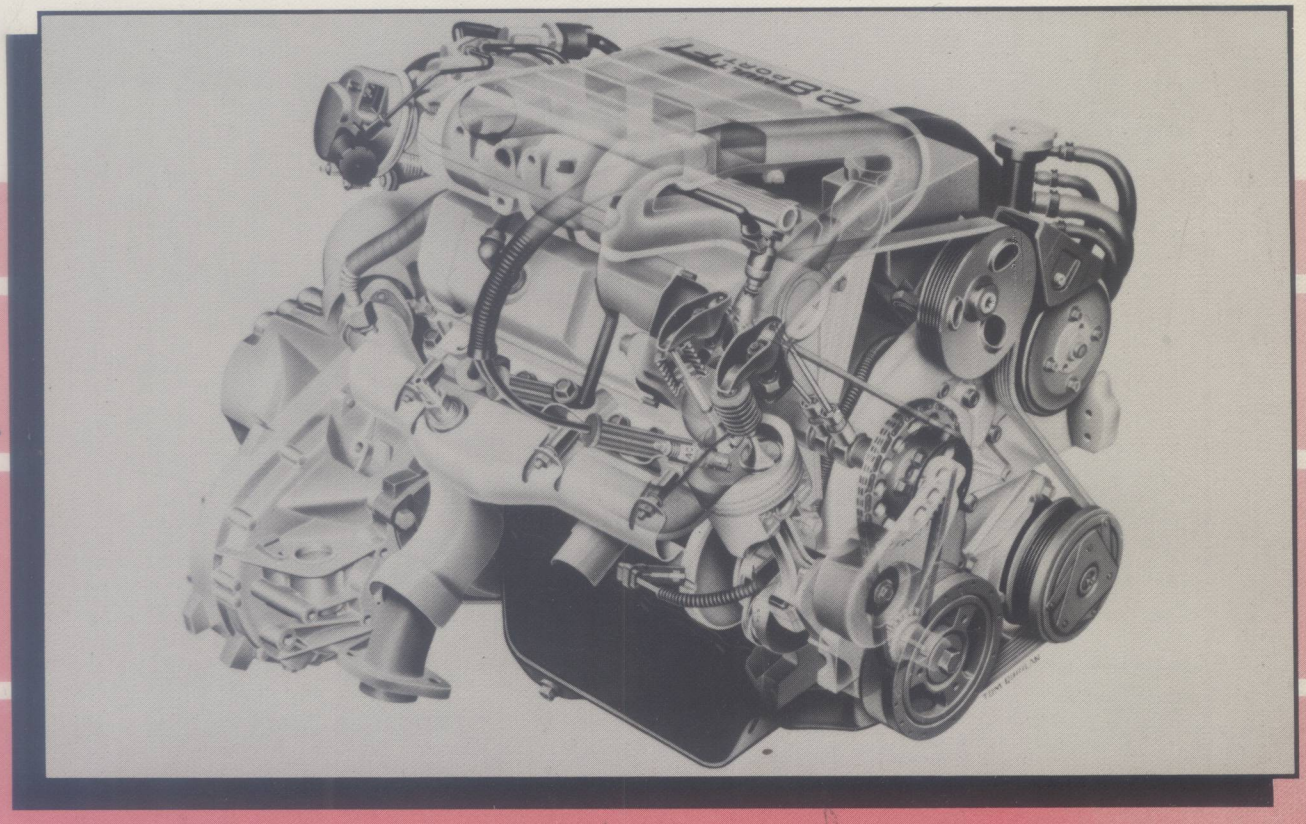
HarperCollins/**Chek-Chart**
Automotive Series

FUEL SYSTEMS AND EMISSION CONTROLS 2ND EDITION



SHOP MANUAL

Fuel Systems and Emission Controls

Second Edition

By Chek-Chart Publications, a Division of H. M. Gousha

Roger Fennema, *Editor*
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Introduction to Fuel Systems and Emission Controls

Fuel Systems and Emission Controls is part of the Harper & Row/Chek-Chart Automotive Series. The package for each course has two volumes, a *Classroom Manual* and a *Shop Manual*.

Other titles in this series include:

- Automatic Transmissions and Transaxles
- Automotive Brake Systems
- Automotive Electrical and Electronic Systems
- Automotive Engine Repair and Rebuilding
- Engine Performance Diagnosis and Tune-Up

Each book is written to help the instructor teach students to become excellent professional automotive mechanics. The 2-manual texts are the core of a complete learning system that leads a student from basic theories to actual hands-on experience.

The entire series is job-oriented, especially designed for students who intend to work in the car service profession. A student will be able to use the knowledge gained from these books and from the instructor to get and keep a job. Learning the material and techniques in these volumes is a giant leap toward a satisfying, rewarding career.

The books are divided into *Classroom Manuals* and *Shop Manuals* for an improved presentation of the descriptive information and study lessons, along with the practical testing, repair, and overhaul procedures. The manuals are to be used together: the descriptive chapters in the *Classroom Manual* correspond to the application chapters in the *Shop Manual*.

Each book is divided into several parts, and each of these parts is complete by itself. Instructors will find the chapters to be complete, readable, and well thought-out. Students will benefit from the many learning aids included, as well as from the thoroughness of the presentation.

The series was researched and written by the editorial staff of Chek-Chart, and was produced by Harper & Row Publishers. For over 59 years, Chek-Chart has provided car and equipment manufacturer's service specifications to the automotive service field. Chek-Chart's complete, up-to-date automotive data bank was used extensively to prepare this textbook series.

Because of the comprehensive material, the hundreds of high-quality illustrations, and the inclusion of the latest automotive technology, instructors and students alike will find that these books will keep their value over the years. In fact, they will form the core of the master mechanic's professional library.

How To Use This Book

Why Are There Two Manuals?

This two-volume text — **Fuel Systems and Emission Controls** — is not like any other textbook you've ever used before. It is actually two books, the *Classroom Manual* and the *Shop Manual*. They should be used together.

The *Classroom Manual* will teach you what you need to know about basic electricity and the electrical systems in a car. The *Shop Manual* will show you how to fix and adjust those systems, and how to repair the electrical parts of a car.

The *Classroom Manual* will be valuable in class and at home, for study and for reference. It has text and pictures that you can use for years to refresh your memory about the basics of automotive electrical systems.

In the *Shop Manual*, you will learn about test procedures, troubleshooting, and overhauling the systems and parts you are studying in the *Classroom Manual*. Use the two manuals together to fully understand how the parts work, and how to fix them when they don't work.

What's In These Manuals?

There are several aids in the *Classroom Manual* that will help you learn more:

1. The text is broken into short bits for easier understanding and review.
2. Each chapter is fully illustrated with drawings and photographs.
3. Key words in the text are printed in **boldface type** and are defined on the same page and in a glossary at the end of the manual.
4. Review questions are included for most chapters. Use these to test your knowledge.
5. A brief summary at the end of most chapters will help you to review for exams.
6. Every few pages you will find short blocks of "nice to know" information, in addition to the main text.
7. At the back of the *Classroom Manual* there is a sample test, similar to those given for National Institute for Automotive Service Excellence (NIASE) certification. Use it to help you study and to prepare yourself when you are ready to be certified as an expert in one of several areas of automobile mechanics.

The *Shop Manual* has detailed instructions on overhaul, test, and service procedures. These are easy to understand, and may have step-by-step, photo-illustrated explanations that guide you through the procedures. This is what you'll find in the *Shop Manual:*

1. Helpful information tells you how to use and maintain shop tools and test equipment.
2. Safety precautions are detailed.
3. System diagrams help you locate trouble-spots while you learn to read the diagrams.
4. Tips the professionals use are presented clearly and accurately.
5. A full index will help you quickly find what you need.
6. Test procedures and troubleshooting hints will help you work better and faster.

Where Should I Begin?

If you already know something about a car's basic electrical system and how to repair it, you may find that parts of this book are a helpful review. If you are just starting in car repair, then the subjects covered in these manuals may be all new to you.

Your instructor will design a course to take advantage of what you already know, and what facilities and equipment are available to work with. You may be asked to take certain chapters of these manuals out of order. That's fine. The important thing is to really understand each subject before you move on to the next.

Study the vocabulary words in boldface type. Use the review questions to help you understand the material. While reading in the *Classroom Manual*, refer to your *Shop Manual* to relate the descriptive text to the service procedures. And when you are working on actual car systems and electrical parts, look back to the *Classroom Manual* to keep the basic information fresh in your mind. Working on such a complicated piece of equipment as a modern car isn't always easy. Use the information in the *Classroom Manual*, the procedures of the *Shop Manual*, and the knowledge of your instructor to help you.

The *Shop Manual* is a good book for work, not just a good workbook. Keep it on hand while you're working on equipment. It folds flat on the workbench and under the car, and can withstand quite a bit of rough handling.

When you do test procedures and overhaul equipment, you will also need a accurate source of manufacturers' specifications. Most auto shops have either the carmaker's annual shop service manuals, which lists these specifications, or an independent guide, such as the **Chek-Chart Car Care Guide**. This unique book, which is updated every year, gives you the complete service instructions, electronic ignition troubleshooting tips, and tune-up information that you need to work on specific cars.

Safety Summary

Many professional mechanics work for years without ever suffering a serious injury. By following a few common sense rules of safety, you can follow in their footsteps and avoid personal injury to yourself or others in the vicinity.

Shop Service Safety

The following precautions should be observed whenever you do any shop activity.

1. Know the location of shop first-aid supplies and where to call for emergency medical assistance.

2. Do not use gasoline as a cleaning agent or solvent unless it is specifically recommended. If you do use gasoline, have a fire extinguisher handy and exercise extreme caution.

3. All auto repair shops have flammable liquids and combustible materials. You can minimize fire hazard by not smoking within the shop area at any time.

4. Keep flames and sparks away from a charging battery. Highly explosive hydrogen gas forms during the charging process.

5. Do not arc the terminals of a battery to see if it is charged. The sparks can ignite the explosive hydrogen gas as easily as an open flame.

6. Always wear safety goggles in any area or during any job where an eye hazard could exist.

7. Remove all jewelry such as rings and watches before starting work. Remove sweaters and tuck in loose clothing.

8. If in doubt about the use of any tool, machine, or test equipment, ask your instructor about its safe operation before using it.

9. Make sure your hands, the floor, and your entire work space are dry before touching any electrical switches or plugs, or using any electrical equipment.

10. Keep floors, aisles, and your work area clear of all tools, parts, and materials. Mop up any spilled liquids immediately.

11. Do not carry sharp tools such as screwdrivers, awls, or scrapers in your pockets. Carry them in your hand with the cutting edge facing down.

12. Make sure that any component you clamp in a vise is properly secured before you work on it.

13. Do not splash cleaning solvents when putting parts into, or removing them from, a cleaning tank.

14. If you use an air nozzle to dry cleaned parts, make sure you direct the airstream away from you and anyone else in the immediate area.

15. Before starting an engine, be sure the parking brake is set, the drive wheels are blocked, and the transmission or transaxle is in neutral (manual) or Park (automatic).
16. Do not run the engine in a closed area or room. Connect the vehicle exhaust pipe to shop exhaust ducts or make sure there is sufficient ventilation to prevent the accumulation of poisonous exhaust gases.
17. Keep your hands and other body parts away from hot exhaust components. Catalytic converters heat up rapidly and retain their heat for a long time after the engine is shut off. If you must work around such objects when they are hot, wear safety gloves.
18. Do not drive a vehicle faster than five miles per hour in, or when entering or leaving the shop area.

Fire Prevention Safety

There are two major subjects of which you should be aware concerning fire prevention safety:
- Proper handling and storage of combustible and flammable materials
- Availability and use of fire extinguishers.

Flammable Materials

There are many flammable materials used in automotive shops, including gasoline, diesel fuel, grease and oil, as well as solvents and thinners. Under certain conditions, these present extreme fire hazards.

Other combustible materials also are commonly found in automotive shops. These include various wood, plastic, and paper materials. Their hazardous nature is increased when they are covered with oil or grease.

It is important that you observe certain basic precautions when using and storing these materials in a shop.
1. Keep combustible and flammable materials away from sparks, open flame, hot metal or cutting torches. Do not smoke in or around such areas.
2. All fuels, lubricants, solvents, and other flammable materials should be stored in approved containers and locations. These containers should be kept closed when not in use.
3. If any flammable material is spilled, it should be cleaned up immediately, and the cleaning materials properly disposed of.
4. Do not allow any accumulation of oily rags or papers. Keep these combustible materials in metal containers designed for their storage and properly dispose of them every day.
5. Containers should be bonded together and electrically grounded whenever you transfer a flammable liquid from one to another. This will prevent any possible sparking from static electricity.

Fire Extinguishers

The shop should be properly equipped with the various types of fire extinguishers used with different types of fires. However, fire extinguishers are useless unless they are properly maintained and ready to go at all times. In addition, everyone in the shop should know the location of all extinguishers, and be familiar with their use.

There are four classes of fire extinguishers. Each class should be used with specific fires:
- *Class A* is designed for use on general combustibles such as cloth, paper and wood. It should not be used on electrical fires or fires containing flammable liquids.
- *Class B* is designed for use on flammable liquids and greases, including gasoline, oil, thinners and solvents.
- *Class C* is used only on electrical fires.
- *Class D* is effective only on combustible metals such as powdered aluminum, sodium, or magnesium.

The extinguishing agent inside the fire extinguisher determines its use. Plain water or bicarbonate of soda is satisfactory for use on Class A fires, but neither should be on electrical fires or flammable liquids. Carbon dioxide (CO_2) extinguishers can be used on flammable liquids and electrical fires, but are not satisfactory to extinguish burning wood or paper.

The class rating is clearly marked on the side of every fire extinguisher. Some units are multipurpose and can be used with more than one type of fire. This type of fire extinguisher often is used in automotive shops.

Cleaning with Solvents and Parts Washing

Automotive shops deal with common chemicals daily. These include fuels, cleaning solvents, lubricants, and adhesives. All these chemicals are necessary, but many are toxic and can be harmful to you, the equipment, and the vehicles on which you are working if they are not handled properly. Observe the following precautions whenever you are working with or near such chemicals:
1. Do not use gasoline as a cleaning agent or

solvent unless it is specifically recommended. It presents an extreme fire hazard.
2. Do not use gasoline, cleaning solvent, or paint thinner to clean your hands. If you must clean parts in such solutions, always wear rubber gloves and arm protection to prevent the solvent from touching your skin. Such chemicals affect the natural oil in your skin and their use can result in a rash, cause nausea or other health problems.
3. Always read the instructions before using any cleaning material. Some cleaning solutions are very caustic, and while they will work with some metals, they will harm others. If in doubt, ask your instructor.
4. Always wash your hands before eating, drinking, or smoking when you have been handling caustic or toxic chemicals.
5. Avoid breathing gasoline vapors when possible and keep the chemical away from your mouth. Gasoline is highly toxic when swallowed or when large quantities of vapors are inhaled.
6. Paint thinner, antifreeze, and gasoline are among the shop chemicals that will damage painted surfaces and rubber or plastic components. Immediately wash any spills with a mild soap and water solution and rinse thoroughly.
7. Always wear safety glasses whenever you are working with solvents or steam cleaners.
8. When parts are to be washed, immerse them carefully in the cleaning tank to avoid splashing solvent.
9. Solvents and many other chemicals used in a shop should always be used in a well-ventilated area. Their toxic fumes often have no odor and your nose cannot warn you of their danger.
10. Dispose of all used chemicals properly. They should be packaged in suitable containers and disposed of according to local health and safety regulations. They should *not* be poured into lavatories, toilets, or waste water drains.

Parts washing tanks usually contain a general-purpose solvent that will remove oil, grease, and dirt from most components. This general-purpose solvent should not be replaced with gasoline or other flammable solvents. The parts washing tank should have a safety cover held open by a chain and fusible link. If a fire occurs in or near the tank, the link will melt and allow the cover to drop closed. Do not use a stick to prop the cover open and override this valuable safety feature.

To clean parts in the washer, you can submerge them and wait for the solvent to dissolve the oil, grease, or dirt. Dunking the parts in the solvent and then brushing them with a soft-bristle brush will accelerate the process. This often is all that's required to clean a part. Many parts washers used to clean carburetor parts have an agitator to circulate the solvent. This speeds the process of dissolving the contamination. General parts washers usually have a nozzle that sprays a stream of solvent on the parts. This solvent is constantly being filtered and recirculated. Washing the parts under the nozzle with the soft-bristle brush is the recommended procedure for a rapid, thorough cleaning.

Engine Fuel System Safety

Everything we have covered to this point applies to working on the fuel system. In addition, however, there are other general practices you should observe:
1. Keep your hands, clothing, hair and tools away from any moving components when you are working under the hood with the engine running.
2. Exercise extreme caution around electric cooling fans, since some designs will start whenever engine coolant temperature reaches a certain level, whether or not the engine is running.
3. Keep your clothes away from hot exhaust system components. Manifolds and catalytic converters remain very hot long after the engine is shut off.
4. Keep all flammable liquids and oily cloths away from running engines or any other source of heat that might cause them to ignite.
5. Plug or cap all fuel lines that are disconnected for service. This will prevent messy and possibly dangerous leaks.
6. Do not use a torch or other form of heat or flame producing device near nylon fuel lines used with fuel injection systems.
7. Leave the engine air cleaner in place whenever possible. This prevents the possibility of a backfire or dropping contamination or small tools into the engine. If the air cleaner must be removed, cover the carburetor or intake manifold openings with clean shop cloths for the same reasons.
8. When servicing any electronic engine control system:
   a. Do not short circuit or ground any solid-state electronic components or electrical terminals, or apply battery voltage directly to electronic components, unless a test procedure specifies otherwise.

b. Refer to the manufacturer's instructions when connecting older test equipment to breakerless ignition systems. Some older test equipment will not work properly and may even damage the system.

c. Make sure the ignition is off before disconnecting or connecting the wiring harness connector to the control unit.

d. Do not remove the grease used to prevent corrosion from the connectors.

9. When servicing any Chrysler electronic ignition or engine control system:

a. Do not touch the switching transistor on the control unit with the engine running. The high voltage present will produce a severe electrical shock.

b. Do not file the sharp edges of the reluctor teeth.

10. When servicing any Ford electronic ignition or engine control system:

a. Do not let a straight pin used to pierce wires for voltage checks touch ground.

b. Do not disconnect the spark plug wires directly above the pick-up coil. An arc from the wire may damage the pick-up coil.

Contents

On the Cover:
Front — A cutaway of a port-fuel-injected V-6 showing the airflow through the engine, courtesy Chevrolet Division of the General Motors Corporation.
Rear — Schematic drawings of a typical EGR valve and diverter valve, courtesy AC-Delco Division of the General Motors Corporation.

PART ONE

Introduction to Fuel and Emission System Service

Chapter

1

Vacuum Control Diagnosis

ENGINE VACUUM

Whenever an automotive engine is running, it produces vacuum. As each piston moves down on its intake stroke, pressure is reduced in the cylinder and in the intake manifold. The total vacuum produced depends upon two factors: engine design and engine condition.

Engine Design

The number of cylinders, displacement, compression ratio, valve overlap and lift — all these help govern the amount of vacuum produced by an engine. Different designs produce different amounts of vacuum. For example, a V-type engine generally produces less vacuum than an inline engine. Engines with emission controls often have high lift cams and greater valve overlap. These engines produce a lower level of vacuum with a less steady reading than those without emission controls.

Engine Condition

How much vacuum an engine will produce depends on how efficiently it does its job. A badly worn engine cannot produce as much vacuum as one in good condition. Piston rings, valves, carburetion, ignition timing, and exhaust all affect engine vacuum. Each has a predictable effect on engine vacuum. This makes it possible to diagnose engine condition and performance by measuring the amount of vacuum.

VACUUM SOURCES

Vacuum drawn directly from a tap at the intake manifold, figure 1-1, is called manifold vacuum. Manifold vacuum is used to diagnose engine condition. Manifold vacuum is greatest at idle and decreases as the throttle is opened. At wide-open throttle, there is very little vacuum in the intake manifold.

Vacuum drawn from an opening in the carburetor just above the throttle valve is called ported vacuum. When the throttle valve is closed during idle or deceleration, there is no significant vacuum at the port, figure 1-2. As the throttle is opened, it uncovers the port and allows vacuum to pass, figure 1-3. Ported vacuum usually operates carburetor assist devices, distributor vacuum advance units, and emission control systems. Ported vacuum cannot exceed manifold vacuum.

TESTING ENGINE VACUUM

Most vacuum readings are taken at engine idle speed. A vacuum gauge, figure 1-4, is used to

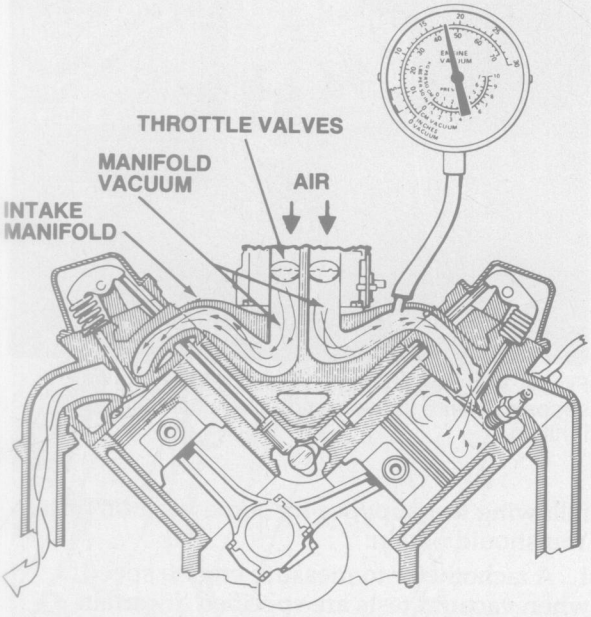

Figure 1-1. The vacuum gauge is connected to a tap on the intake manifold to measure manifold vacuum.

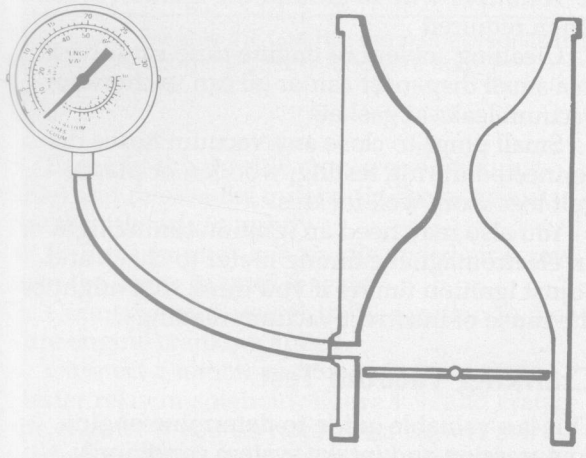

Figure 1-2. Throttle closed, vacuum port covered.

measure the difference between atmospheric pressure and intake manifold pressure, or vacuum. The gauge can be graduated in inches of mercury (in. Hg) or millimeters of mercury (mm Hg). The normal vacuum reading usually varies between 18 and 22 inches or 460 and 560 millimeters of mercury at sea level. Vacuum readings will drop about one inch or 25 millimeters for every 1,000 feet (305 meters) increase in elevation above sea level, figure 1-5.

It is important to know the basic specifications for the engine to be tested. These generally are provided in the automaker's factory

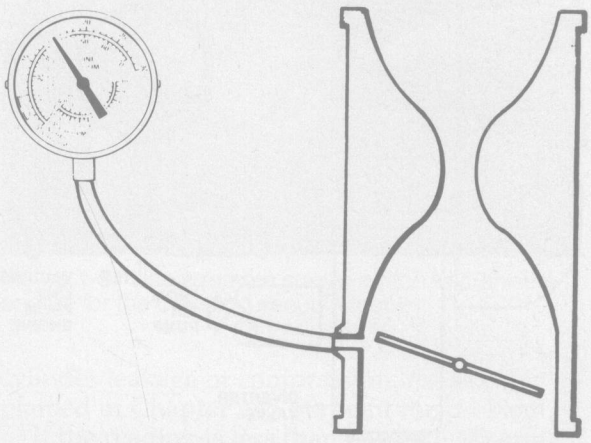

Figure 1-3. Throttle open, vacuum port uncovered.

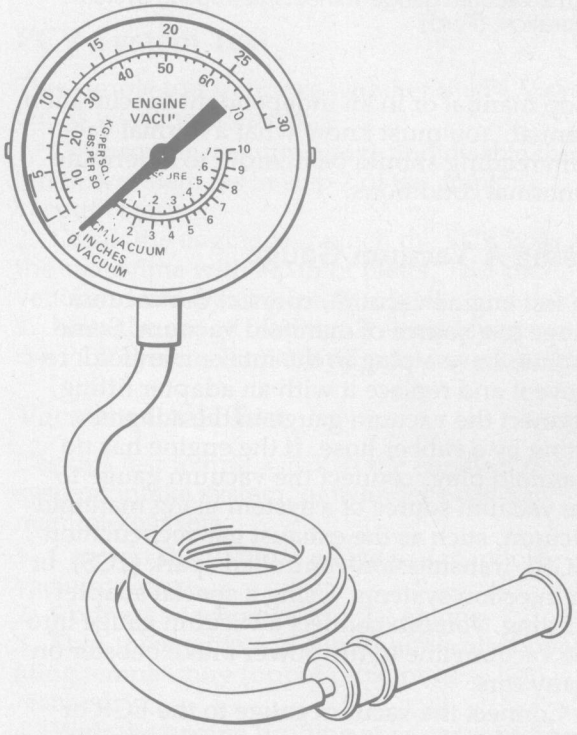

Figure 1-4. A typical vacuum gauge.

ALTITUDE	INCHES OF VACUUM
Sea Level to 1,000 Ft.	18 to 22
1,000 Ft. to 2,000 Ft.	17 to 21
2,000 Ft. to 3,000 Ft.	16 to 20
3,000 Ft. to 4,000 Ft.	15 to 19
4,000 Ft. to 5,000 Ft.	14 to 18
5,000 Ft. to 6,000 Ft.	13 to 17

Figure 1-5. A normal engine produces approximately these vacuum readings at the altitudes shown.

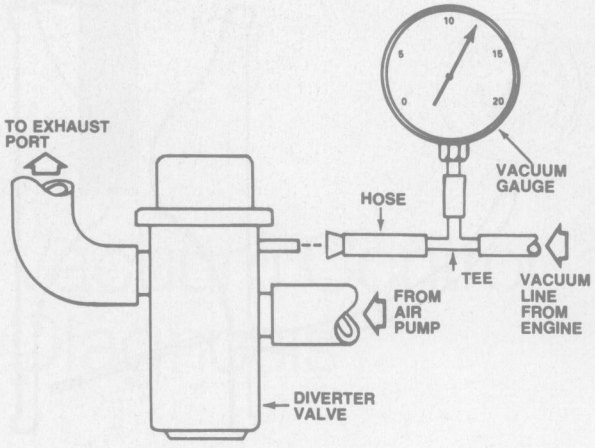

Figure 1-6. The tee inserted in this vacuum line to the diverter valve allows valve operation to be checked with a vacuum gauge without interrupting system operation. (Ford)

shop manual or in an independent specification manual. You must know what a normal vacuum reading should be in order to determine abnormal conditions.

Using A Vacuum Gauge

To test engine vacuum, connect the vacuum gauge to a source of manifold vacuum. Some engines have a plug in the intake manifold; remove it and replace it with an adapter fitting. Connect the vacuum gauge to the adapter fitting by a rubber hose. If the engine has no manifold plug, connect the vacuum gauge to the vacuum source of a system using manifold vacuum, such as the exhaust gas recirculation (EGR), transmission-controlled spark (TCS), or air injection systems. Using a special adapter T-fitting, you can connect a vacuum gauge into the vacuum line to the power brake booster on many cars.

Connect the vacuum gauge to the EGR or TCS system by installing a tee in the system line, figure 1-6. Connect the vacuum gauge line to the tee so the gauge can monitor manifold vacuum without disturbing the system. All connections must be tight and free of leaks. Engine vacuum should be tested with the engine at normal operating temperature.

Other Special Equipment

You will need hand tools and a vacuum gauge with a length of rubber tubing as well as the following test supplies for some vacuum tests. You should obtain:

1. A tachometer to measure engine speed when vacuum tests are specified at certain speeds
2. A remote starter switch (pushbutton) to crank the engine during vacuum tests made at cranking speed
3. A jumper wire to ground the ignition system when required
4. Cleaning solvent or engine tune-up solvent in a small dispenser can or oil can to check for vacuum leaks at gaskets
5. Small plugs to close any vacuum hoses disconnected during testing; wooden or plastic golf tees work well for this.

You also may need an ignition timing light or an electromagnetic timing meter to check and adjust ignition timing if you think that might be the cause of incorrect vacuum readings.

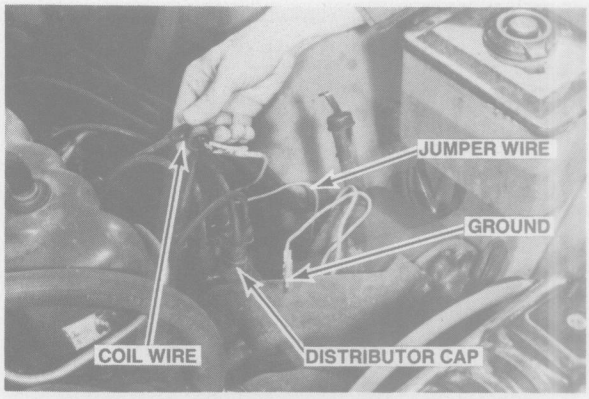

Figure 1-7. Use a jumper wire to ground the coil secondary wire to the engine block to disable the ignition.

Cranking Vacuum Test

This is a valuable guide to determine engine compression and intake system conditions. Cranking vacuum that is high and constant can mean the engine is mechanically sound and has a properly sealed intake manifold. Low vacuum at cranking speed can mean poor engine compression or vacuum leakage at manifold and carburetor gaskets.

1. Connect the vacuum gauge to a manifold vacuum source.
2. Disconnect the secondary coil wire from the distributor. Connect the coil wire to ground with a jumper lead, figure 1-7, to prevent the engine from starting. If the engine has a GM HEI system or a distributorless ignition system, disconnect the battery wire from the ignition system, figure 1-8.