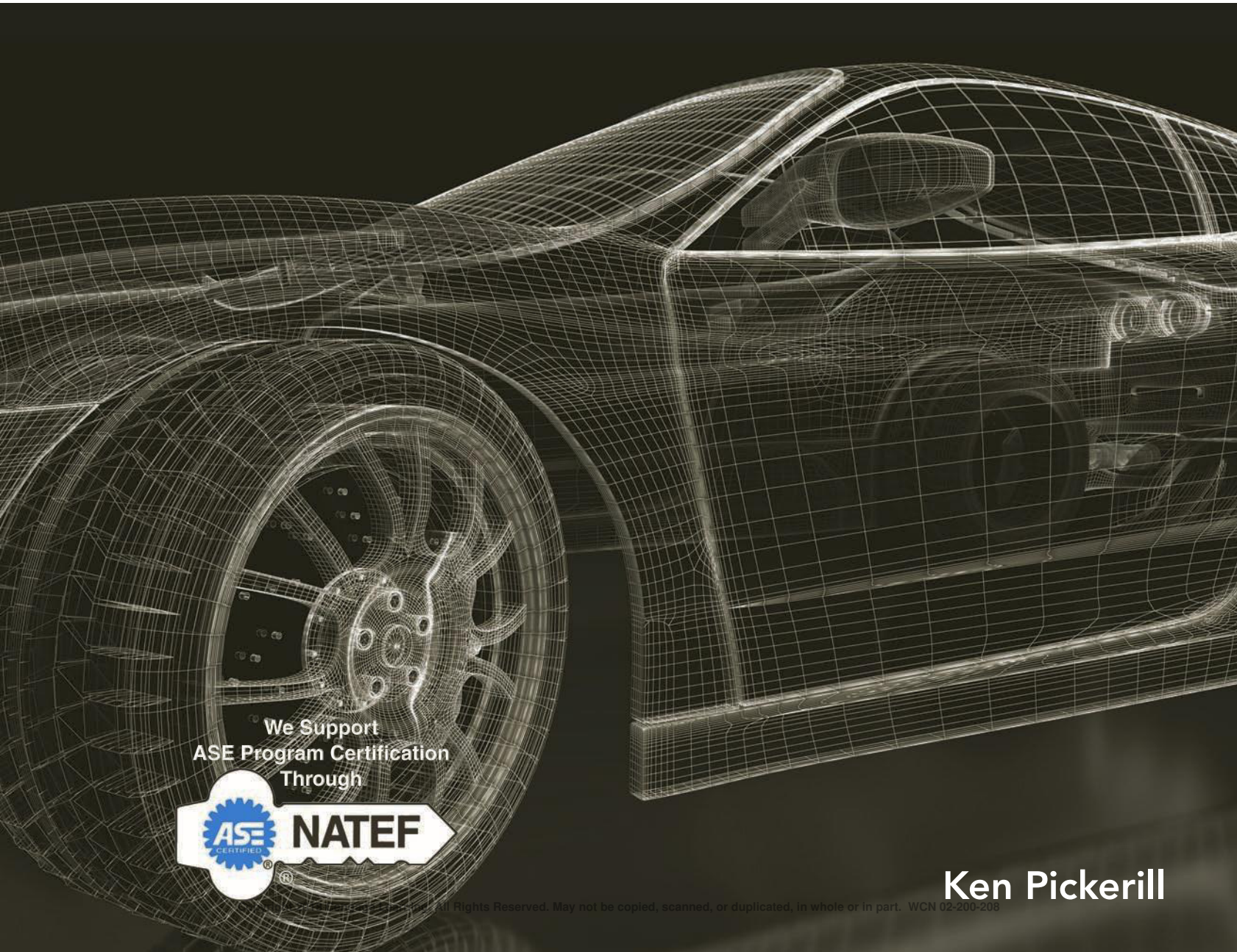
TODAY'S TECHNICIAN™

AUTOMOTIVE ENGINE PERFORMANCE

7

Shop Manual



Ken Pickerill

TODAY'S TECHNICIAN™

SHOP MANUAL

For Automotive Engine Performance

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SHOP MANUAL

For Automotive Engine Performance

SEVENTH EDITION

Ken Pickerill
Southern Illinois University at Carbondale

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Today's Technician: Automotive Engine Performance, Seventh Edition

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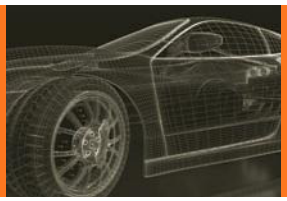


DEDICATION

I want to dedicate this book to the memory of my father, Miles K. Pickerill. Dad taught me love, honesty, and craftsmanship.

Also to Peggy, my wife of 40 years, and my two sons, Adam and Eric.

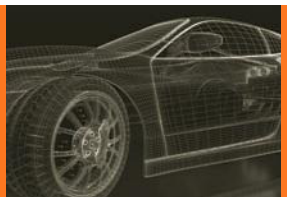
My thanks for their contributions to my career go out to:

The late Doug McNally, who gave me my first automotive job.

The late John Riddle, who guided me as a young apprentice many years ago.

Dennis Price, who always believed in my ability.

Ken Pickerill



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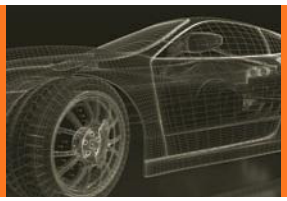

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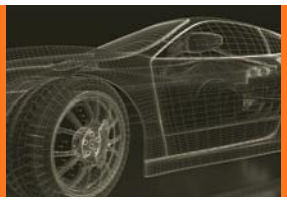
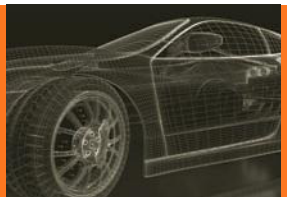


JOB SHEETS



PREFACE

Thanks to the support the *Today's Technician™ Series* has received from those who teach automotive technology, Cengage Learning, the leader in automotive-related textbooks, is able to live up to its promise to provide new editions of the series every few years. By revising this series on a regular basis, we can respond to changes in the industry, changes in technology, changes in the certification process, and to the ever-changing needs of those who teach automotive technology.

The *Today's Technician™ Series* features textbooks and digital learning solutions that cover all mechanical and electrical systems of automobiles and light trucks. The individual titles correspond to the National Automotive Technicians Education Foundation (NATEF) and National Institute for Automotive Service Excellence (ASE) certification areas and are specifically correlated to the 2013 standards for Automotive Service Technicians (AST) and Master Automotive Service Technicians (MAST).

The mission of NATEF is to improve the quality of automotive technician training programs. NATEF evaluates programs against standards developed by the automotive industry and recommends qualified programs for certification (accreditation) from ASE. NATEF's national standards reflect the skills that students must master to be successful. ASE certification through NATEF ensures that certified training programs meet or exceed industry-recognized, uniform standards of excellence. All titles in the *Today's Technician™ Series* include remedial skills and theories common to all of the certification areas, and advanced or specific subject areas that reflect the latest technological trends, such as this updated title on engine performance.

The technician of today and the future must know the underlying theory of all automotive systems and be able to service and maintain those systems. Dividing the material into two volumes, a Classroom Manual and a Shop Manual, provides the student with the information needed to begin a successful career as an automotive technician without interrupting the learning process by mixing cognitive and performance learning objectives into one volume.

The design of Delmar's *Today's Technician™ Series* was based on features that are known to promote improved student learning. The design was further enhanced by a careful study of survey results, in which the respondents were asked to value particular features. Some of these features can be found in other textbooks, while others are unique to this series.

Each Classroom Manual contains the principles of operation for each system and subsystem. The Classroom Manual also discusses design variations in key components used by the different vehicle manufacturers, and considers emerging technologies that will be standard or optional features in the near future. This volume is organized to build upon basic facts and theories. Its primary objective is to help the reader gain an understanding of how each system and subsystem operates. This understanding is necessary to diagnose the complex automobiles of today and tomorrow. Although the basics contained in the Classroom Manual provide the knowledge needed for diagnostics, diagnostic procedures appear only in the Shop Manual. An understanding of the underlying theories is also a requirement for competence in the skill areas covered in the Shop Manual.

A spiral-bound Shop Manual delivers hands-on learning experiences with step-by-step instructions for diagnostic and repair procedures. Photo Sequences are used to

illustrate some of the common service procedures. Other common procedures are listed and are accompanied with fine line drawings and photos that let the reader visualize and conceptualize the finest details of the procedure. This volume explains the reasons for performing the procedures, as well as the circumstances when each particular service is appropriate.

The two volumes are designed to be used together and are arranged in corresponding chapters. Not only are the chapters in the volumes linked together, the contents of the chapters are also linked. The linked content is indicated by marginal callouts that refer the reader to the chapter and page where the same topic is addressed in the companion volume. This valuable feature saves users the time and trouble of searching the index or table of contents to locate supporting information in the other volume. Instructors will find this feature especially helpful when planning the presentation of material and when making reading assignments.

Both volumes contain clear and thoughtfully selected illustrations, many of which are original drawings or photos specially prepared for inclusion in this series. This means that the art is a vital part of each textbook and not merely inserted to increase the number of illustrations.

The page design of this series uses available margin space to deliver helpful information efficiently without interrupting the pedagogical lesson material. This information includes examples of concepts just introduced in the text, explanations or definitions of terms that are not defined in the text, examples of common trade jargon used to describe a part or operation, and unique applications of the system or service described in the text. Many textbooks also include this information but insert it in the main body of text; this tends to interrupt the reader's thought process. By placing this information to the side of the main text, students can read through the text uninterrupted and refer to the additional information when it is best for them.

Jack Erjavec,
Series Editor

HIGHLIGHTS OF THIS NEW EDITION—CLASSROOM MANUAL

We are very proud of the changes made to make the seventh edition of *Today's Technician™: Automotive Engine Performance*. The Classroom Manual has been updated to reflect current changes in automotive engine performance, while retaining some of the more pertinent information on older models that are still in wide use. Engine performance technology is often seen by students as an array of complicated subjects, all of which can be difficult to understand. This is why *Automotive Engine Performance* follows a natural progression of subjects, including basic theories, engine construction, electrical theory, and computer control, to bring all these topics together. More experienced students and working technicians can review the basic theories and then move on to more advanced areas in the latter half of the text.

This edition features an even further investigation of digital fuel injection (DFI) use and operation, pulse width modulated fuel pump control, and variable valve timing, along with expanded and updated coverage of hybrid vehicle technology. Coverage of ignition systems and fuel injection has been updated with coverage that reflects the vehicles in use today. This edition continues to present the latest in sensor technology and new developments in automotive engine performance. The Classroom Manual also has new ASE-style multiple-choice questions to help assess student understanding of the material.

HIGHLIGHTS OF THIS NEW EDITION—SHOP MANUAL

The *Automotive Engine Performance*, seventh edition, Shop Manual follows the same natural progression of the Classroom Manual but focuses on the skill set required to be a successful technician in today's shop. The Shop Manual starts with shop procedures and ASE certification, progresses through electrical testing, basic engine testing, and scan tool procedures, and finally through the most advanced diagnostics used today. The coverage includes new basic engine technology, such as variable valve timing, while retaining a thorough coverage of basic engine testing such as vacuum, compression, cylinder leakage, and engine balance that are the cornerstone of engine performance diagnosis. Students are then led through electrical troubleshooting. This coverage includes basic multimeter, test lamp, logic probe, and oscilloscope pattern reading and use. Electrical wiring and connector repair are also covered, and a review of battery starting and charging diagnostics is given. Engine performance ignition systems coverage reflects modern usage of coil-over-plug systems, while retaining some distributor ignition coverage. Fuel injection system coverage reflects port fuel and direct fuel injection. Engine control systems such as variable valve timing, fuel systems such as returnless fuel systems, pulse width modulated fuel pump control, and emission controls such as PCV, EGR, and evaporative emissions are covered in depth. A section on computer operation and networking is included, as well as a chapter on related systems to bring the operation of the whole vehicle together for the student. This broad coverage makes this edition suitable for a wide range of student capability, from beginning technician to a more seasoned veteran. Other important updates are updated photo sequences. Many job sheets have been added to provide complete coverage of MAST, AST, and MLR tasks.

CLASSROOM MANUAL

Features of the Classroom Manual include the following:

Cognitive Objectives

These objectives outline the chapter's contents and identify what students should know and be able to do upon completion of the chapter. Each topic is divided into small units to promote easier understanding and learning.

Terms to Know List

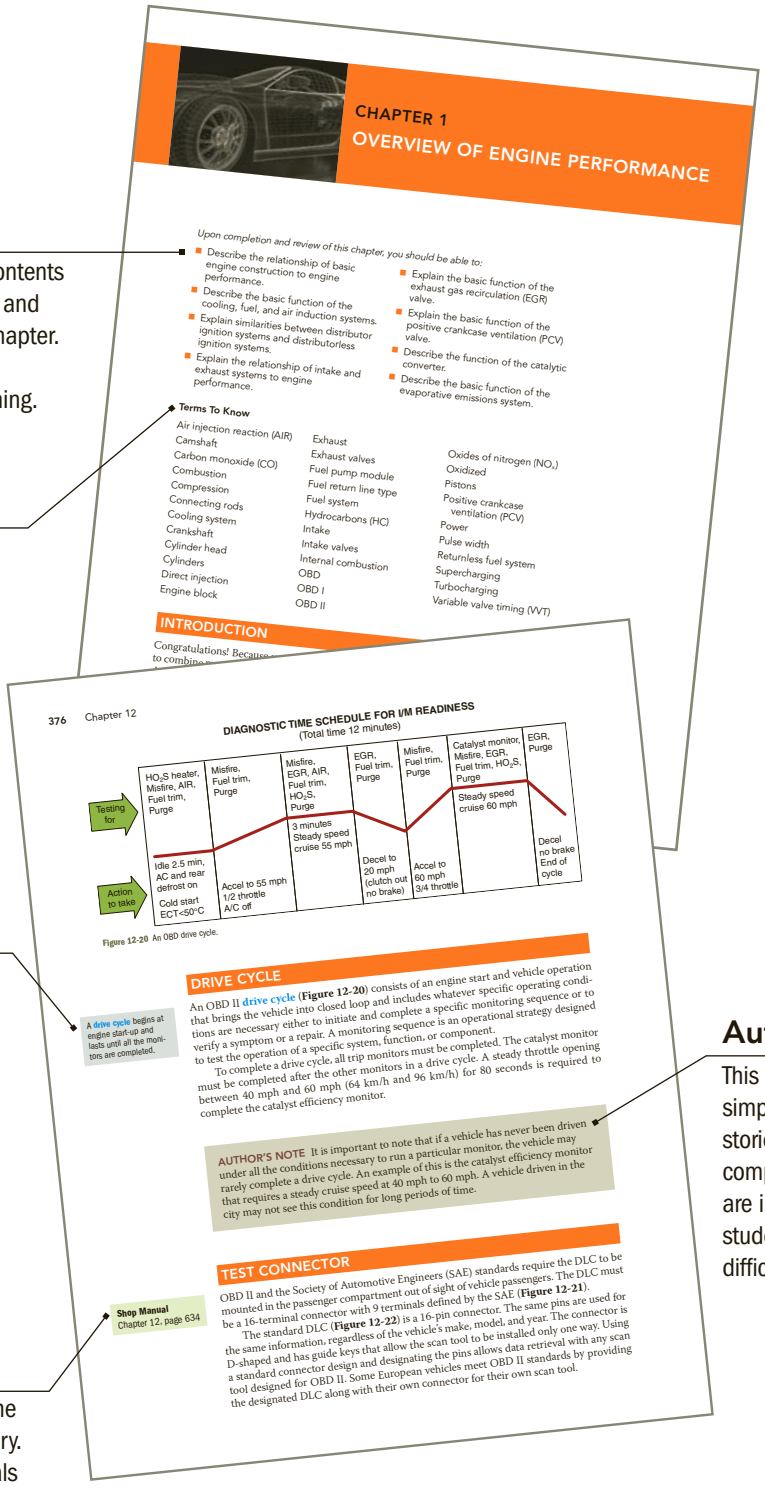
A list of key terms appears immediately after the Objectives. Students will see these terms discussed in the chapter. Definitions can also be found in the Glossary at the end of the manual.

Margin Notes

The most important terms to know are highlighted and defined in the margin. Common trade jargon also appears in the margin and gives some of the common terms used for components. This helps students understand and speak the language of the trade, especially when conversing with an experienced technician.

Cross-References to the Shop Manual

References to the appropriate page in the Shop Manual appear whenever necessary. Although the chapters of the two manuals are synchronized, material covered in other chapters of the Shop Manual may be fundamental to the topic discussed in the Classroom Manual.



CHAPTER 1
OVERVIEW OF ENGINE PERFORMANCE

Upon completion and review of this chapter, you should be able to:

- Describe the relationship of basic engine construction to engine performance.
- Describe the basic function of the cooling, fuel, and air induction systems.
- Explain similarities between distributor ignition systems and distributorless ignition systems.
- Explain the relationship of intake and exhaust systems to engine performance.
- Explain the basic function of the exhaust gas recirculation (EGR) valve.
- Explain the basic function of the positive crankcase ventilation (PCV) valve.
- Describe the function of the catalytic converter.
- Describe the basic function of the evaporative emissions system.

Terms To Know

Air injection reaction (AIR)
Camshaft
Carbon monoxide (CO)
Combustion
Compression
Connecting rods
Cooling system
Crankshaft
Cylinder head
Cylinders
Direct injection
Engine block
Exhaust
Exhaust valves
Fuel pump module
Fuel return line type
Fuel system
Hydrocarbons (HC)
Intake
Intake valves
Internal combustion
OBD
OBD I
OBD II
Oxides of nitrogen (NO_x)
Oxidized
Pistons
Positive crankcase ventilation (PCV)
Power
Pulse width
Returnless fuel system
Supercharging
Turbocharging
Variable valve timing (VVT)

INTRODUCTION

Congratulations! Because

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DIAGNOSTIC TIME SCHEDULE FOR I/M READINESS
(Total time 12 minutes)

Testing for	HO_2S heater, Misfire, AIR, Fuel trim, Purge	Misfire, Fuel trim, Purge	Misfire, EGR, AIR, Fuel trim, HO_2S, Purge	EGR, Fuel trim, Purge	Misfire, Fuel trim, Purge	Catalyst monitor, Misfire, EGR, Fuel trim, HO_2S, Purge	EGR, Purge
Action to take	Idle 2.5 min, AC and rear defrost on Cold start ECT<50°C	Accel to 55 mph 1/2 throttle A/C off	3 minutes Steady speed cruise 55 mph	Decel to 20 mph (clutch out no brake)	Accel to 60 mph 3/4 throttle	Steady speed cruise 60 mph	Decel no brake End of cycle

Figure 12-20 An OBD drive cycle.

A drive cycle begins at engine start-up and lasts until all the monitors are completed.

DRIVE CYCLE

An OBD II drive cycle (**Figure 12-20**) consists of an engine start and vehicle operation that brings the vehicle into closed loop and includes whatever specific operating conditions are necessary either to initiate and complete a specific monitoring sequence or to verify a symptom or a repair. A monitoring sequence is an operational strategy designed to test the operation of a specific system, function, or component.

To complete a drive cycle, all trip monitors must be completed. The catalyst monitor must be completed after the other monitors in a drive cycle. A steady throttle opening between 40 mph and 60 mph (64 km/h and 96 km/h) for 80 seconds is required to complete the catalyst efficiency monitor.

AUTHOR'S NOTE It is important to note that if a vehicle has never been driven under all the conditions necessary to run a particular monitor, the vehicle may rarely complete a drive cycle. An example of this is the catalyst efficiency monitor that requires a steady cruise speed at 40 mph to 60 mph. A vehicle driven in the city may not see this condition for long periods of time.

TEST CONNECTOR

OBD II and the Society of Automotive Engineers (SAE) standards require the DLC to be mounted in the passenger compartment out of sight of vehicle passengers. The DLC must be a 16-terminal connector with 9 terminals defined by the SAE (**Figure 12-21**).

The standard DLC (**Figure 12-22**) is a 16-pin connector. The same pins are used for the same information, regardless of the vehicle's make, model, and year. The connector is D-shaped and has guide keys that allow the scan tool to be installed only one way. Using a standard connector design and designating the pins allows data retrieval with any scan tool designed for OBD II. Some European vehicles meet OBD II standards by providing the designated DLC along with their own connector for their own scan tool.

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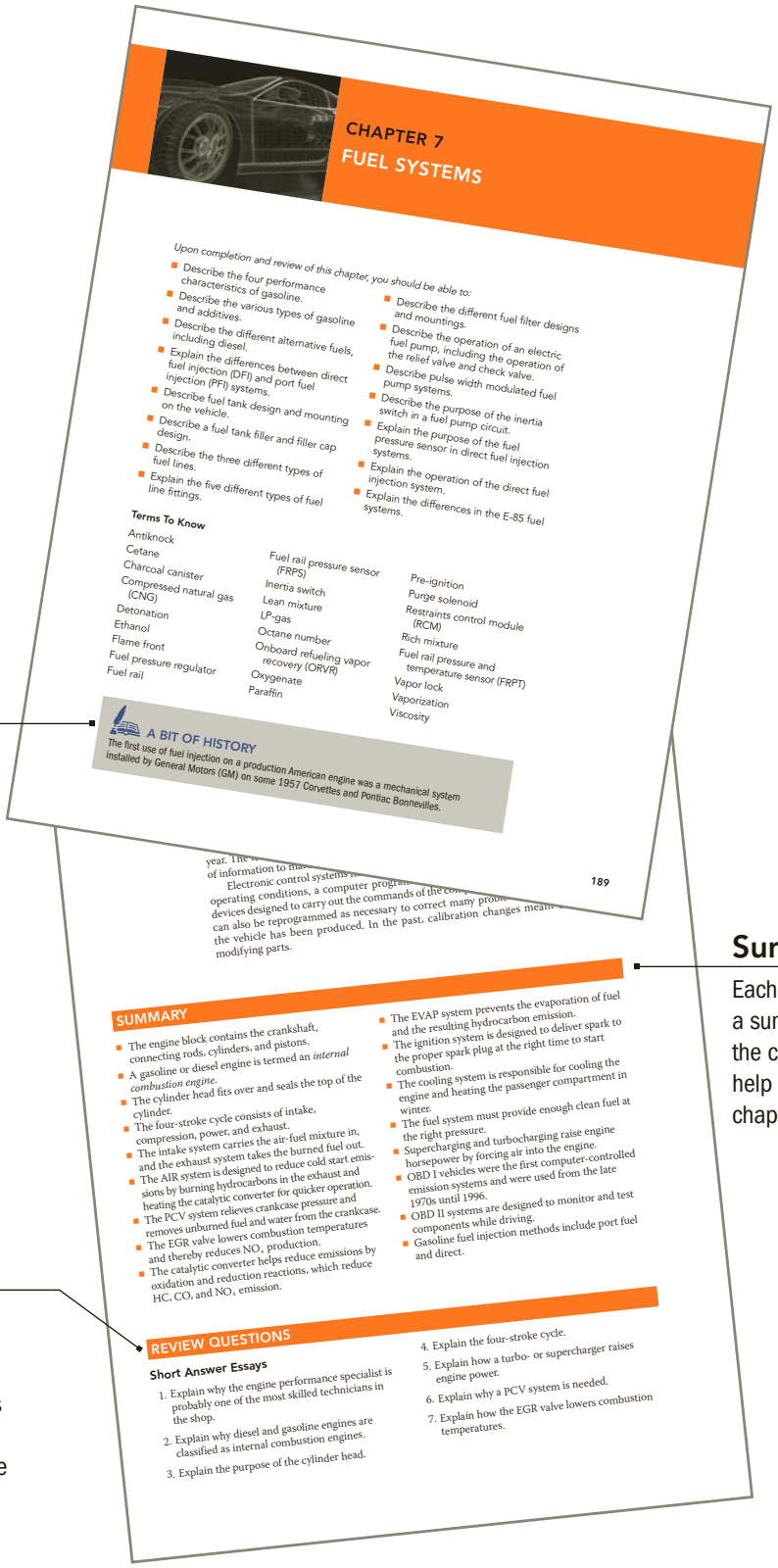
Author's Note

This feature includes simple explanations, stories, or examples of complex topics. These are included to help students understand difficult concepts.


CHAPTER 7
FUEL SYSTEMS

Upon completion and review of this chapter, you should be able to:

- Describe the four performance characteristics of gasoline.
- Describe the various types of gasoline and additives.
- Describe the different alternative fuels, including diesel.
- Explain the differences between direct fuel injection (DFI) and port fuel injection (PFI) systems.
- Describe fuel tank design and mounting on the vehicle.
- Describe a fuel tank filler and filler cap design.
- Describe the three different types of fuel lines.
- Explain the five different types of fuel line fittings.
- Describe the different fuel filter designs and mountings.
- Describe the operation of an electric fuel pump, including the operation of the relief valve and check valve.
- Describe pulse width modulated fuel pump systems.
- Describe the purpose of the inertia switch in a fuel pump circuit.
- Explain the purpose of the fuel pressure sensor in direct fuel injection systems.
- Explain the operation of the direct fuel injection system.
- Explain the differences in the E-85 fuel systems.

Terms To Know

Antiknock
Cetane
Charcoal canister
Compressed natural gas (CNG)
Detonation
Ethanol
Flame front
Fuel pressure regulator
Fuel rail
Fuel rail pressure sensor (FRPS)
Inertia switch
Lean mixture
LP-gas
Octane number
Onboard refueling vapor recovery (ORVR)
Oxygenate
Paraffin
Pre-ignition
Purge solenoid
Restraints control module (RCM)
Rich mixture
Fuel rail pressure and temperature sensor (FRPT)
Vapor lock
Vaporization
Viscosity

A BIT OF HISTORY
The first use of fuel injection on a production American engine was a mechanical system installed by General Motors (GM) on some 1957 Corvettes and Pontiac Bonnevilles.

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A Bit of History

This feature gives the student a sense of the evolution of the automobile. This feature not only contains nice-to-know information, but also should spark some interest in the subject matter.

SUMMARY

- The engine block contains the crankshaft, connecting rods, cylinders, and pistons.
- A gasoline or diesel engine is termed an *internal combustion engine.*
- The cylinder head fits over and seals the top of the cylinder.
- The four-stroke cycle consists of intake, compression, power, and exhaust.
- The intake system carries the air-fuel mixture in, and the exhaust system takes the burned fuel out.
- The AIR system is designed to reduce cold start emissions by burning hydrocarbons in the exhaust and heating the catalytic converter for quicker operation.
- The PCV system relieves crankcase pressure and removes unburned fuel and water from the crankcase.
- The EGR valve lowers combustion temperatures and thereby reduces NO_x production.
- The catalytic converter helps reduce emissions by oxidation and reduction reactions, which reduce HC, CO, and NO_x emission.
- The EVAP system prevents the evaporation of fuel and the resulting hydrocarbon emission.
- The ignition system is designed to deliver spark to the proper spark plug at the right time to start combustion.
- The cooling system is responsible for cooling the engine and heating the passenger compartment in winter.
- The fuel system must provide enough clean fuel at the right pressure.
- Supercharging and turbocharging raise engine horsepower by forcing air into the engine.
- OBD I vehicles were the first computer-controlled emission systems and were used from the late 1970s until 1996.
- OBD II systems are designed to monitor and test components while driving.
- Gasoline fuel injection methods include port fuel and direct.

Summary

Each chapter concludes with a summary of key points from the chapter. These key points help the reader review the chapter contents.

REVIEW QUESTIONS

Short Answer Essays

1. Explain why the engine performance specialist is probably one of the most skilled technicians in the shop.
2. Explain why diesel and gasoline engines are classified as internal combustion engines.
3. Explain the purpose of the cylinder head.
4. Explain the four-stroke cycle.
5. Explain how a turbo- or supercharger raises engine power.
6. Explain why a PCV system is needed.
7. Explain how the EGR valve lowers combustion temperatures.

Review Questions

Short-answer essays, fill-in-the-blanks, and multiple-choice questions are found at the end of each chapter. These questions are designed to accurately assess the student's competence in the stated objectives at the beginning of the chapter.

SHOP MANUAL

To stress the importance of safe work habits, the Shop Manual also dedicates one full chapter to safety. Other important features of this manual include:

Performance-Based Objectives

These objectives define the contents of the chapter and what the student should have learned upon completion of the chapter.

Terms to Know List

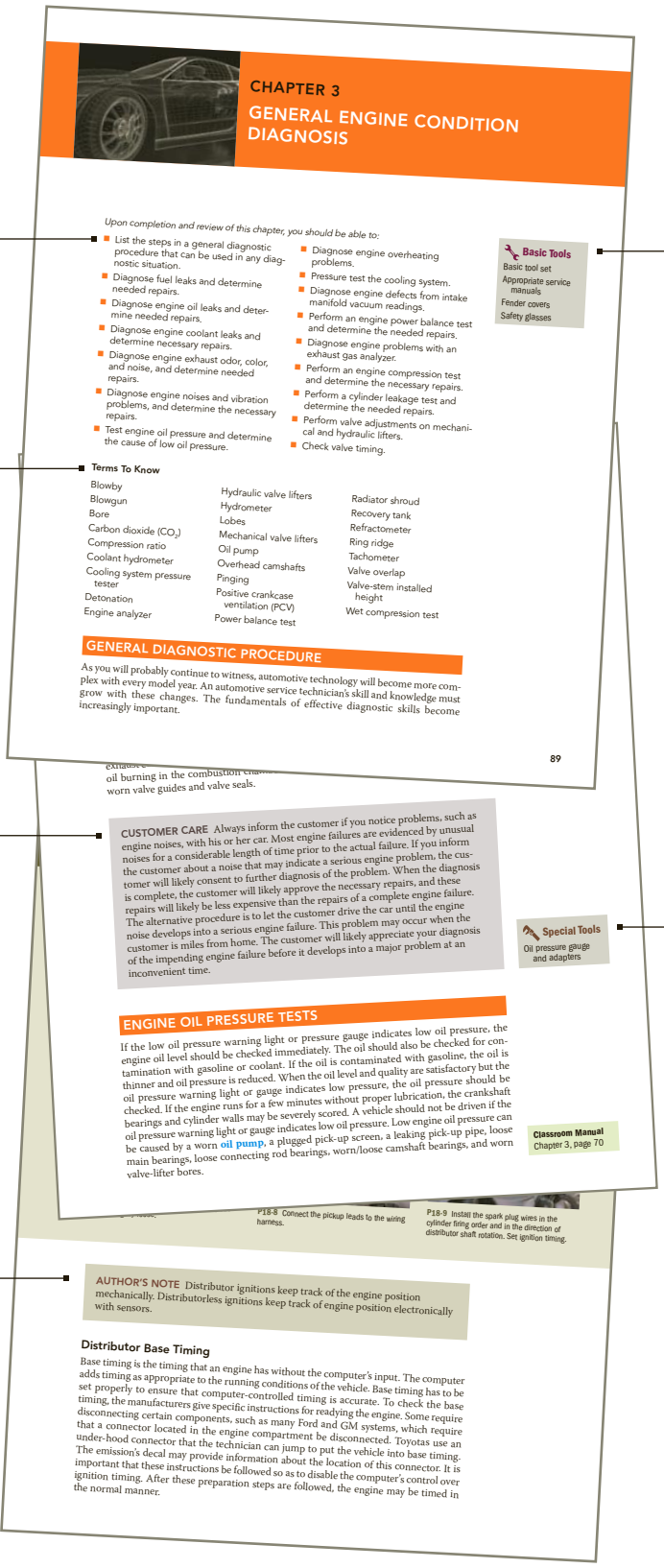
Terms in this list can be found in the Glossary at the end of the manual.

Customer Care

This feature highlights those little things a technician can do or say to enhance customer relations.

Author's Note

This feature includes simple explanations, stories, or examples of complex topics. These are included to help students understand difficult concepts.



CHAPTER 3

GENERAL ENGINE CONDITION DIAGNOSIS

Upon completion and review of this chapter, you should be able to:

- List the steps in a general diagnostic procedure that can be used in any diagnostic situation.
- Diagnose fuel leaks and determine needed repairs.
- Diagnose engine oil leaks and determine needed repairs.
- Diagnose engine coolant leaks and determine necessary repairs.
- Diagnose engine exhaust odor, color, and noise, and determine needed repairs.
- Diagnose engine noises and vibration problems, and determine the necessary repairs.
- Test engine oil pressure and determine the cause of low oil pressure.
- Diagnose engine overheating problems.
- Pressure test the cooling system.
- Diagnose engine defects from intake manifold vacuum readings.
- Perform an engine power balance test and determine the needed repairs.
- Diagnose engine problems with an exhaust gas analyzer.
- Perform an engine compression test and determine the necessary repairs.
- Perform a cylinder leakage test and determine the needed repairs.
- Perform valve adjustments on mechanical and hydraulic lifters.
- Check valve timing.

Basic Tools
Basic tool set
Appropriate service manuals
Fender covers
Safety glasses

Terms To Know

Blowby
Blowgun
Bore
Carbon dioxide (CO_2)
Compression ratio
Coolant hydrometer
Cooling system pressure tester
Detonation
Engine analyzer
Hydraulic valve lifters
Hydrometer
Lobes
Mechanical valve lifters
Oil pump
Overhead camshafts
Pinging
Positive crankcase ventilation (PCV)
Power balance test
Radiator shroud
Recovery tank
Refractometer
Ring ridge
Tachometer
Valve overlap
Valve-stem installed height
Wet compression test

GENERAL DIAGNOSTIC PROCEDURE

As you will probably continue to witness, automotive technology will become more complex with every model year. An automotive service technician's skill and knowledge must grow with these changes. The fundamentals of effective diagnostic skills become increasingly important.

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oil burning in the combustion
worn valve guides and valve seals.

CUSTOMER CARE Always inform the customer if you notice problems, such as engine noises, with his or her car. Most engine failures are evidenced by unusual noises for a considerable length of time prior to the actual failure. If you inform the customer about a noise that may indicate a serious engine problem, the customer will likely consent to further diagnosis of the problem. When the diagnosis is complete, the customer will likely approve the necessary repairs, and these repairs will likely be less expensive than the repairs of a complete engine failure. The alternative procedure is to let the customer drive the car until the engine noise develops into a serious engine failure. This problem may occur when the customer is miles from home. The customer will likely appreciate your diagnosis of the impending engine failure before it develops into a major problem at an inconvenient time.

Special Tools
Oil pressure gauge and adapters

ENGINE OIL PRESSURE TESTS

If the low oil pressure warning light or pressure gauge indicates low oil pressure, the engine oil level should be checked immediately. The oil should also be checked for contamination with gasoline or coolant. If the oil is contaminated with gasoline, the oil is thinner and oil pressure is reduced. When the oil level and quality are satisfactory but the oil pressure warning light or gauge indicates low pressure, the oil pressure should be checked. If the engine runs for a few minutes without proper lubrication, the crankshaft bearings and cylinder walls may be severely scored. A vehicle should not be driven if the oil pressure warning light or gauge indicates low oil pressure. Low engine oil pressure can be caused by a worn **oil pump**, a plugged pick-up screen, a leaking pick-up pipe, loose main bearings, loose connecting rod bearings, worn/loose camshaft bearings, and worn valve-lifter bores.

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P18-8 Connect the pickup leads to the wiring harness.

P18-9 Install the spark plug wires in the cylinder firing order and in the direction of distributor shaft rotation. Set ignition timing.

AUTHOR'S NOTE Distributor ignitions keep track of the engine position mechanically. Distributorless ignitions keep track of engine position electronically with sensors.

Distributor Base Timing

Base timing is the timing that an engine has without the computer's input. The computer adds timing as appropriate to the running conditions of the vehicle. Base timing has to be set properly to ensure that computer-controlled timing is accurate. To check the base timing, the manufacturers give specific instructions for readying the engine. Some require disconnecting certain components, such as many Ford and GM systems, which require that a connector located in the engine compartment be disconnected. Toyotas use an under-hood connector that the technician can jump to put the vehicle into base timing. The emission's decal may provide information about the location of this connector. It is important that these instructions be followed so as to disable the computer's control over ignition timing. After these preparation steps are followed, the engine may be timed in the normal manner.

Basic Tools Lists

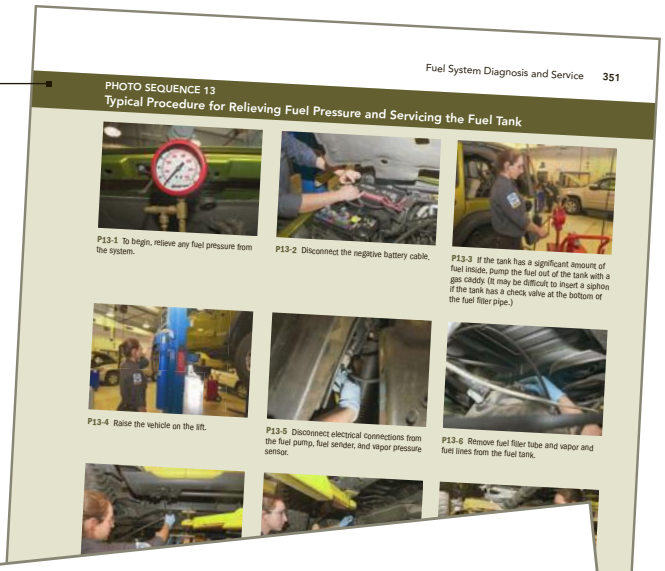
Each chapter begins with a list of the basic tools needed to perform the tasks included in the chapter.

Special Tools Lists

Whenever a special tool is required to complete a task, it is listed in the margin next to the procedure.

Photo Sequences

Many procedures are illustrated in detailed photo sequences. These detailed photographs show the students what to expect when they perform particular procedures. They also can provide the student a familiarity with a system or type of equipment, which the school might not have.



Fuel System Diagnosis and Service 351

PHOTO SEQUENCE 13
Typical Procedure for Relieving Fuel Pressure and Servicing the Fuel Tank

P13-1 To begin, relieve any fuel pressure from the system.

P13-2 Disconnect the negative battery cable.

P13-3 If the tank has a significant amount of fuel inside, pump the fuel out of the tank with a gas caddy. (It may be difficult to insert a siphon if the tank has a check valve at the bottom of the fuel filler pipe.)

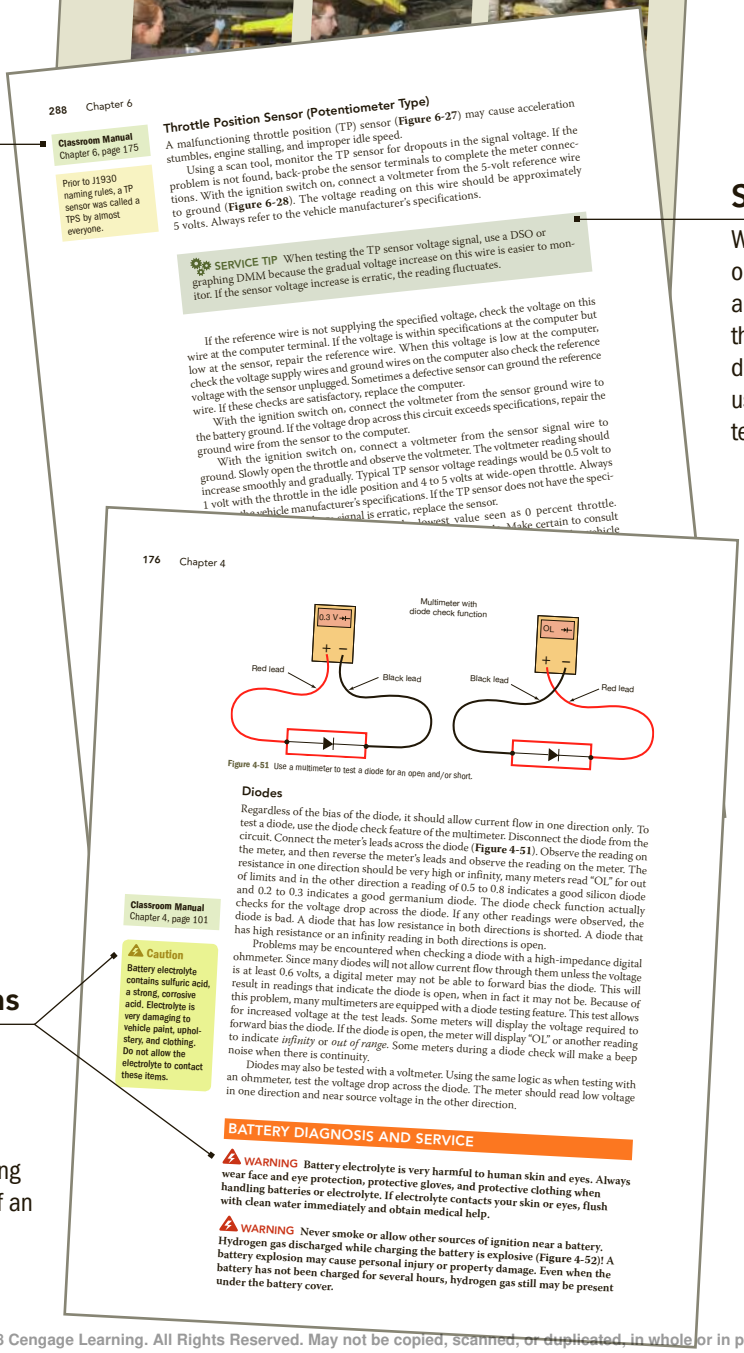
P13-4 Raise the vehicle on the lift.

P13-5 Disconnect electrical connections from the fuel pump, fuel sender, and vapor pressure sensor.

P13-6 Remove fuel filler tube and vapor and fuel lines from the fuel tank.

References to the Classroom Manual

References to the appropriate page in the Classroom Manual appear whenever necessary. Although the chapters of the two manuals are synchronized, material covered in other chapters of the Classroom Manual may be fundamental to the topic discussed in the Shop Manual.



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Chapter 6, page 175

Prior to J1930 naming rules, a TP sensor was called a TPS by almost everyone.

Throttle Position Sensor (Potentiometer Type)

A malfunctioning throttle position (TP) sensor (**Figure 6-27**) may cause acceleration stumbles, engine stalling, and improper idle speed.

Using a scan tool, monitor the TP sensor for dropouts in the signal voltage. If the problem is not found, back-probe the sensor terminals to complete the meter connections. With the ignition switch on, connect a voltmeter from the 5-volt reference wire to ground (**Figure 6-28**). The voltage reading on this wire should be approximately 5 volts. Always refer to the vehicle manufacturer's specifications.

SERVICE TIP When testing the TP sensor voltage signal, use a DSO or graphing DMM because the gradual voltage increase on this wire is easier to monitor. If the sensor voltage increase is erratic, the reading fluctuates.

If the reference wire is not supplying the specified voltage, check the voltage on this wire at the computer terminal. If the voltage is within specifications at the computer but low at the sensor, repair the reference wire. When this voltage is low at the computer, check the voltage supply wires and ground wires on the computer also check the reference voltage with the sensor unplugged. Sometimes a defective sensor can ground the reference wire. If these checks are satisfactory, replace the computer.

With the ignition switch on, connect the voltmeter from the sensor ground wire to the battery ground. If the voltage drop across this circuit exceeds specifications, repair the ground wire from the sensor to the computer.

With the ignition switch on, connect a voltmeter from the sensor signal wire to ground. Slowly open the throttle and observe the voltmeter. The voltmeter reading should increase smoothly and gradually. Typical TP sensor voltage readings would be 0.5 volt to 1 volt with the throttle in the idle position and 4 to 5 volts at wide-open throttle. Always check the vehicle manufacturer's specifications. If the TP sensor does not have the specified signal is erratic, replace the sensor.

Service Tips

Whenever a shortcut or special procedure is appropriate, it is described in the text. Generally, these tips describe common procedures used by experienced technicians.

176 Chapter 4

Figure 4-51 Use a multimeter to test a diode for an open and/or short.

Classroom Manual
Chapter 4, page 101

Caution
Battery electrolyte contains sulfuric acid, a strong, corrosive acid. Electrolyte is very damaging to vehicle paint, upholstery, and clothing. Do not allow the electrolyte to contact these items.

Diodes

Regardless of the bias of the diode, it should allow current flow in one direction only. To test a diode, use the diode check feature of the multimeter. Disconnect the diode from the circuit. Connect the meter's leads across the diode (**Figure 4-51**). Observe the reading on the meter, and then reverse the meter's leads and observe the reading on the meter. The resistance in one direction should be very high or infinity, many meters read "OL" for out of limits and in the other direction a reading of 0.5 to 0.8 indicates a good silicon diode and 0.2 to 0.3 indicates a good germanium diode. The diode check function actually checks for the voltage drop across the diode. If any other readings were observed, the diode is bad. A diode that has low resistance in both directions is shorted. A diode that has high resistance or an infinity reading in both directions is open.

Problems may be encountered when checking a diode with a high-impedance digital ohmmeter. Since many diodes will not allow current flow through them unless the voltage is at least 0.6 volts, a digital meter may not be able to forward bias the diode. This will result in readings that indicate the diode is open, when in fact it may not be. Because of this problem, many multimeters are equipped with a diode testing feature. This test allows for increased voltage at the test leads. Some meters will display the voltage required to forward bias the diode. If the diode is open, the meter will display "OL" or another reading to indicate *infinity* or *out of range*. Some meters during a diode check will make a beep noise when there is continuity.

Diodes may also be tested with a voltmeter. Using the same logic as when testing with an ohmmeter, test the voltage drop across the diode. The meter should read low voltage in one direction and near source voltage in the other direction.

BATTERY DIAGNOSIS AND SERVICE

WARNING Battery electrolyte is very harmful to human skin and eyes. Always wear face and eye protection, protective gloves, and protective clothing when handling batteries or electrolyte. If electrolyte contacts your skin or eyes, flush with clean water immediately and obtain medical help.

WARNING Never smoke or allow other sources of ignition near a battery. Hydrogen gas discharged while charging the battery is explosive (**Figure 4-52**)! A battery explosion may cause personal injury or property damage. Even when the battery has not been charged for several hours, hydrogen gas still may be present under the battery cover.

Warnings and Cautions

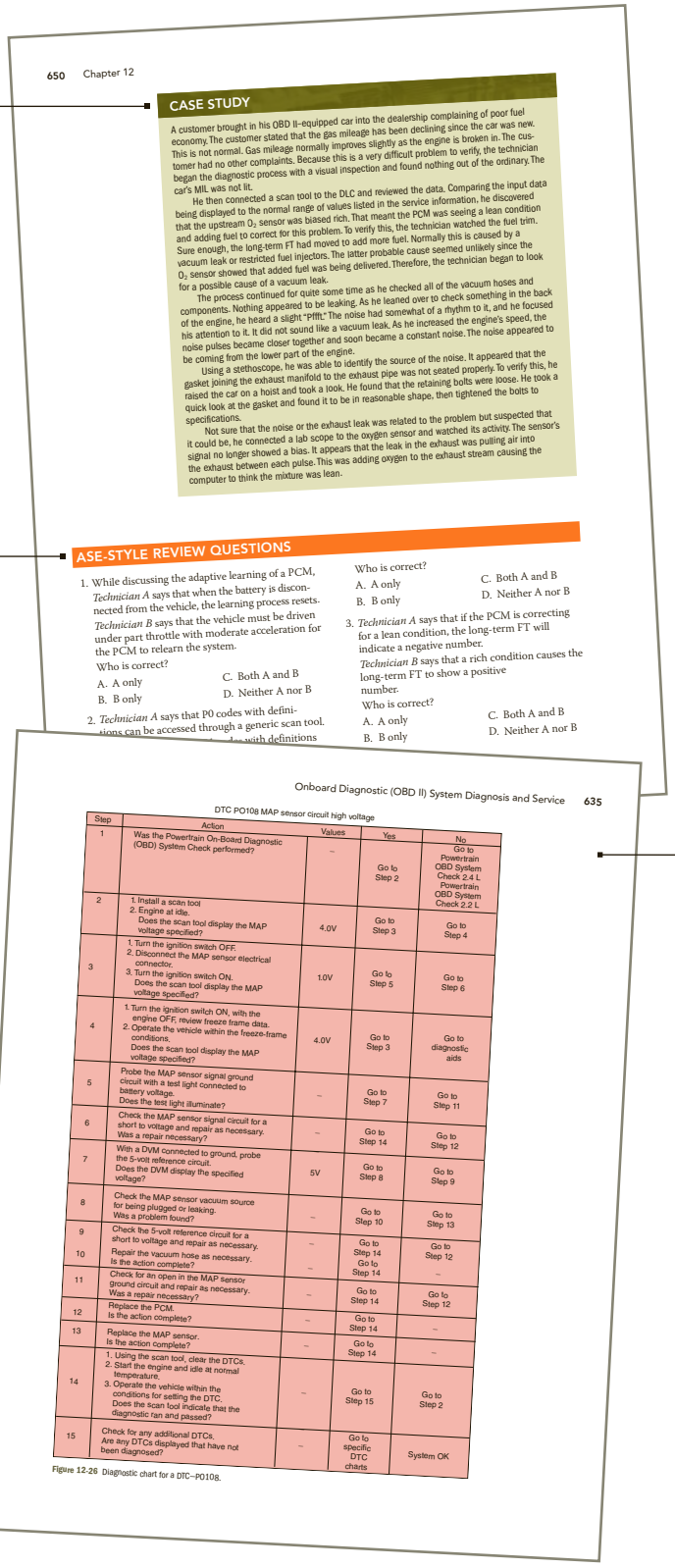
Cautions appear throughout the text to alert readers to potentially hazardous materials or unsafe conditions. Warnings advise the students of things that can go wrong if instructions are not followed or if an incorrect part or tool is used.

Case Studies

Each chapter ends with a Case Study describing a particular vehicle problem and the logical steps a technician might use to solve the problem. These studies focus on system diagnosis skills and help students gain familiarity with the process.

ASE-Style Review Questions

Each chapter contains ASE-Style Review Questions that reflect the performance objectives listed at the beginning of the chapter. These questions can be used to review the chapter as well as to prepare for the ASE certification exam.



650 Chapter 12

CASE STUDY

A customer brought in his OBD II–equipped car into the dealership complaining of poor fuel economy. The customer stated that the gas mileage has been declining since the car was new. This is not normal. Gas mileage normally improves slightly as the engine is broken in. The customer had no other complaints. Because this is a very difficult problem to verify, the technician began the diagnostic process with a visual inspection and found nothing out of the ordinary. The car's MIL was not lit.

He then connected a scan tool to the DLC and reviewed the data. Comparing the input data being displayed to the normal range of values listed in the service information, he discovered that the upstream O_2 sensor was biased rich. That meant the PCM was seeing a lean condition and adding fuel to correct for this problem. To verify this, the technician watched the fuel trim. Sure enough, the long-term FT had moved to add more fuel. Normally this is caused by a vacuum leak or restricted fuel injectors. The latter probable cause seemed unlikely since the O_2 sensor showed that added fuel was being delivered. Therefore, the technician began to look for a possible cause of a vacuum leak.

The process continued for quite some time as he checked all of the vacuum hoses and components. Nothing appeared to be leaking. As he leaned over to check something in the back of the engine, he heard a slight "Pfft." The noise had somewhat of a rhythm to it, and he focused his attention to it. It did not sound like a vacuum leak. As he increased the engine's speed, the noise pulses became closer together and soon became a constant noise. The noise appeared to be coming from the lower part of the engine.

Using a stethoscope, he was able to identify the source of the noise. It appeared that the gasket joining the exhaust manifold to the exhaust pipe was not seated properly. To verify this, he raised the car on a hoist and took a look. He found that the retaining bolts were loose. He took a quick look at the gasket and found it to be in reasonable shape, then tightened the bolts to specifications.

Not sure that the noise or the exhaust leak was related to the problem but suspected that it could be, he connected a lab scope to the oxygen sensor and watched its activity. The sensor's signal no longer showed a bias. It appears that the leak in the exhaust was pulling air into the exhaust between each pulse. This was adding oxygen to the exhaust stream causing the computer to think the mixture was lean.

ASE-STYLE REVIEW QUESTIONS

1. While discussing the adaptive learning of a PCM, *Technician A* says that when the battery is disconnected from the vehicle, the learning process resets. *Technician B* says that the vehicle must be driven under part throttle with moderate acceleration for the PCM to relearn the system.
   Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B
2. *Technician A* says that P0 codes with definitions can be accessed through a generic scan tool.
   Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B
3. *Technician A* says that if the PCM is correcting for a lean condition, the long-term FT will indicate a negative number.
   Technician B says that a rich condition causes the long-term FT to show a positive number.
   Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B

Onboard Diagnostic (OBD II) System Diagnosis and Service 635

DTC P0108 MAP sensor circuit high voltage

Step	Action	Values	Yes	No
1	Was the Powertrain On-Board Diagnostic (OBD) System Check performed?	–	Go to Step 2	Go to Powertrain OBD System Check 2.4 L Powertrain OBD System Check 2.2 L
2	1. Install a scan tool 2. Engine at idle. Does the scan tool display the MAP voltage specified?	4.0V	Go to Step 3	Go to Step 4
3	1. Turn the ignition switch OFF. 2. Disconnect the MAP sensor electrical connector. 3. Turn the ignition switch ON. Does the scan tool display the MAP voltage specified?	1.0V	Go to Step 5	Go to Step 6
4	1. Turn the ignition switch ON, with the engine OFF, review freeze frame data. 2. Operate the vehicle within the freeze-frame conditions. Does the scan tool display the MAP voltage specified?	4.0V	Go to Step 3	Go to diagnostic aids
5	Probe the MAP sensor signal ground circuit with a test light connected to battery voltage. Does the test light illuminate?	–	Go to Step 7	Go to Step 11
6	Check the MAP sensor signal circuit for a short to voltage and repair as necessary. Was a repair necessary?	–	Go to Step 14	Go to Step 12
7	With a DVM connected to ground, probe the 5-volt reference circuit. Does the DVM display the specified voltage?	5V	Go to Step 8	Go to Step 9
8	Check the MAP sensor vacuum source for being plugged or leaking. Was a problem found?	–	Go to Step 10	Go to Step 13
9	Check the 5-volt reference circuit for a short to voltage and repair as necessary.	–	Go to Step 14	Go to Step 12
10	Repair the vacuum hose as necessary. Is the action complete?	–	Go to Step 14	–
11	Check for an open in the MAP sensor ground circuit and repair as necessary. Was a repair necessary?	–	Go to Step 14	Go to Step 12
12	Replace the PCM. Is the action complete?	–	Go to Step 14	–
13	Replace the MAP sensor. Is the action complete?	–	Go to Step 14	–
14	1. Using the scan tool, clear the DTCs. 2. Start the engine and idle at normal temperature. 3. Operate the vehicle within the conditions for setting the DTC. Does the scan tool indicate that the diagnostic ran and passed?	–	Go to Step 15	Go to Step 2
15	Check for any additional DTCs. Are any DTCs displayed that have not been diagnosed?	–	Go to specific DTC charts	System OK

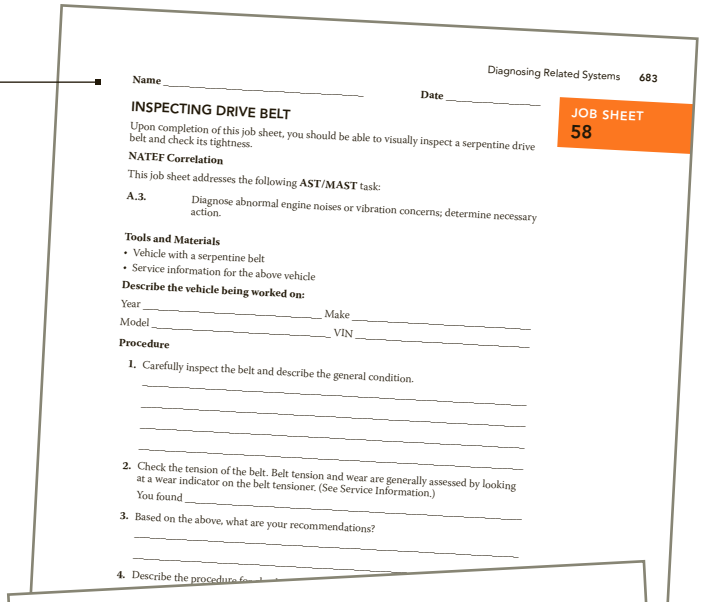
Figure 12-26 Diagnostic chart for a DTC—P0108.

Diagnostic Charts

Some chapters include detailed diagnostic charts that list common problems and most probable causes. They also list a page reference in the Classroom Manual for the student to use to gain a better understanding of the system's operation and a page reference in the Shop Manual to refer the student to details on the procedure necessary for correcting the problem.

Job Sheets

Located at the end of each chapter, the Job Sheets provide a format for students to perform procedures covered in the chapter. A reference to the ASE Task addressed by the procedure is included on the Job Sheet.



Diagnosing Related Systems 683

Name _____ Date _____

JOB SHEET 58

INSPECTING DRIVE BELT

Upon completion of this job sheet, you should be able to visually inspect a serpentine drive belt and check its tightness.

NATEF Correlation

This job sheet addresses the following **AST/MAST** task:

A.3. Diagnose abnormal engine noises or vibration concerns; determine necessary action.

Tools and Materials

- Vehicle with a serpentine belt
- Service information for the above vehicle

Describe the vehicle being worked on:

Year _____ Make _____

Model _____ VIN _____

Procedure

1. Carefully inspect the belt and describe the general condition.

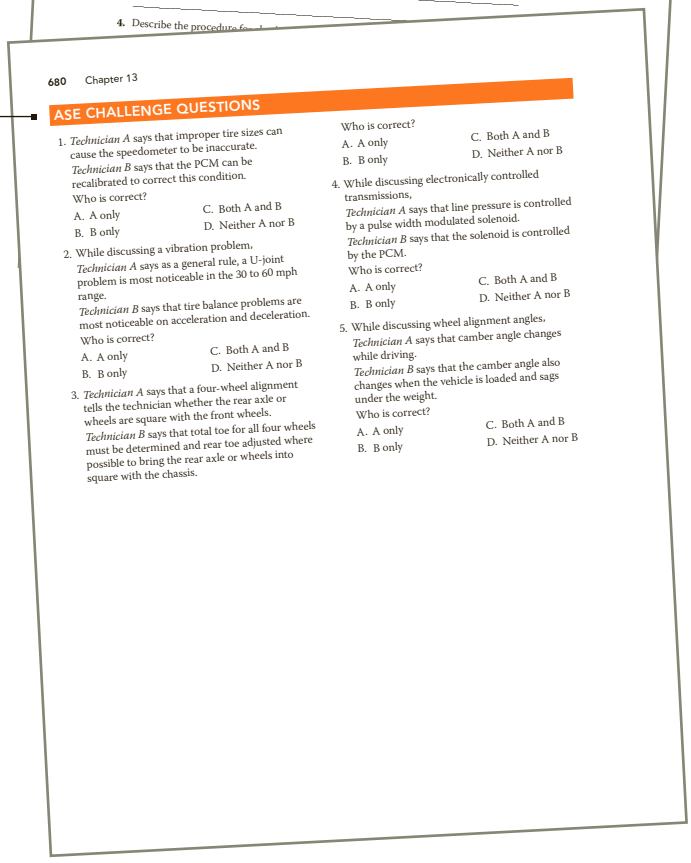
2. Check the tension of the belt. Belt tension and wear are generally assessed by looking at a wear indicator on the belt tensioner. (See Service Information.)
You found _____

3. Based on the above, what are your recommendations?

4. Describe the procedure fo

ASE Challenge Questions

Each technical chapter ends with five ASE Challenge Questions. These are not mere review questions; rather, they test the students' ability to apply general knowledge to the contents of the chapter.



680 Chapter 13

ASE CHALLENGE QUESTIONS

1. *Technician A* says that improper tire sizes can cause the speedometer to be inaccurate.
Technician B says that the PCM can be recalibrated to correct this condition.
Who is correct?
A. A only
B. B only
C. Both A and B
D. Neither A nor B

2. While discussing a vibration problem,
Technician A says as a general rule, a U-joint problem is most noticeable in the 30 to 60 mph range.
Technician B says that tire balance problems are most noticeable on acceleration and deceleration.
Who is correct?
A. A only
B. B only
C. Both A and B
D. Neither A nor B

3. *Technician A* says that a four-wheel alignment tells the technician whether the rear axle or wheels are square with the front wheels.
Technician B says that total toe for all four wheels must be determined and rear toe adjusted where possible to bring the rear axle or wheels into square with the chassis.
Who is correct?
A. A only
B. B only
C. Both A and B
D. Neither A nor B

4. While discussing electronically controlled transmissions,
Technician A says that line pressure is controlled by a pulse width modulated solenoid.
Technician B says that the solenoid is controlled by the PCM.
Who is correct?
A. A only
B. B only
C. Both A and B
D. Neither A nor B

5. While discussing wheel alignment angles,
Technician A says that camber angle changes while driving.
Technician B says that the camber angle also changes when the vehicle is loaded and sags under the weight.
Who is correct?
A. A only
B. B only
C. Both A and B
D. Neither A nor B

SUPPLEMENTS

Instructor Resources

The *Today's Technician* series offers a robust set of instructor resources, available online at Cengage's Instructor Resource Center and on DVD. The following tools have been provided to meet any instructor's classroom preparation needs:

- An Instructor's Guide provides lecture outlines, teaching tips, and complete answers to end-of-chapter questions.
- PowerPoint presentations include images, videos, and animations that coincide with each chapter's content coverage.
- Cengage Learning Testing Powered by Cognero® delivers hundreds of test questions in a flexible, online system. You can choose to author, edit, and manage test bank content from multiple Cengage Learning solutions and deliver tests from your Learning Management System, or you can simply download editable Word documents from the DVD or Instructor Resource Center.
- An Image Gallery includes photos and illustrations from the text.
- The Job Sheets from the Shop Manual are provided in Word format.
- End-of-Chapter Review Questions are also provided in Word format, with a separate set of text rejoinders available for instructors' reference.
- To complete this powerful suite of planning tools, a pair of correlation guides map this edition's content to the NATEF tasks and to the previous edition.

REVIEWERS

The author and publisher would like to extend a special thanks to the following reviewers for their contributions to this text:

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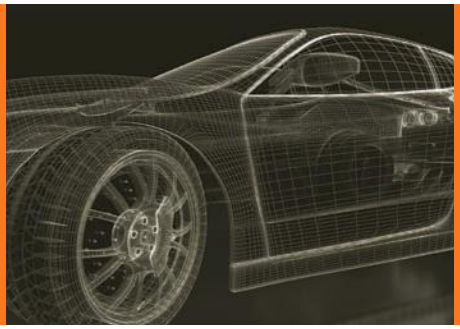

CHAPTER 1
TOOLS AND SAFETY

Upon completion and review of this chapter, you should be able to:

- Understand the importance of safety and accident prevention in an automotive shop.
- Explain the basic principles of personal safety, including protective eyewear, clothing, gloves, shoes, and hearing protection.
- Demonstrate proper lifting procedures and precautions.
- Explain the procedures and precautions for safely using tools and equipment.
- Follow safety precautions regarding the use of power tools.
- Demonstrate proper safety precautions during the use of compressed-air equipment.
- Demonstrate proper vehicle lift operating and safety procedures.
- Observe all safety precautions when hydraulic tools are used in the automotive shop.
- Follow the recommended procedure while operating hydraulic tools such as presses, floor jacks, and vehicle lifts to perform automotive service tasks.
- Follow safety precautions while using cleaning equipment in the automotive shop.
- Observe all shop rules when working in the shop.
- Operate vehicles in the shop according to shop driving rules.
- Explain what should be done to maintain a safe work area, including handling vehicles in the shop and venting carbon monoxide gases.
- Fulfill employee obligations when working in the shop.
- Describe the Automotive Service Excellence (ASE) technician testing and certification process, including the nine areas of certification.
- Follow safety precautions while handling hazardous waste materials.
- Dispose of hazardous waste materials in accordance with state and federal regulations.

Terms To Know

Abrasive cleaning
ASE blue seal of excellence
Carbon monoxide (CO)
Chemical cleaning
Closed-loop system
Corrosive
Environmental Protection Agency (EPA)
Floor jack
Hazard Communication Standard
Hydraulic press
Jack stand
Lift
Material safety data sheets (MSDS)
National Institute for Automotive Service Excellence (ASE)
Neutral
Occupational Safety and Health Act (OSHA)
Park
Particulates
Pneumatic tools
Power tools
Reactive

Resource Conservation and Recovery Act (RCRA)
Right-to-know laws
Safety glasses
Steam cleaning
Sulfuric acid
Thermal cleaning
Toxic
Workplace Hazardous Materials Information Systems (WHMIS)

INTRODUCTION

Safety and accident prevention must be top priorities in all automotive shops. There is great potential for serious accidents simply because of the nature of the business and the equipment used. In fact, the automotive repair industry is rated as one of the most dangerous occupations in the United States.

Vehicles, equipment, and many parts are very heavy, and parts often fit tightly together. Many components become hot during operation, and high fluid pressures can build up inside the cooling system, fuel system, or battery. Batteries contain highly corrosive and potentially explosive acids. Fuels and cleaning solvents are flammable. Exhaust fumes are poisonous. During some repairs, technicians can be exposed to harmful dust particles and vapors.

Good safety practices eliminate these potential dangers. A careless attitude and poor work habits invite disaster. Shop accidents can cause serious injury, temporary or permanent disability, and death. Therefore, safety is a very serious matter. Both the employer and employees must work together to protect the health and welfare of all who work in the shop.

This chapter contains many safety guidelines concerning personal safety, tools and equipment, and work areas, as well as some of the responsibilities you have as an employee and responsibilities your employer has to you. In addition to these rules, special warnings have been used throughout this book to alert you to situations where carelessness could result in personal injury. Finally, when working on cars, always follow the safety guidelines given in service manuals and other technical literature. They are there for your protection.

PERSONAL SAFETY

Personal safety simply involves those precautions you take to protect yourself from injury. These include wearing protective gear, dressing for safety, and handling tools and equipment correctly.

Eye Protection

Your eyes can become permanently damaged by many things in a shop. Some repair procedures, such as grinding, result in tiny particles of metal and dust that are thrown off at very high speeds. These metal and dirt particles can easily get into your eyes, causing scratches or cuts on your eyeball. Pressurized gases and liquids escaping a ruptured hose or fuel line fitting can spray a great distance. If these chemicals get into your eyes, they can cause blindness. Dirt and sharp bits of corroded metal can easily fall down into your eyes while you are working under a vehicle.

If you wear prescription glasses, wear safety goggles that will securely fit over your glasses.

Eye protection should be worn whenever you are exposed to these risks. To be safe, you should wear **safety glasses** whenever you are working in the shop. Many types of eye protection are available (**Figure 1-1**). To provide adequate eye protection, safety glasses have lenses made of safety glass. They also offer some sort of side protection. Regular prescription glasses do not offer sufficient protection and therefore should not be worn as a substitute for safety glasses.

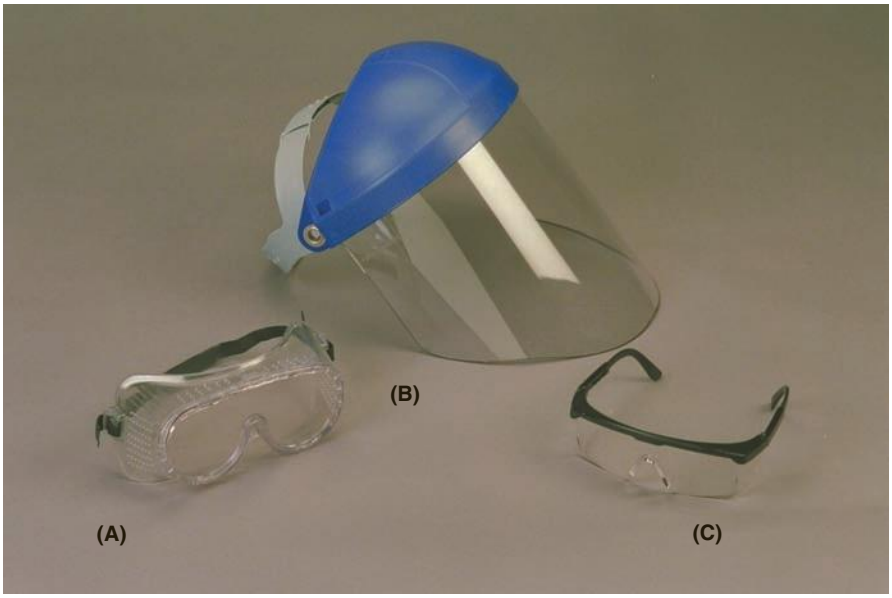

Figure 1-1 (A) Safety goggles, (B) face shield, and (C) safety glasses.

Wearing safety glasses at all times is a good habit to have. To help develop this habit, wear safety glasses that fit well and feel comfortable.

If chemicals such as battery acid, fuel, or solvents get into your eyes, flush them continuously with clean water. Have someone call a doctor and get medical help immediately.

Clothing

Your clothing should be well fitted and comfortable but made with strong material. Loose, baggy clothing can easily become caught in moving parts and machinery. Neckties should not be worn. Some technicians prefer to wear coveralls or shop coats to protect their personal clothing. Cutoffs and short pants are not appropriate for shop work.

Caustic chemicals can burn through cloth and skin.

Foot Protection

Automotive work involves handling many heavy objects that can be accidentally dropped on your feet or toes. Always wear leather or similar material shoes or boots with nonslip soles. Steel-toe safety shoes can give added protection for your feet. Jogging or basketball shoes, street shoes, and sandals are not appropriate in the shop.

Hand Protection

Good hand protection is often overlooked. A scrape, cut, or burn can limit your effectiveness at work for many days. A well-fitted pair of heavy work gloves should be worn during operations such as grinding and welding or when handling high-temperature components. Always wear approved heavy rubber gloves when handling corrosive chemicals.

It is also a very good idea to wear disposable gloves (**Figure 1-2**) when working with products such as used oil, grease, throttle body cleaners, fuel injection cleaners, brake cleaners, and so on. Many of these chemicals are either carcinogens or dangerous chemicals that can be absorbed directly into the skin and can cause serious health problems from paralysis to liver damage.

Caustic chemicals are strong and dangerous chemicals. They can easily burn your skin. Be very careful when handling this type of chemical.

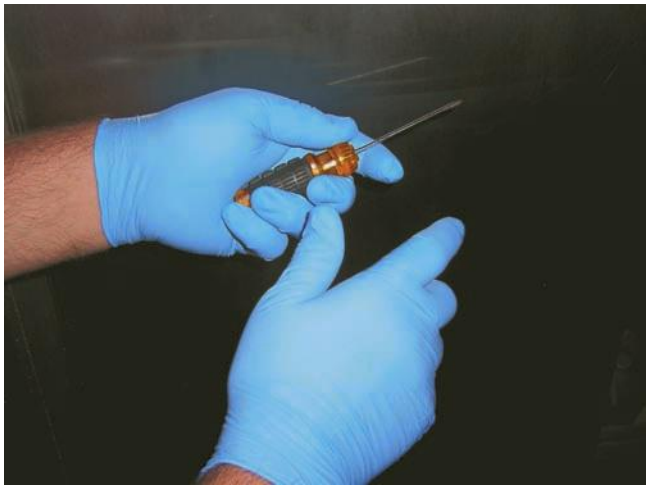

Figure 1-2 Disposable gloves.

Ear Protection

Exposure to very loud noise levels for extended periods of time can lead to a loss of hearing. Air wrenches, engines running under a load, and vehicles running in enclosed areas can all generate annoying and harmful levels of noise. Simple ear plugs or earphone-type protectors should be worn in constantly noisy environments.

Hair and Jewelry

Long hair and loose hanging jewelry can create the same type of hazard as loose-fitting clothing. They can become caught in moving engine parts and machinery. If you have long hair, tie it back or cover it with a brimless cap.

Never wear rings, watches, bracelets, or neck chains. These can easily get caught in moving parts and cause serious injury, especially when working on or near batteries and electrical systems.

Other Personal Safety Warnings

- Never smoke while working on a vehicle or while working with any machine in the shop.
- Playing around or horseplay is not fun when it sends someone to the hospital. Air nozzle fights, creeper races, practical jokes, and the like have no place in the shop.
- To prevent serious burns, keep your skin away from hot metal parts such as the radiator, exhaust manifold, tailpipe, catalytic converter, and muffler.
- When working with a hydraulic press, make sure that the pressure is applied in a safe manner. It is generally wise to stand to the side when operating the press. Always wear safety glasses.
- Properly store all parts and tools by putting them away in a place where people will not trip over them. This practice not only cuts down on injuries but also reduces time wasted looking for a misplaced part or tool.

LIFTING AND CARRYING

Knowing the proper way to lift heavy objects is important. You should also use back protection devices when you are lifting a heavy object. Always lift and work within your ability, and ask others to help when you are not sure that you can handle the size or weight of an object. Even small, compact parts can be surprisingly heavy or unbalanced. Think

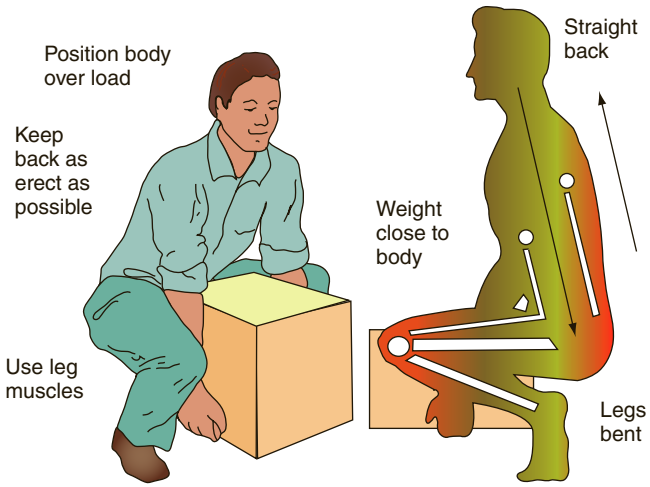

Figure 1-3 Use your leg muscles, never your back, to lift heavy objects.

about how you are going to lift something before beginning. When lifting any object, follow these steps.

1. If the object is to be carried, be sure your path is free from loose parts or tools.
2. Place your feet close to the object. Always position your feet so that you will be able to maintain a good balance.
3. Keep your back and elbows as straight as possible. Bend your knees until your hands reach the best place to get a strong grip on the object (**Figure 1-3**).
4. If the part is in a cardboard box, make sure the box is in good condition. Old, damp, or poorly sealed boxes will tear and the part will fall out.
5. Firmly grasp the object or container. Never try to change your grip as you move the load.
6. Keep the object close to your body and lift it up by straightening your legs. Use your leg muscles, not your back muscles.
7. If you must change your direction of travel, never twist your body. Turn your whole body, including your feet.
8. When placing the object on a shelf or counter, do not bend forward. Place the edge of the load on the shelf and slide it forward. Be careful not to pinch your fingers.
9. When setting down a load, bend your knees and keep your back straight. Never bend forward—this strains the back muscles.
10. Set the object onto blocks of wood to protect your fingers when lowering something heavy onto the floor.

OCCUPATIONAL SAFETY AND HEALTH ACT

The **Occupational Safety and Health Act (OSHA)** was passed by the U.S. government in 1970. The purposes of this legislation are these:

The *Occupational Safety and Health Act (OSHA)* regulates working conditions in the United States.

1. To assist and encourage the citizens of the United States in their efforts to assure safe and healthful working conditions by providing research, information, education, and training in the field of occupational safety and health.
2. To assure safe and healthful working conditions for working men and women by authorizing enforcement of the standards developed under the Act.

Because approximately 25 percent of workers are exposed to health and safety hazards on the job, OSHA is necessary to monitor, control, and educate workers regarding health and safety in the workplace. Employers and employees should be familiar with **Workplace Hazardous Materials Information Systems (WHMIS)**.

SHOP HAZARDS

Shop hazards must be recognized and avoided to prevent personal injury.

Service technicians and students encounter many hazards in an automotive shop. When these hazards are known, basic shop safety rules and procedures must be followed to avoid personal injury. Some of the hazards in an automotive shop are listed below:

1. Flammable liquids such as gasoline and paint must be handled and stored properly in special metal cabinets.
2. Flammable materials such as oily rags must be stored properly in special covered receptacles (**Figure 1-4**) to avoid a fire hazard.
3. Batteries contain a corrosive sulfuric acid solution and produce explosive hydrogen gas while charging.
4. Loose sewer and drain covers may cause foot or toe injuries.
5. Caustic liquids such as those in hot cleaning tanks are harmful to skin and eyes.
6. High-pressure air in the shop's compressed-air system can be very dangerous if it penetrates the skin and enters the bloodstream.
7. Frayed cords on electric equipment and lights may result in severe electrical shock.
8. Hazardous waste material such as batteries and the caustic cleaning solution from a hot or cold cleaning tank must be handled properly to avoid harmful effects.
9. Carbon monoxide from vehicle exhaust is poisonous.
10. Loose clothing or jewelry, or long hair, may become entangled in rotating parts on equipment or vehicles, resulting in serious injury.
11. Dust and vapors generated during some repair jobs are harmful. Asbestos dust generated during brake-lining service and clutch service is a contributor to lung cancer.
12. High noise levels from shop equipment such as an air chisel may be harmful to the ears.
13. Oil, grease, water, or parts-cleaning solutions on shop floors may cause someone to slip and fall, resulting in serious injury.

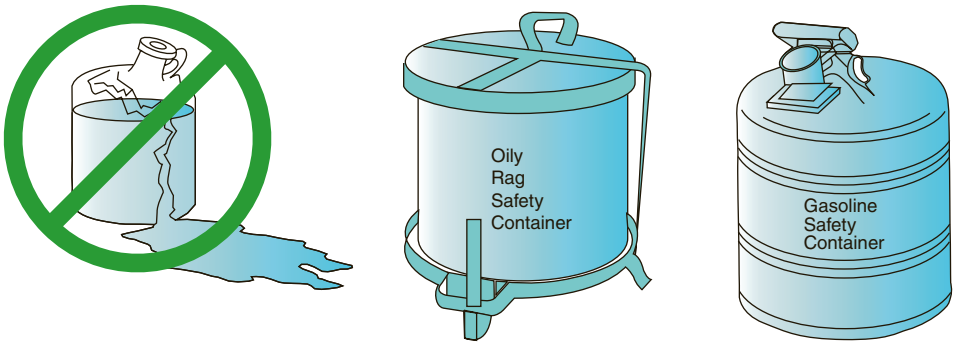

Figure 1-4 Keep combustibles in safety containers.

AUTHOR'S NOTE The old saying "Had I known I was going to live this long, I would have taken better care of myself" should serve as a friendly reminder to all technicians. We do preventive maintenance on our customers' cars, right? So why not take the same measures to prevent temporary or permanent injury to ourselves? Taking care of yourself in the shop in even the simplest way can reward you greatly later in life. This means wearing gloves, eye protection, ear protection, and dust masks when appropriate. Try to anticipate the potential risks of an injury while performing a particular service on a vehicle, then act on methods of protection that will mitigate the risks.

HAND TOOL SAFETY

Many shop accidents are caused by improper use and care of hand tools. These hand tool safety steps must be followed:

1. Keep tools clean and in good condition. Worn tools may slip and result in hand injury. If a hammer with a loose head is used, the head may fly off and cause personal injury or vehicle damage. Keep all hand tools free of grease and in good condition. Tools that slip can cause cuts and bruises. If a tool slips and falls into a moving part, it can fly out and cause serious injury.
2. Use the proper tool for the job. Make sure the tool is of professional quality. Using poorly made tools or the wrong tools can damage parts or the tool itself, or cause injury. Do not use broken or damaged tools.
3. Be careful when using sharp or pointed tools. Do not place sharp tools or other sharp objects in your pockets. They can stab or cut your skin, ruin automotive upholstery, or scratch a painted surface.
4. Tool tips that are intended to be sharp should be kept in a sharp condition. Sharp tools such as chisels will do the job faster and with less effort if they are kept sharp. Dull tools can be more dangerous than sharp tools.
5. Never use a tool for which it is not intended, such as using a screwdriver as a pry bar. The blade or blade tip can break and cause personal injury.
6. Use only impact sockets that are designed for use with an impact wrench. Ordinary sockets can break or shatter if used improperly (**Figure 1-5**).

POWER TOOL SAFETY

Power tools are operated by an outside source of power, such as electricity, compressed air, or hydraulic pressure. Safety around power tools is very important. Serious injury can result from carelessness. Always wear safety glasses when using power tools.

If the tool is electrically powered, make sure it is properly grounded. Check the wiring for cracks in the insulation and bare wires before using it. When using electrical power tools, never stand on a wet or damp floor. Disconnect the power source before performing any service on the machine or tool. Before plugging in any electric tool, make sure the switch is off to prevent serious injury. When you are through using the tool, turn it off and unplug it. Never leave a running power tool unattended. When you leave, turn it off.

When using power equipment on a small part, never hold the part in your hand. Always mount the part in a bench vise or use vise grip pliers. Never try to use a

Figure 1-5 A worn-out impact socket must be replaced.

machine or tool beyond its stated capacity or for operations requiring more than the rated power of the tool.

When working with larger power tools, such as bench or floor equipment, check the machines for signs of damage before using them. Place all safety guards into position (**Figure 1-6**). A safety guard is a protective cover over a moving part. It is designed to prevent injury. Wear safety glasses or a face shield. Make sure there are no people or parts around the machine before starting it up. Keep your hands and clothing away from the moving parts. Maintain a balanced stance while using the machine.

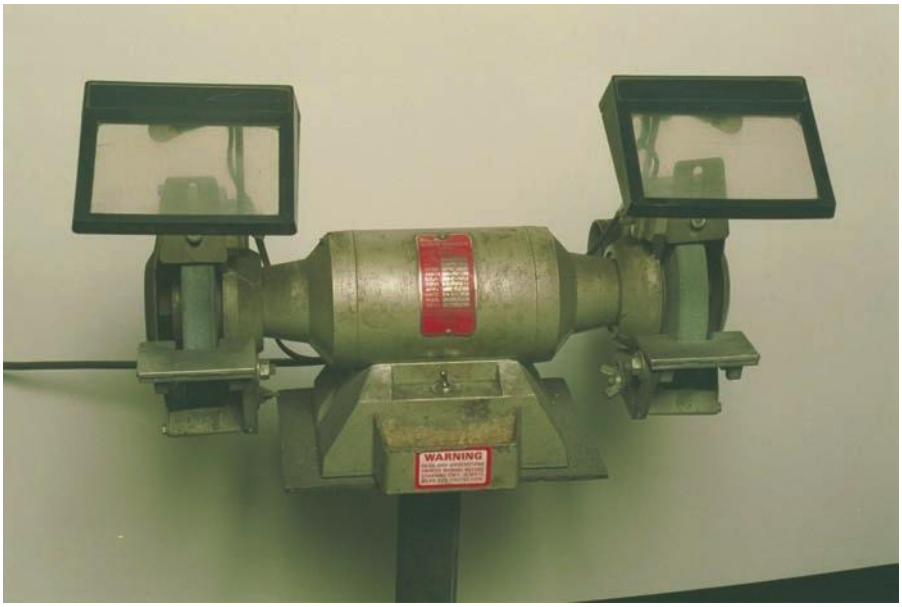

Figure 1-6 Safety guards on a bench grinder.

Hydraulic Press

WARNING When operating a hydraulic press, always be sure that the components being pressed are properly supported on the press bed with steel supports.

When two components have a tight precision fit between them, a **hydraulic press** is used to separate them or press them together. The hydraulic press rests on the shop floor. An adjustable steel beam bed is retained to the lower press frame with heavy steel pins. A hydraulic cylinder and ram are mounted on the top part of the press with the ram facing downward toward the press bed (**Figure 1-7**). The component being pressed is placed on the press bed with the appropriate steel supports. A hand-operated hydraulic pump is mounted on the side of the press. When the handle is pumped, hydraulic fluid is forced into the cylinder, and the ram is extended against the component on the press bed to complete the pressing operation. A pressure gauge on the press indicates the pressure applied from the hand pump to the cylinder. The press frame is designed for a certain maximum pressure. This pressure must not be exceeded during operation.

Electrical Safety

1. Frayed cords on electrical equipment must be replaced or repaired immediately.
2. All electric cords from lights and electric equipment must have a ground connection. The ground connector is the round terminal in a three-prong electrical plug. Do not use a two-prong adapter to plug in a three-prong electrical cord. Three-prong electrical outlets should be mandatory in all shops.
3. Do not leave electrical equipment running and unattended.

On the bench grinder, always make sure the tool rest is no more than 1/8 inch away from the grinding stone.

Caution

When using a hydraulic press, never operate the pump handle when the pressure gauge exceeds the maximum pressure rating of the press. If this pressure is exceeded, some part of the press may suddenly break and cause severe personal injury.

Hybrid vehicles use high voltage and amperage for their electric motor.

Figure 1-7 A hydraulic press.

Hybrid vehicle batteries can have much higher voltage than conventional batteries.

Battery Safety

Batteries give off hydrogen and oxygen gases, which are explosive! Use extreme caution when working around or handling batteries.

1. Always wear eye protection when working near a battery.
2. Do not smoke or allow any open flame around a battery.
3. Do not connect or disconnect a battery charger while the charger is in the "on" position. In addition, it is a good practice to unplug the battery charger from the 110-volt AC outlet before connecting or disconnecting the charger from the battery.
4. Observe proper polarity when installing a battery, connecting a battery charger, or jump-starting the vehicle.
5. Do not allow the battery to exceed 125°F while charging the battery.
6. When using load-test equipment, be certain the load controller is off prior to connecting or disconnecting the unit from the battery.
7. If battery acid contacts your skin, wash immediately for at least 10 minutes.
8. Battery acid can harm skin, eyes, clothing, and some paint finishes.
9. Neutralize any battery acid spills with baking soda.

AUTHOR'S NOTE Hybrid vehicles have as many as three separate voltages running in the same vehicle. Many of these vehicles cannot be charged with a conventional charger (even the 12-volt battery). Some have 36- and 42-volt batteries that should *never* be charged with a conventional charger. *Always* check with the manufacturer's service information *before* connecting any charging equipment to a hybrid vehicle.

Hybrid High-Voltage Safety

Hybrid vehicles require the use of some special procedures and tools. The higher voltage and amperage can be deadly. Whenever a hybrid vehicle is in for service that might involve the electrical system in any way, the high-voltage battery must be disconnected. Hybrid vehicles have a disconnection point (**Figure 1-8**, **Figure 1-9**) that varies according to the

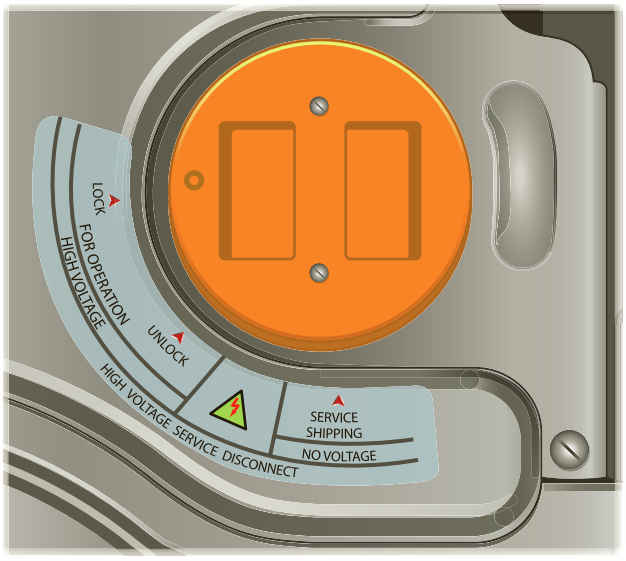

Figure 1-8 A high-voltage battery cutoff on a Hybrid Ford Escape.

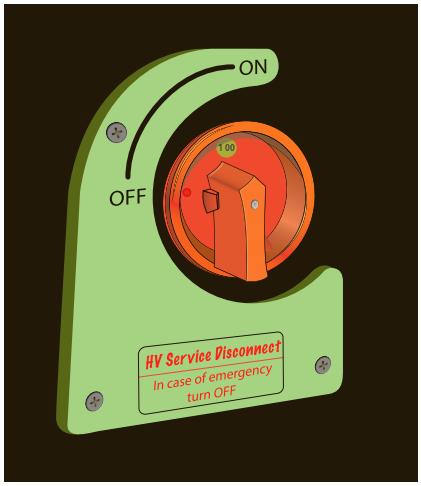

Figure 1-9 A high-voltage battery cutoff on a Mini E.

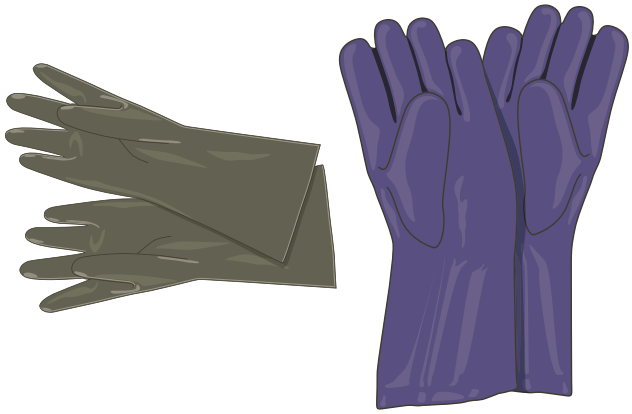

Figure 1-10 Special high-voltage gloves are worn inside leather outer gloves when working on hybrid vehicles' high-voltage electrical systems.

make and model of the vehicle. Additionally, special class zero high-voltage gloves are required whenever working on a hybrid vehicle. The inner, thick rubber gloves are specially made to resist high voltage, and must be retested periodically to ensure they are still safe. Thick leather gloves are worn over the rubber gloves to help protect the rubber gloves from abrasion (**Figure 1-10**). The gloves have to be periodically sent to a lab to recertify their insulating capabilities.

Gasoline Safety

Gasoline is a very flammable liquid! One exploding gallon of gasoline has energy equal to 14 sticks of dynamite. It is the expanding vapors from gasoline that are extremely dangerous. These vapors are present even in cold temperatures. Vapors formed in gasoline tanks in cars are controlled, but vapors from a gasoline storage container may escape from the can, resulting in a hazardous situation. Therefore, gasoline storage containers must be placed in a well-ventilated space.

Approved gasoline storage cans have a flash-arresting screen at the outlet (**Figure 1-11**). These screens prevent external ignition sources from igniting the gasoline within the can

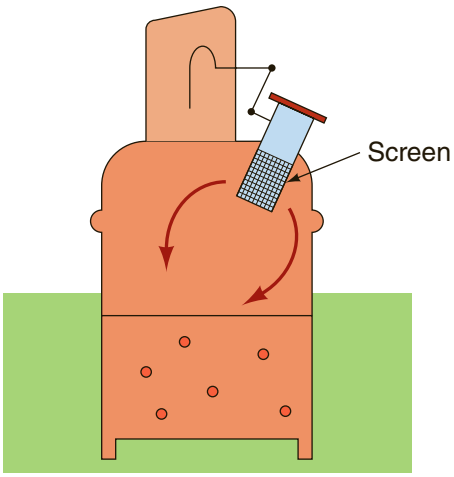

Figure 1-11 An approved gasoline container.

while the gasoline is being poured. Follow these safety precautions regarding gasoline containers:

1. Always use approved gasoline containers that are designed specifically for gasoline and properly labeled as such.
2. Do not fill gasoline containers completely full. Always leave the level of gasoline at least one inch from the top of the container. This action allows expansion of the gasoline at higher temperatures. If gasoline containers are completely full, gasoline vapors will expand when the temperature increases. This expansion forces gasoline from the can and creates a dangerous spill.
3. If gasoline containers must be stored, place them in a well-ventilated area such as a storage shed. Do not store gasoline containers in your home or in the trunk of a vehicle.
4. When a gasoline container must be transported, be sure it is secured against upsets.
5. Do not store a partially filled gasoline container for long periods of time because it may give off vapors and produce a potential danger.
6. Never leave gasoline containers open except while filling or pouring gasoline from the container.
7. Do not prime an engine with gasoline while cranking the engine.
8. Never use gasoline as a cleaning agent.
9. Avoid contact with unprotected skin.

Refrigerant Safety

It is illegal to knowingly discharge or vent air-conditioning refrigerant into the atmosphere. When servicing an air-conditioning system, recover and/or recycle the refrigerant using approved, certified equipment. These services must be performed by an **Environmental Protection Agency (EPA)**—recognized, certified technician following specific procedures. When working around refrigerant or air-conditioning service equipment, it is important to wear full eye protection. Refrigerant can cause immediate blindness.

General Shop Safety

1. All sewer covers must fit properly and be kept securely in place.
2. Always wear a face shield, protective gloves, and protective clothing when necessary. Gloves should be worn when working with solvents and caustic solutions, handling hot metal, or grinding metal. Various types of protective gloves are available. Shop coats and coveralls are the most common types of protective clothing.

3. Never direct high-pressure air from an air gun against human flesh or *any* part of the body. If this action is allowed, air may penetrate the skin and enter the bloodstream, causing serious health problems or even death. Always keep air hoses in good condition. If an end blows off of an air hose, the hose may whip around and result in personal injury. Use only OSHA-approved air gun nozzles.
4. Handle all hazardous waste materials according to state and federal regulations. (These regulations are explained later in this chapter.)
5. Always place a shop exhaust hose on the tailpipe of a vehicle if the engine is running in the shop, and be sure the shop exhaust fan is turned on.
6. Keep hands, long hair, jewelry, and tools away from rotating parts such as fan blades and belts on running engines. Remember that an electric-drive fan may start turning without warning. Avoid wearing rings, watches, or bracelets, especially when working on or around batteries or other electrical systems.
7. When servicing brakes or clutches from manual transmissions, always clean asbestos dust from these components with an approved asbestos dust parts washer, and wear a dust mask.
8. Always use the correct tool for the job. For example, never strike a hardened steel component, such as a piston pin, with a steel hammer. This type of component may shatter, and fragments may penetrate the eyes or skin.
9. Follow the car manufacturer's recommended service procedures.
10. Be sure that the shop has adequate ventilation.
11. Make sure the work area has adequate lighting.
12. Use only fluorescent or LED-style trouble lamps. Incandescent trouble lamps are very dangerous around flammable liquids due to their risk of bursting, and they cause burns to the skin if touched.
13. When servicing a vehicle, always apply the parking brake and place the transmission in **park** with an automatic transmission or **neutral** with a manual transmission if the engine is running. When the engine is stopped, place the transmission in park with an automatic transmission or either reverse or first gear with a manual transmission.
14. Avoid working on a vehicle parked on an incline.
15. Never work under a vehicle unless the vehicle chassis is supported securely on jack stands.
16. When one end of a vehicle is raised, place wheel chocks on both sides of the wheels remaining on the floor.
17. Be sure that you know the location of shop first-aid kits, eyewash fountains, and fire extinguishers.
18. Collect oil, fuel, brake fluid, and other liquids in the proper safety containers.
19. Use only approved cleaning fluids and equipment. Do not use gasoline to clean parts.
20. Obey all state and federal safety, fire, and hazardous material regulations.
21. Always operate equipment according to the equipment manufacturer's recommended procedure.
22. Do not operate equipment unless you are familiar with the correct operating procedure.
23. Do not leave running equipment unattended.
24. Be sure the safety shields are in place on rotating equipment.
25. Ensure all shop equipment has regularly scheduled maintenance and adjustment.
26. Some shops have safety lines around equipment. Always work within these lines when operating equipment.
27. Be sure that shop heating equipment is well ventilated.
28. Do not run in the shop or engage in horseplay.

29. Post emergency phone numbers near the phone. These numbers should include 911, a doctor, and a hospital, as well as direct numbers for ambulance, fire department, and police services.
30. Do not place hydraulic jack handles where someone can trip over them.
31. Keep aisles clear of debris.
32. Use caution when working near a raised lift. Be aware of the available clearance.

Fire Safety

1. Familiarize yourself with the location and operation of all shop fire extinguishers.
2. If a fire extinguisher is used, report it to management so the extinguisher can be recharged.
3. Do not use any type of open-flame heater to heat the work area.
4. Do not turn on the ignition switch or crank the engine with a gasoline line disconnected.
5. Store all combustible materials such as gasoline, paint, and oily rags in approved safety containers.
6. Clean up gasoline, oil, or grease spills immediately.
7. Always wear clean shop clothes. Do not wear oil-soaked clothes.
8. Do not allow sparks and flames near batteries.
9. Welding tanks must be securely fastened in an upright position.
10. Do not block doors, stairways, or exits.
11. Do not smoke when working on vehicles.
12. Do not smoke or create sparks near flammable materials or liquids.
13. Store combustible shop supplies such as paint in a closed steel cabinet.
14. Gasoline must be kept in approved safety containers.
15. If a gasoline tank is removed from a vehicle, do not drag the tank on the shop floor.
16. Know the approved fire escape route from your classroom or shop to the outside of the building.
17. If a fire occurs, do not open doors or windows. This action creates extra draft which makes the fire worse.
18. Do not put water on a gasoline fire because the water will make the fire worse.
19. Call the fire department as soon as a fire begins and then attempt to extinguish the fire.
20. If possible, stand 6 to 10 feet from the fire and aim the fire extinguisher nozzle at the base of the fire with a sweeping action.
21. If a fire produces a lot of smoke in the room, remain close to the floor to obtain oxygen and avoid breathing smoke.
22. If the fire is too hot or the smoke makes breathing difficult, get out of the building.
23. Do not reenter a burning building.
24. Keep solvent containers covered except when pouring from one container to another. When flammable liquids are transferred from bulk storage, the bulk container should be grounded to a permanent shop fixture such as a metal pipe. During this transfer process, the bulk container should be grounded to the portable container. These ground wires prevent the buildup of a static electric charge, which could result in a spark and a disastrous explosion. Always discard or clean empty solvent containers, because fumes in these containers are a fire hazard.
25. Familiarize yourself with different types of fires and fire extinguishers, and know the type of extinguisher to use on each fire.

COMPRESSED-AIR EQUIPMENT SAFETY

Tools that use compressed air are called **pneumatic tools**. Compressed air is used to inflate tires, apply paint, and drive tools. Compressed air can be dangerous when it is not used properly. The shop air supply contains high-pressure air in the shop compressor and air lines. Serious injury or property damage may result from careless operation of compressed-air equipment. Follow these guidelines when working with compressed air:

1. Safety glasses or a face shield should be worn for all shop tasks, including those tasks involving the use of compressed-air equipment.
2. Wear ear protection when using compressed-air equipment.
3. Always maintain air hoses and fittings in good condition. If an end suddenly blows off an air hose, the hose will whip around, and this may cause personal injury.
4. Do not direct compressed air against the skin. This air may penetrate the skin, especially through small cuts or scratches. If compressed air penetrates the skin and enters the bloodstream, it can be fatal or cause serious health complications. Use only air gun nozzles approved by OSHA.
5. Never use an air gun to blow off clothing or hair.
6. Do not clean the workbench or floor with compressed air. This action may blow very small parts against your skin or into your eyes. Small parts blown by compressed air may cause vehicle damage. For example, if the car in the next stall has the air cleaner removed, a small part may go into the throttle body. When the engine is started, this part will likely be pulled into the cylinder by engine vacuum and will penetrate through the top of a piston.
7. Never spin bearings with compressed air because the bearing will rotate at extremely high speed. Under this condition, the bearing may be damaged or it may disintegrate, causing personal injury.
8. All pneumatic tools must be operated according to the manufacturer's recommended operating procedure.
9. Follow the equipment manufacturer's recommended maintenance schedule for all compressed-air equipment.

LIFT SAFETY

A **lift** is used to raise a vehicle so a technician can work under it. The lift arms must be placed under the car at the manufacturer's recommended lift points. There are several types of vehicle lifts in use today. Categories of lifts include single, double, and four-post varieties. Typically, single-post lifts are considered an in-ground type with the hydraulic post and lines located directly under the lift. Above-ground types include twin and four posts with adjustable arms and contact pads or drive-on runways. Others consist of a scissors-type design (**Figure 1-12**). Some lifts have an electric motor that drives a hydraulic pump to create fluid pressure and force the lift upward. Other lifts use air pressure from the shop air supply to force the lift upward. If shop air pressure is used for this purpose, the air pressure is applied to fluid in the lift cylinder. A control lever or switch is placed near the lift. The control lever supplies shop air pressure to the lift cylinder, and the switch turns on the lift pump motor. Always be sure that the safety lock is engaged after the lift is raised. When the safety lock is released, a release lever is operated slowly to lower the vehicle.

Always be careful when raising a vehicle on a lift or a hoist. Adapters and hoist plates must be positioned correctly on twin-post and rail-type lifts to prevent damage to the

Figure 1-12 A scissors-type, drive-on lift.

underbody of the vehicle. There are specific lift points. These points allow the weight of the vehicle to be evenly supported by the adapters or hoist plates. The correct lift points can be found in the vehicle's service manual. **Figure 1-13** shows typical locations for frame and unibody cars. These diagrams are for illustration only, so always follow the manufacturer's instructions. Before operating any lift or hoist, carefully read the operating manual and follow the operating instructions.

WARNING Never use a lift or jack to move something heavier than it is designed for. Always check the rating before using a lift or jack. If a jack is rated for 2 tons, do not attempt to use it for a job requiring 5 tons. It is dangerous for you and the vehicle.

When guiding someone driving a vehicle onto a lift, be sure to stand off to the driver's side of the vehicle rather than in front of it. Use clear, deliberate hand signals and/or verbal

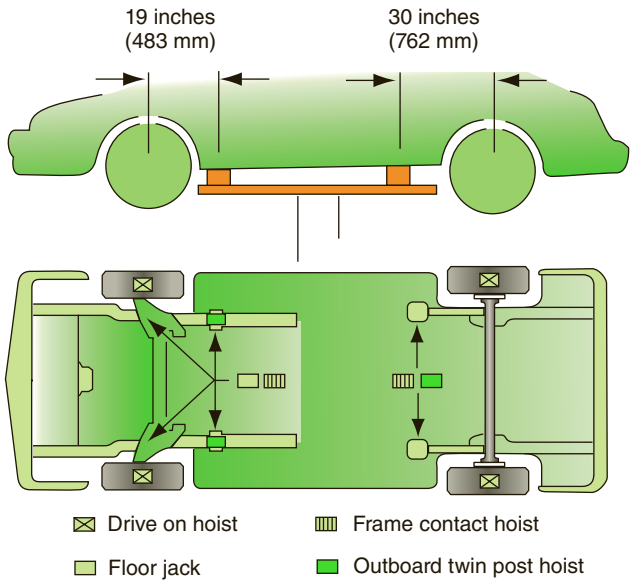

Figure 1-13 Hoisting and lifting points for a typical unibody vehicle.

instructions to the driver to indicate vehicle direction. In the event of an unexpected action by the vehicle, always leave yourself a clear path. It is a good practice to check the clearance underneath the vehicle prior to driving over the lift. Low-hanging accessories or exhaust systems may be damaged when coming in contact with the lift.

Before driving a vehicle over a lift, position the arms and supports to provide an unobstructed clearance. Do not hit or run over lift arms, adapters, or axle supports. This could damage the lift, vehicle, or tires.

Position the lift supports to contact the vehicle at its lifting points. Raise the lift until the supports contact the vehicle. Then, check the supports to make sure they are in full contact with the vehicle. Raise the lift to the desired working height.

Make sure the vehicle's doors, hood, and trunk are closed before raising the vehicle.

Never raise a car with someone inside.

WARNING Before working under a car, make sure the lift's locking device is engaged.

After lifting a vehicle to the desired height, always lower it onto its mechanical safeties. On some vehicles, the removal (or installation) of components can cause a critical shift of the vehicle's weight, which may cause the vehicle to be unstable on the lift. Refer to the vehicle's service manual for the recommended procedures to prevent this from happening.

Make sure tool trays, stands, and other equipment are removed from under the vehicle. Release the lift's locking devices according to the instructions before attempting to lower the lift.

JACK AND JACK STAND SAFETY

An automobile can be raised off the ground by a hydraulic jack (**Figure 1-14**). **Jack stands** (**Figure 1-15**) are supports of different heights that sit on the floor. They are placed under a sturdy chassis member, such as the frame or axle housing, to support the vehicle. Like jacks, jack stands also have a capacity rating. Always use the correct rating of jack stand.

Jack stands are also called "safety stands."

A **floor jack** is a portable unit mounted on wheels. The lifting pad on the jack is placed under the chassis of the vehicle, and the jack handle is operated with a pumping action. This jack handle operation forces fluid into a hydraulic cylinder in the jack, and the cylinder extends to force the jack lift pad upward and lift the vehicle. Always be sure that the lift pad is positioned securely under one of the car manufacturer's recommended lift points. To release the hydraulic pressure and lower the vehicle, the handle or release lever must be turned slowly.

As the vehicle is lifted, the floor jack will roll under the load. Make sure that the wheels on the floor jack are free to roll and are not blocked by gravel or other obstructions on the shop floor. If the jack cannot roll, the lifting plate may be pulled off the vehicle lifting point.

The jack should be removed after the jack stands are set in place. This eliminates a hazard, such as a jack handle sticking out into a walkway. A jack handle that is bumped or kicked can cause a tripping accident or cause the vehicle to fall. Never use a jack by itself to support an automobile. Always use a jack stand with the jack as a safety precaution. Make sure the jack stands are properly placed under the vehicle.

Accidents involving the use of floor jacks and jack stands may be avoided if these safety precautions are followed:

1. Never work under a vehicle unless jack stands are placed securely under the vehicle chassis and the vehicle is resting on these stands.
2. Prior to lifting a vehicle with a floor jack, be sure that the jack lift pad is positioned securely under a recommended lift point on the vehicle. Lifting the front end of a vehicle with the jack placed under a radiator support may cause severe damage to the radiator and support.

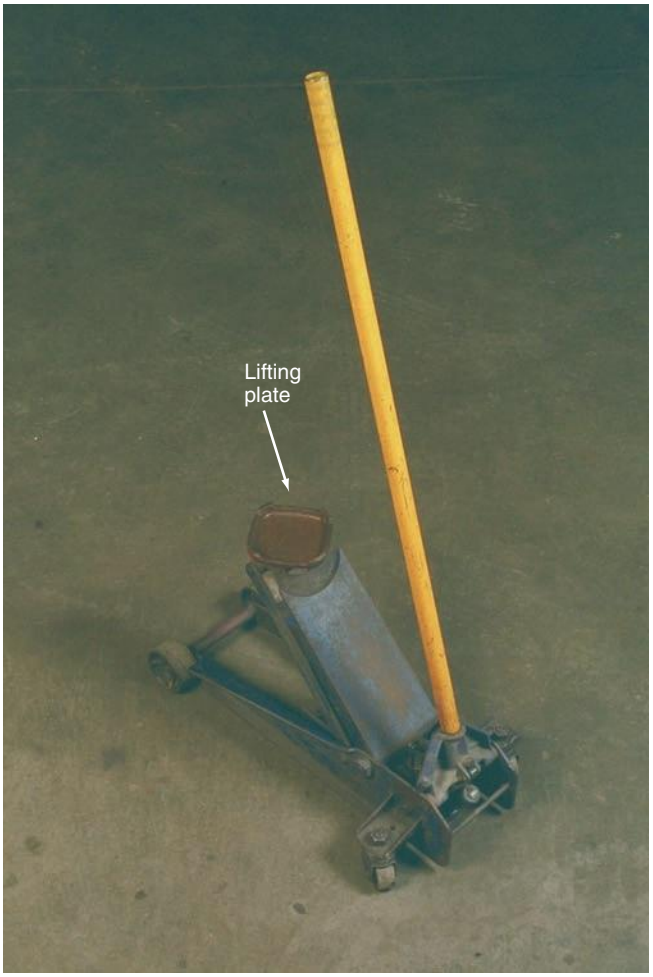

Figure 1-14 A typical hydraulic floor jack.

Figure 1-15 Support stands.

3. Position the jack stands under a strong chassis member, such as the frame or axle housing. The jack stands must contact the vehicle manufacturer's recommended lift points.
4. Because the floor jack is on wheels, the vehicle and jack tend to move as the vehicle is lowered from a floor jack onto jack stands. Always be sure the jack stands remain under the chassis member during this operation, and be sure the jack stands do not tip. All the jack stand legs must remain in contact with the shop floor.

CLEANING EQUIPMENT SAFETY

All technicians are required to clean parts during their normal work routines. Face shields and protective gloves must be worn while operating cleaning equipment. The solution in hot and cold cleaning tanks may be caustic, and contact between this solution and the skin or eyes must be avoided. Parts cleaning often creates a slippery floor, and care must be taken when walking in the parts-cleaning area. The floor in this area should be cleaned frequently. When the caustic cleaning solution in hot or cold cleaning tanks is replaced, environmental regulations require that the old solution be handled as hazardous waste. Use caution when placing aluminum or aluminum alloy parts in a cleaning solution. Caustic solutions will damage these components by reacting with the aluminum. Always follow the cleaning equipment manufacturer's recommendations. Parts cleaning is a

necessary step in most repair procedures. Cleaning automotive parts can be divided into four basic categories.

Chemical cleaning relies primarily on some type of chemical action to remove dirt, grease, scale, paint, or rust. A combination of heat, agitation, mechanical scrubbing, or washing may also be used to help remove dirt. Chemical-cleaning equipment includes small-parts washers, hot and cold tanks, pressure washers, spray washers, and salt baths.

Some parts washers provide electromechanical agitation of the parts to provide improved cleaning action (**Figure 1-16**). These parts washers may be heated with gas or electricity, and various water-based hot-tank cleaning solutions are available depending on the type of metals being cleaned. For example, Kleer-Flo Greasoff Number 1 powdered detergent is available for cleaning iron and steel. Non-heated electromechanical parts washers are also available, and these washers use cold cleaning solutions such as Kleer-Flo Degreasol formulas.

Many cleaning solutions, such as Kleer-Flo Degreasol 99R, contain no ingredient listed as hazardous by the EPA's **Resource Conservation and Recovery Act (RCRA)**. Degreasol 99R is a blend of sulfur-free hydrocarbons, wetting agents, and detergents. It does not contain aromatic or chlorinated solvents, and it conforms to California's Rule 66 for clean air. Always use the cleaning solution recommended by the equipment manufacturer.

Some parts washers have an agitated immersion chamber under the shelves that provides thorough parts cleaning. Folding work shelves provide a large upper cleaning area with a constant flow of solution from the dispensing hose. This cold parts washer operates on Degreasol 99R.

An aqueous parts-cleaning tank uses a water-based, environmentally friendly cleaning solution such as Greasoff 2 rather than traditional solvents. The immersion tank is heated and agitated for effective parts cleaning (**Figure 1-17**). A sparger bar pumps a constant flow of cleaning solution across the surface to push floating oils away, and an integral skimmer removes these oils. This action prevents floating surface oils from redepositing on cleaned parts.

Thermal cleaning relies on heat, which bakes off or oxidizes the dirt. Thermal cleaning leaves an ash residue on the surface that must be removed by an additional cleaning process such as airless shot blasting or spray washing.

Abrasive cleaning relies on physical abrasion to clean the surface. This includes everything from a wire brush to glass bead blasting, airless steel shot blasting, abrasive tumbling, and vibratory cleaning. Chemical in-tank solution sonic cleaning might also be

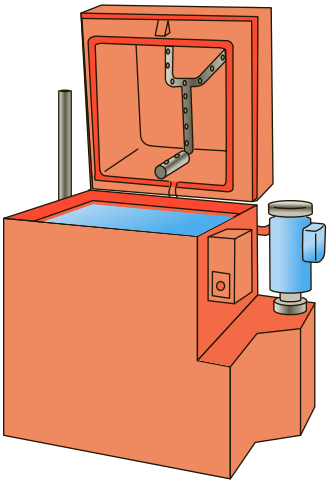

Figure 1-16 A parts washer with an electromechanical agitator.

Figure 1-17 An aqueous parts-cleaning tank.

included here because it relies on the scrubbing action of ultrasonic sound waves to loosen surface contaminants.

Steam cleaning uses hot water vapor mixed with chemical cleaning agents to clean dirt from an object. After steam cleaning, the object should be thoroughly hosed down with clean water, then air dried.

There are several reasons why the use of steam cleaning has rapidly declined in recent years. Concerns about the environment have led to mandates that a **closed-loop system** be used for steam cleaning. This means that the runoff from the cleaning process must be collected and contained within the steam-cleaning system. The runoff cannot flow into a public sewage system.

Steam cleaning is normally done in a non-congested portion of the shop or in a separate building. Care must be taken to protect all painted surfaces and exposed skin. If these were to come into contact with the steam's heat and chemicals, it could result in injury or damage. In addition, care must also be taken when working on the slippery floor that this process creates.

Before using a steam-cleaning machine, check the electrical cords. Pay special attention to the grounding connector at the plug. If the machine is not properly grounded, there is a great possibility of getting an electrical shock. Finally, steam cleaning takes a great deal of time and work. Most shops cannot justify the labor cost for using an open steam-cleaning system.

VEHICLE OPERATION

A Note on Hybrid Vehicle Safety

Even though this book is not intended to be about hybrid vehicles, we discuss them throughout this text. In the interest of safety, I have done some research to come up with a few general statements about working safely around hybrid vehicles. As I looked at the different types from several manufacturers (some of whom offered more than one type), I collected the best possible advice.

At this time, there are too many changes occurring for technicians to service a hybrid without extensive factory training in the specific models they are attempting to service. One such example is the fact that many hybrids use an automatic engine restart to recharge the battery anytime the key is in the ignition or the smart key is in the vicinity of the vehicle. Imagine what might happen if you were changing the oil or had your hands in the engine compartment when this happened!

WARNING Hybrids have very high-voltage systems that can kill you if they are mishandled! Do not attempt to service a hybrid vehicle until you have been trained and understand the proper procedures necessary to keep you safe.

Carbon monoxide (CO) is an odorless, poisonous gas. When it is breathed in, it can cause headaches, nausea, ringing in the ears, tiredness, and heart flutter. A large amount of CO can kill you.

When the customer brings in a vehicle for service, certain shop safety guidelines should be followed. For example, when moving a car into the shop, check the brakes before beginning. Then buckle the safety belt. Drive carefully in and around the shop. Make sure no one is near, that the way is clear, and that there are no tools or parts under the car before you start the engine.

When road testing the car, obey all traffic laws. Drive only as far as is necessary to check the automobile. Never make excessively quick starts, turn corners too quickly, or drive faster than conditions or speed limits allow.

If the engine must be running while you are working on the car, block the wheels to prevent the car from moving. Place the transmission in park for automatic transmissions or in neutral for manual transmissions. Set the emergency brake. Never stand directly in front of or behind a running vehicle.

Figure 1-18 When running an engine in a shop, make sure the vehicle's exhaust is connected to the shop's exhaust ventilation system.

Run the engine only in a well-ventilated area to avoid the danger of poisonous CO in the engine exhaust. If the shop is equipped with an exhaust ventilation system (**Figure 1-18**), use it. If not, use a hose and direct the exhaust out of the building.

WARNING Never run the engine in a vehicle inside the shop without an exhaust hose connected to the tailpipe.

Carbon Monoxide

Vehicle exhaust contains small amounts of CO, which is a poisonous gas. Strong concentrations of CO may be fatal for human beings. All shop personnel are responsible for air quality in the shop. Shop management is responsible for providing an adequate exhaust system to remove exhaust fumes from the maximum number of vehicles that may be running in the shop at the same time. Technicians should never run a vehicle in the shop unless a shop exhaust hose is installed on the tailpipe of the vehicle. The exhaust fan must be switched on to remove exhaust fumes.

If shop heaters or furnaces have restricted chimneys, they release CO emissions into the shop air. Therefore, chimneys should be checked periodically for restriction and proper ventilation.

Monitors are available to measure the level of CO in the shop. Some of these monitors read the amount of CO in the shop air, while other monitors provide an audible alarm if the concentration of CO exceeds the danger level. When CO is breathed in, it can cause headaches, nausea, ringing in the ears, tiredness, and heart flutter. A large amount of CO can kill you.

Diesel exhaust contains some CO, but particulates are also present in the exhaust from these engines. **Particulates** are small carbon particles that can be harmful to the lungs.

Some modern vehicles use up to several thousand pounds per square inch (psi) fuel pressures that can puncture skin. Use external caution around fuel fitting.

Use disposable solvent-resistant gloves when working with solvents such as brake parts cleaner or carburetor cleaner. Many of these solvents can penetrate the skin and may cause serious health concerns if used over a period of time.

Batteries

The **sulfuric acid** solution in car batteries is a very corrosive, poisonous liquid. If a battery is charged with a fast charger at a high rate for a period of time, the battery becomes hot, and the sulfuric acid solution begins to boil. Under this condition, the battery may emit a strong sulfuric acid smell, and these fumes may be harmful to the lungs. If this condition occurs in the shop, the battery charger should be turned off or the charger rate should be reduced considerably.

When an automotive battery is charged, hydrogen and oxygen gases escape from the battery. If these gases are combined, they form water, but hydrogen gas by itself is very explosive. While a battery is charged, sparks, flames, and other sources of ignition must not be allowed near the battery.

Personal injury, vehicle damage, and property damage must be avoided by following safety rules regarding personal protection, substance abuse, electrical safety, gasoline safety, housekeeping safety, fire safety, and general shop safety.

Air Bag Safety

Before working on the steering column or dash areas, make certain that the air bag system has been disarmed according to the manufacturer's recommended procedure. Some general points to keep in mind are as follows:

1. The air bag can deploy for several minutes even after the battery has been disconnected.
2. Never test an air bag circuit using a test lamp or self-powered test lamp.
3. Never split into the air bag harness. The harness can be identified by its bright yellow color and identification markings.
4. Always carry the air bag with the trim cover facing away from your body.
5. Do not place the air bag on a bench with the trim cover down.
6. If the steering column is removed from the vehicle, do not stand the column with the air bag facing down.
7. Do not deploy an air bag by any procedure other than the manufacturer's recommendations.
8. If it is necessary to handle a deployed air bag, make certain to take precautions against the residue left behind; it can cause skin irritation.

Personal Protection

1. Always wear safety glasses or a face shield in the shop (**Figure 1-19**).
2. Wear ear plugs or covers if high noise levels are encountered.
3. Always wear boots or shoes that provide adequate foot protection. Safety work boots or shoes with steel-toed caps are best for working in the automotive shop. Most safety shoes also have slip-resistant soles. Footwear must protect against heavy falling objects, flying sparks, and corrosive liquids. Soles on footwear must protect against punctures by sharp objects. Sneakers and street shoes are not recommended in the shop.

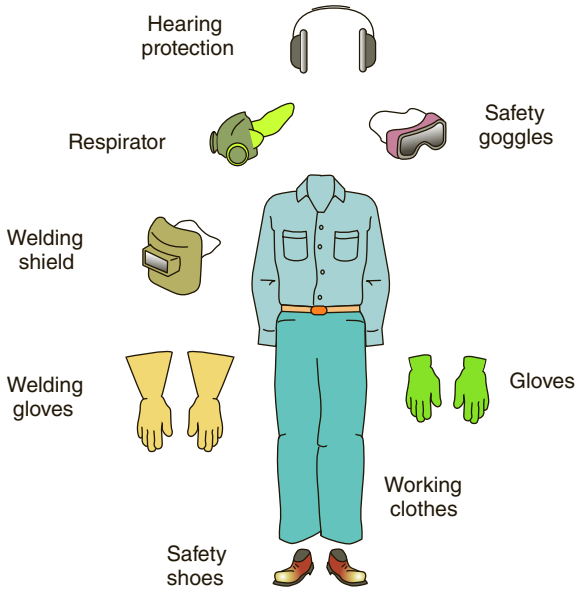

Figure 1-19 Shop safety equipment: this includes safety goggles, a respirator, a welding shield, proper work clothes, ear protection, gloves, and safety shoes.

4. Do not wear watches, jewelry, or rings when working on a vehicle. Severe burns occur when jewelry makes contact between an electric terminal and ground. Jewelry may catch on an object, resulting in painful injury.
5. Do not wear loose clothing, and keep long hair tied behind your head. Loose clothing or long hair is easily entangled in rotating parts.
6. Wear a respirator to protect your lungs when working in dusty conditions.

Special class-zero (also called "class0") gloves and rubber-soled shoes are required for working around hybrid vehicles due to these vehicles' high voltage.

Smoking, Alcohol, and Drugs in the Shop

Do not smoke when working in the shop. If the shop has designated smoking areas, smoke only in these areas. Do not smoke in customers' cars; nonsmokers may not appreciate cigarette odor in their cars. A spark from a cigarette or lighter may ignite flammable materials in the workplace.

The use of drugs or alcohol must be avoided while working in the shop. Even a small amount of drugs or alcohol affects reaction time. In an emergency situation, slow reaction time may cause personal injury. If a heavy object falls off the workbench and your reaction time is slowed by drugs or alcohol, you may not get your foot out of the way in time, resulting in foot injury. When a fire starts in the workplace and you are a few seconds slower when getting a fire extinguisher into operation because of alcohol or drug use, it could make the difference between extinguishing a fire and incurring expensive fire damage.

The improper or excessive use of alcoholic beverages and/or drugs may be referred to as substance abuse.

Caution

Always know the location of all safety equipment in the shop, and be familiar with the operation of this equipment.

WORK AREA SAFETY

Your work area should be kept clean and safe. The floor and bench tops should be kept clean, dry, and orderly. Any oil, coolant, or grease on the floor can make it slippery. Slips can result in serious injuries. To clean up oil, use commercial oil absorbent. Keep all water off the floor. Water is slippery on smooth floors, and electricity flows well through water. Aisles and walkways should be kept clean and wide enough to easily move through. Make sure the work areas around machines are large enough to safely operate the machine.

Proper ventilation of space heaters, which are used in some shops, is necessary to reduce the CO levels in the shop. Also, proper ventilation is very important in areas where volatile solvents and chemicals are used. A volatile liquid is one that vaporizes very quickly.

Keep an up-to-date list of emergency telephone numbers clearly posted next to the telephone. These numbers should include 911, a doctor, a hospital, and direct numbers for local fire and police departments. Also, the work area should have a first-aid kit for treating minor injuries. There should also be eye-flushing kits readily available.

Gasoline is a highly flammable volatile liquid. Always keep gasoline or diesel fuel in an approved safety can, and never use it to clean your hands or tools. Oily rags should also be stored in an approved metal container. When these oily, greasy, or paint-soaked rags are left lying about or are not stored properly, they can cause spontaneous combustion. Spontaneous combustion results in a fire that starts by itself without a match.

Make sure that all drain covers are snugly in place. Open drains or covers that are not flush to the floor can cause toe, ankle, and leg injuries.

Oil absorbent must be treated as hazardous waste.

Handle all solvents (or any liquids) with care to avoid spillage. Keep all solvent containers closed, except when pouring. Be extra careful when transferring flammable materials from bulk storage (**Figure 1-20**). Static electricity can build up enough to create a spark that could cause an explosion. Discard or clean all empty solvent containers. Solvent fumes in the bottom of these containers are very flammable. Never light matches or smoke near flammable solvents and chemicals, including battery acids. Solvent and other combustible materials must be stored in approved and designated storage cabinets or rooms (**Figure 1-21**). Storage rooms should have adequate ventilation.

Shop rules, vehicle operation in the shop, and shop housekeeping are serious business. Each year a significant number of technicians are injured and vehicles are damaged by disregarding shop rules, careless vehicle operation, and sloppy housekeeping.

Figure 1-20 Flammable liquids should be stored in safety-approved containers.

Figure 1-21 Store combustible materials in approved safety cabinets.

Know where the fire extinguishers are and what types of fires they put out (**Figure 1-22**). A multipurpose dry chemical fire extinguisher will put out ordinary combustibles, flammable liquids, and electrical fires. Never put water on a gasoline fire. The water will just spread the fire. Use a fire extinguisher to smother the flames. Remember that during a fire, never open doors or windows unless it is absolutely necessary; the extra draft will only make the fire worse. A good rule is to call the fire department first and then attempt to extinguish the fire.

To extinguish a fire, stand 6 to 10 feet from the fire. Hold the extinguisher firmly in an upright position. Aim the nozzle at the base, and use a side-to-side motion, sweeping the entire width of the fire. Stay low to avoid inhaling the smoke. If it becomes too hot or too smoky, get out. Remember: never go back into a burning building for anything.

First-Aid Kits

First-aid kits should be clearly identified and conveniently located (**Figure 1-23**). These kits contain such items as bandages and ointment required for minor cuts. All shop personnel must be familiar with the location of first-aid kits. At least one of the shop personnel should have basic first-aid training, and this person should be in charge of administering first aid and keeping first-aid kits filled.

HAZARDOUS WASTE DISPOSAL

Hazardous waste materials in automotive shops are chemicals or components that the shop no longer needs and that pose a danger to people and the environment if they are disposed of in ordinary garbage cans or sewers. However, it should be noted that no material is considered hazardous waste until the shop has finished using it and is ready to dispose of it. When handling any hazardous waste, always wear proper protective clothing, which may include a respirator and gloves (**Figure 1-24**), and use equipment detailed in the right-to-know laws. The EPA publishes a list of hazardous materials that is included

	Class of Fire	Typical Fuel Involved	Type of Extinguisher
Class A Fires (green)	**For Ordinary Combustibles** Put out a Class A fire by lowering its temperature or by coating the burning combustibles.	Wood Paper Cloth Rubber Plastics Rubbish Upholstery	Water*[1] Foam* Multipurpose dry chemical[4]
Class B Fires (red)	**For Flammable Liquids** Put out a Class B fire by smothering it. Use an extinguisher that gives a blanketing, flame-interrupting effect; cover whole flaming liquid surface.	Gasoline Oil Grease Paint Lighter fluid	Foam* Carbon dioxide[5] Halogenated agent[6] Standard dry chemical[2] Purple K dry chemical[3] Multipurpose dry chemical[4]
Class C Fires (blue)	**For Electrical Equipment** Put out a Class C fire by shutting off power as quickly as possible and by always using a nonconducting extinguishing agent to prevent electric shock.	Motors Appliances Wiring Fuse boxes Switchboards	Carbon dioxide[5] Halogenated agent[6] Standard dry chemical[2] Purple K dry chemical[3] Multipurpose dry chemical[4]
Class D Fires (yellow)	**For Combustible Metals** Put out a Class D fire of metal chips, turnings, or shaving by smothering or coating with a specially designed extinguishing agent.	Aluminum Magnesium Potassium Sodium Titanium Zirconium	Dry powder extinguishers and agents only

*Cartridge-operated water, foam, and soda-acid types of extinguishers are no longer manufactured. These extinguishers should be removed from service when they become due for their next hydrostatic pressure test.

Notes:

(1) This freezes in low temperatures unless treated with antifreeze solution, usually weighs over 20 pounds, and is heavier than any other extinguisher mentioned.
(2) Also called "ordinary" or "regular" dry chemical (solution bicarbonate).
(3) Has the greatest initial fire-stopping power of the extinguishers mentioned for class B fires. Be sure to clean residue immediately after using the extinguisher so that sprayed surfaces will not be damaged (potassium bicarbonate).
(4) The only extinguishers that fight A, B, and C class fires. However, they should not be used on fires in liquified fat or oil of appreciable depth. Be sure to clean residue immediately after using the extinguisher so sprayed surfaces will not be damaged (ammonium phosphates).
(5) Use with caution in unventilated, confined spaces.
(6) May cause injury to the operator if the extinguishing agent (a gas) or the gases produced when the agent is applied to a fire is inhaled.

Figure 1-22 Guide to fire extinguisher selection.

Figure 1-23 First-aid kit.

Figure 1-24 Wear recommended safety clothing and equipment when handling hazardous materials.

The *Environmental Protection Agency (EPA)* is a government agency that oversees activities and laws designed to protect water, air, land, and the public from harmful pollution or contamination.

in the Code of Federal Regulations. Waste is considered hazardous if it is included on the EPA list of hazardous materials or has one or more of these characteristics:

1. *Reactive.* Any material that reacts violently with water or other chemicals is considered hazardous. When exposed to low-pH acid solutions, if a material releases cyanide gas, hydrogen sulfide gas, or similar gases, it is hazardous.
2. *Corrosive.* If a material burns the skin or dissolves metals and other materials, it is considered hazardous.
3. *Toxic.* Materials are **toxic** if they leach one or more of eight heavy metals in concentrations greater than 100 times the primary drinking water standard.
4. *Ignitable.* A liquid is ignitable if it has a flashpoint below 140°F (60°C), and a solid is ignitable if it ignites spontaneously.

A material that reacts violently with water or other chemicals is referred to as **reactive**.

The automotive service industry is considered a generator of hazardous wastes. However, the vehicles it services are the real generators. Once you drain oil from an engine, you have generated the waste and now become responsible for the proper disposal of this hazardous waste. There are many other wastes that need to be handled properly after you have removed them, such as batteries, brake fluid, and transmission fluid.

Engine coolant should not be allowed to go down sewage drains. This is also true for all liquids drained from a car. Coolant should be captured and recycled or disposed of properly.

Corrosive materials burn the skin or dissolve metals or other materials.

Filters for fluids (transmission, fuel, and oil filters) also need to be handled in designated ways. Used filters need to be drained and then crushed or disposed of in a special shipping barrel. Most regulations demand that oil filters be drained for at least 24 hours before they are disposed of or crushed.

Federal and state laws control the disposal of hazardous waste materials. Every shop employee must be familiar with these laws. Hazardous waste disposal laws include the Resource Conservation and Recovery Act. This law basically states that hazardous material users are responsible for hazardous materials from the time they become a waste until the proper waste disposal is completed. Many automotive shops hire an independent hazardous waste hauler to dispose of hazardous waste material (**Figure 1-25**). The shop owner or manager should have a written contract with the hazardous waste hauler. Rather than have hazardous waste material hauled to an approved hazardous waste disposal site, a shop may choose to recycle the material in the shop. Therefore, the user must store hazardous waste material properly and safely and be responsible for the transportation of this material until it arrives at an approved hazardous waste disposal site and is processed according to the law.

Materials are toxic if they exceed levels greater than 100 times that in drinking water.

Figure 1-25 Hazardous waste hauler.

The RCRA controls these types of automotive waste:

1. Paint and body repair products waste
2. Solvents for parts and equipment cleaning
3. Batteries and battery acid
4. Mild acids used for metal cleaning and preparation
5. Waste oil, engine coolants, or antifreeze
6. Air-conditioning refrigerants
7. Engine oil filters

Never, under any circumstances, use these methods to dispose of hazardous waste material:

1. Pour hazardous wastes on weeds to kill them.
2. Pour hazardous wastes on gravel streets to prevent dust.
3. Throw hazardous wastes in a dumpster.
4. Dispose of hazardous wastes anywhere but an approved disposal site.
5. Pour hazardous wastes down sewers, toilets, sinks, or floor drains.
6. Bury hazardous wastes in the ground.

The **right-to-know laws** state that employees have a right to know when the materials they use at work are hazardous. The right-to-know laws started with the **Hazard Communication Standard** published by OSHA in 1983. This document was originally intended for chemical companies and manufacturers that required employees to handle hazardous materials in their work situation. At the present time, most states have established their own right-to-know laws. Meanwhile, the federal courts have decided to apply these laws to all companies, including automotive service shops. Under the right-to-know laws, the employer has three responsibilities regarding the handling of hazardous materials by its employees.

First, all employees must be trained about the types of hazardous materials they will encounter in the workplace. The employees must be informed about their rights under legislation regarding the handling of hazardous materials. All hazardous materials must be properly labeled, and information about each hazardous material must be posted on **material safety data sheets (MSDS)**, which are available from the manufacturer (**Figure 1-26**). In Canada, MSDS sheets are called workplace hazardous materials information systems (WHMIS).

The employer has a responsibility to place MSDS where they are easily accessible by all employees. The MSDS provide extensive information about the hazardous material such as the following:

1. Chemical name
2. Physical characteristics
3. Protective equipment required for handling
4. Explosion and fire hazards
5. Other incompatible materials
6. Health hazards such as signs and symptoms of exposure, medical conditions aggravated by exposure, and emergency and first-aid procedures
7. Safe handling precautions
8. Spill and leak procedures

Second, the employer has a responsibility to make sure that all hazardous materials are properly labeled. The label information must include health, fire, and reactivity hazards posed by the material, as well as the protective equipment necessary to handle the material. The manufacturer must supply all warning and precautionary information about

HEXANE
==========
MSDS Safety Information
==========
Ingredients
==========
Name: HEXANE (N_HEXANE)
% Wt: >97
OSHA PEL: 500 PPM
ACGIH TLV: 50 PPM
EPA Rpt Qty: 1 LB
DOT Rpt Qty: 1 LB
==========
Health Hazards Data
==========
LD50 LC50 Mixture: LD50:(ORAL,RAT) 28.7 KG/MG
Route Of Entry Inds _ Inhalation: YES
Skin: YES
Ingestion: YES
Carcinogenicity Inds _ NTP: NO
IARC: NO
OSHA: NO
Effects of Exposure: ACUTE:INHALATION AND INGESTION ARE HARMFUL AND MAY BE FATAL. INHALATION AND INGESTION MAY CAUSE HEADACHE, NAUSEA, VOMITING, DIZZINESS, IRRITATION OF RESPIRATORY TRACT, GASTROINTESTINAL IRRITATION AND UNCONSCIOUSNESS. CONTACT W/SKIN AND EYES MAY CAUSE IRRITATION. PROLONGED SKIN MAY RESULT IN DERMATITIS (EFTS OF OVEREXP)
Signs and Symptoms Of Overexposure: HLTH HAZ:CHRONIC:MAY INCLUDE CENTRAL NERVOUS SYSTEM DEPRESSION.
Medical Cond Aggravated By Exposure: NONE IDENTIFIED.
First Aid: CALL A PHYSICIAN. INGEST:DO NOT INDUCE VOMITING. INHAL:REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN. EYES:IMMED FLUSH W/PLENTY OF WATER FOR AT LEAST 15 MINS. SKIN:IMMED FLUSH W/PLENTY OF WATER FOR AT LEAST 15 MINS WHILE REMOVING CONTAMD CLTHG & SHOES. WASH CLOTHING BEFORE REUSE.
==========
Handling and Disposal
==========
Spill Release Procedures: WEAR NIOSH/MSHA SCBA & FULL PROT CLTHG. SHUT OFF IGNIT SOURCES:NO FLAMES, SMKNG/FLAMES IN AREA. STOP LEAK IF YOU CAN DO SO W/OUT HARM. USE WATER SPRAY TO REDUCE VAPS. TAKE UP W/SAND OR OTHER NONCOMBUST MATL & PLACE INTO CNTNR FOR LATER (SU PDAT)
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Methods: DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS. EPA HAZARDOUS WASTE NUMBER:D001 (IGNITABLE WASTE).
Handling And Storage Precautions: BOND AND GROUND CONTAINERS WHEN TRANSFERRING LIQUID. KEEP CONTAINER TIGHTLY CLOSED.
Other Precautions: USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET TLVREQUIREMENTS. STORAGE COLOR CODE RED (FLAMMABLE).
==========
Fire and Explosion Hazard Information
==========
Flash Point Method: CC
Flash Point Text: 9ºF, 23ºC
Lower Limits: 1.2%
Upper Limits: 77.7%
Extinguishing Media: USE ALCOHOL FOAM, DRY CHEMICAL OR CARBON DIOXIDE. (WATER MAY BE INEFFECTIVE).
Fire Fighting Procedures: USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT (FP N).
Unusual Fire/Explosion Hazard: VAP MAY FORM ALONG SURFS TO DIST IGNIT SOURCES & FLASH BACK. CONT W/STRONG OXIDIZERS MAY CAUSE FIRE. TOX GASES PRDCED MAY INCL:CARBON MONOXIDE, CARBON DIOXIDE.
==========

Figure 1-26 Material safety data sheets (MSDS) inform employees about hazardous materials. N-hexane is commonly used in solvents and many brake-cleaning products.

hazardous materials, and this information must be read and understood by the employee before handling the material.

Third, employers are responsible for maintaining permanent files regarding hazardous materials. These files must include information on hazardous materials in the shop, proof of employee training programs, and information about accidents such as spills or leaks of hazardous materials. The employer's files must also include proof that employees' requests for hazardous material information such as MSDS have been met. A general right-to-know compliance procedure manual must be maintained by the employer.

HAND TOOLS AND DIAGNOSTIC EQUIPMENT

Automotive engine performance is among the most challenging areas of automotive service and encompasses many different theories and service aspects. A thorough understanding of the theory and application of engine mechanics, chemistry, mathematics, electricity, physics, computer operation, safety, and more must be practiced regularly. Part of your responsibility as a professional is to remain current in advancing service technology, tool and equipment usage, as well as any regulatory practices that you need to adhere to including any local, state, or federal licensing or certification mandates. Performing safe, accurate, effective, and efficient service on an automobile—specifically in the area of engine performance—will require a wide array of tools and equipment. Tools are designed to be work savers. When used as designed, they will reduce the amount of time or effort used in performing a service operation. In addition, many tool manufacturers are producing hand tools that are ergonomically designed and comfortable to use to help reduce stress and fatigue on muscles and joints. You also need various types of specialty tools in order to perform different diagnostic tests. Tool and equipment manufacturers are continually upgrading and introducing new products to keep pace with automobile changes. You may invest in some of these tools and diagnostic equipment, but some will belong to the shop due to their cost. The following brief list provides you, the technician, with both common and specialty tools that are typically used in the area of automotive engine performance.

1. Basic hand tools. The basic hand tool set generally includes common tool favorites such as the following:
   - A variety of metric and SAE-size wrenches and sockets
   - Screwdrivers, Torx® drivers, and hex-key wrenches
   - Hammers, chisels, and punches
   - Ratchets and extensions
   - An assortment of various pliers
   - A gear puller set, files, and saws
   - A stethoscope
   - Power tools and torque wrenches
2. Safety and protection equipment:
   - Gloves and hand protection
   - Safety glasses and earplugs
   - Fender and seat covers
   - First-aid kit
3. Measuring devices:
   - Feeler gauges and a spark plug gapping tool
   - Fuel pressure gauges and vacuum gauges
   - Thermometer
   - Various micrometers and dial indicators
   - An engine compression tester
4. Electrical tools:
   - A test light and jumper leads
   - A circuit tester, a logic probe, and test probes
   - A soldering gun and a wire repair kit
   - Crimping and stripping tools
   - A battery tester and battery service tools

Power tools are operated by outside power sources.

5. Diagnostic test equipment:
   - A graphing and/or digital multi-meter (DMM) and a lab scope
   - A scan tool
   - An infrared exhaust gas analyzer
   - A cylinder leakage tester and a vacuum hand pump
   - A fuel injector tester, injector test lights, and a spark tester
   - Test probes and a charging system tester
6. Service information:
   - Online service information for repair, parts and labor time guides
   - Reference manuals and hotline support assistance

EMPLOYER AND EMPLOYEE OBLIGATIONS

When you begin employment, you enter into a business agreement with your employer. A business agreement involves an exchange of goods or services that have value. Although the automotive technician may not have a written agreement with his or her employer, the technician exchanges time, skills, and effort for money paid by the employer. Both the employee and the employer have obligations. The automotive technician's obligations include the following:

1. *Quality*. Each repair job should be a quality job! Work should never be done in a careless manner. Nothing improves customer relations like quality workmanship.
2. *Productivity*. As an automotive technician, you have a responsibility to your employer to make the best possible use of time on the job. Each job should be done in a reasonable length of time. Employees are paid for their skills, effort, and time.
3. *Teamwork*. The shop staff is a team, and everyone, including technicians and management personnel, are team members. You should cooperate with, and care about, other team members. Each member of the team should strive for harmonious relations with fellow workers. Cooperative teamwork helps to improve shop efficiency, productivity, and customer relations. Customers may be turned off by bickering between shop personnel.
4. *Honesty*. Employers and customers expect and deserve honesty from automotive technicians. Honesty creates a feeling of trust between technicians, employers, and customers.
5. *Loyalty*. As an employee, you are obliged to act in the best interests of your employer, both on and off the job.
6. *Attitude*. Employees should maintain a positive attitude at all times. As in other professions, automotive technicians have days when it may be difficult to maintain a positive attitude. For example, there will be days when the technical problems on a certain vehicle are difficult to solve. However, developing a negative attitude certainly will not help the situation. A positive attitude has a positive effect on the job situation as well as on your customers and employer.
7. *Responsibility*. You are responsible for your conduct on the job and your work-related obligations. These obligations include always maintaining good workmanship and customer relations. Attention to details, such as always placing fender and seat covers on customer vehicles prior to driving or working on the vehicle, greatly improves customer relations.
8. *Following directions*. All of us like to do things our way. Such action may not be in the best interests of the shop, and, as an employee, you have an obligation to follow the supervisor's directions.

9. *Punctuality and regular attendance*. Employees have an obligation to be on time for work and to be regular in attendance on the job. It is very difficult for a business to operate successfully if it cannot count on its employees to be on the job at the appointed time.
10. *Regulations*. Automotive technicians should be familiar with all state and federal regulations pertaining to their job situation such as the OSHA and hazardous waste disposal laws. In Canada, employees should be familiar with WHMIS.

Employer-to-employee obligations include the following:

1. *Wages*. The employer has a responsibility to inform the employee regarding the exact amount of financial remuneration he or she will receive and when that wage will be paid.
2. *Fringe benefits*. A detailed description of all fringe benefits should be provided by the employer. These benefits may include holiday pay, sickness and accident insurance, and pension plans.
3. *Working conditions*. A clean, safe workplace must be provided by the employer. The shop must have adequate safety equipment and first-aid supplies. Employers must be certain that all shop personnel maintain the shop area and equipment to provide adequate safety and a healthy workplace atmosphere.
4. *Employee instruction*. Employers must provide employees with clear job descriptions and be sure that each worker is aware of his or her obligations.
5. *Employee supervision*. Employers should inform their workers regarding the responsibilities of their immediate supervisors and other management personnel.
6. *Employee training*. Employers must make sure that employees are familiar with the safe operation of all the equipment that they are required to use in their job situation. Because automotive technology is changing rapidly, employers should provide regular update training for their technicians. Under the right-to-know laws, employers are required to inform all employees about hazardous materials in the shop. Employees should be familiar with the MSDS (or, in Canada, the WHMIS), which detail the labeling and handling of hazardous waste and the health problems if exposed to hazardous waste.

An automotive technician has specific responsibilities regarding each job performed on a customer's vehicle:

1. Do every job to the best of your ability. There is no place in the automotive service industry for careless workmanship! Automotive technicians and students must realize they have a very responsible job. During many repair jobs, you, as a student or technician working on a customer's vehicle, actually have the customer's life and the safety of his or her vehicle in your hands. For example, if you are doing a brake job and leave the wheel nuts loose on one wheel, that wheel may fall off the vehicle at high speed. This could result in serious personal injury or death for the customer and others, plus extensive vehicle damage. If this type of disaster occurs, the individual who worked on the vehicle and the shop may be involved in a very expensive legal action. As a student or technician working on customer vehicles, you are responsible for the safety of every vehicle that you work on. Even when careless work does not create a safety hazard, it leads to dissatisfied customers who often take their business to another shop, and nobody benefits when that happens.
2. Treat customers fairly and honestly on every repair job. Do not install parts that are unnecessary to complete the repair job.
3. Use published specifications; do not guess at adjustments.
4. Follow the service procedures in the service manual provided by the vehicle manufacturer or an independent manual publisher.

5. When the repair job is completed, always be sure the customer's complaint has been corrected.
6. Do not be too concerned with work speed when you begin working as an automotive technician. Speed comes with experience.

NATIONAL INSTITUTE FOR AUTOMOTIVE SERVICE EXCELLENCE (ASE) CERTIFICATION

The Advanced Engine Performance Test is best known as the L1 test.

The **National Institute for Automotive Service Excellence (ASE)** has provided voluntary testing and certification of automotive technicians on a national basis for many years. The image of the automotive service industry has been enhanced by the ASE certification program. More than 350,000 ASE-certified automotive technicians now work in a wide variety of automotive service shops. The ASE provides certification in these nine basic areas of automotive repair:

1. Engine repair
2. Automatic transmissions and transaxles
3. Manual drivetrain and axles
4. Suspension and steering systems
5. Brake systems
6. Electrical systems
7. Heating and air-conditioning systems
8. Engine performance
9. Light vehicle diesel

In addition to these nine basic tests, a technician can take advanced tests (e.g., Advanced Engine Performance L1 or Light Duty Hybrid/Electric Vehicle Specialist Test (L3)) and become certified in that area. The advanced tests require the technician to have particular basic certifications before attempting to be certified at an advanced level.

A technician may take the ASE test and become certified in any or all of the nine basic areas. When a technician passes an ASE test in one of the nine areas, an automotive technician's shoulder patch is issued by the ASE. If a technician passes the A1 to A8 regular tests (light vehicle diesel (A9) is not required for Master Technician Certification), he or she receives a Master Technician's shoulder patch (**Figure 1-27**). Retesting at 5-year intervals is required to remain certified.

The certification test in each of the nine areas contains 40 to 80 multiple-choice questions. The test questions are written by a panel of automotive service experts from

Figure 1-27 ASE certification patches.