

EIGHTH EDITION

AUTOMOTIVE ENGINES THEORY AND SERVICING

JAMES D. HALDERMAN

AUTOMOTIVE ENGINES

THEORY AND SERVICING

E I G H T H E D I T I O N

James D. Halderman

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Printer/Binder: R.R. Donnelley/Willard
Cover Printer: Lehigh-Phoenix Color/Hagerstown
Text Font: Helvetica Neue

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Library of Congress Cataloging-in-Publication Data

Halderman, James D.,
Automotive engines: theory and servicing/James D. Halderman. —Eighth edition.
p. cm
Includes index.
ISBN-13: 978-0-13-351500-8 (alk. paper)
ISBN-10: 0-13-351500-1 (alk. paper)
1. Automobiles—Motors. 2. Automobiles—Motors—Maintenance and repair. I. Title.
TL210.H29 2015
629.25'040288—dc23

2013028873

10 9 8 7 6 5 4 3 2 1

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ISBN 10: 0-13-351500-1
ISBN 13: 978-0-13-351500-8

PREFACE

PROFESSIONAL TECHNICIAN SERIES Part of Pearson Automotive’s Professional Technician Series, the eighth edition of *Automotive Engines: Theory and Servicing* represents the future of automotive textbooks. The series is a full-color, media-integrated solution for today’s students and instructors. The series includes textbooks that cover all 8 areas of ASE certification, plus additional titles covering common courses.

The series is also peer reviewed for technical accuracy.

UPDATES TO THE EIGHTH EDITION

- All content is correlated to the latest NATEF tasks.
- A dramatic, new full-color design enhances the subject material.
- Many new full-color line drawing and photos have been added to help bring the subject to life.
- Infection control precautions have been added (Chapter 1).
- New OSHA standards information added (Chapter 2).
- Additional information on security and external Torx drivers (Chapter 4).
- Updated content on service information (Chapter 8).
- New content on the Atkinson cycle engine design (Chapter 10).
- New content on engine power rated in kilowatts (Chapter 10).
- Updated information on the role of the PCM and spark timing (Chapter 18).
- New content on pressure relief valves on intake manifolds (Chapter 23).
- Updated information on best practices when pre-lubing an engine (Chapter 34).
- Many new color photos and line drawings have been added to this edition.
- Content has been streamlined for easier reading and comprehension.

- This text is fully integrated with MyAutomotiveKit, an online supplement for homework, quizzing, testing, multi-media activities, and videos.
- Unlike other textbooks, this book is written so that the theory, construction, diagnosis, and service of a particular component or system is presented in one location. There is no need to search through the entire book for other references to the same topic.

NATEF CORRELATED NATEF certified programs need to demonstrate that they use course material that covers NATEF tasks. All Professional Technician textbooks have been correlated to the appropriate NATEF task lists. These correlations can be found in an appendix to the book.

A COMPLETE INSTRUCTOR AND STUDENT SUPPLEMENTS PACKAGE All Professional Technician textbooks are accompanied by a full set of instructor and student supplements. Please see page vi for a detailed list of supplements.

A FOCUS ON DIAGNOSIS AND PROBLEM SOLVING The Professional Technician Series has been developed to satisfy the need for a greater emphasis on problem diagnosis. Automotive instructors and service managers agree that students and beginning technicians need more training in diagnostic procedures and skill development. To meet this need and demonstrate how real-world problems are solved, “Real World Fix” features are included throughout and highlight how real-life problems are diagnosed and repaired.

The following pages highlight the unique core features that set the Professional Technician Series book apart from other automotive textbooks.

IN-TEXT FEATURES

chapter 1

SHOP SAFETY

LEARNING OBJECTIVES: After studying this chapter, the reader should be able to: • Describe the personal protective equipment used by technicians. • Explain the safety tips for technicians and the cleaning methods and processes used in vehicle service. • Discuss shop safety procedures. • Discuss the purpose of fire extinguishers, fire blankets, and first aid and eye wash stations.

KEY TERMS: ANSI 2 • Bump cap 2 • Decibel (dB) 3 • Eye wash station 8 • Fire blankets 7 • Microbes 5 • *PASS* 6 • Personal protective equipment (PPE) 2 • Spontaneous combustion 4

PERSONAL PROTECTIVE EQUIPMENT

Safety is not just a buzzword on a poster in the work area. Safe work habits can reduce accidents and injuries, ease the workload, and keep employees pain free.

SAFETY GLASSES The most important personal protective equipment (PPE) a technician should wear all the time are safety glasses, which meet standard ANSI Z87.1. ● SEE FIGURE 1-1.

STEEL-TOED SHOES Steel-toed safety shoes are also a good investment. ● SEE FIGURE 1-2. If safety shoes are not available, then leather-topped shoes offer more protection than canvas or cloth covered shoes.

GLOVES Wear gloves to protect your hands from rough or sharp surfaces. Thin rubber gloves are recommended when



FIGURE 1-1 Safety glasses should be worn at all times when working on or around any vehicle or servicing any component.

working around automotive liquids such as engine oil, antifreeze, transmission fluid, or any other liquids that may be hazardous. Several types of gloves and their characteristics include:

- **Latex surgical gloves.** These gloves are relatively inexpensive, but tend to stretch, swell, and weaken when exposed to gas, oil, or solvents.
- **Vinyl gloves.** These gloves are also inexpensive and are not affected by gas, oil, or solvents. ● SEE FIGURE 1-3.
- **Polyurethane gloves.** These gloves are more expensive, yet very strong. Even though these gloves are also not affected by gas, oil, or solvents, they tend to be slippery.
- **Nitrile gloves.** These gloves are exactly like latex gloves, but are not affected by gas, oil, or solvents, yet they tend to be expensive.



FIGURE 1-2 Steel-toed shoes are a worthwhile investment to help prevent foot injury due to falling objects. Even these well-worn shoes can protect the feet of this service technician.

SHOP SAFETY 1



SAFETY TIP

Shop Cloth Disposal

Always dispose of oily shop cloths in an enclosed container to prevent a fire. ● SEE FIGURE 1-69. Whenever oily cloths are thrown together on the floor or workbench, a chemical reaction can occur, which can ignite the cloth even without an open flame. This process of ignition without an open flame is called **spontaneous combustion**.

SAFETY TIPS alert students to possible hazards on the job and how to avoid them.



REAL WORLD FIX

Valve Springs Can Vary

A technician was building a small block Chevrolet V-8 engine at home and was doing the final detailed checks, and found that many of the valve springs did not have the same tension. Using a borrowed valve spring tester, the technician visited a local parts store and measured all of the valve springs that the store had in stock. The technician selected and purchased the 16 valve springs that were within specification and within a very narrow range of tension. Although having all valve springs equal may or may not affect engine operation, the technician was pleased that all of the valve springs were equal.

OBJECTIVES AND KEY TERMS appear at the beginning of each chapter to help students and instructors focus on the most important material in each chapter. The chapter objectives are based on specific ASE and NATEF tasks.



TECH TIP

It Just Takes a Second

Whenever removing any automotive component, it is wise to screw the bolts back into the holes a couple of threads by hand. This ensures that the right bolt will be used in its original location when the component or part is put back on the vehicle.

TECH TIPS feature real-world advice and “tricks of the trade” from ASE-certified master technicians.

REAL WORLD FIXES present students with actual automotive scenarios and shows how these common (and sometimes uncommon) problems were diagnosed and repaired.



FREQUENTLY ASKED QUESTION

How Many Types of Screw Heads Are Used in Automotive Applications?

There are many, including Torx, hex (also called Allen), plus many others used in custom vans and motor homes. ● SEE FIGURE 1-9.

FREQUENTLY ASKED QUESTIONS are based on the author’s own experience and provide answers to many of the most common questions asked by students and beginning service technicians.

NOTE: Most of these “locking nuts” are grouped together and are commonly referred to as *prevailing torque nuts*. This means that the nut will hold its tightness or torque and not loosen with movement or vibration.

NOTES provide students with additional technical information to give them a greater understanding of a specific task or procedure.

CAUTION: *Never use hardware store (nongraded) bolts, studs, or nuts on any vehicle steering, suspension, or brake component. Always use the exact size and grade of hardware that is specified and used by the vehicle manufacturer.*

CAUTIONS alert students about potential damage to the vehicle that can occur during a specific task or service procedure.

WARNING

Do not use incandescent trouble lights around gasoline or other flammable liquids. The liquids can cause the bulb to break and the hot filament can ignite the flammable liquid which can cause personal injury or even death.

WARNINGS alert students to potential dangers to themselves during a specific task or service procedure.

EVACUATION ROUTES

fire extinguisher and other safety related items. ● SEE FIGURE 1-17.

POSTED MAPS Check the location of posted evacuation routes and be sure to read, understand, and follow the instructions for evacuating the area in case of an emergency. The evacuation routes are commonly posted throughout the building and often include the location of the nearest

AISLE MARKINGS Aisles leading to the emergency exist must be marked with yellow paint or tape at least 2 inches (5 cm) wide. The aisles should also be 40 to 48 inches (102 to 122 cm) wide. Aisles should lead to exits as directly as possible. ● SEE FIGURE 1-18.

SUMMARY

1. All service technicians should wear safety glasses that meet standard ANSI Z87.1.
2. Ear protection should be worn anytime the noise level is at 90 decibels (dB) or higher.
3. Safety should be exercised when working with electrical cords or when jump-starting another vehicle.
4. If a fire extinguisher is needed, remember: Pull the safety pin, aim the nozzle, squeeze the lever, and sweep the nozzle from side-to-side.

REVIEW QUESTIONS

1. List four items that are personal protective equipment (PPE).
2. What are the types of fire extinguishers and their usage?
3. What items are included in a typical first aid box?

CHAPTER QUIZ

1. What do you call the service technician's protective head cover?
 - a. Cap
 - b. Hat
 - c. Bump cap
 - d. Helmet
2. All safety glasses should meet the standards set by
 - a. ANSI
 - b. SAE
 - c. ASE
 - d. DOT
3. When washing hands, the water should be at what temperature?
 - a. 98°F (37°C)
 - b. 110°F (43°C)
 - c. 125°F (52°C)
 - d. 135°F (57°C)
4. Hearing protection should be worn anytime the noise level exceeds
 - a. 60 dB
 - b. 70 dB
 - c. 80 dB
 - d. 90 dB
5. Two technicians are discussing the safe use of a wrench. Technician A says that a wrench should be pulled toward you. Technician B says that a wrench should be pushed away from you. Which technician is correct?
 - a. Technician A only
 - b. Technician B only
 - c. Both Technicians A and B
 - d. Neither Technician A nor B
6. Exhaust hoses should be used because one of the exhaust gases is deadly in high concentration. This gas is
 - a. Carbon monoxide (CO)
 - b. Carbon dioxide (CO₂)
 - c. Hydrocarbons (HC)
 - d. Oxides of nitrogen (NO_x)
7. The process of combustion occurring without an open flame is called
 - a. Direct ignition
 - b. Non-open flame combustion
 - c. Spontaneous combustion
 - d. Cold fusion
8. When using a fire extinguisher, what word can be used to remember what to do?
 - a. PASS
 - b. FIRE
 - c. RED
 - d. LEVER
9. Which type of fire extinguisher can create a corrosive compound when discharged?
 - a. CO₂
 - b. Dry chemical
 - c. Water
 - d. CO
10. Which item is usually *not* included in a first aid kit?
 - a. Eye wash solution
 - b. Antibiotic cream
 - c. Fire blanket
 - d. Bandages

8 CHAPTER 1

THE SUMMARY, REVIEW QUESTIONS, AND CHAPTER QUIZ at the end of each chapter help students review the material presented in the chapter and test themselves to see how much they've learned.

HOISTING THE VEHICLE
STEP BY STEP

1 The first step in hoisting a vehicle is to properly align the vehicle in the center of the aisle.

2 Most vehicles will be correctly positioned when the left front tire is centered on the lift pad.

3 The arms can be moved in and out and most pads can be rotated to allow for many different types of vehicle construction.

4 Most lifts are equipped with short pad extensions that are often necessary to use to allow the pad to contact the base of a vehicle without causing the area of the lift to hit and damage parts of the body.

5 Pad pad extensions can also be used to gain access to the frame of a vehicle. This position is needed to safely hoist many pickup trucks, vans, and sport utility vehicles.

6 An additional extension may be necessary to hold a truck or van equipped with running boards to give the necessary clearance.

7 Position the pads under the vehicle under the recommended locations.

8 After being sure all pads are correctly positioned, use the electromechanical controls to raise the vehicle.

9 With the vehicle raised one foot (30 cm) off the ground, jounce down on the vehicle to check to see if it is stable on the pads. If the vehicle rocks, lower the vehicle and re-eval the pads. The vehicle can be raised to any desired working level. Be sure the safety is engaged before working on or under the vehicle.

10 If raising a vehicle without a frame, place the flat pads under the pinch weld area to support the load. If additional clearance is necessary, the pads can be rotated as shown.

11 When the service work is completed, the lift should be raised slightly and the safety released before using the hydraulic to lower the vehicle.

12 After lowering the vehicle, be sure all arms of the lift are moved out of the way before driving the vehicle out of the work area.

G4 CHAPTER 4
VEHICLE LIFTING AND HOISTING 65

STEP BY STEP photo sequences show in detail the steps involved in performing a specific task or service procedure.

SUPPLEMENTS

RESOURCES IN PRINT AND ONLINE

Automotive Engines

| Name of Supplement | Print | Online | Audience | Description |
|--|-------|--------|-------------|---|
| Instructor Resource Manual 0-13-351617-2 | | ✓ | Instructors | NEW! The Ultimate teaching aid: Chapter summaries, key terms, chapter learning objectives, lecture resources, discuss/demonstrate classroom activities, MyAutomotiveLab correlation, and answers to the in text review and quiz questions. |
| TestBank 0-13-351599-0 | | ✓ | Instructors | Test generation software and test bank for the text. |
| PowerPoint Presentation 0-13-351615-6 | | ✓ | Instructors | Slides include chapter learning objectives, lecture outline of the text, and graphics from the book. |
| Image Bank 0-13-351584-2 | | ✓ | Instructors | All of the images and graphs from the text-book to create customized lecture slides. |
| Instructors Resource CD-ROM 0-13-351622-9 | ✓ | | | Take your instructor resources with you! This convenient CD houses the text PowerPoint presentation, Image Bank, instructors manual, and TestGen. |
| NATEF Correlated Task Sheets – for instructors 0-13-351616-4 | | ✓ | Instructors | Downloadable NATEF task sheets for easy customization and development of unique task sheets. |
| NATEF Task Sheets – For Students 0-13-351623-7 | ✓ | | Students | Study activity manual that correlates NATEF Automobile Standards to chapters and pages numbers in the text. Available to students at a discounted price when packaged with the text. |
| CourseSmart eText 0-13-351614-8 | | ✓ | Students | An alternative to purchasing the print textbook, students can subscribe to the same content online and save up to 50% off the suggested list price of the print text. Visit www.coursesmart.com |

All online resources can be downloaded from the Instructor's Resource Center: www.pearsonighered.com/irc

ACKNOWLEDGMENTS

A large number of people and organizations have cooperated in providing the reference material and technical information used in this text. The author wishes to express sincere thanks to the following organizations for their special contributions:

ASE
Automotion, Inc.
Society of Automotive Engineers (SAE)

TECHNICAL AND CONTENT REVIEWERS The following people reviewed the manuscript before production and checked it for technical accuracy and clarity of presentation. Their suggestions and recommendations were included in the final draft of the manuscript. Their input helped make this textbook clear and technically accurate while maintaining the easy-to-read style that has made other books from the same author so popular.

Jim Anderson
Greenville High School

Victor Bridges
Umpqua Community College

Darrell Deeter
Saddleback College

Dr. Roger Donovan
Illinois Central College

A. C. Durdin
Moraine Park Technical College

Herbert Ellinger
Western Michigan University

Al Engledahl
College of Dupage

Larry Hagelberger
Upper Valley Joint Vocational School

Oldrick Hajzler
Red River College

Betsy Hoffman
Vermont Technical College

Richard Krieger
Michigan Institute of technology

Steven T. Lee
Lincoln Technical Institute

Carlton H. Mabe, Sr.
Virginia Western Community College

Roy Marks
Owens Community College

Tony Martin
University of Alaska Southeast

Kerry Meier
San Juan College

Fritz Peacock
Indiana Vocational Technical College

Dennis Peter
NAIT (Canada)

Kenneth Redick
Hudson Valley Community College

Mitchell Walker
St. Louis Community College at Forest Park

Jennifer Wise
Sinclair Community College

Special thanks to instructional designer **Alexis I. Skriloff James**

PHOTO SEQUENCES The author wishes to thank Blaine Heeter, Mike Garblik, and Chuck Taylor of Sinclair Community College in Dayton, Ohio, and James (Mike) Watson who helped with many of the photos. A special thanks to Dick Krieger for his detailed and thorough reviews of the manuscript before publication.

Most of all, I wish to thank Michelle Halderman for her assistance in all phases of manuscript preparation.

—James D. Halderman

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chapter 1

SHOP SAFETY

LEARNING OBJECTIVES: After studying this chapter, the reader should be able to: • Describe the personal protective equipment used by technicians. • Explain the safety tips for technicians and the cleaning methods and processes used in vehicle service. • Discuss shop safety procedures. • Discuss the purpose of fire extinguishers, fire blankets, and first aid and eye wash stations.

KEY TERMS: ANSI 1 • Bump cap 2 • Decibel (dB) 2 • Eye wash station 7 • Fire blankets 6 • Microbes 4 • “PASS” 5 • Personal protective equipment (PPE) 1 • Spontaneous combustion 3

PERSONAL PROTECTIVE EQUIPMENT

Safety is not just a buzzword on a poster in the work area. Safe work habits can reduce accidents and injuries, ease the workload, and keep employees pain free.

SAFETY GLASSES The most important **personal protective equipment (PPE)** a technician should wear all the time are safety glasses, which meet standard **ANSI Z87.1**. ● **SEE FIGURE 1-1**.

STEEL-TOED SHOES Steel-toed safety shoes are also a good investment. ● **SEE FIGURE 1-2**. If safety shoes are not available, then leather-topped shoes offer more protection than canvas or cloth covered shoes.

GLOVES Wear gloves to protect your hands from rough or sharp surfaces. Thin rubber gloves are recommended when

working around automotive liquids such as engine oil, antifreeze, transmission fluid, or any other liquids that may be hazardous. Several types of gloves and their characteristics include:

- **Latex surgical gloves.** These gloves are relatively inexpensive, but tend to stretch, swell, and weaken when exposed to gas, oil, or solvents.
- **Vinyl gloves.** These gloves are also inexpensive and are not affected by gas, oil, or solvents. ● **SEE FIGURE 1-3**.
- **Polyurethane gloves.** These gloves are more expensive, yet very strong. Even though these gloves are also not affected by gas, oil, or solvents, they tend to be slippery.
- **Nitrile gloves.** These gloves are exactly like latex gloves, but are not affected by gas, oil, or solvents, yet they tend to be expensive.

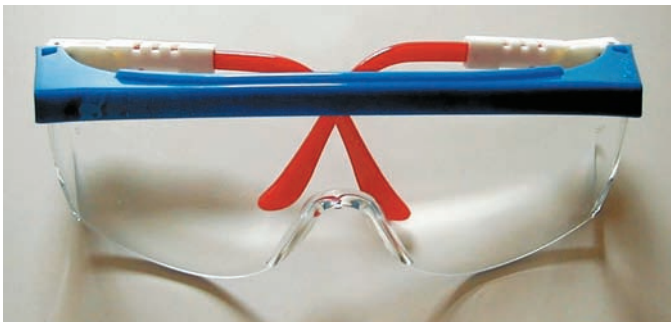


FIGURE 1-1 Safety glasses should be worn at all times when working on or around any vehicle or servicing any component.



FIGURE 1-2 Steel-toed shoes are a worthwhile investment to help prevent foot injury due to falling objects. Even these well-worn shoes can protect the feet of this service technician.



FIGURE 1-3 Protective gloves such as these vinyl gloves are available in several sizes. Select the size that allows the gloves to fit snugly. Vinyl gloves last a long time and often can be worn all day to help protect your hands from dirt and possible hazardous materials.



FIGURE 1-5 Remove all jewelry before performing service work on any vehicle.



FIGURE 1-4 One version of a bump cap is this padded plastic insert that is worn inside a regular cloth cap.

- **Mechanic's gloves.** These gloves are usually made of synthetic leather and spandex and provide thermo protection, as well as protection from dirt and grime.

BUMP CAP Service technicians working under a vehicle should wear a **bump cap** to protect the head against under-vehicle objects and the pads of the lift. ● **SEE FIGURE 1-4.**

HANDS, JEWELRY, AND CLOTHING Remove jewelry that may get caught on something or act as a conductor to an exposed electrical circuit. ● **SEE FIGURE 1-5.**

Take care of your hands. Keep your hands clean by washing with soap and hot water that is at least 110°F (43°C). Avoid loose or dangling clothing. Also, ear protection should be worn

TECH TIP

Professional Behavior in the Shop Is a Must

To be respected as a professional service technician and for safety, always behave in a professional manner. These behaviors include, but are not limited to the following:

- Show respect to other technicians and employees. For example, the shop owner or service manager may not always be right, but they are always the boss.
- Avoid horseplay or practical jokes.
- Act as if a customer is observing your behavior at all times because this is often the case.

if the sound around you requires that you raise your voice (sound level higher than 90 **decibels [dB]**).

NOTE: A typical lawnmower produces noise at a level of about 110 dB. This means that everyone who uses a lawnmower or other lawn or garden equipment should wear ear protection.

SAFETY TIPS FOR TECHNICIANS

- When lifting any object, get a secure grip with solid footing. Keep the load close to your body to minimize the strain. Lift with your legs and arms, not your back.
- Do not twist your body when carrying a load. Instead, pivot your feet to help prevent strain on the spine.



FIGURE 1-6 Always connect an exhaust hose to the tailpipe of the engine of a vehicle to be run inside a building.



FIGURE 1-8 An electric pusher used to push vehicles into or around the shop.



FIGURE 1-7 A magnetic tray is a helpful item to keep tools needed up where they can be easily reached without having to bend over saving time and energy over the course of a long day in the shop.



FIGURE 1-9 All oily shop cloths should be stored in a metal container equipped with a lid to help prevent spontaneous combustion.

- Ask for help when moving or lifting heavy objects.
- Push a heavy object rather than pull it. (This is opposite to the way you should work with tools—never push a wrench! If you do and a bolt or nut loosens, your entire weight is used to propel your hand(s) forward. This usually results in cuts, bruises, or other painful injury.)
- Always connect an exhaust hose to the tailpipe of any running vehicle to help prevent the buildup of carbon monoxide (CO) inside a closed garage space. ● **SEE FIGURE 1-6.**
- When standing, keep objects, parts, and tools with which you are working between chest height and waist height. If seated, work at tasks that are at elbow height. ● **SEE FIGURE 1-7.**



SAFETY TIP

Shop Cloth Disposal

Always dispose of oily shop cloths in an enclosed container to prevent a fire. ● **SEE FIGURE 1-9.** Whenever oily cloths are thrown together on the floor or workbench, a chemical reaction can occur which can ignite the cloth even without an open flame. This process of ignition without an open flame is called **spontaneous combustion.**

- Always be sure the hood is securely held open.
- Ask for help when pushing a vehicle or use a motorized pusher. ● **SEE FIGURE 1-8.**



TECH TIP

Pound with Something Softer

If you must pound on something, be sure to use a tool that is softer than what you are about to pound on to avoid damage. Examples are given in the following table.

| The Material Being Pounded | What to Pound With |
|----------------------------|---|
| Steel or cast iron | Brass or aluminum hammer or punch |
| Aluminum | Plastic or rawhide mallet or plastic-covered dead-blow hammer |
| Plastic | Rawhide mallet or plastic dead-blow hammer |

CLEANING METHODS AND PROCESSES

There are four basic types of cleaning methods and processes used in vehicle service.

POWER WASHING Power washing uses an electric- or gasoline-powered compressor to increase the pressure of water and force it out of a nozzle. The pressure of the water itself is usually enough to remove dirt, grease, and grime from vehicle components. Sometimes a chemical cleaner, such as a detergent, is added to the water to help with cleaning.

SAFE USE OF POWER WASHERS. Because water is being sprayed at high pressure, a face shield should be worn when using a power washer to protect not only the eyes but also the face in the event of the spray being splashed back toward the technician. Also use a pressure washer in an area where the runoff from the cleaning will not contaminate local groundwater or cause harm to plants or animals.

CHEMICAL/MICROBE CLEANING Chemical cleaning involves one of several cleaning solutions, including detergent, solvents, or small, living microorganisms called **microbes** that eat oil and grease. The microbes live in water and eat the hydrocarbons that are the basis of grease and oil.

SAFE USE OF CHEMICAL CLEANING. A face shield should be worn when cleaning parts using a chemical cleaner. Avoid spilling the cleaner on the floor to help prevent slipping accidents. Clean and replace the chemical cleaner regularly.

ABRASIVE CLEANING Abrasive cleaning is used to clean disassembled parts, such as engine blocks. The abrasives used include steel shot, ground walnut shells, or in the case of cleaning paint from a vehicle body, baking soda can be used.

SAFE USE OF ABRASIVE CLEANERS. Always wear a protective face shield and protective clothing, including gloves, long sleeves, and long pants.

THERMAL OVENS Thermal cleaning uses heat to bake off grease and dirt with special high-temperature ovens. This method of cleaning requires the use of expensive equipment but does not use any hazardous chemicals and is environmentally safe.

SAFE USE OF THERMAL OVENS. Because thermal ovens operate at high temperatures, often exceeding 600°F (315°C), the oven should be turned off and allowed to cool overnight before removing the parts from the oven to avoid being exposed to the high temperature.

ELECTRICAL CORD SAFETY

Use correctly grounded three-prong sockets and extension cords to operate power tools. Some tools use only two-prong plugs. Make sure these are double insulated and repair or replace any electrical cords that are cut or damaged to prevent the possibility of an electrical shock. When not in use, keep electrical cords off the floor to prevent tripping over them. Tape the cords down if they are placed in high foot traffic areas.

JUMP-STARTING AND BATTERY SAFETY

To jump-start another vehicle with a dead battery, connect good-quality copper jumper cables as indicated in **FIGURE 1-10** or use a jump box. The last connection made should always be on the engine block or an engine bracket as far from the battery as possible. It is normal for a spark to be created when the jumper cables finally complete the jumper cable connections, and this spark could cause an explosion of the gases around the battery. Many newer vehicles have special ground connections built away from the battery just for the purpose of jump-starting. Check the owner manual or service information for the exact location.

Batteries contain acid and should be handled with care to avoid tipping them greater than a 45-degree angle. Always remove jewelry when working around a battery to avoid the

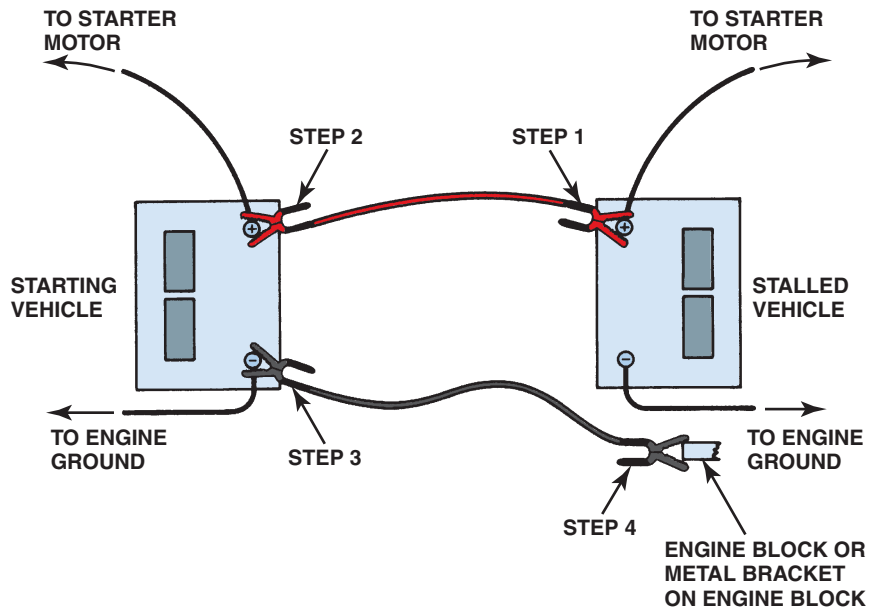


FIGURE 1-10 Jumper cable usage guide.



SAFETY TIP

Compressed Air Safety

Improper use of an air nozzle can cause blindness or deafness. Compressed air must be reduced to less than 30 PSI (206 kPa). ● **SEE FIGURE 1-11.** If an air nozzle is used to dry and clean parts, make sure the air stream is directed away from anyone else in the immediate area. Always use an OSHA-approved nozzle with side slits that limit the maximum pressure at the nozzle to 30 PSI. Coil and store air hoses when they are not in use.



FIGURE 1-11 The air pressure going to the nozzle should be reduced to 30 PSI or less.

possibility of electrical shock or burns, which can occur when the metal comes in contact with a 12 volt circuit and ground, such as the body of the vehicle.

FIRE EXTINGUISHERS

There are four classes of fire extinguishers. Each class should be used on specific fires only.

- *Class A* is designed for use on general combustibles, such as cloth, paper, and wood.
- *Class B* is designed for use on flammable liquids and greases, including gasoline, oil, thinners, and solvents.
- *Class C* is used only on electrical fires.

- *Class D* is effective only on combustible metals such as powdered aluminum, sodium, or magnesium. The class rating is clearly marked on the side of every fire extinguisher. Many extinguishers are good for multiple types of fires. ● **SEE FIGURE 1-12.** When using a fire extinguisher, remember the word **“PASS.”**
 - P = Pull the safety pin.
 - A = Aim the nozzle of the extinguisher at the base of the fire.
 - S = Squeeze the lever to actuate the extinguisher.
 - S = Sweep the nozzle from side to side.
- **SEE FIGURE 1-13.**



FIGURE 1-12 A typical fire extinguisher designed to be used on type class A, B, or C fires.



FIGURE 1-14 A treated wool blanket is kept in this easy-to-open wall-mounted holder and should be placed in a centralized location in the shop.



FIGURE 1-13 A CO₂ fire extinguisher being used on a fire set in an open steel drum during a demonstration at a fire department training center.

TYPES OF FIRE EXTINGUISHERS Types of fire extinguishers include the following:

- **Water.** A water fire extinguisher, usually in a pressurized container, is good to use on Class A fires by reducing the temperature to the point where a fire cannot be sustained.
- **Carbon dioxide (CO₂).** A carbon dioxide fire extinguisher is good for almost any type of fire, especially Class B or Class C materials. A CO₂ fire extinguisher works by removing the oxygen from the fire and the cold CO₂ also helps reduce the temperature of the fire.
- **Dry chemical (yellow).** A dry chemical fire extinguisher is good for Class A, B, or C fires by coating the flammable materials, which eliminates the oxygen from the fire. A dry chemical fire extinguisher tends to be very corrosive and will cause damage to electronic devices.

FIRE BLANKETS

Fire blankets are required to be available in the shop areas. If a person is on fire, a fire blanket should be removed from its storage bag and thrown over and around the victim to smother the fire. ● **SEE FIGURE 1-14** showing a typical fire blanket.

FIRST AID AND EYE WASH STATIONS

All shop areas must be equipped with a first aid kit and an eye wash station centrally located and kept stocked with emergency supplies.

FIRST AID KIT A first aid kit should include:

- Bandages (variety)
- Gauze pads
- Roll gauze
- Iodine swab sticks
- Antibiotic ointment
- Hydrocortisone cream
- Burn gel packets
- Eye wash solution
- Scissors
- Tweezers
- Gloves
- First aid guide



FIGURE 1-15 A first aid box should be centrally located in the shop and kept stocked with the recommended supplies.



FIGURE 1-16 A typical eye wash station. Often a thorough flushing of the eyes with water is the best treatment in the event of eye contamination.

● **SEE FIGURE 1-15.** Every shop should have a person trained in first aid. If there is an accident, call for help immediately.

EYE WASH STATION An **eye wash station** should be centrally located and used whenever any liquid or chemical gets into the eyes. If such an emergency does occur, keep eyes in a constant stream of water and call for professional assistance. ● **SEE FIGURE 1-16.**

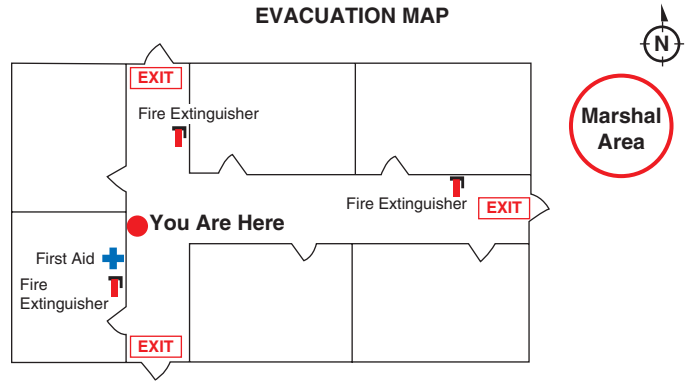


FIGURE 1-17 The evacuation routes from where you are in the building is shown on maps that are attached to the walls in schools and commercial buildings.

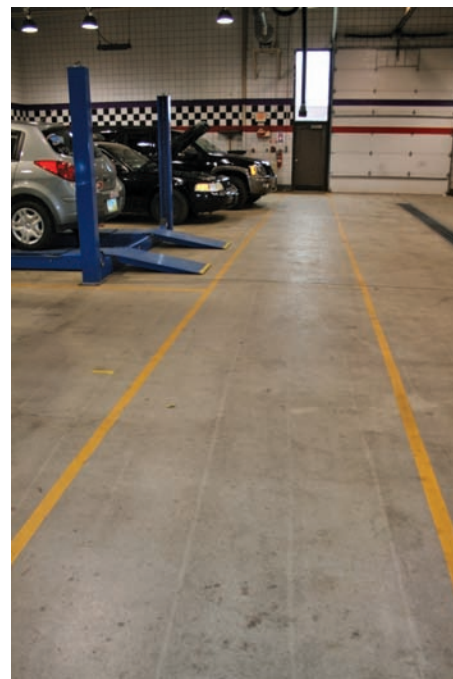


FIGURE 1-18 A properly marked aisle using yellow paint strips leading to an exit.



SAFETY TIP

Infection Control Precautions

Working on a vehicle can result in personal injury including the possibility of being cut or hurt enough to cause bleeding. Some infections such as hepatitis B, HIV (which can cause acquired immunodeficiency syndrome, or AIDS), and hepatitis C virus are transmitted through blood. These infections are commonly called blood-borne pathogens. Report any injury that involves blood to your supervisor and take the necessary precautions to avoid coming in contact with blood from another person.

EVACUATION ROUTES

POSTED MAPS Check the location of posted evacuation routes and be sure to read, understand, and follow the instructions for evacuating the area in case of an emergency. The evacuation routes are commonly posted throughout the building and often include the location of the nearest

fire extinguisher and other safety related items. ● **SEE FIGURE 1-17.**

AISLE MARKINGS Aisles leading to the emergency exist must be marked with yellow paint or tape at least 2 inches (5 cm) wide. The aisles should also be 40 to 48 inches (102 to 122 cm) wide. Aisles should lead to exits as directly as possible. ● **SEE FIGURE 1-18.**

SUMMARY

1. All service technicians should wear safety glasses that meet standard ANSI Z87.1.
2. Ear protection should be worn anytime the noise level is at 90 decibels (dB) or higher.
3. Safety should be exercised when working with electrical cords or when jump-starting another vehicle.
4. If a fire extinguisher is needed, remember: Pull the safety pin, aim the nozzle, squeeze the lever, and sweep the nozzle from side-to-side.

REVIEW QUESTIONS

1. List four items that are personal protective equipment (PPE).
2. What are the types of fire extinguishers and their usage?
3. What items are included in a typical first aid box?

CHAPTER QUIZ

1. What do you call the service technician's protective head cover?
 - a. Cap
 - b. Hat
 - c. Bump cap
 - d. Helmet
2. All safety glasses should meet the standards set by _____.
 - a. ANSI
 - b. SAE
 - c. ASE
 - d. DOT
3. When washing hands, the water should be at what temperature?
 - a. 98°F (37°C)
 - b. 110°F (43°C)
 - c. 125°F (52°C)
 - d. 135°F (57°C)
4. Hearing protection should be worn anytime the noise level exceeds _____.
 - a. 60 dB
 - b. 70 dB
 - c. 80 dB
 - d. 90 dB
5. Two technicians are discussing the safe use of a wrench. Technician A says that a wrench should be pulled toward you. Technician B says that a wrench should be pushed away from you. Which technician is correct?
 - a. Technician A only
 - b. Technician B only
 - c. Both Technicians A and B
 - d. Neither Technician A nor B
6. Exhaust hoses should be used because one of the exhaust gases is deadly in high concentration. This gas is _____.
 - a. Carbon monoxide (CO)
 - b. Carbon dioxide (CO₂)
 - c. Hydrocarbons (HC)
 - d. Oxides of nitrogen (NO_x)
7. The process of combustion occurring without an open flame is called _____.
 - a. Direct ignition
 - b. Non-open flame combustion
 - c. Spontaneous combustion
 - d. Cold fusion
8. When using a fire extinguisher, what word can be used to remember what to do?
 - a. PASS
 - b. FIRE
 - c. RED
 - d. LEVER
9. Which type of fire extinguisher can create a corrosive compound when discharged?
 - a. CO₂
 - b. Dry chemical
 - c. Water
 - d. CO
10. Which item is usually *not* included in a first aid kit?
 - a. Eye wash solution
 - b. Antibiotic cream
 - c. Fire blanket
 - d. Bandages

chapter 2

ENVIRONMENTAL AND HAZARDOUS MATERIALS

LEARNING OBJECTIVES: After studying this chapter, the reader should be able to: • Identify hazardous waste materials in accordance with federal and state laws. • Discuss asbestos hazards and asbestos handling guidelines. • Explain the storage and disposal of brake fluid, used oil, coolants, lead-acid batteries, used tires, and air-conditioning refrigerant oil. • Explain the characteristics of hazardous solvents, fuel safety and storage, and airbag handling.

KEY TERMS: Aboveground storage tank (AGST) 12 • Asbestosis 11 • BCI 15 • CAA 10 • CFR 9 • EPA 9 • Hazardous waste material 9 • HEPA vacuum 11 • Mercury 17 • MSDS 10 • OSHA 9 • RCRA 10 • Right-to-know laws 10 • Solvent 11 • Underground storage tank (UST) 12 • Used oil 12 • WHMIS 10

HAZARDOUS WASTE

DEFINITION OF HAZARDOUS WASTE **Hazardous waste materials** are chemicals, or components, that the shop no longer needs that pose a danger to the environment and people if they are disposed of in ordinary garbage cans or sewers. However, no material is considered hazardous waste until the shop has finished using it and is ready to dispose of it.

PERSONAL PROTECTIVE EQUIPMENT (PPE) When handling hazardous waste material, one must always wear the proper protective clothing and equipment detailed in the right-to-know laws. This includes respirator equipment. All recommended procedures must be followed accurately. Personal injury may result from improper clothing, equipment, and procedures when handling hazardous materials.

FEDERAL AND STATE LAWS

OCCUPATIONAL SAFETY AND HEALTH ACT The United States Congress passed the **Occupational Safety and Health Act (OSHA)** in 1970. This legislation was designed 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.

- Safe and healthful working conditions for working men and women by authorizing enforcement of the standards developed under the Act.

Because about 25% of workers are exposed to health and safety hazards on the job, the OSHA standards are necessary to monitor, control, and educate workers regarding health and safety in the workplace.

EPA The **Environmental Protection Agency (EPA)** publishes a list of hazardous materials that is included in the **Code of Federal Regulations (CFR)**. The EPA considers waste hazardous if it is included on the EPA list of hazardous materials, or it has one or more of the following characteristics:

- **Reactive.** Any material that reacts violently with water or other chemicals is considered hazardous.
- **Corrosive.** If a material burns the skin, or dissolves metals and other materials, a technician should consider it hazardous. A pH scale is used, with the number 7 indicating neutral. Pure water has a pH of 7. Lower numbers indicate an acidic solution and higher numbers indicate a caustic solution. If a material releases cyanide gas, hydrogen sulfide gas, or similar gases when exposed to low pH acid solutions, it is considered hazardous.
- **Toxic.** Materials are hazardous if they leak one or more of eight different heavy metals in concentrations greater than 100 times the primary drinking water standard.
- **Ignitable.** A liquid is hazardous if it has a flash point below 140°F (60°C), and a solid is hazardous if it ignites spontaneously.