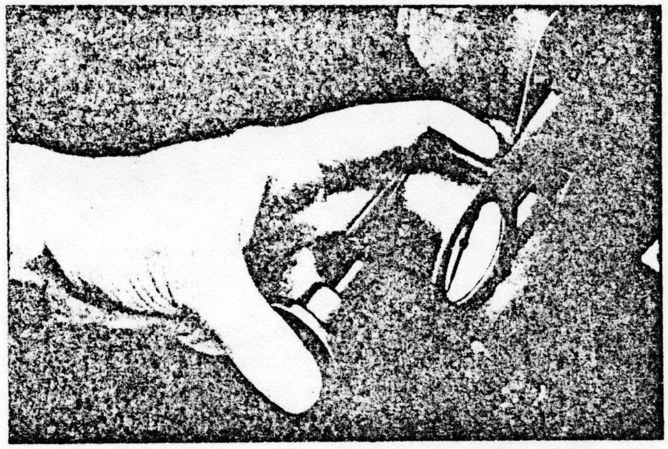


Figure 15

AIR INJECTOR PUMP

Remove one of the outlet hoses. Accelerate the engine to approximately 1500 rpm and observe the air flow. If air flow increases as the engine is accelerated, the pump is operating satisfactorily. If the air flow does not increase or is not present, proceed as follows:

1. Check for proper drive belt tension.
2. Check for a leaky pressure relief valve (on pumps so equipped). Air may be heard leaking out of the valve with the pump running.

NOTE: The AIR system is not completely noiseless. Under normal conditions, noise rises slightly in pitch as engine speed increases. To determine if excessive noise is the fault of the AIR system, operate the engine with the pump drive belt removed.

Before replacing a pump for excessive noise, make sure that it has been operated in excess of the 100 mile break-in period. Also check all hose connections and combustion pipe assemblies, as well as proper mounting for the pump.

CAUTION: Do not introduce oil (Fig. 4) into the pump through the front bearing vent hole. This may quiet down the pump for a little while, but will not fix it permanently and will eventually lead to early pump failure.

DIVERTER VALVE

1. Check the condition and routing of all lines, especially the vacuum signal line. All lines must be secure, without crimps, and not leaking.

2. Disconnect the signal line at the valve. A vacuum signal must be available with the engine running (Fig. 16).

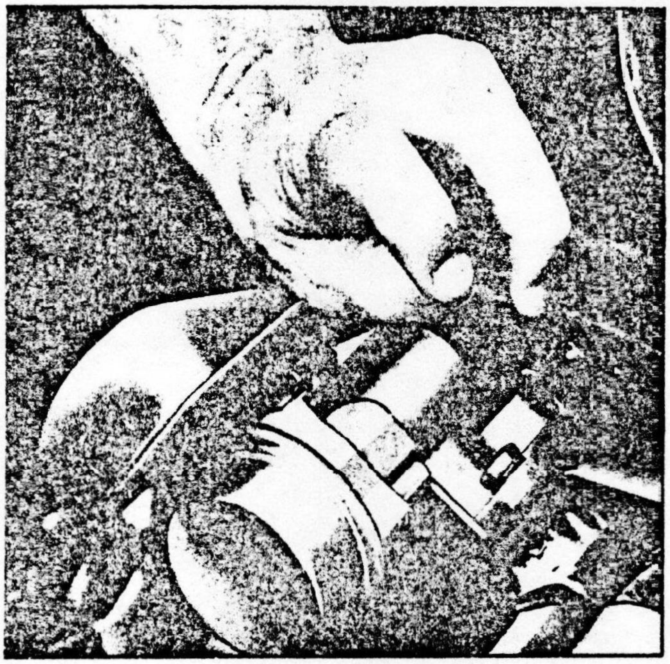


Figure 16

3. Reconnect the vacuum hose. With the engine stabilized at idle, no air should be escaping through the muffler. Manually open and quickly close the throttle. A momentary blast of air should discharge through the muffler for at least one second (Fig. 17).
4. Defective valves should be replaced. They are not serviceable internally.

CAUTION: Although sometimes similar in appearance, diverter valves are designed to meet the particular requirements of various engines. Therefore, be sure to look it up first, and then install the correct valve.

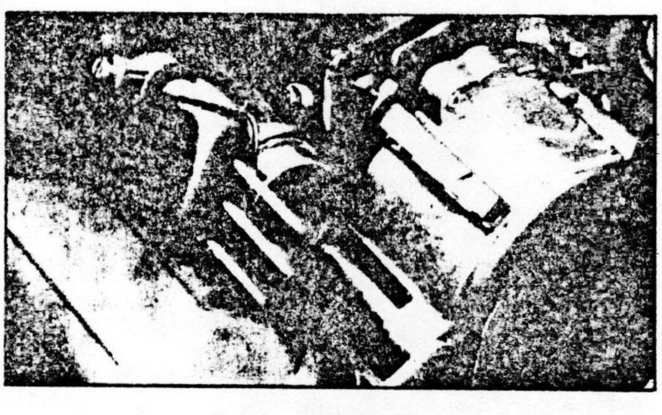


Figure 17

AIR MANIFOLDS AND HOSES

1. Inspect all hoses for deterioration or holes.
2. Inspect air manifolds for cracks or holes.
3. Check all hose and manifold connections.
4. Check all hose routings. Interference may cause wear.
5. If a leak is suspected on the pressure side of the system, check the involved component or connection with a soapy water solution. With the pump running, bubbles will form if a leak exists (Fig. 18). Be careful to keep the soapy water solution away from the centrifugal filter of a 2-vane pump.

CAUTION: AIR hoses are made of special high temperature material. If a hose must be replaced use only the proper type hose for the purpose Do not use a substitute.

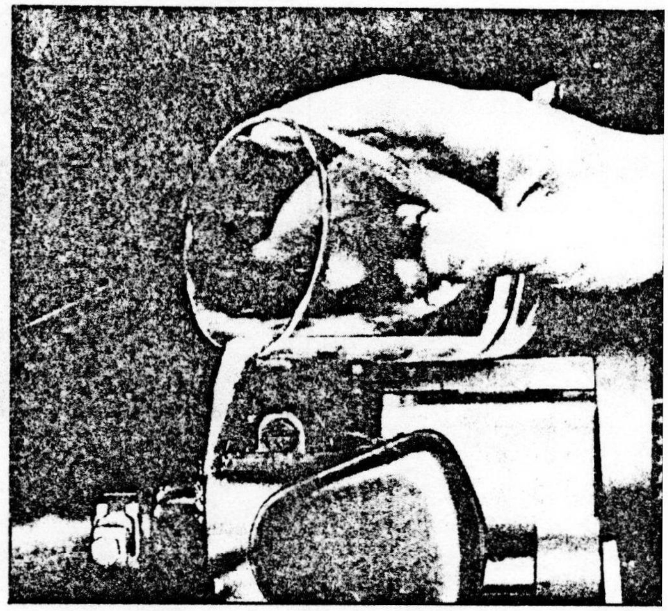


Figure 18

CHECK VALVE

1. The check valve should be inspected whenever the hose is disconnected from the check valve or whenever check valve failure is suspected An inoperative pump that shows signs of having had exhaust gases in the pump indicates a check valve failure.
2. Orally blow through the check valve toward the air manifold, then attempt to suck back through the check valve. Flow should be in one direction only—toward the air manifold (Fig. 19).

AIR INJECTOR TUBES

1. There is no periodic service or inspection for the air injector tubes. However, whenever the cylinder heads or exhaust manifolds are removed from an engine, inspect the air injector tubes for carbon build-up and warped or burnt tubes.
2. Remove any carbon build-up with a wire brush.
3. Warped or burnt tubes must be replaced.

AIR SYSTEM DIAGNOSIS

The AIR system will limit exhaust emission to a level below requirements if it is properly installed and maintained. But will not provide the desired reduction in exhaust emissions if some of the engine components malfunction.

Because of the relationship between Engine Tune Up and Unburned Exhaust Gases, the condition of the engine should be checked whenever the AIR system seems to be malfunctioning. Particular care should be taken in checking items that affect the fuel-air ratio, such as the crankcase ventilation system, the carburetor, and the carubretor air cleaner.

If all other components seem to be operating satisfactorily, visually inspect the AIR system as previously explained.

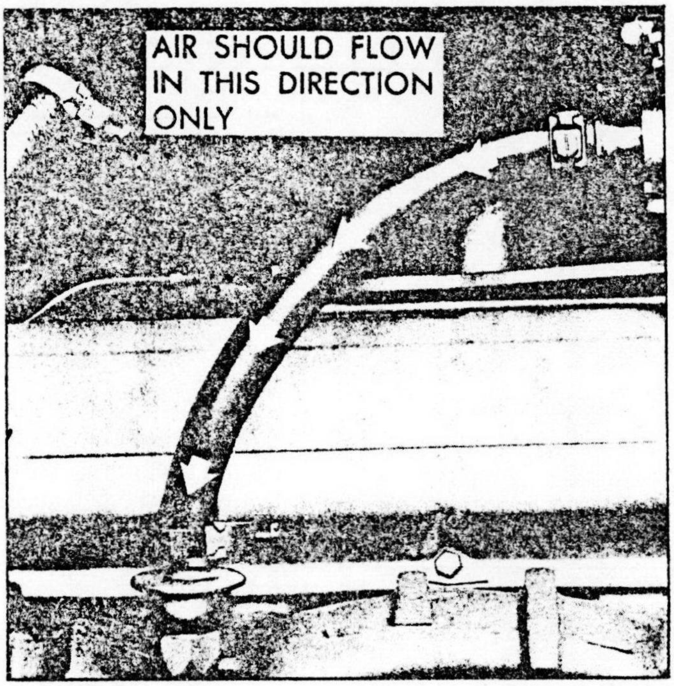


Figure 19

If malfunction persists after completion of tune-up and visual inspection, refer to the following diagnosis chart for symptoms, probable cause, and remedy.

TROUBLE	PROBABLE CAUSE	REMEDY
A. PUMP NOISY	Before trying to isolate the cause, it should be noted that the AIR system is not completely noiseless. Under normal conditions, noise rises in amplitude as engine speed increases. Air pump noise can be confused with other engine noises.	
	Hose disconnected or leaking.	Re-connect or replace.
	Overly torqued pivot bolt.	Torque to 15 – 20 ft. lbs.
	Faulty relief valve (if mounted in pump).	Replace valve.
	A "chirping" noise may be prevalent on new pump.	Allow break-in time.
	A continuous "knocking" noise is indicative of rear breaking failure.	Replace pump.
	Improper belt tension.	Readjust.
	Seized or binding pump.	Replace.
	Incorrect or missing pressure setting plug (if relief valve is mounted on pump).	Replace plug.
	Bent or misaligned pulleys.	Inspect belt alignment, replace pulleys.

TROUBLE (Cont'd.)	PROBABLE CAUSE (Cont'd.)	REMEDY (Cont'd.)
B. POPPING IN EXHAUST SYSTEM: HOT IDLE	Sound similar to muffler hitting floor pan. Caused by rich idle mixture.	Adjust idle mixture screws, as shown in United Delco 60A100-1 Specification Manual.
COLD IDLE (CHOKE ON)	Same as above. Moderate popping is inherent design characteristic of system when cold.	Same as above. Also inspect choke and vacuum break operation and settings. On manual choke models, instruct owner on proper operation.
ACCELERATION	Popping appears under load from idle. Popping noise level varies with timing (decreases with advance of timing) and carb. accelerator pump shot duration.	Check ignition spark timing.* Check accelerator pump adjustment.
C. BACKFIRE IN EXHAUST SYSTEM	Rich fuel mixture caused by: Inoperative choke, misadjusted or sticking closed.	Inspect choke operation, correct as necessary.
	Inoperative vacuum break.	Replace vacuum break.
	Use of manual choke: Generally over-choking.	Closer control of choking period.
	Air cleaner element restricted.	Replace element.
	Improper crankcase vent maintenance.	Inspect system. Replace PCV valve. Check fitting at carburetor; may be plugged with crankcase deposits. Check PCV filter. Replace if dirty.
	High fuel level.	Adjust float level.
	Diverter valve stuck in open position.	Check valve. Replace if defective.
	Diverter valve and distributor timing vacuum lines switched.	Correct hose routing.
D. BACKFIRE OR POPPING IN INLET MANIFOLD	Leaking inlet manifold.	Check manifold bolts for tightness.
	Incorrect ignition timing.	Check timing and set to specs.*
E. OFF IDLE HESITATION AND ROUGH IDLE (HOT)	Appears in acceleration period from a standing start to approximately 900 rpm and result from the following:	
	Vacuum leak – more noticeable on hot engine. This results from unconnected, split, or oversized hoses, or from hot idle compensator not closing, or opening prematurely. Can also be caused by a leaking carburetor or intake manifold gasket.	Inspect hoses, gaskets, and fittings for leaks. Close carburetor hot idle compensator. If this corrects condition, replace hot idle compensator.

TROUBLE (Cont'd.)	PROBABLE CAUSE (Cont'd.)	REMEDY (Cont'd.)
E. OFF IDLE HESITATION AND ROUGH IDLE (HOT) (CONT'D.)	A third cause can be insufficient fuel shot from carb. accelerator pump, or fuel leaking past seal during pump travel. (This does not apply to diaphragm type accelerator pumps).	Check accelerator pump adjustment. If rubber seal is hard, or falls into cavity by its own weight (with return spring removed), it should be replaced. There should be slight interference between cup and wall.
	Carburetor float level low.	Adjust as required.
	Initial timing out of specification.	Check initial setting to specification.*
F. ROUGH IDLE OR SURGE	Improper carburetor adjustment, idle speed, idle fuel mixture, choke, etc.	Check carburetion and adjust as necessary.*
	Improper ignition timing.	Set timing to specs.*
	Vacuum leak at signal line to diverter valve or distributor, vacuum leak at carburetor or intake manifold.	Inspect and correct lines and connections. Check for leaks at carburetor and intake manifold gaskets.
G. ENGINE IDLE SPEED HIGH	Throttle linkage sticking or obstructed by hoses.	Inspect linkage and eliminate points of interference.
	Idle speed set incorrectly.	Reset idle speed to specs.*
H. ENGINE "DIESELS" AFTER IGNITION IS TURNED OFF	Idle speed too high.	Reset idle to specs.*
	Solenoid (on units so equipped) stuck in "up" position.	Free-up or replace solenoid.
	Low octane fuel.	Use higher octane fuel or premium.
I. OVERHEATED EXHAUST SYSTEM	Ignition timing retarded, excessive burning in exhaust system.	Reset timing to specs.*
	Incorrect or missing pressure relief valve plug in air pump.	Check for correct plug. Install if missing.
J. CHARRED, DETERIORATED SUPPLY HOSE	Defective check valves.	Replace check valves.
K. CONSTANT AIR NOISE	Broken hose.	Replace hose.
	Diverter valve stuck closed.	Replace diverter valve.

*Refer to United Delco 60A100-1 Specification Manual

CAUTION: Because the AIR pump air filter provides a direct path into the pump, cover the filter whenever cleaning the engine.

The Chrysler method for control of both crankcase and exhaust emissions is called the Cleaner Air Package (CAP). It is sometimes referred to as the Cleaner Air System (CAP) (Fig. 20).

In the CAP system, crankcase emissions are controlled by a positive, fully closed crankcase ventilation system that is similar to the typical system described in Manual No. I.

For exhaust emission control, the CAP system uses modified carburetion and ignition timing, plus some basic engine design refinements.

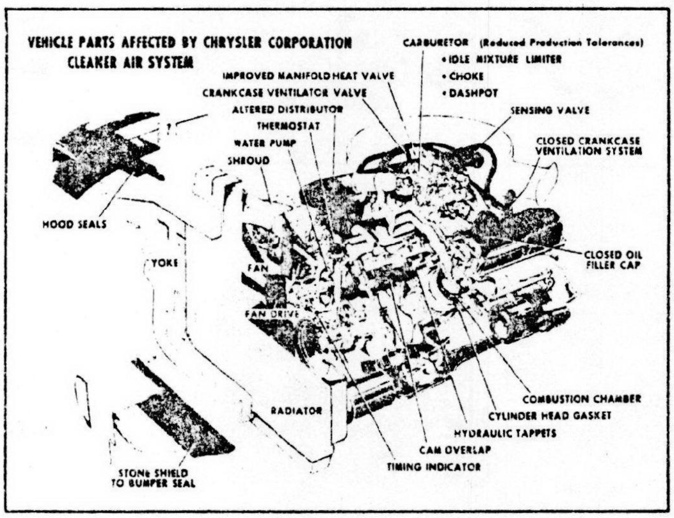


Figure 20

The specially calibrated CAP carburetor delivers a leaner idle mixture than non-CAP cars. There are no significant changes in the calibration of the other carburetor circuits.

The basic timing of CAP engines has been altered to provide retarded ignition at idle speed. Although the CAP distributor is essentially the same as a conventional distributor, the mechanical and vacuum advance curves are specially calibrated for CAP ignition requirements.

In addition, on some models, a vacuum control valve is used to provide maximum vacuum advance during deceleration.

Primarily, CAP equipped cars require periodic and precise tune-up to maintain desired control of exhaust emissions. Aside from standard tune-up pro cedures, special consideration should be given t vacuum control valve checks where applicable an carburetor adjustments.

VACUUM CONTROL VALVE OPERATION

The vacuum control valve is connected by vacuun hoses to the distributor advance unit, the carbureto vacuum port, and the intake manifold (Fig. 21).

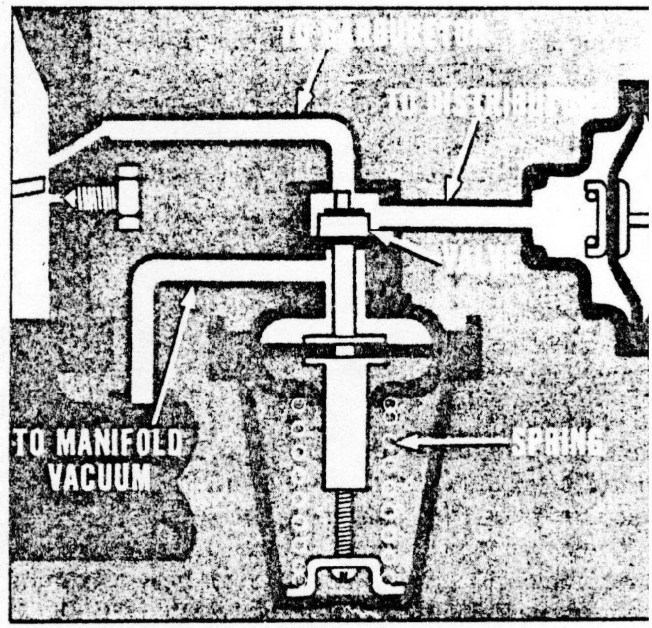


Figure 21

The chamber on one side of the valve is connecte to both the carburetor vacuum port and the distri butor vacuum advance unit. The chamber on th other side of the vacuum valve is connected to th intake manifold. A spring holds the valve in a close position. However, strong manifold vacuum, actin on the valve's diaphragm, can overcome the sprin force and open the valve.

At engine idle speed, the vacuum control valve doe not affect timing because intake manifold vacuum i not strong enough to open the valve. The onl vacuum force acting on the distributor advance uni is supplied by the carburetor port. At idle, vacuun from the carburetor port is not strong enough t move the distributor diaphragm and advance th ignition timing (Fig. 22).

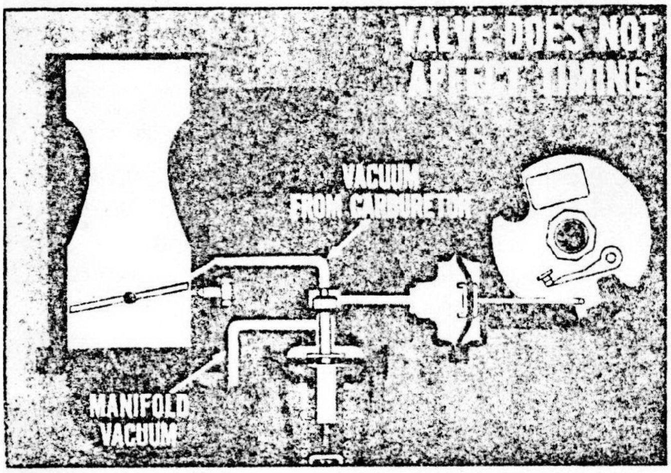


Figure 22

During acceleration and at cruising speeds, the carburetor throttle is open and manifold vacuum is not strong enough to open the vacuum control valve. That means that only vacuum from the carburetor port is applied to the distributor vacuum advance unit.

Since carburetor port vacuum is relatively high during acceleration and at cruising speeds, normal ignition advance is provided, just as it is in a conventional ignition system.

During deceleration, the throttle is closed. Since carburetor vacuum port is above the throttle valve, vacuum from this source is not strong enough to provide vacuum advance at the distributor. However, manifold vacuum is now at or near maximum, so it opens the vacuum valve (Fig. 23).

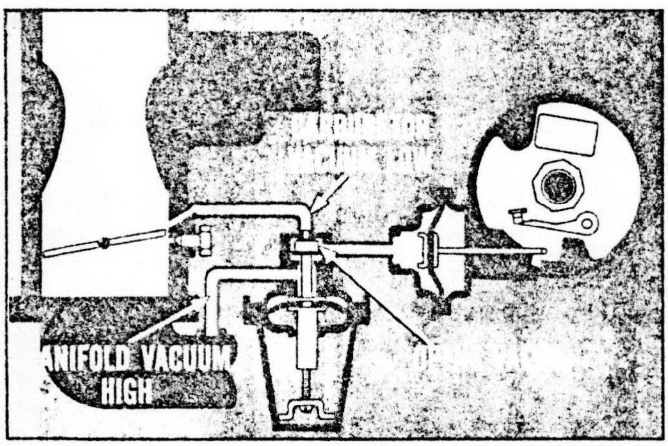


Figure 23

When the vacuum control valve opens, intake manifold vacuum acts on the distributor vacuum advance unit. This provides maximum vacuum advance during deceleration (Fig. 24).

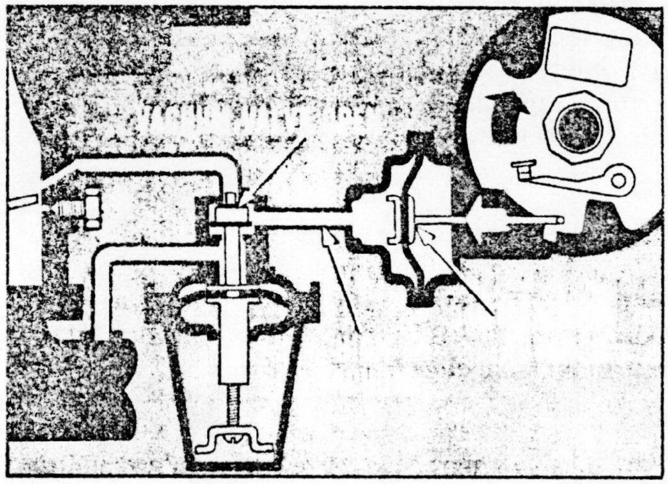


Figure 24

Because the ignition timing is greatly advanced on CAP cars during deceleration, combustion starts much earlier, allowing more time for complete combustion. As a result, exhaust emissions are reduced to an acceptable level.

IDLE SPEED AND MIXTURE ADJUSTMENTS

It is normal procedure to adjust idle mixture and speed before testing or adjusting the vacuum control valve. To eliminate the possibility of the timing being advanced due to a leaking or incorrectly adjusted vacuum control valve either remove and plug the manifold vacuum hose at the control valve end, or use a spring clamp to pinch it shut. When a clamp is used, make sure it does close off the hose completely and without damaging the hose (Fig. 25).

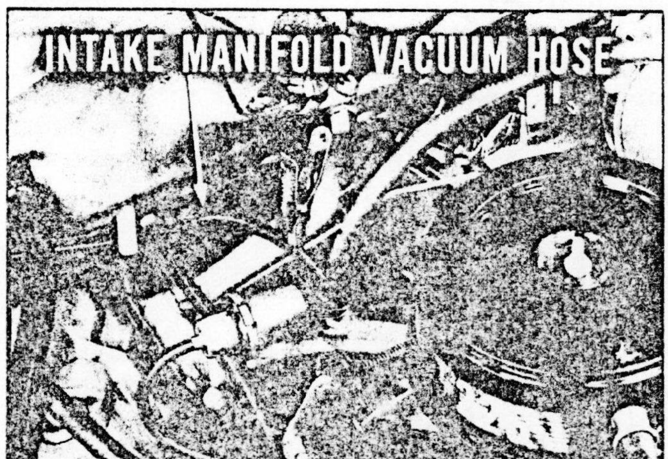


Figure 25

For adjusting idle speed and mixture both a tachometer and combustion analyzer are used. When adjusting idle mixture, remember that a combustion analyzer is a very sensitive instrument. It takes about ten seconds for the meter to stabilize after each mixture adjustment. For best results, turn he mixture adjustment no more than about 1/16 of a turn between readings.

Final idle mixture adjustment must be made by adjusting from rich to lean not from lean to rich (Fig. 26).

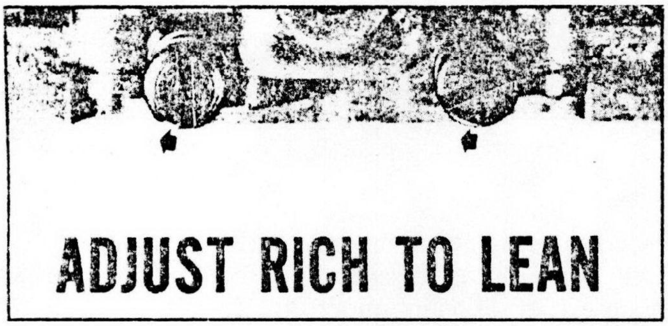


Figure 26

If the mixture is too lean, the idle will be very rough, and it will be difficult to keep the engine running at specified engine speed. It is very important to maintain specified idle speed when adjusting idle mixture.

Watch the tachometer as well as the combustion meter. If idle speed changes appreciably when adjusting mixture, readjust idle speed before proceeding with mixture adjustment.

In the case of multiple-barrel carburetors with two mixture screws, a final independent adjustment of the mixture screws may be made to improve idle smoothness. Make sure this final adjustment doesn't put the air-fuel ratio outside of CAP specifications. If the air cleaner was removed when the idle mixture screws were adjusted be sure to recheck meter readings after air cleaner has been reinstalled.

CARBURETOR VACUUM CHECK

Before testing or adjusting the vacuum control valve, make sure that vacuum at the carburetor vacuum port above the throttle blade is correct.

To check, warm engine up to the normal operating temperature. Connect a tachometer to the engine. Connect a vacuum gauge into the distributor vacuum line. Use a tee fitting with the same inside diameter as the line.

If the carburetor is equipped with a dash pot, adjust it so that it does not contact the throttle lever at idle speed.

Disconnect and plug hose that connects the vacuum control valve to the intake manifold. Remove the distributor vacuum hose at the distributor and plug hose. The distributor vacuum must be zero (0) to six (6) inches of mercury with the engine running at idle. If vacuum is higher than six (6) inches of mercury, recheck idle speed, timing, and air/fuel ratio.

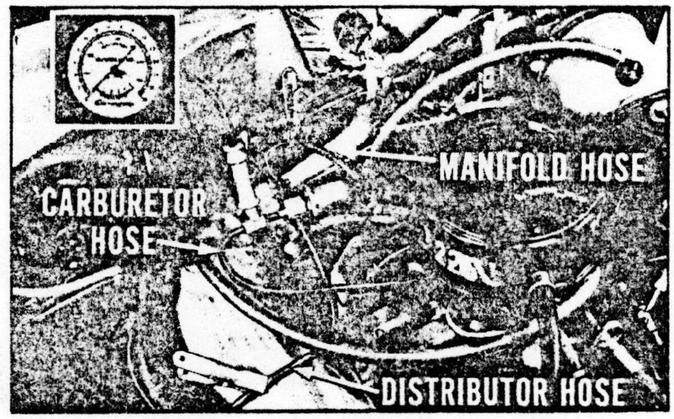


Figure 27

VACUUM CONTROL VALVE TESTS

One test hook-up is used to test both the operation and the calibration of the vacuum control valve. The vacuum gauge is connected into the distributor hose. The distributor and manifold vacuum hoses are connected normally and are not clamped shut (Fig. 28).

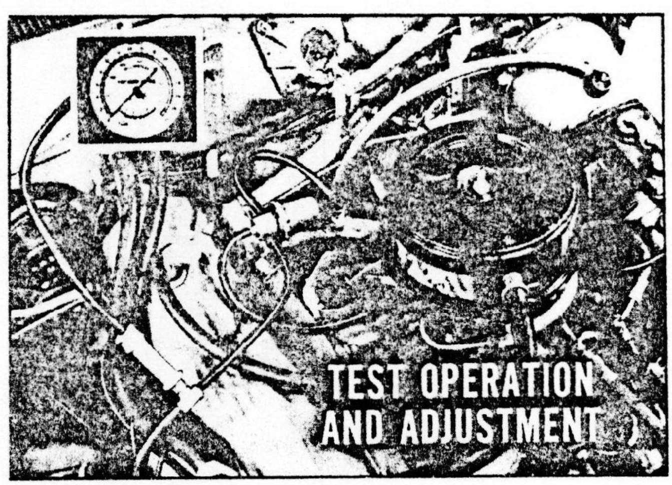


Figure 28

Remember that during deceleration, high manifold vacuum should open the vacuum control valve. To check, simply speed the engine up to about 2000 rpm and hold for 5 seconds. Then release the throttle and let the engine return to idle speed. If the distributor vacuum increases to about 15 inches of mercury the valve is opening as it should.

If the vacuum gauge holds this high reading for at least one, but not more than three seconds, the valve is operating properly. If vacuum drops immediately, the valve is closing faster than it should (Fig. 29).

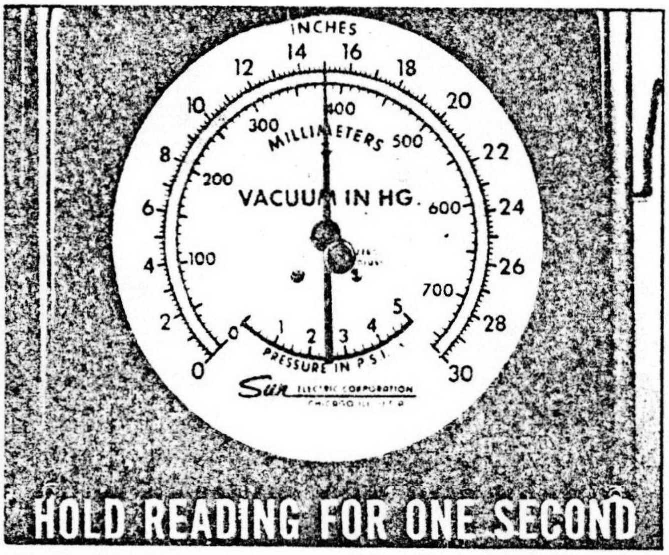


Figure 29

The vacuum should drop below six inches of mercury in not more than three seconds (Fig. 30). If vacuum drops below six in less than one second—or takes more than three seconds to drop below 6—the valve must be adjusted.

The adjustment of the spring in the vacuum control valve determines how long the valve will be held open by manifold vacuum.

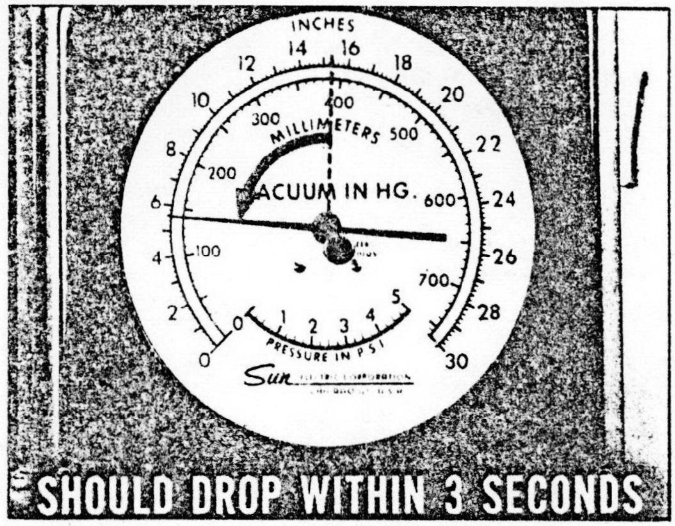


Figure 30

VACUUM CONTROL VALVE ADJUSTMENT

The vacuum control valve adjusting screw is at the spring end of the valve. Remove the valve cover to adjust.

To Increase Time Valve Is Open: Turn the valve adjusting screw counterclockwise. This reduces the effective closing pressure of the spring, and lets the valve stay open longer.

To Decrease Time Valve Is Open: Turn the valve adjusting screw clockwise.

One Turn Equals 1/2-Inch: One turn of the adjusting screw will change the valve setting approximately 1/2-inch of mercury. For example, if at the end of three seconds the vacuum reading has only dropped back to seven inches, two clockwise turns of the screw should drop the reading to about six inches in three seconds.

Be sure to retest the valve closing time after adjusting it. If the valve cannot be adjusted to specifications, it must be replaced.

Delco GM

POWER SERVICE

PROCEDURE CHECK SHEET

Name__________ Make of Vehicle__________ Year__________

Address__________ Model:__________

Telephone No.__________ 4 cyl. ☐ 6 cyl. ☐ 8 cyl. ☐

CUSTOMER'S STORY

Mileage since last tune-up__________

Mileage since last carburetor overhaul__________

Customer Performance Complaints:

Poor Acceleration__________ Rough Idle__________

Engine Knocks or Pings__________ Stalls__________

Hard Starting Hot_____ Cold_____ High Speed Miss_____

Preventive maintenance tune-up desired

(No specific performance complaints)__________

I. BATTERY AND CABLES

1. Clean battery, battery and cable terminals, [illegible] holding. ☐
2. Check battery [illegible] and [illegible] of charge.

Defective ☐ Satisfactory ☐

Discharged ☐

II. CRANKING MOTOR AND CIRCUIT

1. Clean and tighten terminal connections. ☐
2. Operates at satisfactory speed and sound. ☐
3. Electrical check—Unsatisfactory ☐ Satisfactory ☐

III. ENGINE MECHANICAL CONDITION

(Determined by compression or cylinder balance test, etc.)

Cylinder Check

1	2	3	4	5	6	7	8

Questionable ☐ Satisfactory ☐

If questionable, call owner before proceeding with tune-up. Suggest use of carburetor and combustion chamber conditioner as [illegible] corrective measure.

IV. SPARK PLUGS

1. Replace. ☐
2. Clean and regap—Gap Specifications__________ ☐

V. DISTRIBUTOR AND IGNITION CIRCUIT CHECKS

1. Inspect cap and rotor. ☐
2. Check centrifugal and vacuum advance units. ☐
3. Check condition of primary and secondary wiring. ☐
4. Replace contact points and condenser as required. ☐
5. [illegible] as required. ☐

VI. IGNITION CIRCUIT TESTS AND ADJUSTMENTS

1. Electrical check for high resistance, grounds, shorts, etc.

   Unsatisfactory ☐ Satisfactory ☐
2. Adjust cam dwell—Specification__________ ☐
3. Adjust timing—Specification__________ ☐

VII. FUEL, MANIFOLD AND EXHAUST EMISSION SYSTEM SERVICE

1. Free heat riser valve with cleaner and lubricant. ☐
2. Service P.C.V. and exhaust emission system. ☐
3. Use carburetor and combustion chamber conditioner. ☐

VIII. CARBURETOR AND FUEL SYSTEM SERVICE

1. Test fuel pump pressure. ☐
2. Test fuel pump volume—approximately one pint in one minute. ☐
3. Simplified carburetor tune-up as required. ☐
4. Fuel filter service. ☐
5. Air cleaner service. ☐
6. Check choke linkage—unloader operation. ☐
7. Adjust idle mixture. ☐
8. Adjust idle speed. ☐

IX. CHARGING SYSTEM

1. Check charging voltage—Specification__________ ☐
2. Charge battery as required. ☐

X. GENERAL VEHICLE INSPECTION

Road Test. ☐

WE USE GENUINE UNITED DELCO PARTS

MI-226 Printed in U.S.A.

Figure 31

The first five steps in a complete engine tune-up procedure were explained in the Number I Manual. Following is an explanation of the remaining five steps. You will note that each of these procedures relates to the unscreened portion of the "Power Service" check sheet on the opposite page. Using this type of procedure check sheet on every tune-up job will not only help you in recording necessary information but will assure the completion of all checks and adjustments before a car is delivered to its owner.

VI. IGNITION CIRCUIT TESTS AND ADJUSTMENTS

1A Voltage Checks

Two simple checks will indicate any "ground" or poor connections and reveal any "open" in the coil primary windings or elsewhere in the primary ignition circuit. (Fig. 32) Connect the positive lead of a voltmeter (on negative ground systems) to the primary terminal on the ignition switch side of the coil and the negative lead to ground:

a. With the ignition switch on and the distributor points open the meter should read battery voltage.

b. With the ignition switch on and the distributor points closed the meter should normally read 4.5 to 7.5 volts (12 volt system). A 12 volt reading would indicate a shorted or by-passed primary ignition resistance.

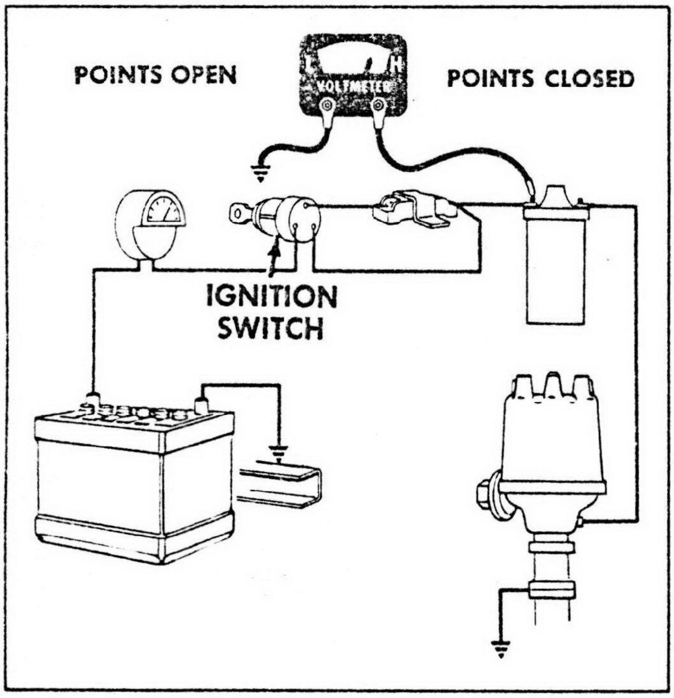


Figure 32

A test for distributor primary circuit and contact point resistance should be made to assure that points have been installed and connected properly. (Fig. 33).

Connect the positive voltmeter lead either to the distributor primary terminal or the primary terminal on distributor side of the coil. Connect the negative meter lead to ground. With the ignition switch on and distributor points closed, the voltmeter should read .2 volt maximum.

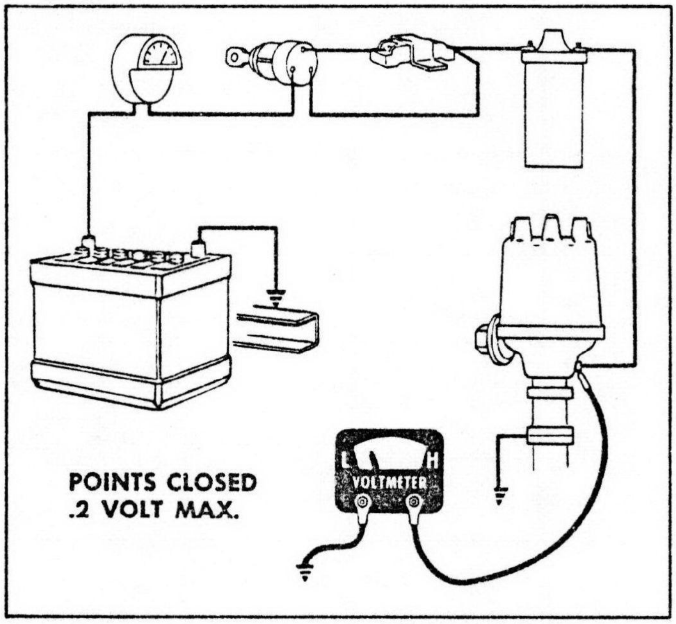


Figure 33

1B Ignition Wave Form Analysis

BASIC IGNITION WAVE FORM (Fig. 34)

Ignition wave form analysis with an oscilloscope is a good method of checking the complete ignition system. It requires an understanding of basic ignition as well as a knowledge of the particular oscilloscope being used.

A characteristic wave form (Fig. 34) indicates voltage variations during the points closed portions of a complete ignition cycle. For analysis purposes the pattern is divided into three well defined sections that makes it possible, by comparison, to isolate abnormal conditions to specific related areas in the ignition circuit.

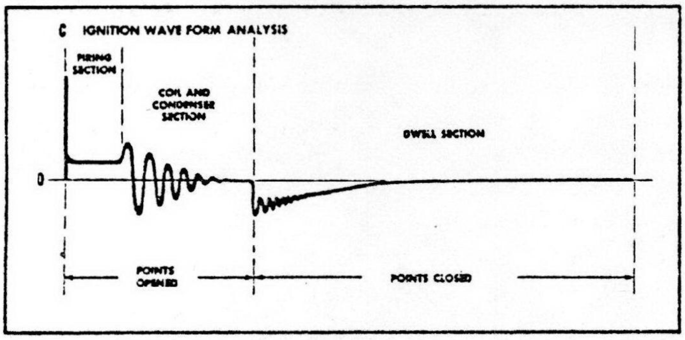


Figure 34

POINTS OPEN (Fig. 35)

As the points open, instantaneous collapse of the coil magnetic field produces the high voltage required to fire the spark plug. (Fig. 35) This is indicated by the vertical firing line. Voltage then drops to the lower level required to maintain the spark as indicated by the spark line. The oscillations represent dissiplation of energy in the circuit after the spark has ceased.

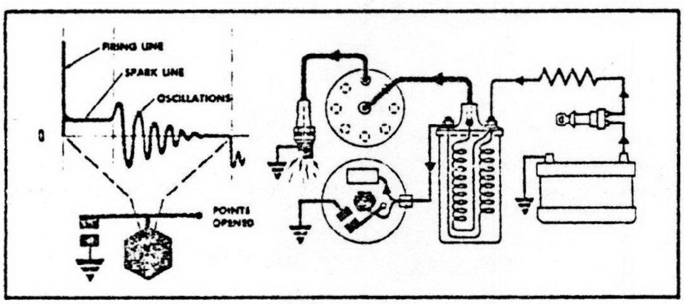


Figure 35

POINTS CLOSED (Fig. 36)

As the points close, all action in the secondary circuit has ceased and current starts to flow in the primary circuit. (Fig. 36) This action continues for the entire points closed (cam dwell) period thus building up the coil magnetic field in preparation for the next firing impulse. A normal points closed signal is represented by a slight voltage drop followed by diminishing oscillations. Variations at this point, or at the end of the points closed period, indicate poor breaker point action.

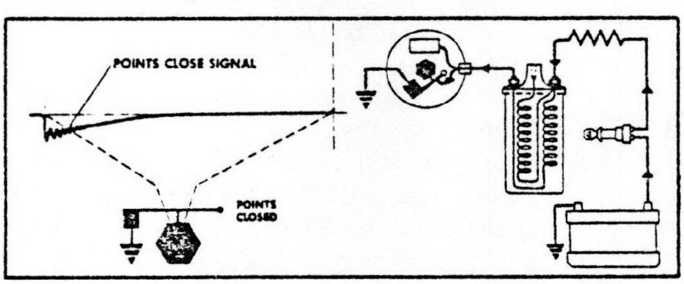


Figure 36

FOUR CYLINDER PATTERN COMPARISO
(Fig. 37)

Analysis starts with the comparison of the pa tern for any one cylinder against a recognize normal pattern and is followed by a comple comparison of the patterns for all cylinder (Fig. 37) If variations from normal are notice in all patterns, trouble exists in that portion c the circuit affecting all cylinders. A variatio in one pattern isolates trouble to the portio of the circuit affecting that cylinder only.

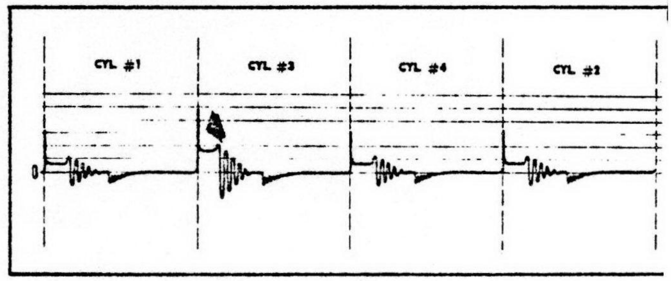


Figure 37

FIRING SECTION VARIATIONS (Fig. 38)

- The next step in analysis is to examine varia tions that might exist in each of the thre basic wave form sections. For each variatio shown there is one most common source o trouble. In the firing section:
- High firing line with high short spark line in dicates wide spark plug gap.
- Low firing line with low long spark line indi cates narrow plug gap.
- Normal firing line with sloping spark line indi cates excessive series resistance in cables, plug or suppressors.
- Spark line sloping from top of firing line indi cates leaded or fouled plugs.

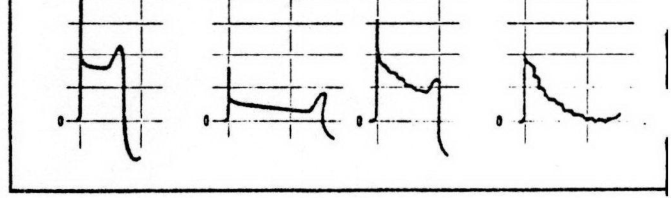


Figure 38

FIRING AND COIL SECTION VARIATION
(Fig. 39)

- Extremely high oscillations with no firing o spark line indicates an open circuit conditio or a pattern that can be obtained for test purposes by removing a spark plug lead. The upward extent of oscillations indicates available voltage.

- A false start at the spark line indicates contaminated points or high series resistance in condenser.
- Lack of normal oscillations indicates defective coil.

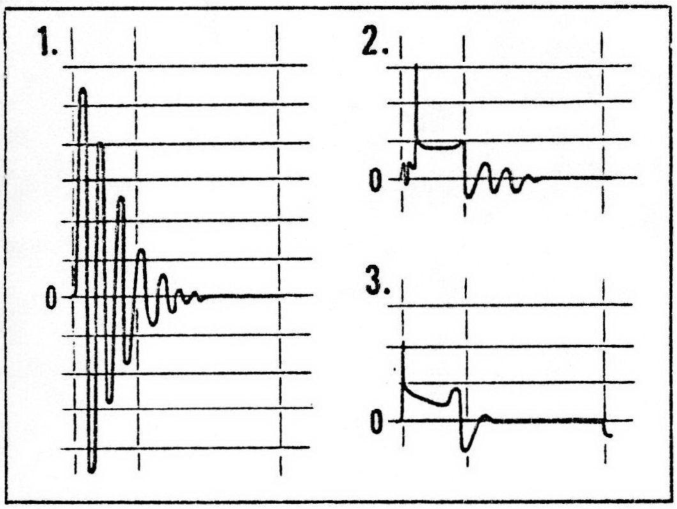


Figure 39

DWELL SECTION VARIATIONS (Fig. 40)

- Excessive cam dwell is indicated when the complete point closed portion of pattern is longer than normal.
- Short dwell is indicated when points closed period is less than normal.
- A points closed signal with the first oscillation shorter than the second indicates poor point alignment.
- Flashing or lack of a clean break at end of pattern indicates arcing contact points.

2. Adjust cam dwell (angle) (Fig. 41) with a meter using exact specifications as found in the United Delco 60A-100-1 Specification Manual. This is preferable to adjusting contact point opening with a feeler gauge, since it eliminates the possibility of getting oil or dirt on contact surfaces. On internal adjustment type distributors, the adjustment can be performed at cranking speed and double checked with the engine running. On external adjustment distributors, the adjustment can be made with the engine running as shown in Fig. 41.

   Prior to adjusting cam dwell, be sure to calibrate meter and place the cylinder selector switch in the correct position. Then connect

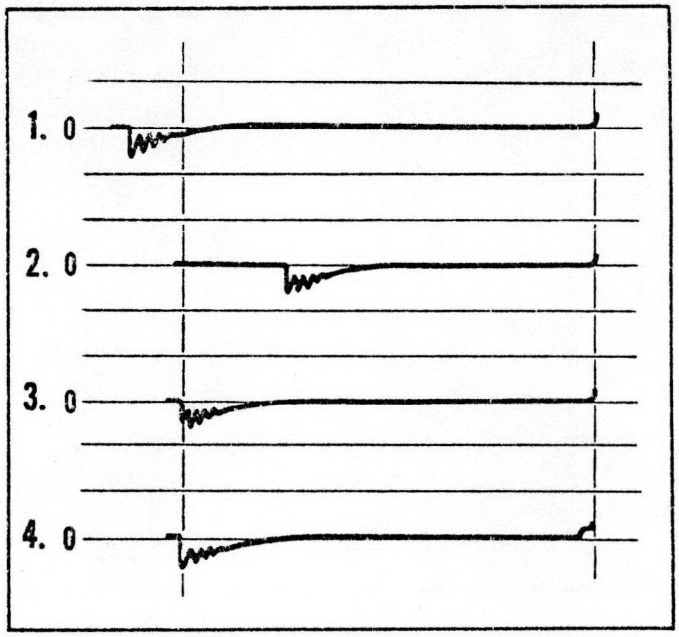


Figure 40

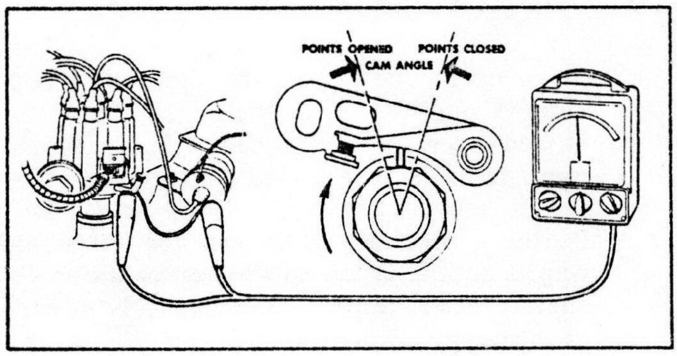


Figure 41

positive meter lead (on negative ground systems) to distributor primary terminal or distributor side of coil and negative lead to good engine ground position. Dwell adjustment should be made at idle speed.

3. The final step in servicing the ignition system is to adjust initial spark timing. Refer to the 60A-100-1 United Delco Specification Manual for the following information on the specific engine involved:

   a. Location of No. 1 cylinder
   b. Timing mark location
   c. Timing Specification

   Connect timing light according to equipment manufacturer instructions. The engine should be at idle speed or at the speed specified for timing in the specification manual and the vacuum line should be disconnected from the distributor and plugged.

Timing adjustment is accomplished by loosening the distributor hold down screws and rotating the distributor until the timing marks line up according to exact timing specifications. This is one of the most critical adjustments required for emission control. Be sure to set to specification.

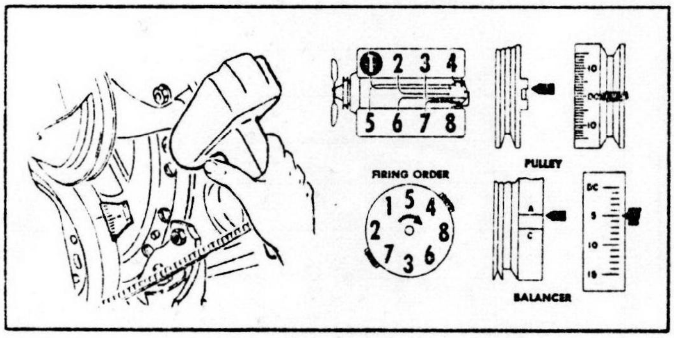


Figure 42

VII MANIFOLD AND EMISSION SYSTEM SERVICE

1. Servicing the heat riser (manifold heat control) valve (Fig. 43) is one of the most overlooked operations in tune-up. Valve should move freely and return to closed position by the action of the spring. Tap valve shaft lightly, if necessary, and check for free spring weight action. When valve is operating freely apply special cleaner - lubricant to both ends of valve shaft. Do not use oil.

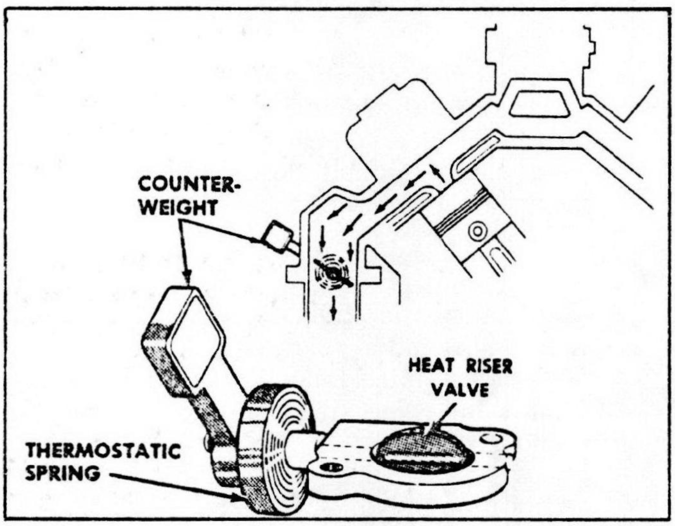


Figure 43

2. Servicing the PCV and exhaust emission systems during tune-up consists of the following:

   a. Replace PCV Valve
   b. Replace or clean PCV system filter
   c. Check complete PCV system with tester (Fig. 44)
   d. Check and/or adjust pump drive belt tension on air injector equipped cars.
   e. Visually check temperature controlled hot air cleaner operation on vehicles so equipped.

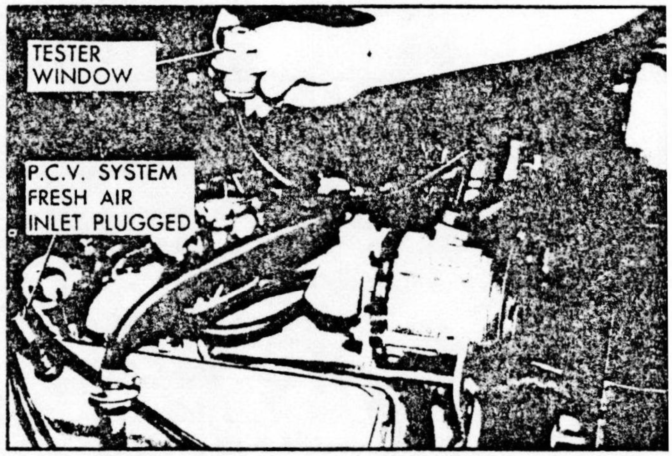


Figure 44

3. Use of a carburetor and combustion chamber conditioner is recommended during each tune-up (Fig. 45). This solvent will clean out carbon and gum deposits around the choke valve and in the carburetor bore. It will also remove these deposits from the intake manifold and combustion chambers. In most instances, uneven or abnormal compression will be corrected.

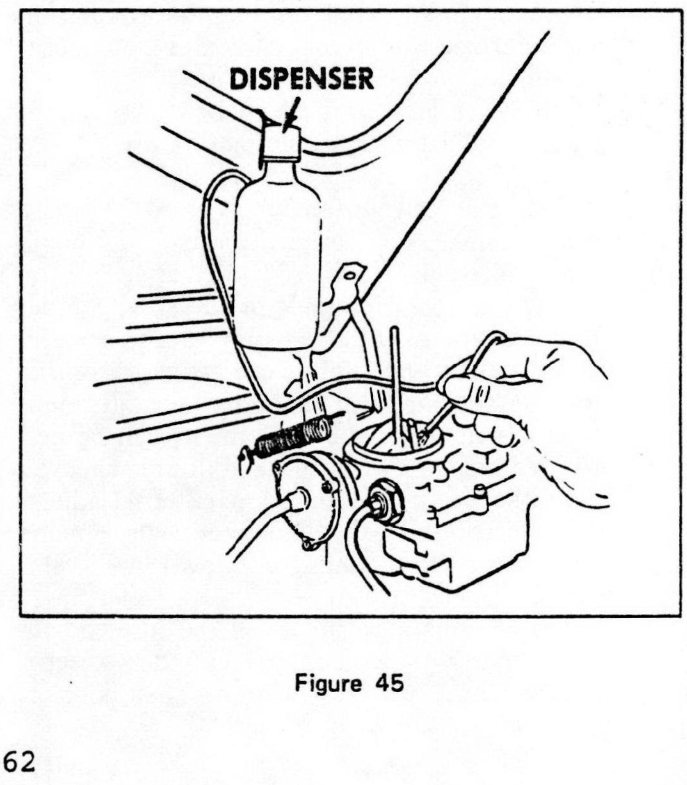


Figure 45

VIII CARBURETOR AND FUEL SYSTEM SERVICE

1-5 A complete tune-up procedure should include a check of fuel pump pressure and volume (Fig. 46). Where required minor service should be performed on the carburetor. This should include float level adjustment as well as replacement of the pump plunger, needle and seat and bowl cover gasket. For high mileage cars, a complete carburetor overhaul or unit replacement should be considered.

On every tune-up, the fuel strainer (filter) and carburetor air filter should be checked and cleaned or replaced as required.

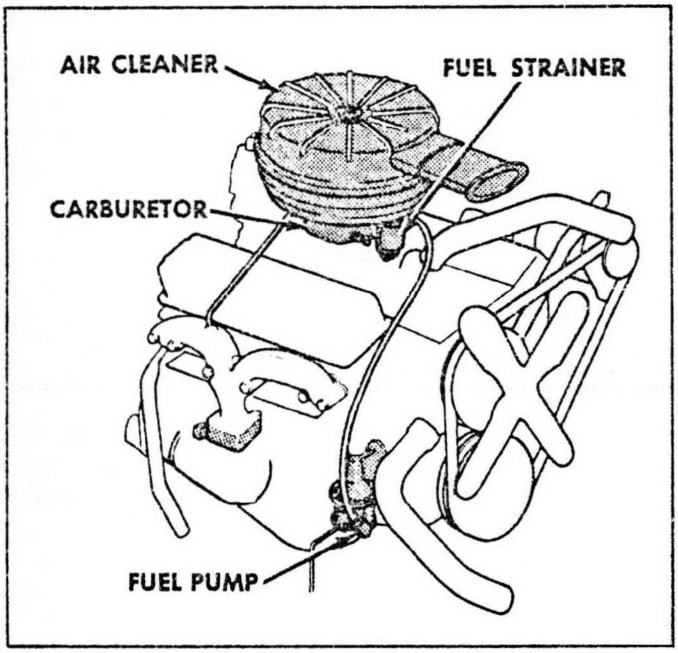


Figure 46

6. Any air leaks into the manifold or carburetor can be detrimental to engine performance. Always check the tightness of both manifold and carburetor hold down nuts (Fig. 47). Also tighten all carburetor cover screws.

   Many types of vacuum hoses will be found on emission controlled engines. They should be checked for disconnections or leaks as well as for proper re-connection if they have been removed for any reason.

   Check all carburetor linkage for binding or excessive looseness. With the accelerator pedal depressed to floor board, observe the carburetor throttle valve to determine that it goes to the wide open position. At this point observe the choke valve to insure that it is in a partial open or unloading position.

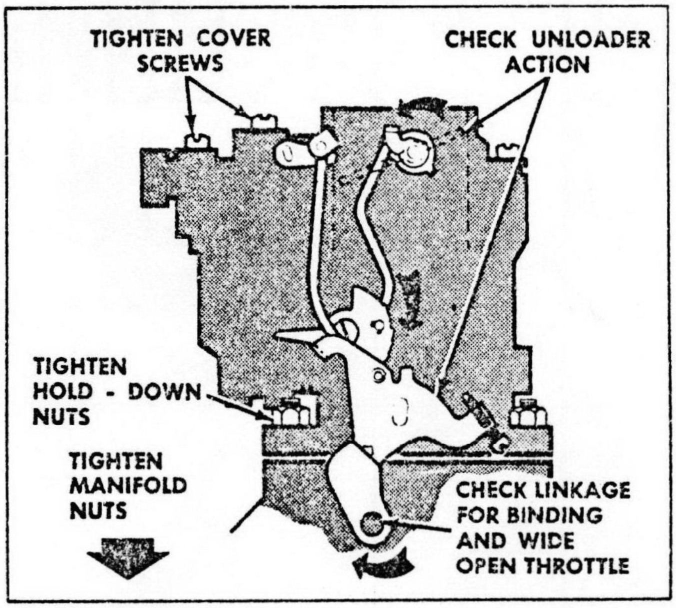


Figure 47

7. Adjustment of carburetor idle mixture (Fig. 48) is a most important procedure particularly on emission controlled engines. With most engines, this adjustment is performed with a tachometer. However, with Chrysler emission controlled engines an exhaust gas analyzer is also recommended.

   For specific procedure applicable to each engine application refer to the United Delco 60A-100-1 Specification Manual. Follow these procedures closely to obtain proper engine performance as well as control of exhaust emissions.

   Idle mixture adjustments should be made at normal engine operating temperatures. To insure accuracy make sure that idle compensator is closed on carburetors so equipped.

8. Carburetor idle speed is also a particularly important adjustment on emission controlled engines. Basically these engines require a higher idle speed setting but it should not be exceeded. The most basic requirement is an accurate tachometer - make sure your tachometer is checked and calibrated periodically.

   Adjust idle speed after referring to Specification Manual for exact speed setting and position of shift lever, drive or neutral, in

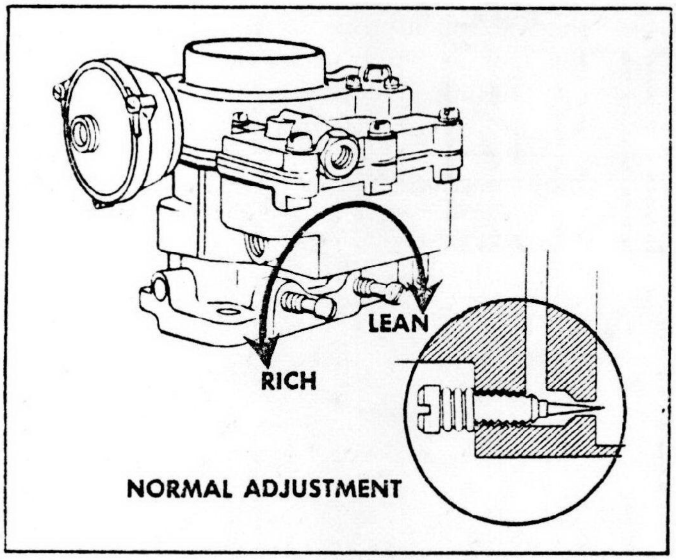


Figure 48

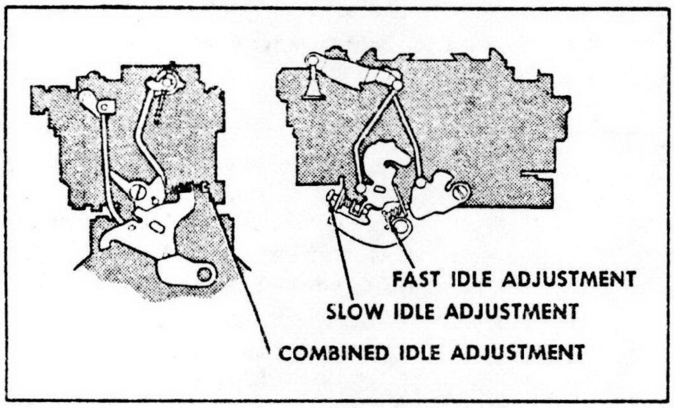


Figure 49

which adjustment should be made. On carburetor with two throttle stop screws (Fig. 49) be sure to use only the one for slow idle adjustment.

Since idle speed and mixture adjustments are inter-related, it might be necessary to repeat both adjustments to obtain best idle performance at specified idle speed.

Engines equipped with a throttle stop solenoid require two idle speed adjustments. Curb-idle is obtained by adjusting the solenoid stop screw with the solenoid energized. Slow idle (stop) speed is obtained by adjusting the carburetor throttle stop screw with the solenoid de-energized (disconnected).

IX CHARGING SYSTEM

1. Check charging voltage with a voltmeter connected across the battery posts (Fig. 50). If voltage is within specified range, it indicates that all units of the charging circuit are functioning properly and that battery should maintain a full charge condition.

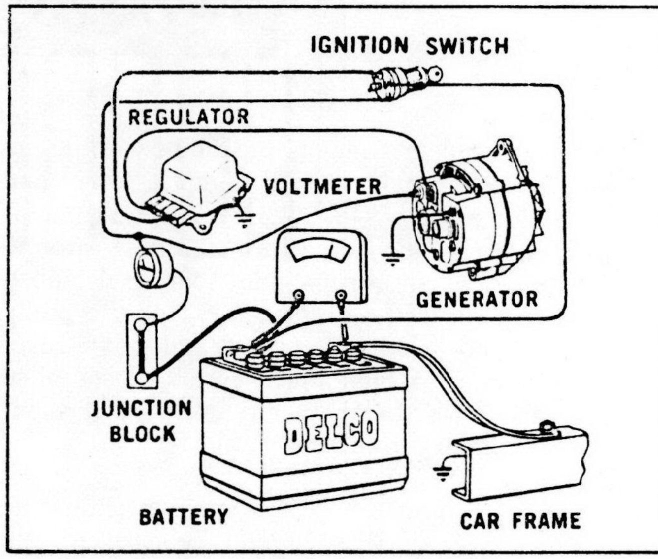


Figure 50

2. A final recommendation - never deliver a tuned up car with the battery in a low state of charge. Even though there is no charging circuit trouble, the battery might have become discharged due to abnormal operation. Charge the battery and make your tune-up complete.

X GENERAL VEHICLE INSPECTION

Final safety checks during tune-up should include inspection of lights, windshield wipers, horns, brakes, and exhaust system.

Customer satisfaction with tune-up is assured through a final road test that checks vehicle performance under normal operating conditions. Check for ease of starting, acceleration, performance in the 30 to 35 MPH and 50 to 60 MPH ranges, stall at sudden stop and roughness at hot idle.

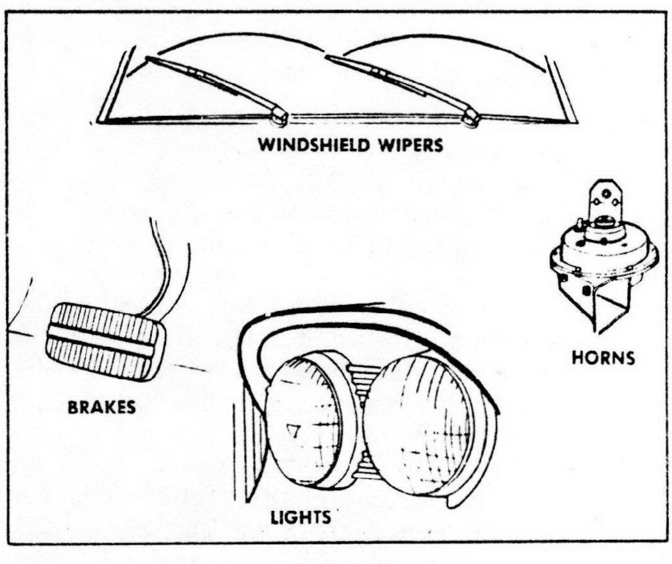


Figure 51

TABLE OF CONTENTS

INTRODUCTION

This Emission Control Service Part III Manual, is an extension of the information contained in Manuals No. I and No. II. These are available through your United Delco wholesaler. Essentially, this new manual covers the emission control systems used on 1968 through 1973 domestic vehicles.

The task of controlling automotive emissions requires the industry to conduct continuous and extensive research and development programs. Changes in systems are made as research indicates their effectiveness. Information in this and the previous two Emission Control Manuals is obtained from reliable sources but should not be considered absolutely accurate, complete or final.

In Emission Control Service Part No. I, you were introduced to the closed-type Positive Crankcase Ventilation System (PCV), which is used on all '68 and later vehicles, and the Controlled Combustion System (CCS) with the Thermostatically-Controlled Air Cleaner, still used on most '68 through '73 cars. Since the current versions of these devices are essentially the same as those described in Manual I, no further explanation of their operation will be covered in this Manual.

In Emission Control Service Part No. II, you were introduced to the Air Injector Reactor System (AIR), that helps complete the burning of any fuel leaving the combustion chamber, by injecting air into the exhaust manifold. Again, since the AIR devices used on '68 through '73 cars are essentially the same as those described in Manual II, no further explanation of AIR will be covered in this Manual.

In addition, Manuals No. I and II introduced you to some new devices added to the carburetor-distributor system which (1) controlled the position of the throttle stop (such as the idle stop solenoid) or (2) which modified the basic spark advance curve (such as the dual-action vacuum advance-retard control). While some of these devices are still used as described, others have been refined or combined into new systems. For this reason, the area of throttle stop and advance controls, as used on '68 through '73 cars, will be covered in detail.

This Manual will also cover two systems not previously described. These are the Evaporation Emission Control System (EEC), which prevents fuel vapors from the fuel tank and carburetor from being vented to the atmosphere, and the Exhaust Gas Recirculation System (EGR), which recycles a metered amount of exhaust gas back through the induction system.

To test your understanding of the material presented, an examination is included with this Manual. You are already familiar with these quizzes if you completed the previous two Manual examinations. From each of the three possible answers, select the one that you believe to be correct. Mark down your choice in the proper box on the answer card and drop the post paid card in the mail.

When you have successfully completed the examinations, you will receive a diploma which will assure your customers that you have received United Delco Power Service training in Emission Control Systems.

CURRENT APPROACHES TO EMISSION CONTROL

Before undertaking the detailed description of the various emission control systems and devices used on '68 through '73 domestic vehicles, let's take a moment to review, in general terms, the basic methods, currently used, to provide acceptable levels of hydrocarbon and carbon monoxide emission.

The basic feature of all current automotive engines is a specially-calibrated carburetor that mixes a larger amount of air with a given amount of gasoline. The resulting air-fuel mixture is leaner than was previously normal. In addition to the carburetor, all current engines use a Thermostatically-Controlled Air Cleaner (TAC), that insures that, after the first few minutes of engine operation, the air reaching the carburetor is warm regardless of outside temperature. The warmed air allows for leaner calibrations while retaining responsive engine operation in cold weather.

It's important to recognize some vital facts about today's leaner-mixture-burning engines:

1. The fact that a leaner mixture (less fuel per unit of air) is used is, by itself, no guarantee that there will be fewer exhaust emissions. The fact that today's leaner mixture engines use *more* fuel to produce comparable performance is proof that more fuel must be passing into the exhaust system in un- or partially-burned form, before releasing useful heat energy in the combustion chambers.

2. The fact is that leaner mixtures, even though they burn less efficiently in the combustion chamber, do lend themselves to an engine design that provides greatly improved fuel burning *in the exhaust manifold*, with the result that fewer unburned fuel emissions reach the atmosphere.

Consequently, some of the emission-control devices, currently used, are for the purpose of providing more complete burning of un- or partially-burned combustibles in the exhaust manifold. Let's take a closer look at how this works and why it is necessary.

LEAN MIXTURE EMISSION CONTROL

In today's automotive engines, there is not sufficient time, during the power and exhaust strokes, to allow all the fuel to burn completely within the combustion chamber. Some unburned fuel will escape into the exhaust, causing a potential emission problem.

With a normal mixture and spark advance, burning occurs relatively quickly and efficiently with most of the heat energy in the fuel converted into useful power. As a result, the gases exhausted into the exhaust manifold are relatively cool . . . so cool that there is insufficient heat to complete the burning of residual fuel in the exhaust system. This causes the high emission levels of normal engines.

With a lean mixture, burning is much slower, so when a normal spark advance is used, more unburned fuel escapes into the exhaust system. While the temperature of this gas is hotter than that of a normal mixture, it is still not hot enough to insure complete burning in the exhaust manifold.

Advancing the spark (to provide more burning time) does not solve the problem since this results in even colder exhaust temperatures as well as running the risk of damaging detonation. Instead, in current practice, the spark is retarded. While this results in a further drop in power efficiency, it does raise the exhaust temperature sufficiently high to insure relatively complete burning of any unburned fuel reaching the exhaust manifold, resulting in acceptably-low emission levels leaving the tail-pipe.

A comparatively-recent development, the Air Injection Reactor (AIR), further enhances this process by injecting additional air into the exhaust manifold to insure more complete burning of fuel residues.

LEAN MIXTURE DRIVEABILITY CONTROL

The great bulk of driving is done under steady speed conditions under which a retarded spark gives satisfactory driveability. However, under certain short-duration situations, the retarded spark can cause problems, such as hard starting, cold-engine stalling, poor acceleration.

To minimize these effects, some of the emission devices used on current engines are designed to improve driveability by providing a temporary spark advance, during these transient conditions. Some of these spark-advance devices may be actuated by low or very-high engine temperatures, low-gear or low-speed operation, time, or by low manifold vacuum. Although it's true that while these devices are operating emissions are increased, the total amount of such operations during a typical drive are sufficiently brief so that the total amount of emissions produced are held within acceptable limits.

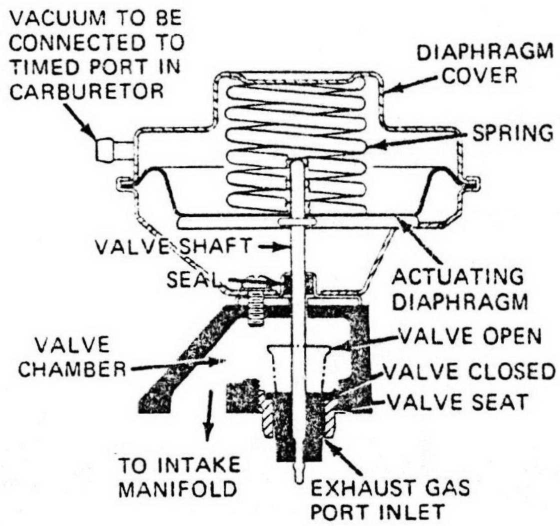
In the following discussion, we will cover just what type of lean-mixture emission and driveability controls are used on which cars, as well as how they operate.

EXHAUST GAS RECIRCULATION (EGR)

Most 1973 Models

The purpose of EGR is to reduce combustion temperatures, by diluting the incoming air-fuel mixture with small amounts of exhaust gases drawn from the exhaust manifold. The principle is that since exhaust gases have already been burned they can't be burned again, so their presence in the combustion chamber adds a cooling effect, reducing peak combustion temperatures.

The prime purpose of the EGR is to reduce the formation of oxides of nitrogen (NO_x) which occur most readily at high combustion temperatures.



BUICK EGR CONTROL VALVE

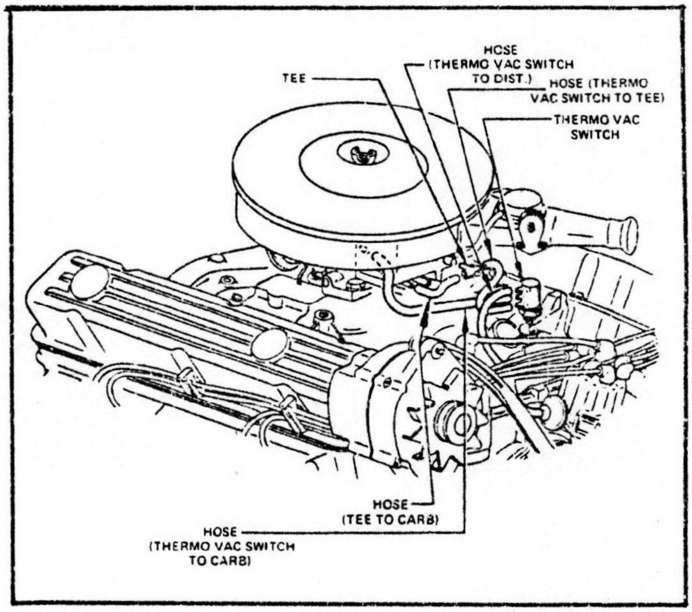
GENERAL MOTORS COMBUSTION CONTROL DEVICES ON 1968 AND LATER CARS

Thermostatic Vacuum Switch (TVS)

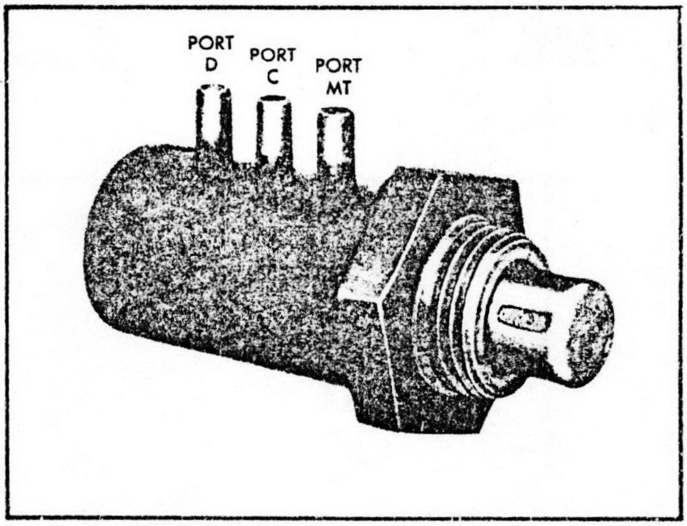
The retarded spark advance, used to insure most satisfactory combustion of lean mixtures, at low engine speeds, can cause overheating in prolonged idle or low speed conditions. To protect against overheating, many General Motors engines are equipped with a thermostatic vacuum switch (TVS); actually a valve that is located in the engine cooling jacket to control the vacuum spark advance system. While the TVS in later cars may be part of other GM control systems (TCS, SCS, CEC), its function is distinct.

One function of the TVS is to permit normal spark advance when the engine coolant exceeds a specified temperature level (235°F.). When this happens, the valve opens against spring pressure and allows intake manifold vacuum (through port "MT") to reach the distributor spark advance system (through port "D") advancing the spark, resulting in a faster idle for better fan cooling and less heat rejection into the cooling system.

A second function is to provide spark advance whenever the throttle is opened slightly above the idle position, at normal engine temperature. Opening the throttle slightly produces high vacuum at a port in the carburetor which is carried to the TVS at port "C", bypassing the spring-loaded valve, so the vacuum acts directly on the distributor spark vacuum advance through port "D". This is termed "Timed Spark". On 1968-1970 Air-conditioned Cadillacs, the TVS incorporates a fourth port, designated "FIP" (Fast Idle Port). This port is connected to a fast idle device, located on the carburetor, which is actuated by manifold vacuum, when the TVS valve is opened by high heat conditions.



TYPICAL GM TVS HOSE ROUTING

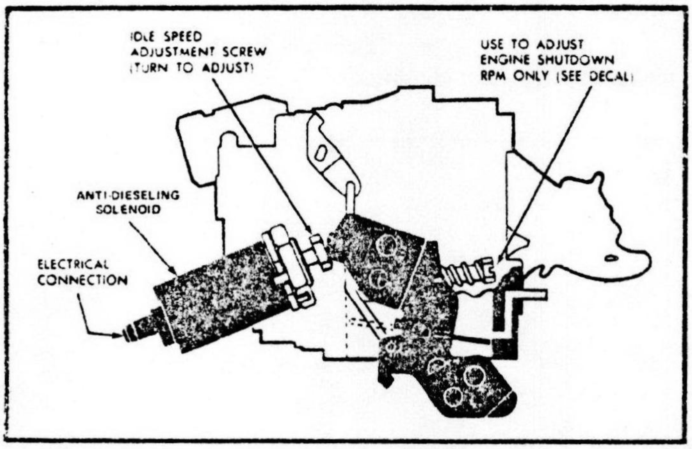


TYPICAL GM TVS VALVE

Anti-Dieseling Solenoid

One characteristic of engines designed for emission control is higher idle speed, often high enough to cause "dieseling" or "running on" of the engine after the ignition switch is turned off. To prevent this, a solenoid is incorporated into the idle stop. When the ignition switch is "on", the solenoid plunger moves out (energized) to provide a normal idle position. However, when the switch is turned "off", a spring returns the solenoid plunger to a position that permits an almost complete closing of the throttle plate, starving the engine to a stop.

Initially, the anti-dieseling solenoid was used only in engines most prone to dieseling. However, as emission control devices have become more effective and dieseling more common, the Anti-Dieseling Solenoid is now used on all Buicks, Cadillacs and Chevrolets, and most Oldsmobiles and Pontiacs.

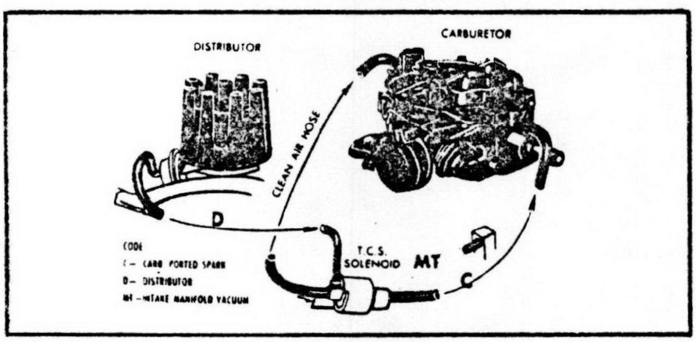


TYPICAL ANTI-DIESELING SOLENOID INSTALLATION

GENERAL MOTORS COMBUSTION CONTROL DEVICES AND SYSTEMS ON 1970 AND LATER CARS

Transmission Controlled Spark (TCS)

The TCS system prevents normal spark advance when the car is operating in the lower gears. In some cars, the system functions only when the engine is at normal operating temperatures. A greater throttle opening is required to achieve a given level of acceleration, thus improving mixture distribution and combustion emission efficiency. HC and CO emissions are reduced at low speeds.



1970 VERSION OF TCS SYSTEM

TCS Solenoid

The key element of the TCS system is a solenoid that, when energized, cuts off manifold vacuum to the spark advance system of the distributor. The solenoid is energized by a transmission switch that is normally closed when the transmission is in the lower gears.

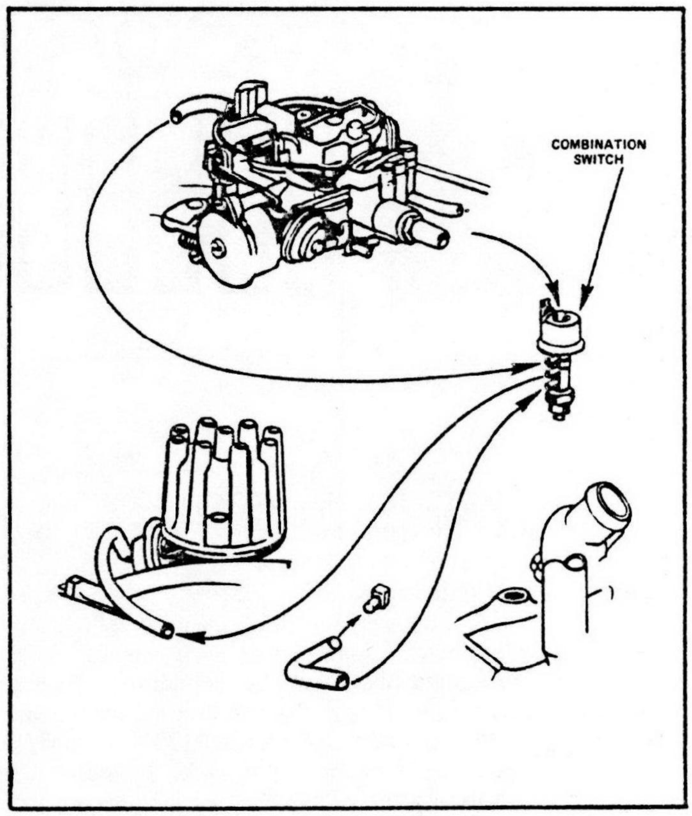
The switch is oil pressure operated on automatic transmission cars, mechanically operated on manual transmission cars. When the transmission is in "drive" or final gear, the transmission switch is open, de-energizing the solenoid and allowing normal spark advance.

On some models of General Motors cars, a temperature override switch, located in the engine block, is incorporated into the circuit which deactivates the solenoid (permitting normal advance) when the coolant is below or above certain temperatures, to improve cold-engine operation or improve engine cooling (see switch and relay circuit in illustration). On Cadillacs, some Buicks and Olds engines, the overheat protection is provided by a separate TVS valve.

GENERAL MOTORS COMBUSTION CONTROL DEVICES AND SYSTEMS ON 1971 AND LATER CARS

TVS-TCS Combination Switch

The TVS-TCS switch (sometimes called the distributor Vacuum Control Switch) was first used on some 1971 Olds engines. Essentially, it combines the functions of the TCS solenoid and the TVS valves into one block-mounted unit. The unit advances the spark whenever the transmission is in third or fourth gear, or whenever coolant temperature reaches blow-off temperatures (about 235°F.).

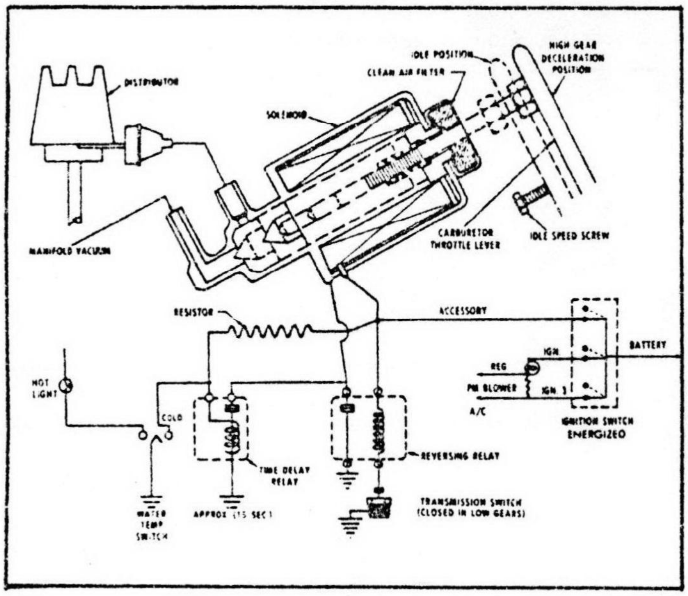


TVS-TCS COMBINATION SWITCH

As in the separate TVS valve, the source of vacuum for advancing the spark is from the intake manifold when temperature is in excess of 235°F. or a port in the carburetor throat above the throttle valves at normal engine temperatures.

Combined Emission Control (CEC)

The heart of the CEC system is a solenoid that provides two functions: A transmission-controlled spark advance (like TCS), and a two position throttle stop. The solenoid is controlled by four electrical units: a temperature override switch, a time-delay relay, and a transmission switch, working in conjunction with a reversing relay. Except Vega, the CEC system is used on all 1971 Chevrolets and 1972 six-cylinder Chevrolets and Pontiacs.



COMBINATION EMISSION CONTROL (CEC) SYSTEM

CEC Solenoid

While the CEC solenoid is similar to other GM TCS solenoids in that it permits spark advance only in final gears, it differs in one important aspect: When in lower gears, the solenoid is *de-energized* to cut off spark advance; in high gears the solenoid is *energized* to permit spark advance. This energize-de-energize pattern is just the *opposite* of that of other GM TCS systems.

Another distinction is that the plunger of the solenoid extends from the housing. When energized, the plunger is extended to provide a fast idle throttle position to improve emission control during high gear deceleration. When the solenoid is de-energized, the plunger retracts to allow the throttle lever to return to curb idle position (adjustable by a separate Idle Stop screw). Since the curb idle speed is relatively low, there is no tendency to diesel when turning the ignition switch off.

Transmission Switch and Reversing Relay

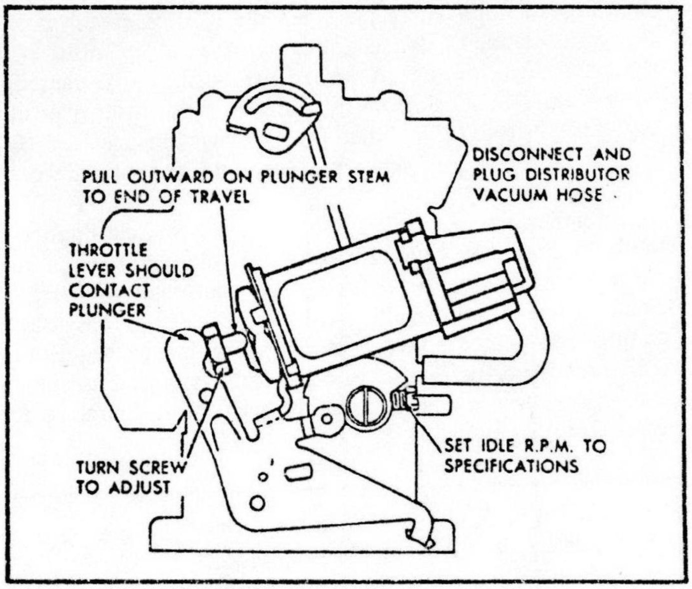
Although the CEC transmission switch is normally closed in lower gears (as in TCS systems), the switch energizes a reversing relay (instead of the solenoid). When energized, the relay *opens* the circuit to the solenoid and de-energizes it. Opening the transmission switch (high gear) de-energizes the reversing relay closing the circuit to the solenoid and *energizing* it.

Temperature Override Switch

The temperature switch includes a cold override feature which provides vacuum advance whenever coolant temperatures are below 80°F. On some high-performance engines, a hot override is also provided in the same switch.

Time-Delay Relay

The time-delay relay is energized from the ignition switch to provide 20 seconds of vacuum advance to improve hot-engine starting. When the engine is cold, the relay does not function, since current is by-passed into the closed cold override switch to ground.



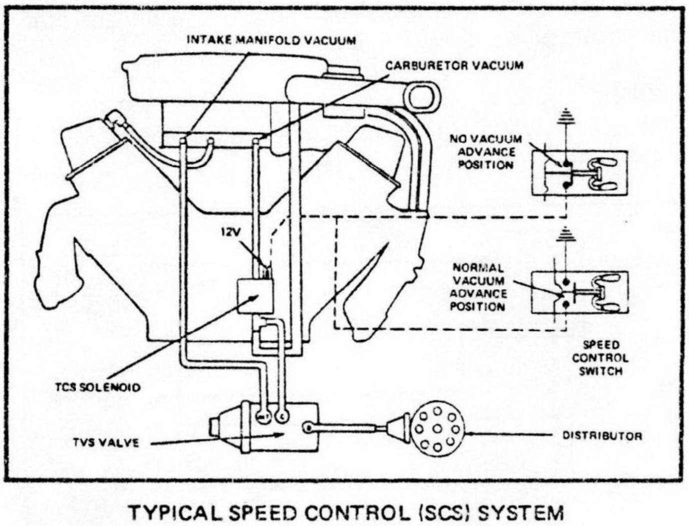
CEC SOLENOID ON CARBURETOR

GENERAL MOTORS COMBUSTION CONTROL DEVICES AND SYSTEMS ON 1972 AND LATER CARS

Speed Control Spark (SCS) System

The SCS system used on Cadillacs and some Pontiac models is similar in function to the TCS system. However, in place of the TCS's transmission switch, the SCS system uses a car speed sensing switch, mounted in the transmission or in series with the speedometer cable.

The SCS switch, controlled by centrifugal fly-weights, is normally closed and keeps the solenoid energized to prevent vacuum spark advance. When car speed reaches approximately 35 mph, the fly-weights spread, opening the switch, de-energizing the solenoid and permitting vacuum advance. However, on deceleration, car speed must fall below 25 mph before the switch closes, shutting off vacuum advance.

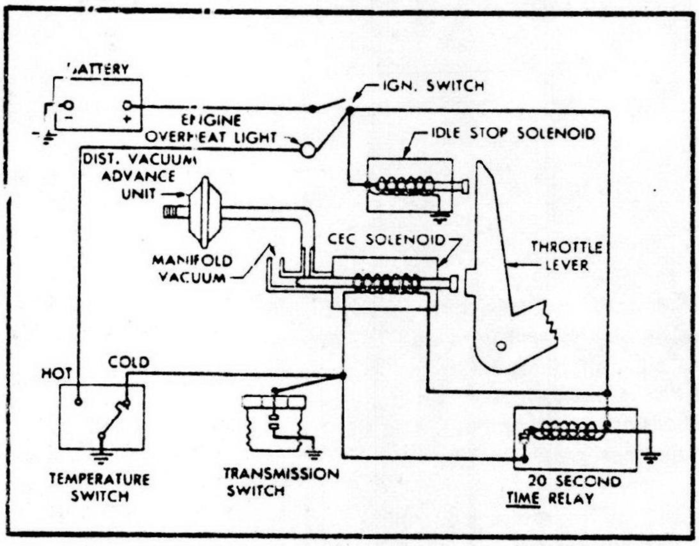


TYPICAL SPEED CONTROL (SCS) SYSTEM

Combined Emission Control (CEC) System

The CEC system used on 1972 Chevrolet and Pontiac Six engines differs somewhat from the 1971 version of CEC. In '72, the solenoid plunger, when energized in high gear (giving vacuum advance) still extends to provide a fast idle throttle stop position. However, when the plunger is de-energized (low gear), the curb idle position is provided by a separate anti-dieseling solenoid (energized when the ignition switch is on – plunger extended). When the anti-dieseling solenoid is de-energized (ignition switch turned off – plunger retracted), a more complete closing of the throttle plate insures positive shut-down. Note, then, that the CEC system provides *three* throttle stop positions: Fast idle, curb idle, and shut-down.

Another feature of the '72 CEC system is the elimination of the reversing relay. The CEC vacuum advance solenoid is energized by grounding a normally-open transmission switch (in place of the '71 normally-closed switch which was used in conjunction with the reversing relay). This insures retention of a characteristic distinctive to Chevrolet systems: the solenoid is *energized* to provide vacuum advance (not de-energized as in other GM systems).



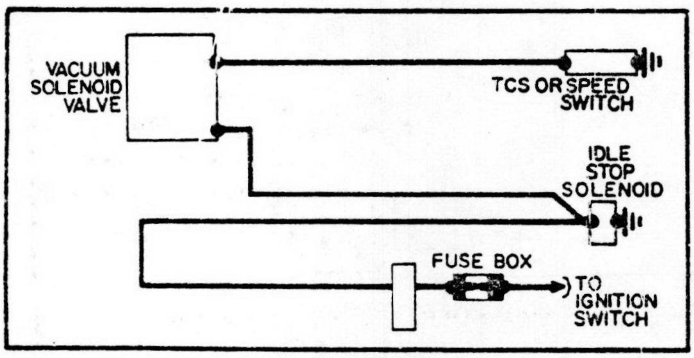
CEC ELECTRICAL DIAGRAM (1972)

TCS and SCS Systems

All other 1972 General Motors cars use a TCS or SCS system in which the vacuum advance solenoid is essentially the same as in previous years: Energizing the solenoid prevents vacuum advance (except Chevrolet V-8s). However, there are other component and circuit differences.

Cadillac

Cadillac uses a SCS system with temperature factors handled by a separate TVS valve.



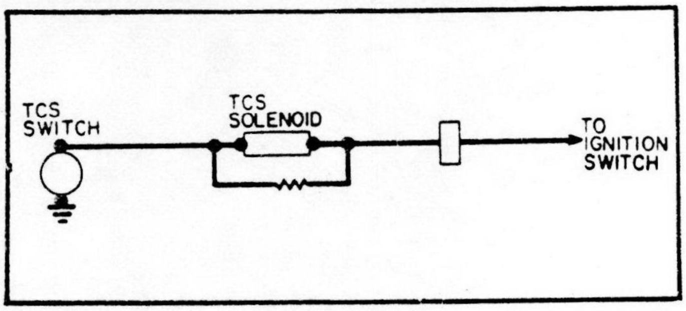
CADILLAC SCS CIRCUIT

Buick

The Buick uses a TCS system. Temperature factors on some engines are handled by a separate TVS valve.

Olds

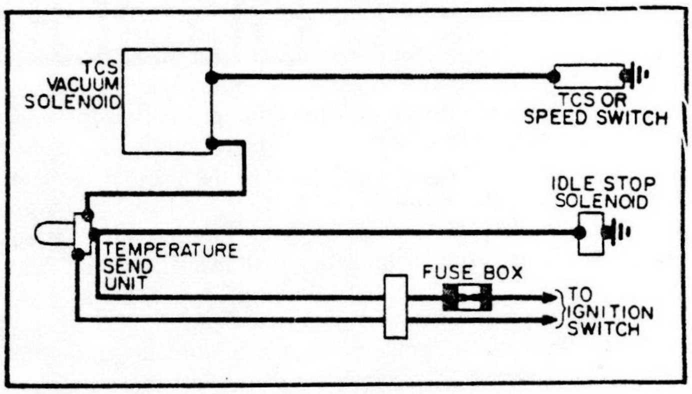
The Olds uses a TCS system. Temperature factors on all engines (except 350 V-8 with manual transmission) are handled by the TVS valve which is an integral part of the vacuum advance solenoid (TCS-TVS Combination Switch). An anti-dieseling solenoid is used on *most* engines.



OLDS TCS CIRCUIT
(ENGINES WITHOUT ANTI-DIESELING SOLENOID)

Pontiac V-8

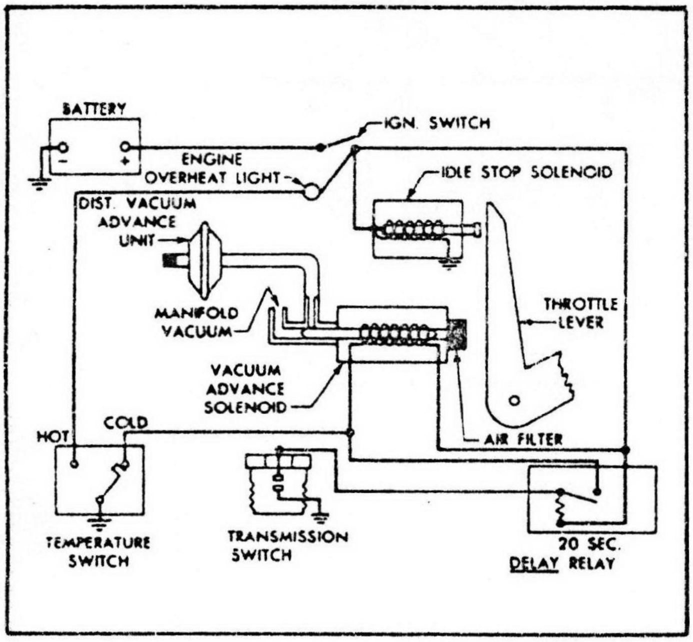
All Pontiac V-8s (except those with 4-speed or 307 C.I.D. engine) use a SCS system. Those with 4-speed or 307 C.I.D. engine use a TCS system. Temperature factors are handled by a temperature hot/cold override switch, controlling the vacuum advance solenoid. In addition, 307 engines (TCS system) incorporate a TCS delay relay which delays vacuum advance when the car is shifted into high gear for a period of 20 seconds. This requires a greater throttle opening to achieve a given level of acceleration. Mixture distribution and combustion efficiency are improved thereby reducing HC and CO emissions at low engine speed. An anti-dieseling solenoid is used only on 307 and 4-barrel carburetor engines.



PONTIAC TCS AND SCS CIRCUIT
(ENGINES WITHOUT ANTI-DIESELING SOLENOID)

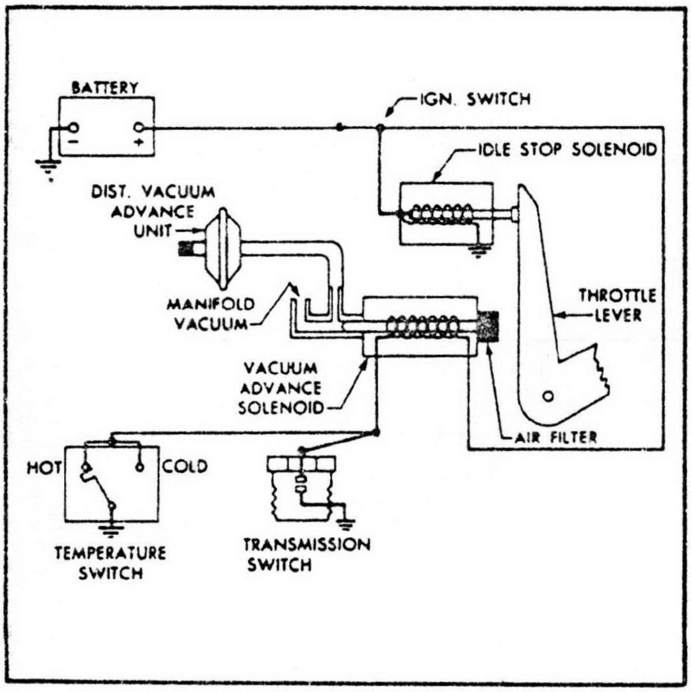
Chevrolet V-8

The Chevrolet V-8 uses a TCS system in which the vacuum advance solenoid is *energized* to provide spark advance. All use a normally-open transmission switch, an anti-dieseling solenoid, and a hot/cold temperature switch. On Corvette engines, the temperature switch provides both hot and cold override of the transmission switch to provide vacuum advance, regardless of gear position. On other Chevrolet engines, only cold override is provided, with the hot switch serving only to light an engine overheat light on the instrument panel. In addition, all small-block V-8s incorporate a 20-second delay of vacuum advance when the transmission is shifted to high gear. The TCS delay relay is normally open.



1972 SMALL-BLOCK CHEVROLET
TCS DIAGRAM

Temperature switch wiring is typical of all Chevrolet (small block and big block) V-8s. TCS delay relay is typical of all small block Chevrolet and Corvette V-8s.

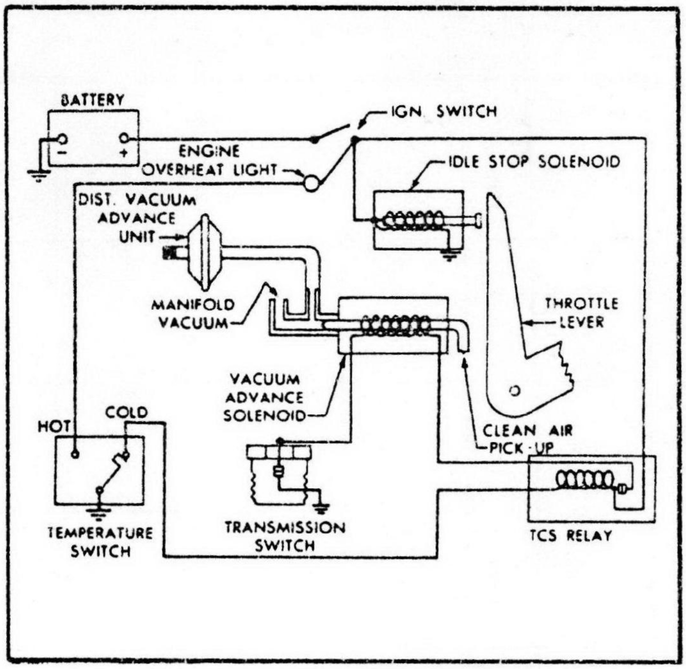


1972 BIG BLOCK CORVETTE
TCS DIAGRAM

Temperature switch wiring is typical of all Corvette engines. Also big block engines do not use a TCS delay relay.

Vega

The 1971-72 Vega TCS system is similar to that of the small block Chevrolet V-8, except that the transmission switch and the TCS relay are *normally closed.* This means that when the TCS solenoid is energized (in low gears) it *prevents* vacuum advance of the spark.

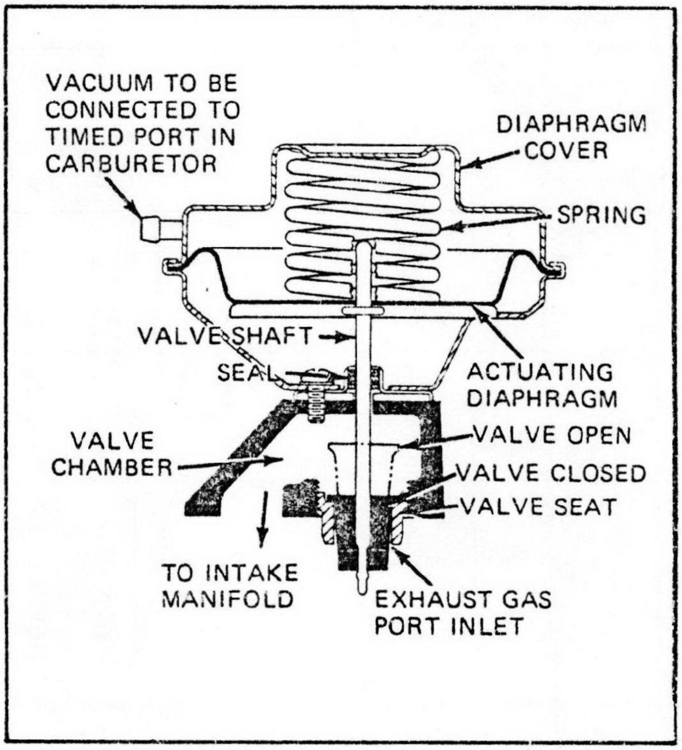


1972 VEGA TCS DIAGRAM

EGR System

This system is used on all 1973 General Motors cars and light duty trucks (except Chevrolet-Luv) and all 1972 California and manual transmission Buicks.

In this system, exhaust gases are recirculated to reduce peak combustion temperatures and lower the formation of oxides of nitrogen (NO_X). Control is provided by the EGR valve which is responsive to vacuum above the carburetor throttle valve (ported vacuum). Since the valve doesn't start to open until approximately 3" of vacuum has developed, exhaust gas recirculation which would cause rough idle is prevented at idling speeds.



EGR CONTROL VALVE

1972 GM COMBUSTION CONTROL EQUIPMENT

1972	A.I.R.	THERMAC AIR CLEANER	ANTI-DIESEL SOLENOID	TVS	TCS SOLENOID	TVS-TCS COMB. VALVE	SCS	TEMP OVERRIDE SWITCH HOT	TEMP OVERRIDE SWITCH COLD	CEC WITH DELAY AFTER START	TCS-SCS DELAY AFTER UPSHIFT
BUICK	All Calif., All 455, All MT	All	All	350 AGS with A/C; 350 MT with A/C or HD Cool; 455 AGS, GS, STG-1	350 Ex. A/C, HD Cool; 350 AGS with A/C; 455 AGS, GS, STG-1	350 Auto A/C Ex. AGS with A/C; 455 Ex. AGS, GS, STG-1					
CADILLAC	All	All	All	All			All				
CHEVROLET	Vega: All Calif. engines and RPO L11, L53, L55, LT1 and Z-28	All Ex. Z-28, Corvette and some light duty truck L-6 engines	All		All			All	All	All 6 Cyl.*	307, 350, 400
OLDSMOBILE		All	350-2 Bbl., 455-MT, Toro & W-30		350-MT Ex. A/C HD Cool	All Ex. 350 MT					
PONTIAC	All 6 cyl. Calif.	All	All V-8 with 4 Bbl. & 307		All 4 SP & 307		All V-8 Ex. 4 SP & 307	All	All	All 6 Cyl.*	307

AGS - Special Grand Sport
CEC - Combined Emission Control
* has delay after start
EGR - Exhaust Gas Recirculation
GS - Grand Sport
L11: 140 CID, 90 HP
LS3; 402 CID, 140 HP
LS5; 454 CID, 270 HP
LT-1, Z-28 - 255 HP, 350 CID in Corvette, Camaro
MT - Manual Transmission
SCS - Speed Control Spark
STG-1 - Stage 1 Option
TCS - Transmission Control Spark
TVS - Thermal Vacuum Switch
W-30 - Air Induction 455 CID

1971 GM COMBUSTION CONTROL EQUIPMENT

1971	THERMAC AIR CLEANER	A.I.R.	ANTI DIESEL SOLENOID	T.V.S.	T.C.S. SOLENOID	T.V.S.-T.C.S. COMB VALVE	T.C.S. TEMP. OVERRIDE HOT	COLD	C.E.C.
BUICK	All		(Some models) All V-8 All L-6 Throttle Cracker on V-8 manual trans.	All 350 with A/C or H.D. cooling. All455 with auto. trans.	All				
CADILLAC	All	All	All	All	All				
CHEVROLET	All engines ex-cept those equipped with open element air cleaner	All engines equipppd with open element air cleaner	(part of C.E.C. solenoid)		(part of C.E.C. solenoid)		Camaro with LS3 (402) and also auto. trans. and A/C. Base Corvette with A/C & auto. trans. Corvette w/LS5 & A/C & auto. trans.	All	All
OLDSMOBILE	All		All 6 Cyl.		All 350 with man. trans. w/o A/C or H.D. cooling	All V-8 ex-cept 350 man. trans. w/o A/C or H.D. cooling		6 cyl.	All 6 cyl.
PONTIAC	All		455 HO engine	455 HO engine	All 350, 400 & 455 V-8 except 455 HO		230°F.	85° F.	All 250 6 cyl. All 307 V-8

1970 GM COMBUSTION CONTROL EQUIPMENT

1970	THERMAC AIR CLEANER	A.I.R.	ANTI DIESEL SOLENOID	T.V.S.	T.C.S. SOLENOID	T.C.S. TEMP. OVERRIDE HOT	COLD
BUICK	All		L-6	All 455 & 350 upper series. All with auto. trans.	L-6 & 455		
CADILLAC	All			All	All		
CHEVROLET	All engines except 153 4 cyl. and engines with open element air cleaner	All 153 4 cyl. and engines with open element air cleaner	All engines		All	<u>Chevelle</u> <u>Camaro</u> All V-8 auto. trans. with A/C, all Mark IV. <u>Chevrolet</u> All V-8 auto. trans. except Base 350 w/o A/C. <u>Nova</u> All except LS-7 <u>Corvette</u> All V-8 auto. trans. with A/C <u>Monte Carlo</u> All V-8 auto. trans. with A/C, LF-6 with auto. trans., all Mark IV.	All
OLDSMOBILE	All		All 6 cyl.	All 350 with A/C or H.D. cooling. All 455 with A/C or H.D. cooling except W30 with man. trans.	All		6 cyl.
PONTIAC	All		All 250 6 cyl., 400 V-8 and Ram Air IV engines		All	V-8 220° F. 6 cyl. 225° F.	V-8 85°F 6 cyl. 82°F.

1969 GM COMBUSTION CONTROL EQUIPMENT

1969	THERMAC AIR CLEANER	A.I.R.	ANTI DIESEL SOLENOID	T.V.S.
BUICK	All		L-6	All 400, 430 engines and 350 upper series cars. All with auto. trans.
CADILLAC		All 472		All 472 with A/C
CHEVROLET	Chevrolet, Chevelle, Chevy II & Camaro with auto. trans. (except HPO L34 & RPO L35)	Corvair (all) Corvette (all) Chevrolet, Chevelle, Chevy II & Camaro with man. trans. & all RPO L34 (396, 350 H.P.) & Camaro RPO L35 (396,325 H.P.)	(idle stop) All 6 cyl. with Power-glide	
OLDSMOBILE	All		350 w/ 2 Bbl. carb. All 6 cyl.	All 350 with A/C or H.D. cooling. All 400 (except W30). All 455 w/A/C or H.D. cooling. All Toronado
PONTIAC	All		400 V-8 Ram Air IV engines	All V-8

1968 GM COMBUSTION CONTROL EQUIPMENT

1968	THERMAC AIR CLEANER	A.I.R.	ANTI DIESEL SOLENOID	T.V.S.
BUICK	All V-8 All L-6 with auto. trans.		All L-6	All 400, 430 cars & 350 upper series; all with auto. trans.
CADILLAC		All 472		All 472 with A/C
CHEVROLET	Chevrolet, Chevelle, Chevy II & Camaro w/auto. trans. (except RPO L34 & Camaro RPO L35 & engines with open element air cleaner.)	Corvair (all) Corvette (all) Chevrolet, Chevelle, Chevy II & Camaro w/man. trans. & all RPO L34 (396, 350 H.P.) & Camaro RPO L35 (396, 325 H.P.) & engines with open element air cleaner	All 6 cyl. w/Power-glide	
OLDSMOBILE	All		All 6 cyl. All 350 with 2 Bbl. carb.	All 350 with A/C or H.D. Cooling. All 400 w/2 Bbl. Carb. & A/C. All 400 w/4 Bbl. carb. (except W-30) All 455 with A/C or H.D. cooling All Toronado
PONTIAC	All		All	All V-8

FORD MOTOR COMPANY COMBUSTION CONTROL DEVICES AND SYSTEMS ON 1968 AND LATER CARS

The three major combustion control devices used by Ford Motor in the period from '68 to '72 are:

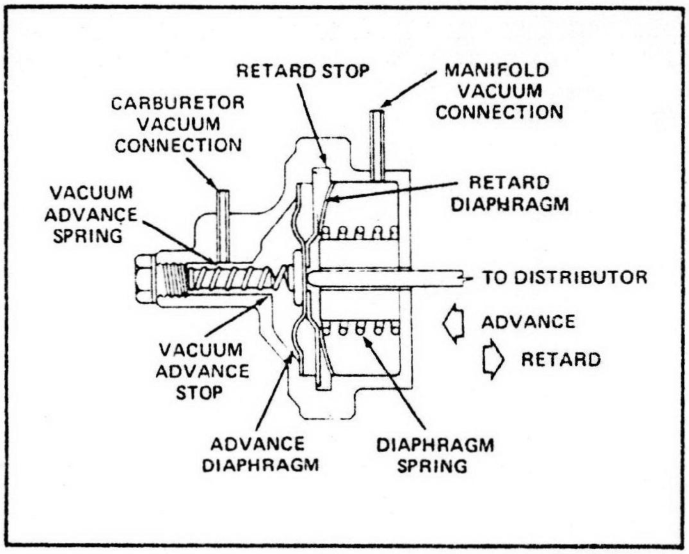
1. A dual-diaphragm vacuum-advance mechanism at the distributor;
2. A distributor vacuum control valve (sometimes referred to as the PVS valve); and
3. A distributor vacuum advance control valve (sometimes referred to as a deceleration valve)

With few exceptions, one or more of these devices will be found on all '68 through '72 Ford Motor cars. When the devices are used with an air injection system, the system is called a Thermactor system. Without air injection, the system is called an IMCO (Improved Combustion) system.

Dual-Diaphragm Vacuum-Advance Mechanism

With this mechanism, control of spark advance is provided by two independent diaphragms which work in opposition to each other.

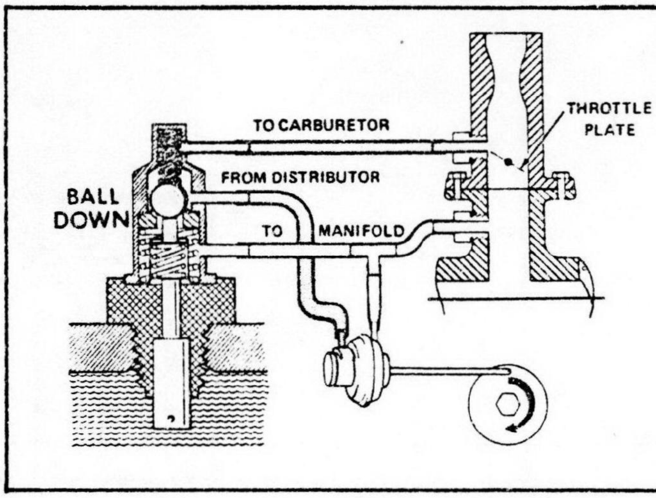
The advance (primary) diaphragm uses carburetor vacuum to provide a conventional advance-retard curve when the throttle is not closed. The retard (secondary) diaphragm uses intake manifold vacuum which overpowers the primary diaphragm vacuum from the carburetor under closed-throttle deceleration or idling. This extra retard position provides better and more complete combustion by starting ignition approximately 12 degrees later than the normal retard position of the primary diaphragm.



DUAL-DIAPHRAGM VACUUM ADVANCE MECHANISM

Distributor Vacuum Control Valve

This unit provides the same basic function of the General Motors TVS valve, namely spark advance when the engine reaches an overheat condition, such as caused by prolonged idling. The advance increases idling speed to increase fan cooling. The Ford unit differs in that it uses a ball valve (instead of a sleeve valve). It acts directly on the primary diaphragm in dual-diaphragm distributors or the diaphragm in single-diaphragm distributors.



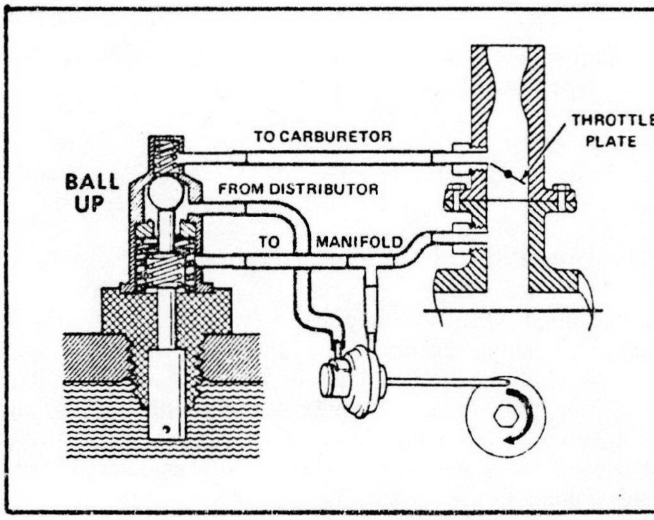
DISTRIBUTOR VACUUM CONTROL VALVE (WITH DUAL-DIAPHRAGM) NORMAL TEMPERATURE CONDITION-SPARK RETARDED

Distributor Vacuum Advance Control Valve (Deceleration Valve)

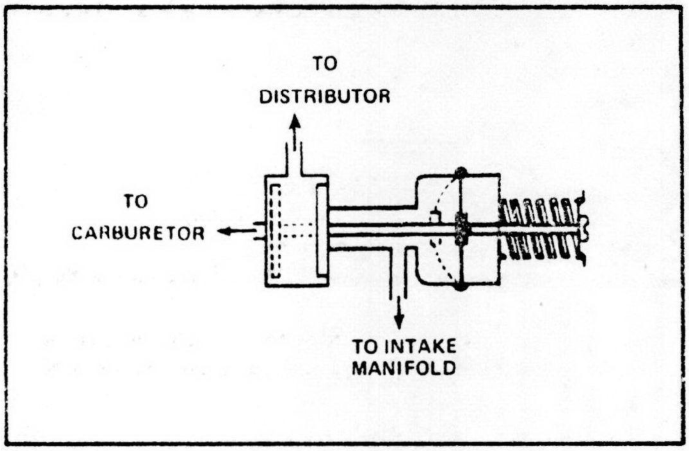
This unit is designed to provide acceptable high-speed closed-throttle deceleration characteristics. Under the conditions when high engine speed and a retarded spark are present, there is the likelihood of popping or backfiring in the exhaust manifold. This is especially likely when a dual-diaphragm vacuum advance mechanism is used which provides an extreme retard position. Accordingly, the deceleration valve is used only when an engine is equipped with a dual-diaphragm vacuum advance and a PVS valve, as well. In operation during closed-throttle deceleration, manifold pressure is high enough to overcome spring pressure causing the valve to open, allowing manifold vacuum to reach the distributor for normal spark advance.

On small-displacement engines, the output from the deceleration valve is routed directly to the primary diaphragm of the dual-diaphragm vacuum advance mechanism.

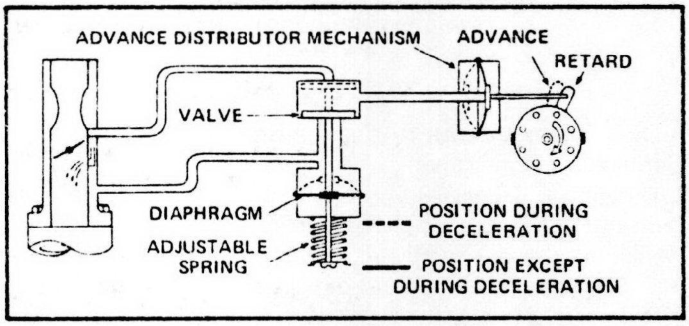
On high-displacement engines, it is customary to route the deceleration valve output to the vacuum advance control valve instead of directly to the distributor.



DISTRIBUTOR VACUUM CONTROL VALVE (WITH DUAL-DIAPHRAGM) OVERHEAT CONDITION-SPARK ADVANCED



DISTRIBUTOR VACUUM ADVANCE CONTROL VALVE (DECELERATION VALVE)



DECELERATION VALVE DIAGRAM (LOW-DISPLACEMENT ENGINE)

FORD MOTOR COMPANY COMBUSTION CONTROL DEVICES AND SYSTEMS ON 1970 AND LATER CARS

Distributor Modulator System (DMS)

The DMS is similar in function to the GM-SCS system, in that it prevents spark advance below certain speeds, during acceleration and deceleration.

The DMS consists of the following:

- An electronic speed sensor;
- An electronic amplifier and solenoid valve; and
- A thermal switch

In addition, the DMS makes use of the engine's PVS (positive ventilation system) valve.

Speed Sensor

The sensor is a miniature generator connected to the speedometer cable. Voltage output increases with car speed.

Electronic Control Modulator (Amplifier) and Solenoid Valve

The solenoid, when de-energized, prevents spark advance (no vacuum reaching distributor diaphragm). When car speed reaches 23 mph, the speed sensor produces enough voltage, when amplified, to energize the solenoid, permitting carburetor vacuum to reach distributor diaphragm for normal spark advance. Slowing the car below 18 mph de-energizes the solenoid to provide spark retard.

Thermal Switch

This switch, located on the front door hinge pillar, is closed when outside air temperature is below 58°F, energizing the solenoid to provide normal spark advance regardless of car speed.

PVS Valve

On some installations the vacuum line from the solenoid to the distributor is routed through the PVS valve (or distributor vacuum control valve). With this layout, engine overheat conditions permit intake manifold vacuum (instead of carburetor vacuum) to reach the advance diaphragm, increasing spark advance to provide a higher idling speed.

FORD MOTOR COMPANY COMBUSTION CONTROL DEVICES ON 1971 AND LATER CARS

Pinto Decel Valve

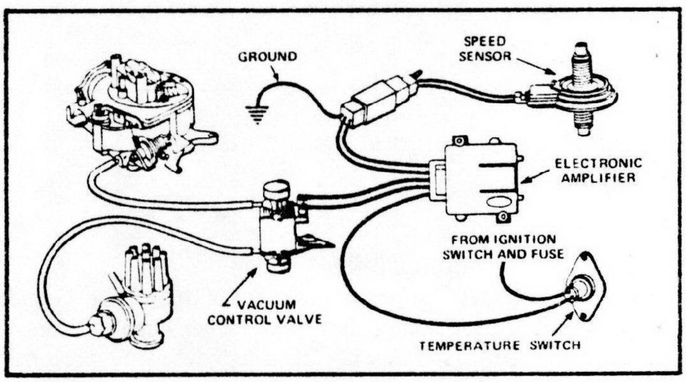
This unit, not to be confused with the Distributor Vacuum Advance Control Valve (or deceleration valve) is used on the Pinto engine only. Instead of advancing the spark or opening the throttle plate during deceleration (as the GM CEC solenoid does), the decel valve supplies additional fuel-air mixture to the engine (by-passing the carburetor fuel-air delivery) during deceleration. When actuated, the valve prevents popping or backfiring in the exhaust manifold. The unit is mounted on the intake manifold and is actuated by a diaphragm responsive to manifold vacuum.

FORD MOTOR COMPANY COMBUSTION CONTROL DEVICE AND SYSTEMS ON 1972 AND LATER CARS

Electronic Spark Control (ESC)

The ESC system is a refinement of the DMS system used on some '70 and '71 Ford products. The major differences are:

1. The electronic control modulator (amplifier) may have one of four-pre-set energizing speeds and are color-coded accordingly.
   Black cuts in at 23 mph
   White cuts in at 28 mph
   Blue cuts in at 33 mph
   Green cuts in at 35 mph
   All modulator-amplifiers cut-out (open circuit to solenoid) when speed drops below 18 mph.
2. The modulator-amplifier is not separate from vacuum control solenoid valve.
3. The thermal switch is in series with the primary energizing lead to the system, so system is completely de-



TYPICAL 1972 ESC SYSTEM
A PVS valve (not shown in this example), may be installed in series with the vacuum line from the solenoid to the distributor to provide overheat control.

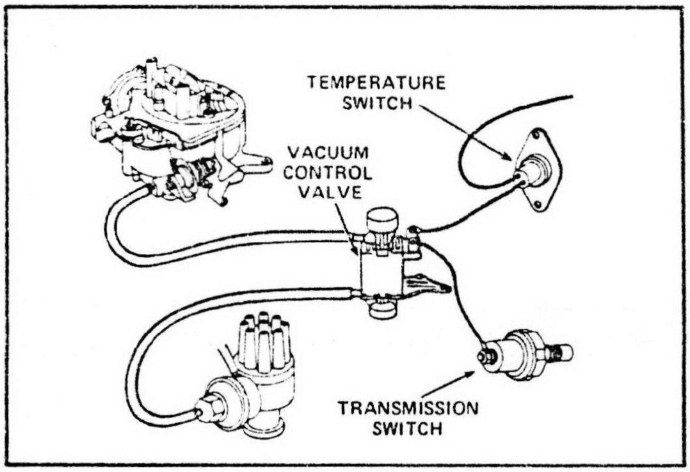
energized (thermal switch open) when outside air temperatures are below 60°F.

Transmission Regulated Spark (TRS) Control System

The TRS system is similar in function to the GM TCS system in that it prevents spark advance when the car is operating in lower gears. However, it differs in that it allows normal spark advance when the outside air temperature is below a certain temperature (not when engine coolant temperature is below a certain temperature as in the GM TCS system).

It differs from the Ford ECS system in that the ECS's speed sensor and amplifier are replaced with a transmission switch which completes the system's circuit to ground when the transmission is in lower gears or "Neutral" (manual transmissions), or, with automatic transmissions, when there is no hydraulic servo pressure in third or reverse.

Like the ECS system, the thermal switch is wired in series to the primary energizing lead to the system. Therefore, when this switch is open (air temperature below 60°F.) the system is de-energized, permitting spark advance.



TRS SYSTEM

On some TRS installations, a Spark Delay Valve may be used in the vacuum line between the distributor primary diaphragm and the carburetor port. It is a combination air restrictor and check valve that slows down the draining of air from the primary diaphragm (delaying spark advance), but offers little restriction when air is draining back into the diaphragm (fast spark retard).

The delay function occurs only during mild accelerations from idle to 16 mph when carburetor vacuum is high.

FORD MOTOR COMBUSTION CONTROL EQUIPMENT

During 1968 through 1971 Ford built "Thermactor" (exhaust air injection) and "IMCO" (IMproved COmbustion with air injection) engines. No '72 engines used air injection.

1972

Thermostatic Air Cleaner: All engines.

Transmission-Regulated Spark (TRS): All manual transmission Sixes and V-8 , except 240 1-bbl and 351 2-bbl.

Speed Regulated Spark (Using speed sensor): Automatic transmission 240 Six and 351 V-8 (except HO).

Electronic Spark Control (ESC): All other auto-trans. engines.

Dual-diaphragm distributor, Distributor Vacuum Control valve, or Distributor vacuum advance control valve: some engines (6 & V-8).

Decel Valve: All Pinto engines.

1971

Thermostatic Air Cleaner: All engines.

Thermactor: 302 Boss, 429 Super Cobra, 460.

IMCO: Other Sixes and V-8s, Pinto 4.

Electronic Distributor Modulator: Most Sixes and V-8s with automatic transmissions.

Dual-diaphragm distributor, Distributor Vacuum Control or **Distributor vacuum advance control valve:** Some 6 & V-8 engines.

Decel valve: All Pinto engines.

1970

Thermostatic Air Cleaner: All engines.

Thermactor: 302 Boss, 428 Police and Cobra Jet, 460.

IMCO: All Sixes, 302 & 429 (Exc. high perf.) 351 "C" & "W", 390.

Electronic Distributor Modulator: 240, 302 std., 351 4-bbl, 390 with AT.

Dual-Diaphragm distributor, Distributor vacuum control valve, or **Distributor vacuum advance control valve:** Some 6 & V-8 engines.

1969

Thermostatic Air Cleaner: All IMCO and some Thermactor engines.

Thermactor: 428 Cobra Jet and 427.

IMCO: All other engines.

Dual-Diaphragm Distributor, Distributor vacuum advance control valve, or **Distributor vacuum control valve:** Various combinations used on all engines.

1968

Thermostatic Air Cleaner: All IMCO and some Thermactor engines.

Thermactor: All manual transmission engines, 427 with auto.

IMCO: All other automatic transmission engines.

Dual-Diaphragm Distributor, Distributor vacuum control valve, or **Distributor vacuum advance control valve:** Various combinations used on all engines (exc. 427 AT)

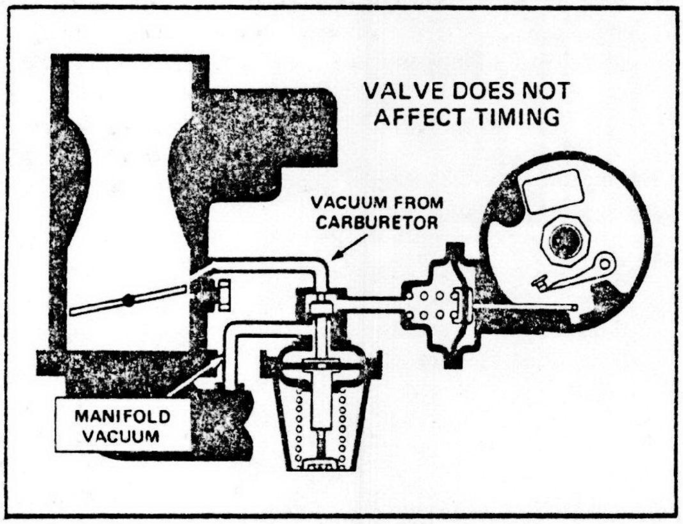
CHRYSLER CORPORATION COMBUSTION CONTROL DEVICES ON 1968 AND LATER CARS

Vacuum Control Valve

This unit, used on some engines, is similar to the Ford distributor vacuum advance control valve (deceleration valve) and performs the same function: Provides vacuum spark advance, during conditions of closed-throttle deceleration to eliminate popping and backfiring in the exhaust manifold.

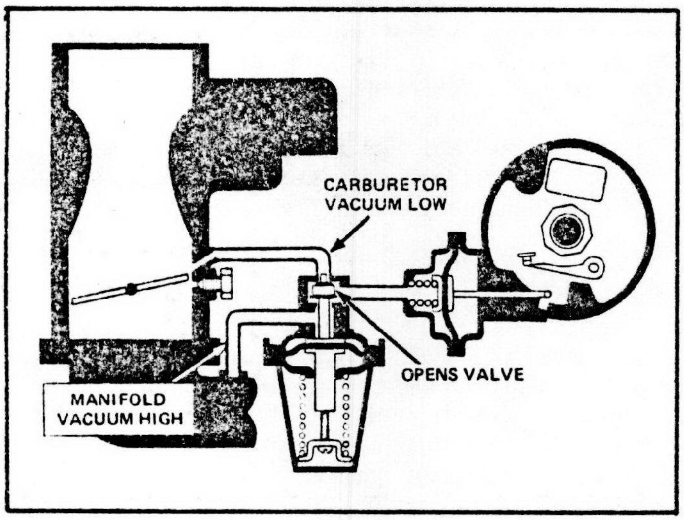
During idling there is little manifold vacuum so spring pressure keeps the valve closed, allowing carburetor vacuum to reach distributor. Since this vacuum is weak at idling, there is no vacuum advance.

During acceleration and steady speed, manifold vacuum remains weak, so spring pressure keeps the valve closed. High carburetor vacuum reaches the distributor, providing vacuum advance.



VACUUM CONTROL VALVE,
IDLING CONDITION

During closed-throttle deceleration, manifold vacuum is high, overcoming spring pressure and opening the valve allowing manifold vacuum to reach distributor to advance the spark.



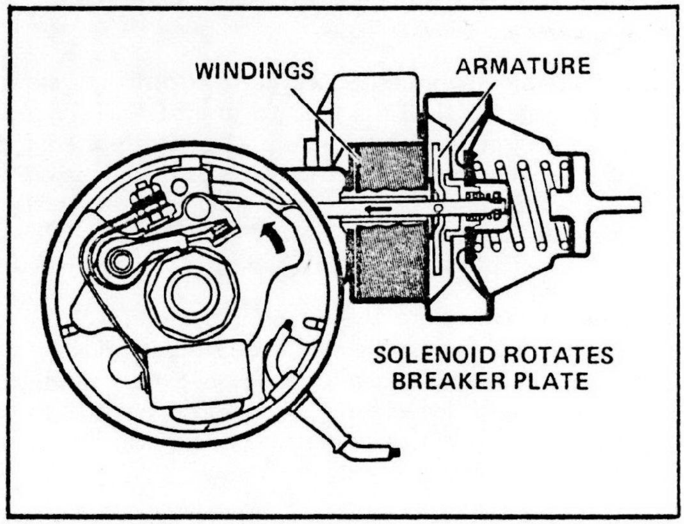
VACUUM CONTROL VALVE,
CLOSED-THROTTLE
DECELERATION CONDITION

CHRYSLER CORPORATION COMBUSTION CONTROL SYSTEMS AND DEVICES ON 1970 AND LATER CARS

Distributor Solenoid (Or Distributor Modulator)

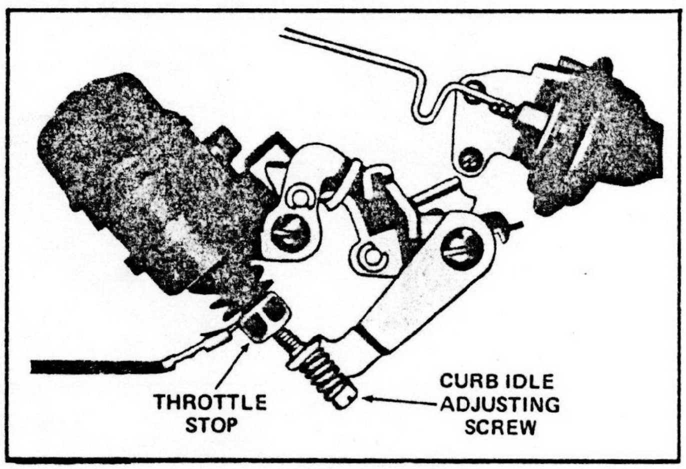
This system, used on high-displacement V-8s, consists of a solenoid, located on the distributor between the advance diaphragm and breaker plate, energized by a grounding switch incorporated in the throttle or idle stop at the carburetor. A new "fast curb idle" adjustment screw is also incorporated at this point.

The system permits the use of a higher-than-normal advance curve to provide easier starting and better highway performance, since it introduces a greatly-retarded spark at curb idle (for reduced emission) when the solenoid is energized by the throttle stop switch.



DISTRIBUTOR SOLENOID

The Distributor Modulator system is used with a throttle stop solenoid (see Throttle Stop Switch illustration). This is identical in function and operation to the GM anti-dieseling solenoid.



THROTTLE STOP SWITCH
(ON CARBURETOR)

CHRYSLER CORPORATION COMBUSTION CONTROL DEVICES AND SYSTEMS ON 1971 AND LATER CARS

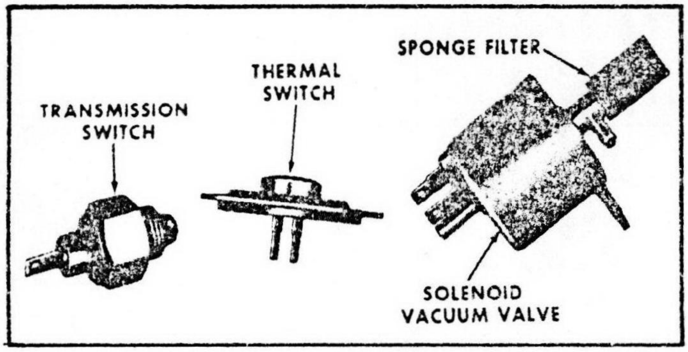
Chrysler NO_x System

Starting in 1971 Chrysler introduced devices to reduce nitrogen oxide emissions on cars for sale in California. In addition to a higher-overlap camshaft and a lower (185°F.) coolant thermostat, the system features a transmission-controlled or speed-controlled spark.

Transmission Controlled Spark System (Manual Transmission Cars)

This system is very similar to the Ford TRS system, in that it uses (1) distributor vacuum solenoid control valve which, when energized, prevents carburetor vacuum from reaching the distributor and advancing the spark. The solenoid is controlled by (2) a thermal switch which closes when air temperature is above 70°F. and (3) a transmission switch which closes when the transmission is in lower gears. Thus the solenoid is energized to prevent normal advance only when the car is in a lower gear with temperatures above 70°F.

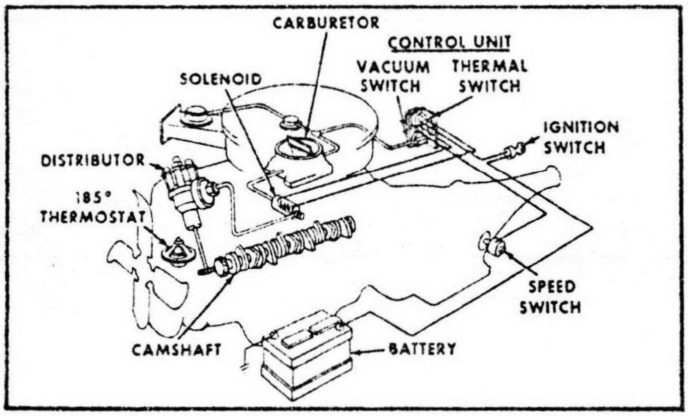
With this unit the thermal switch is used ony on early production cars and is located in the plenum chamber.



CHRYSLER MANUAL TRANSMISSION
TCS COMPONENTS

Speed Controlled Spark System (Automatic Transmission Cars)

In this system, vacuum advance is cotrolled by car speed, air temperature and, in some cases, coolant temperature. It consists of a distributor vacuum solenoid control valve, a control unit assembly (which contains a vacuum switch and a thermal switch), and a speed switch.



CHRYSLER AUTOMATIC TRANSMISSION
SCS DIAGRAM

Solenoid Control Valve

This unit is identical to that used in the TCS system. When energized it prevents carburetor vacuum from reaching the distributor advance diaphragm.

Speed Switch

This unit, mounted at the transmission or at the mid-point of the speedometer cable, is closed at speeds below 30 mph (energizing) and open (de-energizing) at speeds above 30 mph. It is wired to the control unit assembly.

Control Unit Assembly

The assembly contains a thermal switch which is closed at air temperatures above 70°F, open when temperatures are below 70°F. Output from the thermal switch and speed switch feed into the assembly's control module, which, in turn, energizes or de-energizes the solenoid control valve.

In addition, the assembly includes a vacuum switch which is controlled by manifold vacuum. During periods of acceleration, when manifold vacuum is low, the switch closes, energizing the solenoid valve, through the control module, and preventing vacuum advance at the distributor.

From the above, it can be seen that the SCS prevents vacuum advance (1) when speed is below 30 mph, (2) when air temperatures are above 70°F, and (3) whenever the car is accelerating.

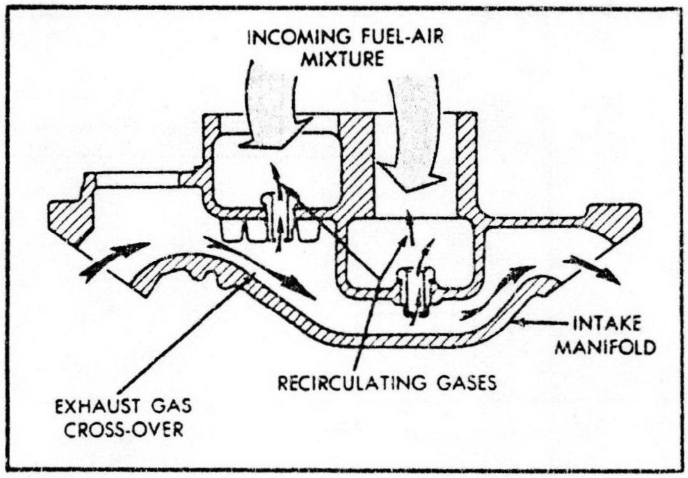
In addition, some cars also include a separate coolant temperature vacuum by-pass valve (similar to the GM TVS) which provides vacuum advance for faster idling when an overheat condition exists.

Distributor Starting Solenoid

This unit, used on certain 1972 high-displacement engines, is similar in appearance to the distributor solenoid (modulator) used on some '70 and '71 engines. However, instead of *retarding* distributor breaker plate during *idling*, it *advances* the breaker plate during *starting*. Accordingly, the idle stop switch is eliminated, and the solenoid energized directly from the ignition circuit through the alternator field lead and grounded through the throttle-levers stop screw. When the throttle is opened, after starting, the circuit is broken, returning the distributor to purely vacuum control.

EGR System

Similar in purpose to the General Motors EGR system, the Chrysler system differs in the method used to help reduce oxides of nitrogen (NO_X) emissions. No control valve is used. Instead, recirculation is metered by fixed orifice jets located between the exhaust and intake manifolds.



CHRYSLER EGR SYSTEM

CHRYSLER CORPORATION COMBUSTION CONTROL EQUIPMENT

1972

Thermostatic Air Cleaner: All engines.

Air Injection: All California Sixes & 400, 440 V-8s.

Distributor Solenoid (advance for start): 400 & 440 V-8s.

Exhaust Gas Recirculation: All California cars.

Transmission Controlled Spark: All California Cars with MT.

Speed Controlled Spark: All California cars with auto. trans.

1971

Thermostatic Air Cleaner: All except 340, 426 Hemi, 440 Six-Pack.

Distributor Solenoid (retard when throttle closed): 383,440 (exc. with Six-Pack).

Idle stop solenoid (anti-dieseling): High performance 340, 440, and 426 Hemi.

Transmission Controlled Spark: All California man. trans. cars.
Speed Controlled Spark: All California auto. trans. cars.

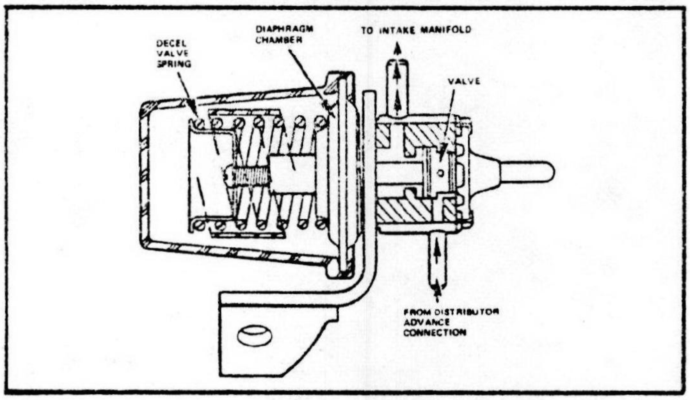
1970
Thermostatic Air Cleaner: All except 340, 426 Hemi and 440 Six-Pack.
Distributor Solenoid (retard when throttle closed): 383, 440.
Idle Stop solenoid (anti-dieseling): High perf. 440 & 426 Hemi.

1968-1969
Vacuum Control Valve: All

AMERICAN MOTORS COMBUSTION CONTROL DEVICES AND SYSTEMS ON 1970 THROUGH 1972 CARS

Deceleration Valve

This unit is used only on 1970 199 and 232 Sixes and the 390 V-8, when equipped with manual transmissions. In operation and function it is quite similar to the Chrysler vacuum control valve: Provides vacuum spark advance at the distributor diaphragm, during conditions of closed-throttle deceleration, to eliminate popping and backfiring in the exhaust manifold. Like the Chrysler valve, the deceleration valve features a screw adjustment to vary spring pressure (to adjust the amount of time vacuum is available at the distributor).

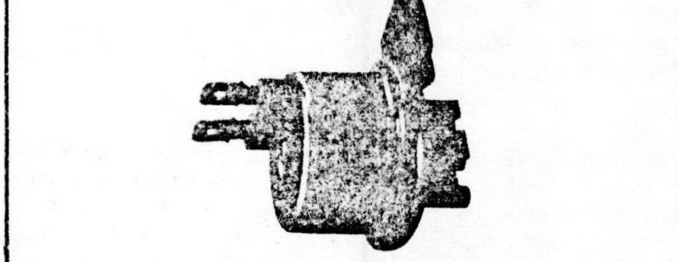


1970 AMERICAN MOTORS DECELERATION VALVE

Transmission-And Speed-Controlled Spark Systems

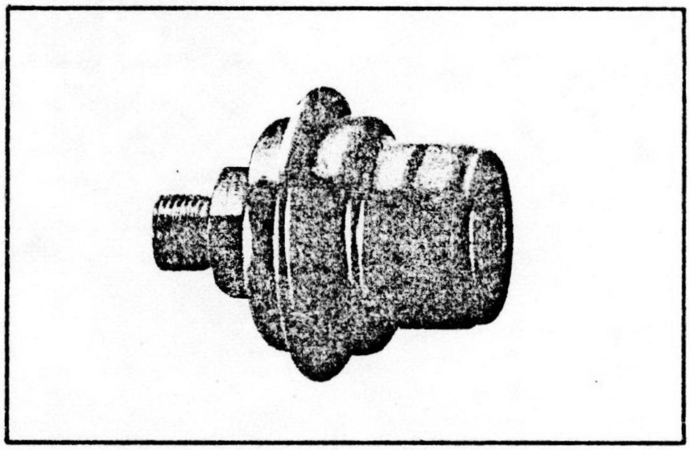
The American Motors system, first introduced on '71 cars, uses:

1. A *solenoid vacuum valve* which when energized vents the distributor diaphragm so no vacuum advance occurs. When de-energized, ported vacuum reaches the diaphragm.

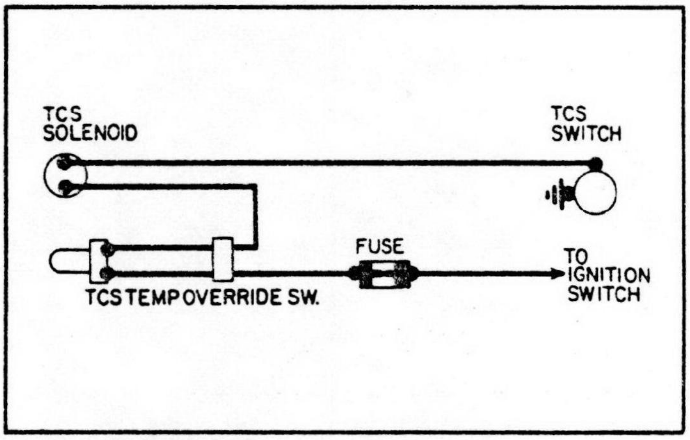


SOLENOID VACUUM VALVE

2. A *transmission switch* (manual transmissions) which closes to energize the solenoid in lower gears, or a *speed switch* (automatic transmissions) which closes to energize the solenoid at speeds below 34 mph (25-30 on Jeep engines).



SPEED SWITCH
(AUTOMATIC TRANSMISSION)

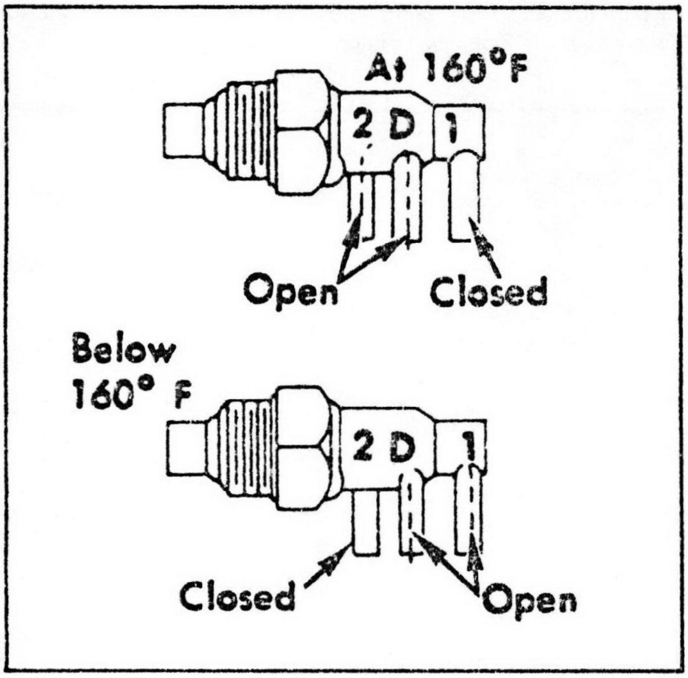


AMERICAN MOTORS AND JEEP SPARK CONTROL DIAGRAM

3. A *temperature override switch* which opens to de-energize the entire system when air temperatures are below 63°F, insuring normal spark advance, regardless of gear position or speed.

Coolant Temperature Override Switch

This unit, introduced on '72 cars, is used with all American Motors spark-controlled engines, as well as some engines without spark controls. The unit is mounted in the thermostat housing. Essentially a cold-override valve, the unit directs manifold vacuum directly to the distributor diaphragm, when coolant temperatures are below 160°F, to provide full vacuum advance for easy starting and cold-engine acceleration. In this condition, the switch completely by-passes the spark control solenoid, so full advance is obtained at any speed, gear position or air temperature when coolant is below 160°F. When coolant temperature reaches 160° and above, the manifold pressure port is closed and ported vacuum from the carburetor is routed directly to the distributor diaphragm (cars without spark control) permitting normal ported vacuum advance, or (in cars with spark control) routed from the solenoid vacuum valve, permitting control of vacuum advance by the temperature override switch or the transmission speed switch.



COOLANT TEMPERATURE OVERRIDE
SWITCH VACUUM CIRCUIT

AMERICAN MOTORS COMBUSTION CONTROL EQUIPMENT

1972
Thermostatic Air Cleaner: All engines.
Air-Guard (air injection): All V-8 engines with auto. trans.
Transmission Controlled Spark: All manual transmission engines.
Speed Controlled Spark: All automatic transmission engines.

1971
Thermostatic Air Cleaner: All V-8 engines.
Air-Guard (air injection): All V-8s with manual trans.
Transmission Controlled Spark: All manual transmission engines.
Speed Controlled Spark: All automatic transmission engines.

1970
Thermostatic Air Cleaner: All V-8 engines.
Air-Guard (air injection): 304, 360, 390 engines with man. trans.
Dual-Diaphragm Distributor: All except 232 with auto. and late production 390.
Deceleration valve: 199, 232 and 390 with manual trans.

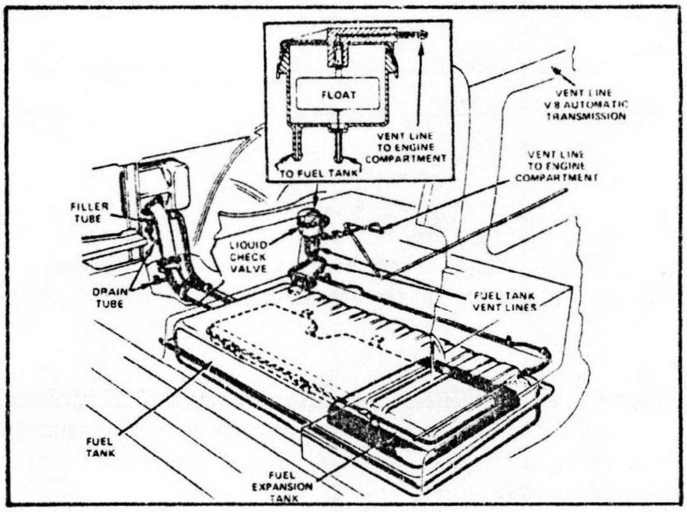
1968-1969
Thermostatic Air Cleaner: All V-8s.
Air-Guard (air injection): 290, 343, and 390 with man. trans.

EVAPORATIVE EMISSION CONTROL SYSTEMS (EEC) ALL MAKES 1970-72

The purpose of the EEC system is to prevent the emission of fuel vapors (HC) into the atmosphere. This requires a fuel system that is totally-sealed. However, when a fuel system is sealed, provisions must be made for conditions such as relief from pressure build-up from vapors or fuel expansion, vacuum caused by fuel consumption, etc. Providing for these and other conditions requires considerable modification of the fuel system, and, of course, the modifications vary from manufacturer to manufacturer and year to year. The EEC systems, introduced in 1970, were installed only on cars built for sale in California. EEC systems were installed in '71 and later on all domestic cars. (The system used in 1970 was available as an extra cost option on some GM cars).

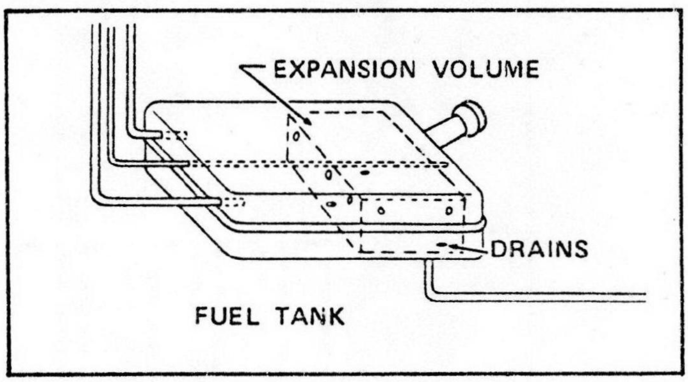
Fuel Expansion Provisions

Thermal expansion of fuel (caused by high air temperatures) can cause unacceptable levels of pressure in a sealed fuel tank. Accordingly, an air chamber or space in the tank must be provided into which the fuel and fuel vapor can safely expand. In American Motors cars and '70 and '71Chrysler Corporation cars a fuel expansion tank is mounted inside the fuel tank. Small holes at the bottom of the fuel expansion tank allow fuel under pressure to flow, until inner tank and fuel tank pressures are balanced.



AMERICAN MOTORS FUEL
EXPANSION TANK

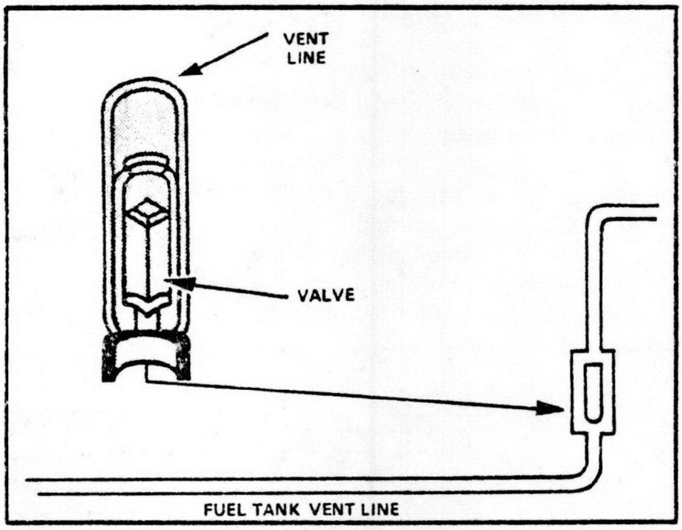
In place of a vented tank, 1971 General Motors cars use an air trap chamber inside the tank (essentially a tank with no bottom) to accomplish the same purpose.



1971 GM AIR TRAP CHAMBER

The most common method of providing for fuel expansion is to locate the fuel filler tube outlet in the tank well down in the tank so when fuel is added to the level of the outlet, no more fuel can be added, leaving a trapped volume of air above the fuel, for fuel expansion. Since the chamber is usually vented (to the rest of the system), pressure from the chamber could escape (reducing needed expansion space). On some

Ford and Chrysler cars, a valve in the vent line is normally closed during filling but opens when normal vent pressure is present. On Chrysler the valve is called an Overfill Limiting valve. On Ford, it is part of a three-way valve (see Pressure-Vacuum Relief section).



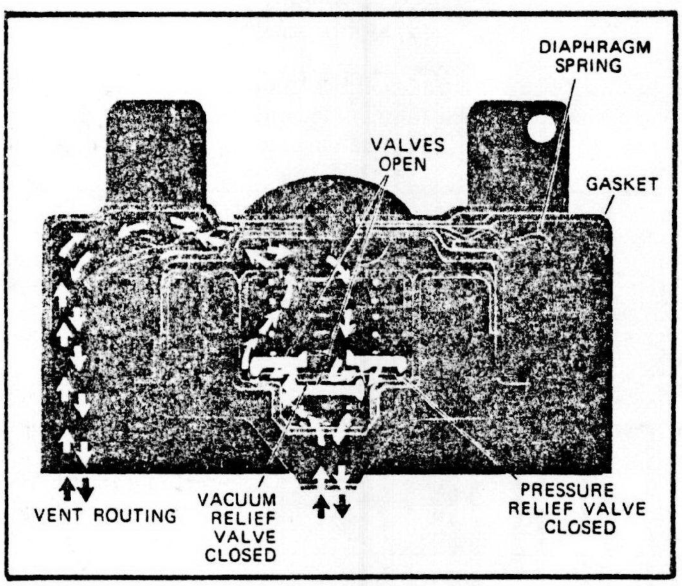
1972 CHRYSLER OVERFILL LIMITING VALVE

Pressure-Vacuum Relief Provision

In a sealed system, pressure or vacuum relief is needed to provide for thermal expansion and contraction of fuel, air and fuel vapors and by fuel consumption.

Two-Way Fuel Filler Cap

One method is to incorporate a combination pressure and vacuum relief valve in the filler cap. Excess pressure is vented to the atmosphere.

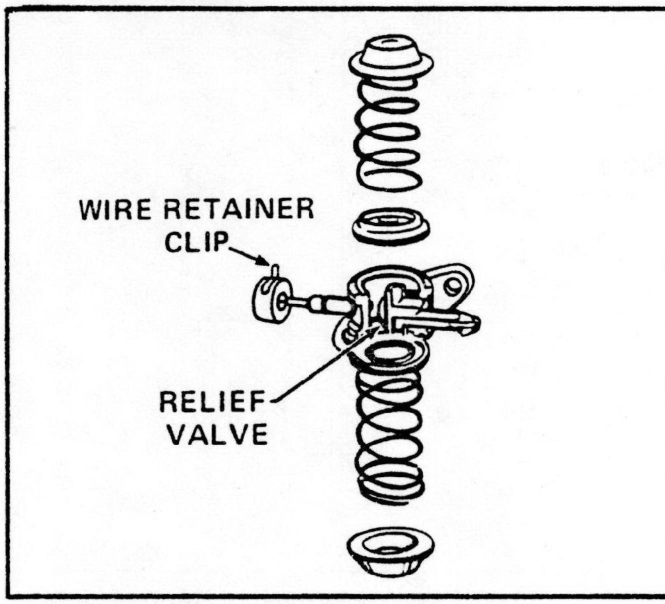


TWO-WAY FUEL FILLER CAP

Under tank vacuum conditions, the valve in the cap opens to admit air into the tank. At all other times the cap is sealed.

Three-Way Valve (Ford)

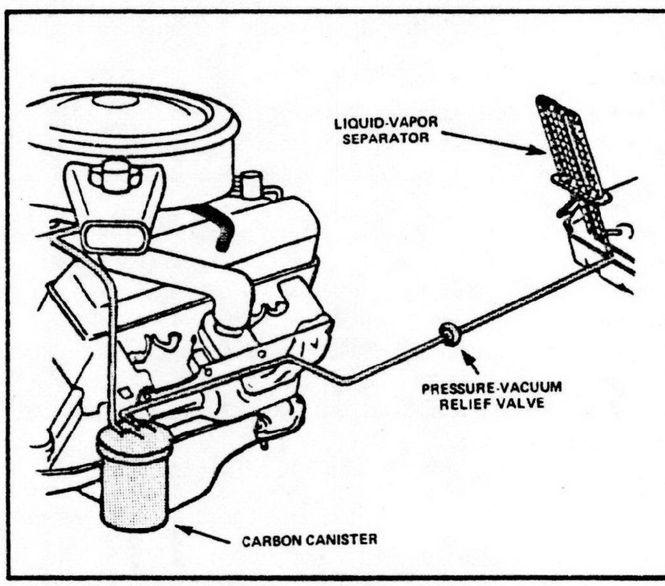
This valve is normally closed (to retain space in the air chamber of the tank). However, when pressure or vacuum exceeds certain limits, spring pressure is overcome to permit air to enter or escape from the system.



FORD 3-WAY VALVE

Pressure-Vacuum Relief Valve

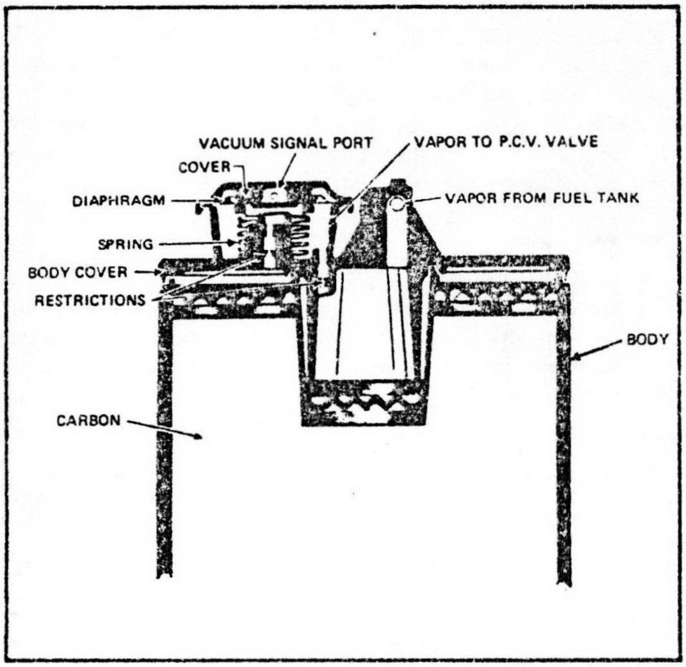
This valve, found in many GM cars which do not use a vented filler cap, provides a point in the fuel line system at which air can escape or enter under tank pressure and vacuum conditions. It is located in the line between the liquid-vapor separator and the charcoal canister.



PRESSURE-VACUUM RELIEF VALVE

Canister Demand Valve-Relief Valve

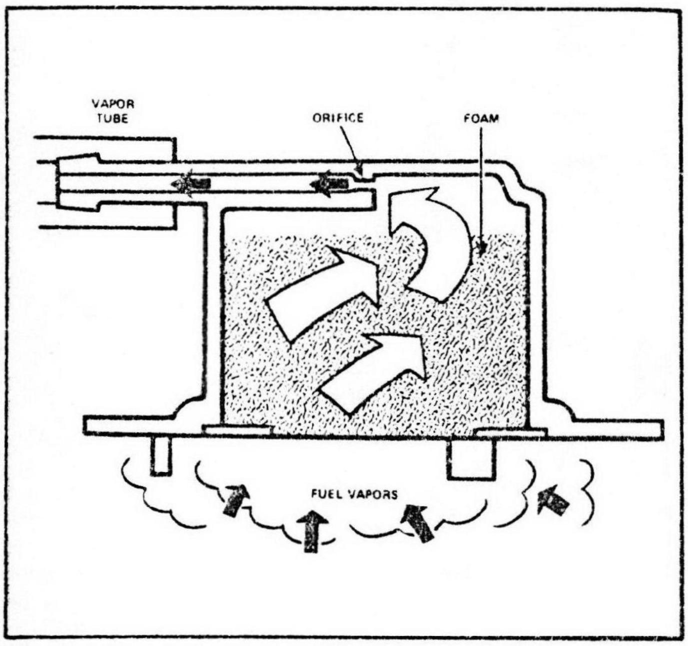
This unit, used in the 1970 Pontiac, provides pressure and vacuum relief in a pair of valves located in the top of the carbon canister. Under pressure from the fuel tank vent line, the demand valve will raise, permitting pressure to escape into the canister. Under vacuum conditions, the umbrella-type relief valve opens, allowing filtered air to be drawn into the vent line and back to the tank.



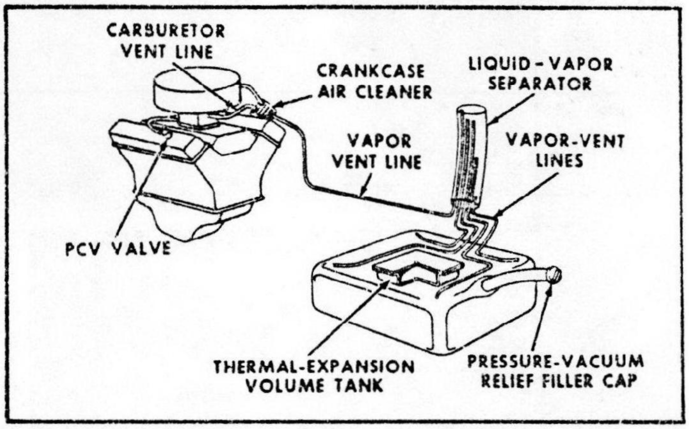
CANISTER DEMAND VALVE-RELIEF VALVE

Liquid Fuel Retention

Liquid fuel must be prevented from flowing uncontrolled from the fuel tank to the vapor canister. To function properly, the system's vent lines must be kept free of liquid fuel (caused by sloshing or tank inclination) or heavily-saturated fuel vapors likely to cause fuel condensation in the lines. The most common device to prevent this is the liquid-vapor separator, mounted at the top of the fuel tank or close to it. While the separators used vary in shape and type, all have the same characteristics: a large amount of exposed surface to encourage condensation of vapor, a high point at which the lightest vapors can escape into the vent, and a low point from which liquid fuel can be returned to the fuel tank.



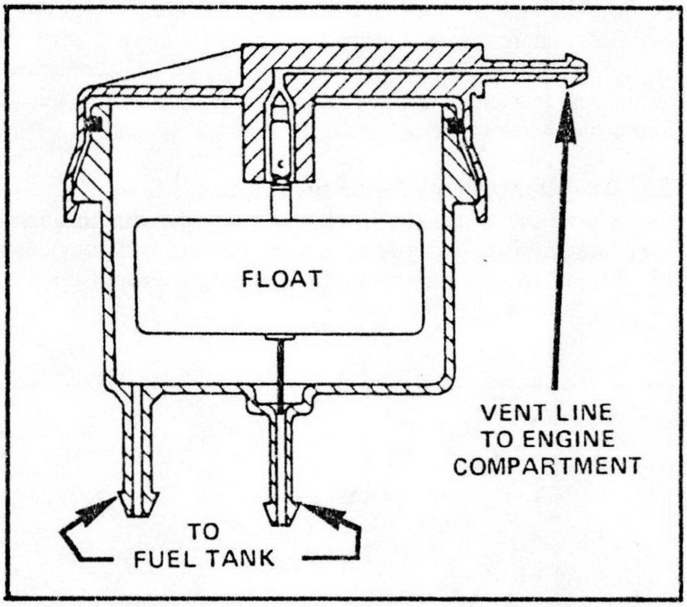
LIQUID-VAPOR SEPARATOR



MULTI-TUBE-TYPE LIQUID-VAPOR SEPARATOR

Overflow Float Check Valve (AM – except Gremlins)

This float valve closes when its chamber becomes filled with liquid fuel (such as caused by parking on an extreme incline) preventing it from passing into the vent line. A vacuum release valve is incorporated at the top of the float chamber to relieve internal vacuum which would otherwise tend to hold fuel in the chamber when the tank is leveled.



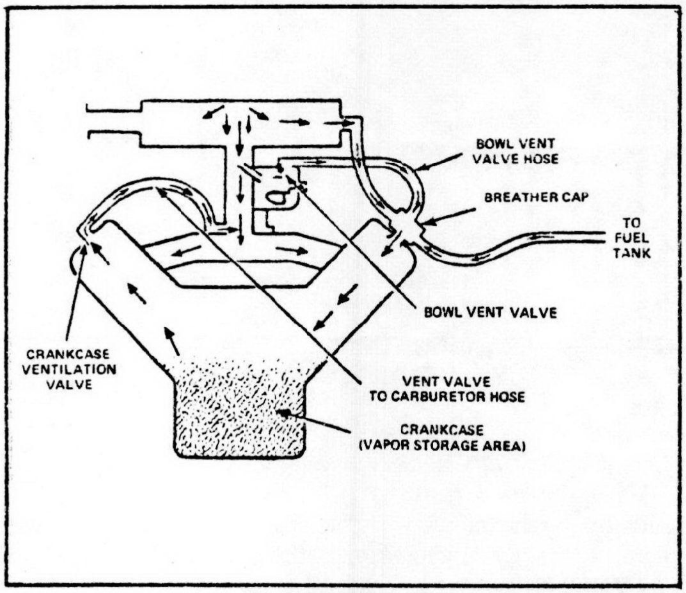
AM OVERFLOW FLOAT CHECK VALVE

Vapor Storage And Purging

The constant evaporation of fuel within the fuel tank develops system pressure, which for good emission control should not be continually discharged into the air. One method of preventing this is to provide surfaces on which the fuel vapor particles can attach themselves. The inner exposed surfaces of the fuel tank (and of some liquid-vapor separators) do provide enough surface to achieve this.

Crankcase Vapor Storage

One method of providing additional storage space for vapor is to vent the fuel tank to the engine crankcase through the engine valve cover. When the engine is started, stored vapors are drawn into the engine induction system through the PCV valve. This "purges" the crankcase surfaces of stored vapor so they are ready for more vapor storage when the engine is turned off.



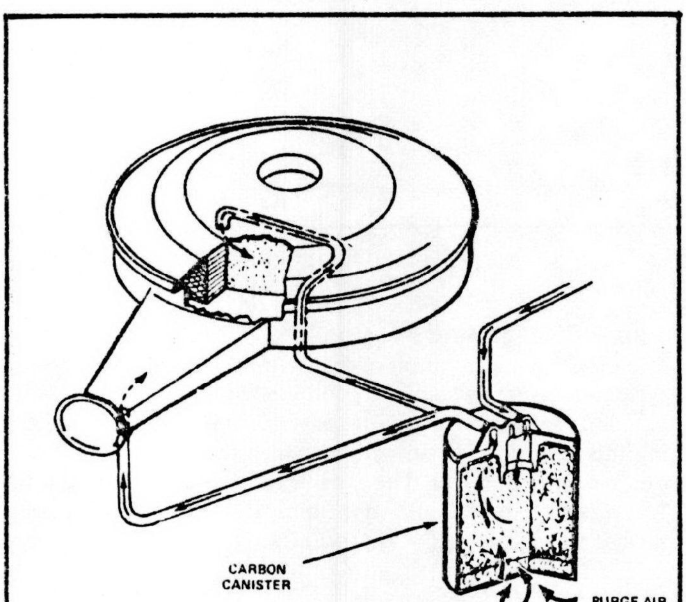
CRANKCASE VAPOR STORAGE SYSTEM
('70 CHRYSLER)

Carbon Canister Vapor Storage

A different method is to vent the tank to a canister containing activated charcoal. The typical canister contains about a pound of carbon which provides an exposed surface area of about one-quarter square mile, enough to store almost a cup of liquid fuel when vaporized.

Purging Methods

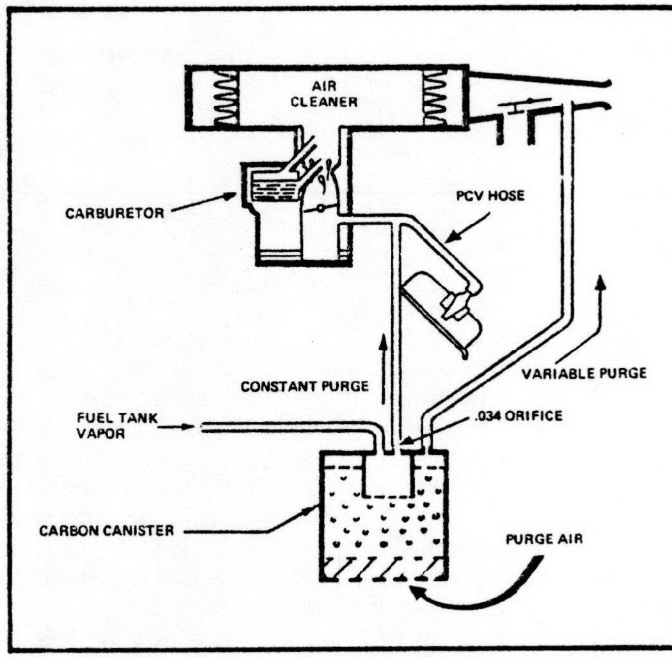
In the simplest of canister hook-ups, purging occurs through a vent line from the canister to the air cleaner. This provides a *variable* purge since the amount of purging is proportional to air flow through the air cleaner.



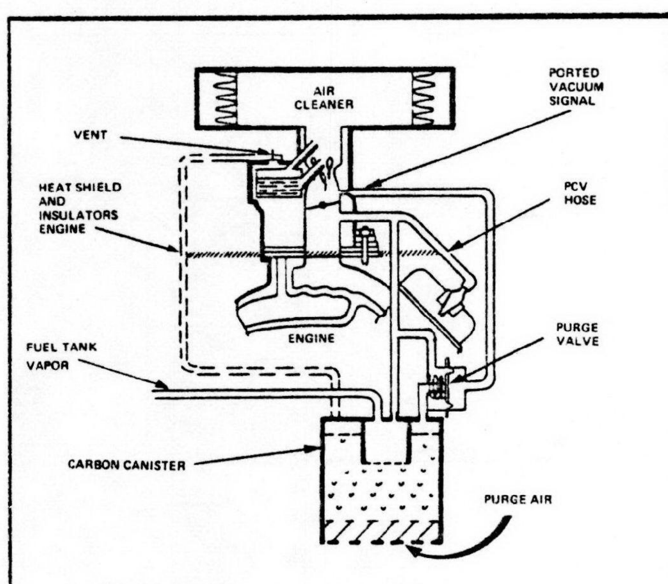
CANISTER HOOK-UP FOR VARIABLE PURGE

By using intake manifold vacuum and a small fixed orifice on the canister outlet, purging through the outlet is controlled at a fixed rate, known as *constant* purge. Still another method is used in the '70 Pontiac. (see previous illustration). A demand valve at the canister does not allow purging until a certain level of vacuum occurs at the canister outlet. A variation is where intake manifold vacuum controls a valve at the canister to allow purging to take place. This results in *demand* purging.

Constant purging is in recognition of the fact that little air flow through the canister is needed to provide adequate purging. Demand purging is designed to insure that purging occurs during conditions of engine operation which will be least affected by purge air-fuel mixtures on the performance and driveability of the engine.



CANISTER USING CONSTANT PURGE



CANISTER USING CONSTANT AND DEMAND PURGE (HEAT SHIELD ALSO SHOWN)

EVAPORATION EMISSION CONTROL SYSTEMS
By Make and Year - 1970 Through 1972

	1970				1971				1972			
	GM	FORD	CHRYS	AM	GM	FORD	CHRYS.	AM	GM	FORD	CHRYS.	AM
FUEL EXPANSION PROVISION												
Inner Tank or Trap			All	All			All	(3)				(3)
Air Chamber Fuel Tank	All	All			All	All		Grem.	All	All	All	Grem.
Overfill Check Valve		(1)	All								All	
PRESSURE - VACUUM RELIEF PROVISION												
2-Way Cap	Some		All	All		All	All	All		All	All	All
Ventline P-R Relief Valve	Some				All				All			
3-Way Valve		All										
Canister Demand - Vacuum Relief Valve	(2)											
LIQUID FUEL RETENTION												
Liquid Vapor Separator	All	All	All		All	All	All		All	All	All	
Overflow Float Valve				All				(3)				(3)
VAPOR STORAGE												
Crankcase		Some	All	All			All	All				All
Carbon Canister	All				All	All			All	All	All	
(1) Part of 3-Way Valve				(2) 1970 Pontiac					(3) All Except Gremlin			

APPENDIX I

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