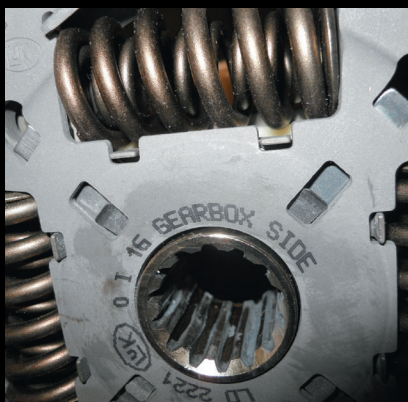
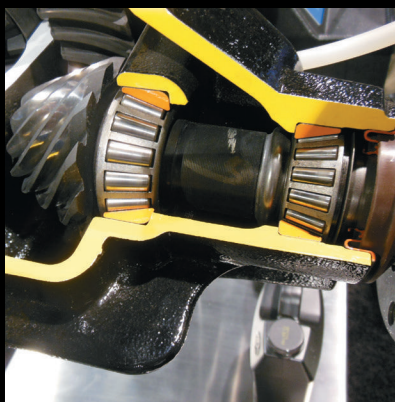
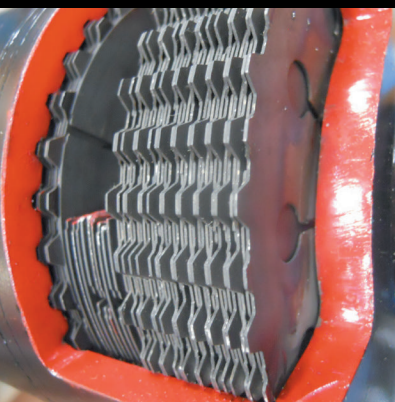
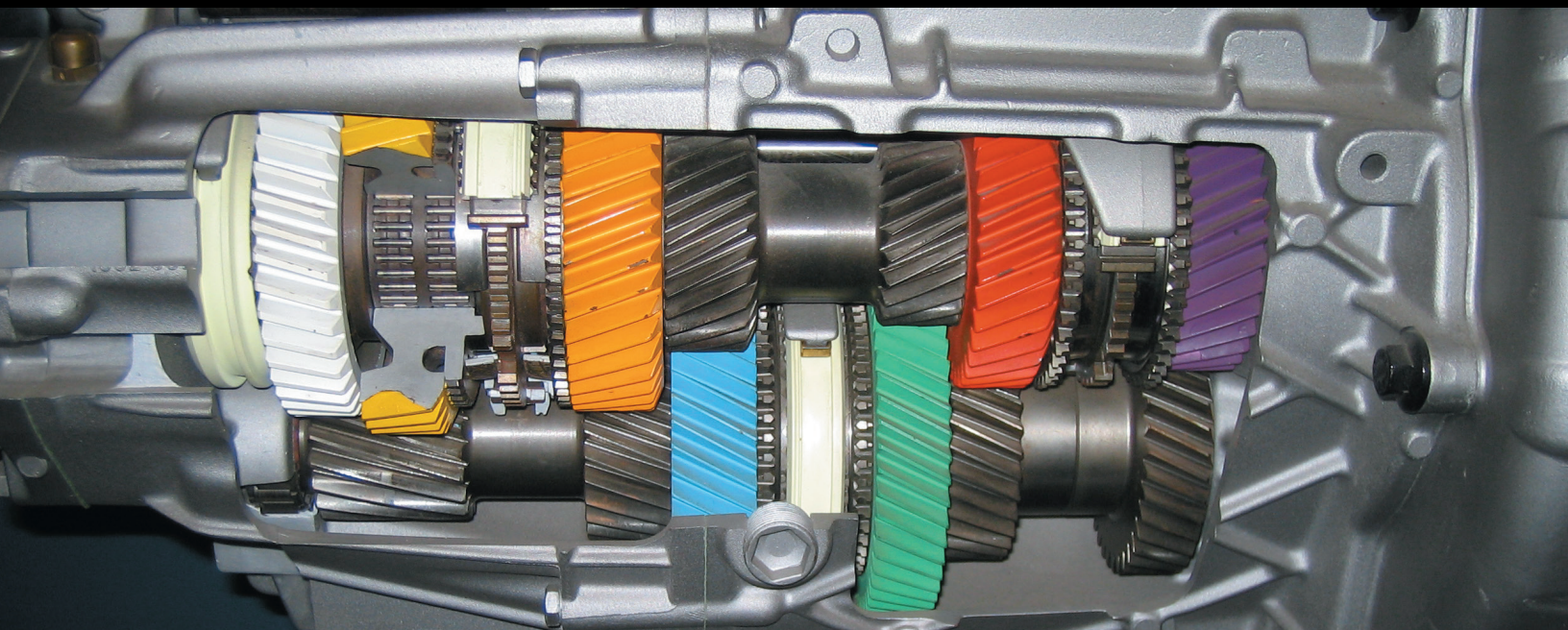


Manual Drivetrains and Axles

Eighth Edition

James D. Halderman



MANUAL DRIVETRAINS AND AXLES

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

James D. Halderman



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PREFACE

PROFESSIONAL TECHNICIAN SERIES Part of the *Pearson Automotive Professional Technician Series*, the eighth edition of *Manual Drivetrains and Axles* 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 eight areas of ASE certification, plus additional titles covering common courses. The series is peer-reviewed for technical accuracy.

UPDATES TO THE EIGHTH EDITION

- The content has been updated throughout and correlated to the latest NATEF and ASE tasks for Manual Drive Trains and Axles (A3).
- Over 40 new or enhanced full color photos and line drawing have been added to help make the subject come alive.
- New Case Studies have been added to many chapters that include the “Three Cs” (Complaint, Cause and Correction).
- Additional information on spur-type gears is included in Chapter 3.
- New content on pre-filled hydraulic clutch systems added to Chapter 5.
- Chapter 11 has two new Tech Tips and a new Case Study.
- Chapter 14 has a new conventional and global electrical symbol chart added.
- Chapter 17 has a new FAQ and a new Tech Tip.

ASE AND NATEF CORRELATED NATEF certified programs need to demonstrate that they use course material that covers NATEF and ASE tasks. All Professional Technician textbooks have been correlated to the appropriate ASE and 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

SERVICE INFORMATION, TOOLS, AND SAFETY

LEARNING OBJECTIVES

After studying this chapter, the reader will be able to:

1. Locate and interpret vehicle and major component identification numbers.
2. Identify the strength ratings of threaded fasteners.
3. Explain the difference between the brand name (trade name) and the proper name for tools.
4. Describe what tool is the best to use for each job.
5. Explain how to maintain hand tools.
6. Identify the personal protective equipment (PPE) that all service technicians should wear.
7. Discuss how to safely use hand tools.
8. Describe how to safely hoist a vehicle.

This chapter will help you understand the ASE content knowledge for vehicle identification and the proper use of tools and shop equipment.

KEY TERMS

| | |
|------------------------------|---------------------------|
| Bench grinder 23 | PPE 24 |
| Bolts 4 | Pinch weld seam 27 |
| Breaker bar 10 | Pitch 5 |
| Bump cap 24 | Pliers 15 |
| Calibration codes 3 | Punches 17 |
| Campaign 4 | Ratchet 10 |
| Casting number 3 | Recall 4 |
| Cheater bar 13 | Screwdrivers 11 |
| Chisels 18 | Ships 17 |
| Drive sizes 10 | Socket 10 |
| Extensions 10 | Socket adapter 13 |
| Eye wash station 32 | Spontaneous combustion 26 |
| Files 17 | SST 21 |
| Fire blanket 31 | Stud 4 |
| Fire extinguisher classes 30 | Tensile strength 6 |
| GAWR 2 | Trouble light 21 |
| Grade 6 | TSB 4 |
| GWWR 2 | UNC 5 |
| Hacksaws 18 | UNF 5 |
| Hammers 13 | Universal joint 10 |
| HEV 33 | VECI 2 |
| LED 22 | VIN 2 |
| Metric bolts 6 | Washers 7 |
| Nuts 7 | Wrenches 8 |

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.



Case Study

The Case of the Hard Shifting Acura

An Acura Civic (140,000 mi) came in with a hard shifting concern. A road test confirmed that the car shifted hard into every gear. There was no grinding that would indicate a clutch problem. The fluid level was good, and seemed to be SAE 5W-30 engine oil.

The technician drained, flushed, and filled the transaxle with Honda manual transmission fluid (MTF), and this fixed the hard shift problem.

Summary:

- **Complaint**—Owner complained of hard shifting.
- **Cause**—Appeared to have had engine oil instead of Honda manual transmission fluid.
- **Correction**—Replaced the transaxle fluid with the specified fluid.

LEARNING 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.

CASE STUDIES present students with actual automotive scenarios and show 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.

SUMMARY

1. Bolts, studs, and nuts are commonly used as fasteners in the chassis. The sizes for fractional and metric threads are different and are not interchangeable. The grade is the rating of the strength of a fastener.
2. Whenever a vehicle is raised above the ground, it must be supported at a substantial section of the body or frame.
3. Wrenches are available in open end, box end, and combination open and box end.
4. An adjustable wrench should only be used where the proper size is not available.
5. Line wrenches are also called flare-nut wrenches, fitting wrenches, or tube-nut wrenches and are used to remove fuel or refrigerant lines.
6. Sockets are rotated by a ratchet or breaker bar, also called a flex handle.
7. Torque wrenches measure the amount of torque applied to a fastener.
8. Screwdriver types include straight blade (flat tip) and Phillips.
9. Hammers and mallets come in a variety of sizes and weights.
10. Pliers are a useful tool and are available in many different types, including slip-joint, multigroove, linesman's, diagonal, needle-nose, and locking pliers.
11. Other common hand tools include snap-ring pliers, files, cutters, punches, chisels, and hacksaws.
12. Hybrid electric vehicles should be de-powered if any of the high-voltage components are going to be serviced.

REVIEW QUESTIONS

1. List three precautions that must be taken whenever hoisting (lifting) a vehicle.
2. Describe how to determine the grade of a fastener, including how the markings differ between fractional and metric bolts.
3. List four items that are personal protective equipment (PPE).
4. List the types of fire extinguishers and their usage.
5. Why are wrenches offset 15 degrees?
6. What are the other names for a line wrench?
7. What are the standard automotive drive sizes for sockets?
8. Which type of screwdriver requires the use of a hammer or mallet?
9. What is inside a dead-blow hammer?
10. What type of cutter is available in left and right cutters?

CHAPTER QUIZ

1. The correct location for the pads when hoisting or jacking the vehicle can often be found in the _____.
 - a. Service manual
 - b. Shop manual
 - c. Owner's manual
 - d. All of the above
2. For the best working position, the work should be _____.
 - a. At neck or head level
 - b. At knee or ankle level
 - c. Overhead by about 1 foot
 - d. At chest or elbow level
3. A high-strength bolt is identified by _____.
 - a. A UNC symbol
 - b. Lines on the head
 - c. Strength letter codes
 - d. The coarse threads
4. A fastener that uses threads on both ends is called a _____.
 - a. Cap screw
 - b. Stud
 - c. Machine screw
 - d. Crest fastener
5. When working with hand tools, always _____.
 - a. Push the wrench—don't pull toward you
 - b. Pull a wrench—don't push a wrench away from you
6. The proper term for Channel Locks is _____.
 - a. Vise Grips
 - b. Crescent wrench
 - c. Locking pliers
 - d. Multigroove adjustable pliers
7. The proper term for Vise Grips is _____.
 - a. Locking pliers
 - b. Slip-joint pliers
 - c. Side cuts
 - d. Multigroove adjustable pliers

SERVICE INFORMATION, TOOLS, AND SAFETY 37

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



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

Manual Drivetrains and Axles

| NAME OF SUPPLEMENT | PRINT | ONLINE | AUDIENCE | DESCRIPTION |
|--|-------|--------|-------------|--|
| Instructor Resource Manual 0-13-460370-2 | | ✓ | Instructors | NEW! The Ultimate teaching aid: Chapter summaries, key terms, chapter learning objectives, lecture resources, discuss/demonstrate classroom activities, and answers to the in-text review and quiz questions. |
| TestGen 0-13-460371-0 | | ✓ | Instructors | Test generation software and test bank for the text. |
| PowerPoint Presentation 0-13-460375-3 | | ✓ | Instructors | Slides include chapter learning objectives, lecture outline of the test, and graphics from the book. |
| Image Bank 0-13-460373-7 | | ✓ | Instructors | All of the images and graphs from the textbook to create customized lecture slides. |
| NATEF Correlated Task Sheets – For Instructors 0-13-460367-2 | | ✓ | Instructors | Downloadable NATEF task sheets for easy customization and development of unique task sheets. |
| NATEF Task Sheets – For Students 0-13-460374-5 | ✓ | | Students | Study activity manual that correlates NATEF Automobile Standards to chapters and page numbers in the text. Available to students at a discounted price when packaged with the text. |
| VitalSource eBook 0-13-460372-9 | | ✓ | Students | As 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.vitalsource.com |

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

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Plews
Quarter Master Industries
Racepak
RAM Automotive
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Rockland Standard Gear
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Jim Halderman

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BRIEF CONTENTS

| | |
|-------------------|---|
| chapter 1 | Service Information, Tools, and Safety 1 |
| chapter 2 | Environmental and Hazardous Materials 39 |
| chapter 3 | Introduction to Drivetrains 52 |
| chapter 4 | Clutch Parts and Operation 69 |
| chapter 5 | Clutch Diagnosis and Service 85 |
| chapter 6 | Manual Transmissions Parts and Operation 105 |
| chapter 7 | Manual Transaxle Parts and Operation 124 |
| chapter 8 | Manual Transmission/Transaxle Diagnosis and Service 132 |
| chapter 9 | Drive Shafts and CV Joints 162 |
| chapter 10 | Drive Axle Shaft and CV Joint Service 174 |
| chapter 11 | Wheel Bearings and Service 190 |
| chapter 12 | Drive Axles and Differentials 210 |
| chapter 13 | Drive Axle and Differential Diagnosis and Service 226 |
| chapter 14 | Drivetrain Electricity and Electronics 255 |
| chapter 15 | Four-Wheel and All-Wheel Drive 281 |
| chapter 16 | Four-Wheel Drive Diagnosis and Service 304 |
| chapter 17 | Vibration and Noise Diagnosis and Correction 320 |
| appendix 1 | Sample ASE-Type Certification Test 335 |
| appendix 2 | 2013 NATEF Correlation Chart 339 |
| | Glossary 342 |
| | Index 349 |

CONTENTS

chapter 1

SERVICE INFORMATION, TOOLS, AND SAFETY 1

- Learning Objectives 1
- Key Terms 1
- Vehicle Identification 2
- Service Information 3
- Threaded Fasteners 4
- Hand Tools 8
- Screwdrivers 11
- Torx 14
- Pliers 15
- Basic Hand Tool List 18
- Tool Sets and Accessories 20
- Electrical Hand Tools 20
- Hand Tool Maintenance 21
- Trouble Lights 21
- Air and Electrically Operated Tools 22
- Personal Protective Equipment 24
- Safety Precautions 25
- Vehicle Protection 26
- Safety Lifting (Hoisting) a Vehicle 26
- Jacks and Safety Stands 28
- Drive-On Ramps 28
- Electrical Cord Safety 28
- Jump Starting and Battery Safety 29
- Fire Extinguishers 30
- Fire Blankets 31
- First Aid and Eye Wash Stations 31
- Hybrid Electric Vehicle Safety Issues 33

HOISTING THE VEHICLE 35

SUMMARY 37

REVIEW QUESTIONS 37

CHAPTER QUIZ 37

chapter 2

ENVIRONMENTAL AND HAZARDOUS MATERIALS 39

- Learning Objectives 39
- Key Terms 39
- Hazardous Waste 40
- Federal and State Laws 40

- Asbestos Hazards 42
- Used Brake Fluid 43
- Used Oil 43
- Solvents 44
- Coolant Disposal 45
- Lead-Acid Battery Waste 46
- Fuel Safety and Storage 47
- Airbag Handling 47
- Used Tire Disposal 48
- Air-Conditioning Refrigerant Oil Disposal 48

SUMMARY 50

REVIEW QUESTIONS 50

CHAPTER QUIZ 51

chapter 3

INTRODUCTION TO DRIVETRAINS 52

- Learning Objectives 52
- Key Terms 52
- Drivetrains 53
- Torque 53
- Horsepower 54
- Gears 55
- Gear Ratios 58
- Transmissions 59
- Manual Transmissions 59
- Automatic Transmissions 60
- Rear-Wheel Drive Vs. Front-Wheel Drive 64
- Transaxles 64
- Driveshafts 65
- Drive Axle Assemblies 65
- Towing Capability 66
- Four-Wheel Drive 67

SUMMARY 68

REVIEW QUESTIONS 68

CHAPTER QUIZ 68

chapter 4

CLUTCH PARTS AND OPERATION 69

- Learning Objectives 69
- Key Terms 69
- Clutches 70

- Clutch Discs 72
- Pressure Plates 74
- Flywheels 76
- Dual-Mass Flywheels 77
- Pilot Bearings 78
- Clutch Pedal Linkage 79
- Release (Throwout) Bearing 80
- Clutch Pedal Switch 82

SUMMARY 83

REVIEW QUESTIONS 83

CHAPTER QUIZ 83

chapter 5

CLUTCH DIAGNOSIS AND SERVICE 85

- Learning Objectives 85
- Key Terms 85
- Introduction 86
- Clutch Inspection 86
- Clutch Problem Diagnosis 88
- Clutch Symptom Guide 89
- Clutch Replacement 89
- Clutch Component Inspection 90
- Clutch Installation 94
- Hydraulic Clutch Service 95

CLUTCH REPLACEMENT—REAR-WHEEL DRIVE 97

CLUTCH REPLACEMENT—FRONT-WHEEL DRIVE 100

SUMMARY 103

REVIEW QUESTIONS 103

CHAPTER QUIZ 103

chapter 6

MANUAL TRANSMISSIONS PARTS AND OPERATION 105

- Learning Objectives 105
- Key Terms 105
- Purpose of Manual Transmissions 106
- Construction 106
- Reverse 107
- Speed Gears 108
- Synchronizers 108
- Five-Speed Transmission Torque Flow 113

- Shift Mechanisms 115
- Manual Transmission Gears 117
- Transmission Case and Bearings 119
- Manual Transmission Lubrication 120

SUMMARY 122

REVIEW QUESTIONS 122

CHAPTER QUIZ 123

chapter 7

MANUAL TRANSAXLE PARTS AND OPERATION 124

- Learning Objectives 124
- Key Terms 124
- Purpose and Function 125
- Transaxle Construction 126
- Transaxle Operation 126

SUMMARY 131

REVIEW QUESTIONS 131

CHAPTER QUIZ 131

chapter 8

MANUAL TRANSMISSION/TRANSAXLE DIAGNOSIS AND SERVICE 132

- Learning Objectives 132
- Key Terms 132
- Preventive Maintenance 133
- Manual Transmission/Transaxle Diagnosis 135
- Transaxle/Transmission Removal 138
- Transaxle/Transmission Overhaul 140
- Transmission Disassembly 142
- Shift Mechanism 148
- Case and Covers 149

TRANSMISSION REMOVAL AND INSTALLATION 152

MANUAL TRANSMISSION DISASSEMBLY/REASSEMBLY 155

MANUAL TRANSAXLE DISASSEMBLY/REASSEMBLY 158

SUMMARY 161

REVIEW QUESTIONS 161

CHAPTER QUIZ 161

chapter 9

DRIVE SHAFTS AND CV JOINTS 162

- Learning Objectives 162
- Key Terms 162
- Drive shafts 163
- Driveshaft Balance 165
- U-Joint Design and Operation 165
- Double-Cardan Joints 167
- Constant Velocity Joints 167

SUMMARY 172

REVIEW QUESTIONS 172

CHAPTER QUIZ 172

chapter 10

DRIVE SHAFT AND CV JOINT SERVICE 174

- Learning Objectives 174
- Key Terms 174
- U-Joint Diagnosis 175
- Driveshaft and U-Joint Inspection 175
- U-Joint Replacement 177
- U-Joint Working Angles 179
- CV Joint Diagnosis 180
- Replacement Shaft Assemblies 181
- CV Joint Service 181

DRIVE AXLE SHAFT REPLACEMENT 186

SUMMARY 188

REVIEW QUESTIONS 188

CHAPTER QUIZ 188

chapter 11

WHEEL BEARINGS AND SERVICE 190

- Learning Objectives 190
- Key Terms 190
- Antifriction Bearings 191
- Bearing Greases 193
- Seals 194
- Bearing Diagnosis 194
- Wheel Bearing Service 195
- Sealed Bearing Replacement 200
- Rear Drive Axle Classifications 200

- Rear Axle Bearing and Seal Replacement 201
- Bearing Failure Analysis 204

REAR AXLE BEARING SERVICE 206

SUMMARY 208

REVIEW QUESTIONS 208

CHAPTER QUIZ 208

chapter 12

DRIVE AXLES AND DIFFERENTIALS 210

- Learning Objectives 210
- Key Terms 210
- Drive Axle Terminology 211
- Drive Axle Assembly 211
- Axle Designs 211
- Ring and Pinion Gears 212
- Differential Carriers 215
- Differentials 216
- Limited Slip Differentials 218

SUMMARY 224

REVIEW QUESTIONS 224

CHAPTER QUIZ 224

chapter 13

DRIVE AXLE AND DIFFERENTIAL DIAGNOSIS AND SERVICE 226

- Learning Objectives 226
- Key Terms 226
- Drive Axle Service 227
- Drive Axle Lubrication 228
- Drive Axle Diagnosis 230
- In-The-Shop Inspections 231
- On-Vehicle Service Operations 233
- Pinion Shaft Seal Replacement 236
- Differential Carrier Service 237
- Differential Assembly Service 239
- Drive Pinion Shaft 241
- Carrier Assembly and Setup 245
- Limited Slip Differential Service 250

DRIVE AXLE SERVICE 251

SUMMARY 254

REVIEW QUESTIONS 254

CHAPTER QUIZ 254

chapter 14

DRIVETRAIN ELECTRICITY AND ELECTRONICS 255

- Learning Objectives 255
- Key Terms 255
- Introduction 256
- Electricity 256
- How Electrons Move Through a Conductor 258
- Units of Electricity 258
- Electrical Circuits 260
- Electrical Schematics 260
- Types of Circuit Faults 261
- Fused Jumper Wire 263
- Test Light 264
- Digital Meters 265
- Inductive Ammeters 268
- Terminals and Connectors 269
- Wire Repair 269
- Relays 272
- Switches 273
- Speed Sensors 274
- Throttle Position (TP) Sensor 275
- Networks 276
- Network Classifications 278
- Controller Area Network 278

SUMMARY 279

REVIEW QUESTIONS 280

CHAPTER QUIZ 280

chapter 15

FOUR-WHEEL AND ALL-WHEEL DRIVE 281

- Learning Objectives 281
- Key Terms 281
- Four-Wheel Drive 282
- Terminology 283
- Transfer Cases 283
- Part-Time Four-Wheel Drive 284
- Full-Time Four-Wheel Drive 285
- Center Differential 286
- Transfer Cases 287

- Electronic Transfer Cases 291
- Power Transfer Unit 293
- Couplers and Torque Bias Devices 294
- Front Drive Axles 295
- Drive Axle/Wheel Disconnect Systems 297

VACUUM HUB SERVICE 299

SUMMARY 303

REVIEW QUESTIONS 303

CHAPTER QUIZ 303

chapter 16

FOUR-WHEEL DRIVE DIAGNOSIS AND SERVICE 304

- Learning Objectives 304
- Key Terms 304
- Four-Wheel-Drive Problem Diagnosis 305
- Visual Inspection 305
- Four-Wheel-Drive Diagnostic Procedures 307
- Check Electrical Components 310
- Front Hub Removal and Replacement 312
- Transfer Case/Unit Removal and Replacement 313
- Transfer Case/Unit Overhaul 314

NV-242 TRANSFER CASE SERVICE 315

SUMMARY 319

REVIEW QUESTIONS 319

CHAPTER QUIZ 319

chapter 17

VIBRATION AND NOISE DIAGNOSIS AND CORRECTION 320

- Learning Objectives 320
- Key Terms 320
- Causes of Vibration and Noise 321
- Test-Drive 322
- Neutral Run-up Test 323
- Vibration During Braking 323
- Vibration Speed Ranges 323
- Frequency 326
- Correcting Driveline Angles 328

- Checking Driveshaft Runout 329
- Measuring Driveshaft U-Joint Phasing 329
- Companion Flange Runout 329
- Balancing the Driveshaft 329
- Noise Diagnosis 330
- Noise Correction 332

SUMMARY 333

REVIEW QUESTIONS 334

CHAPTER QUIZ 334

appendix 1

SAMPLE ASE-TYPE CERTIFICATION TEST 335

appendix 2

2013 NATEF CORRELATION CHART 339

GLOSSARY 342

INDEX 349

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chapter 1

SERVICE INFORMATION, TOOLS, AND SAFETY

LEARNING OBJECTIVES

After studying this chapter, the reader will be able to:

1. Locate and interpret vehicle and major component identification numbers.
2. Identify the strength ratings of threaded fasteners.
3. Explain the difference between the brand name (trade name) and the proper name for tools.
4. Describe what tool is the best to use for each job.
5. Explain how to maintain hand tools.
6. Identify the personal protective equipment (PPE) that all service technicians should wear.
7. Discuss how to safely use hand tools.
8. Describe how to safely hoist a vehicle.

This chapter will help you understand the ASE content knowledge for vehicle identification and the proper use of tools and shop equipment.

KEY TERMS

| | | | |
|---------------------------|----|------------------------|----|
| Bench grinder | 23 | PPE | 24 |
| Bolts | 4 | Pinch weld seam | 27 |
| Breaker bar | 10 | Pitch | 5 |
| Bump cap | 24 | Pliers | 15 |
| Calibration codes | 3 | Punches | 17 |
| Campaign | 4 | Ratchet | 10 |
| Casting number | 3 | Recall | 4 |
| Cheater bar | 13 | Screwdrivers | 11 |
| Chisels | 18 | Snips | 17 |
| Drive sizes | 10 | Socket | 10 |
| Extensions | 10 | Socket adapter | 13 |
| Eye wash station | 32 | Spontaneous combustion | 26 |
| Files | 17 | SST | 21 |
| Fire blanket | 31 | Stud | 4 |
| Fire extinguisher classes | 30 | Tensile strength | 6 |
| GAWR | 2 | Trouble light | 21 |
| Grade | 6 | TSB | 4 |
| GVWR | 2 | UNC | 5 |
| Hacksaws | 18 | UNF | 5 |
| Hammers | 13 | Universal joint | 10 |
| HEV | 33 | VECI | 2 |
| LED | 22 | VIN | 2 |
| Metric bolts | 6 | Washers | 7 |
| Nuts | 7 | Wrenches | 8 |

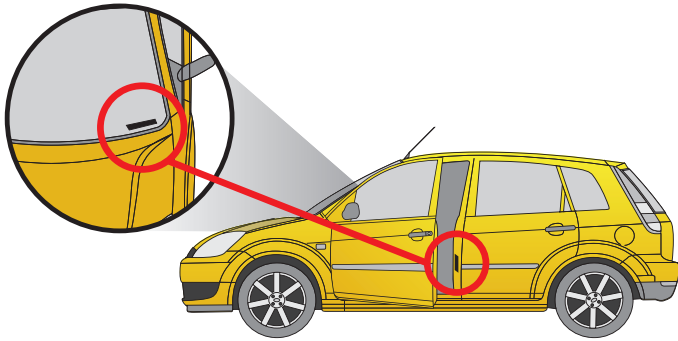


FIGURE 1-1 The vehicle identification number (VIN) is visible through the base of the windshield and on a decal inside the driver's door.

VEHICLE IDENTIFICATION

MAKE, MODEL, AND YEAR All service work requires that the vehicle and its components be properly identified. The most common identification is the make, model, and year of the vehicle.

Make: e.g., Chevrolet

Model: e.g., Impala

Year: e.g., 2008

VEHICLE IDENTIFICATION NUMBER The year of the vehicle is often difficult to determine exactly. A model may be introduced as the next year's model as soon as January of the previous year. Typically, a new model year starts in September or October of the year prior to the actual new year, but not always. This is why the **vehicle identification number**, usually abbreviated **VIN**, is so important. ● **SEE FIGURE 1-1.**

Since 1981, all vehicle manufacturers have used a VIN that is 17 characters long. Although every vehicle manufacturer assigns various letters or numbers within these 17 characters, there are some constants, including:

- The first number or letter designates the country of origin. ● **SEE CHART 1-1.**
- The fourth or fifth character is the car line/series.
- The sixth character is the body style.
- The seventh character is the restraint system.
- The eighth character is often the engine code. (Some engines cannot be determined by the VIN number.)
- The tenth character represents the year on all vehicles. ● **SEE CHART 1-2.**

| | | |
|-------------------|-----------------|--------------------|
| 1 = United States | J = Japan | T = Czechoslovakia |
| 2 = Canada | K = Korea | U = Romania |
| 3 = Mexico | L = China | V = France |
| 4 = United States | M = India | W = Germany |
| 5 = United States | N = Turkey | X = Russia |
| 6 = Australia | P = Philippines | Y = Sweden |
| 8 = Argentina | R = Taiwan | Z = Italy |
| 9 = Brazil | S = England | |

CHART 1-1

The first number or letter in the VIN identifies the country where the vehicle was made.

| | | |
|---------------|---------------|---------------|
| A = 1980/2010 | L = 1990/2020 | Y = 2000/2030 |
| B = 1981/2011 | M = 1991/2021 | 1 = 2001/2031 |
| C = 1982/2012 | N = 1992/2022 | 2 = 2002/2032 |
| D = 1983/2013 | P = 1993/2023 | 3 = 2003/2033 |
| E = 1984/2014 | R = 1994/2024 | 4 = 2004/2034 |
| F = 1985/2015 | S = 1995/2025 | 5 = 2005/2035 |
| G = 1986/2016 | T = 1996/2026 | 6 = 2006/2036 |
| H = 1987/2017 | V = 1997/2027 | 7 = 2007/2037 |
| J = 1988/2018 | W = 1998/2028 | 8 = 2008/2038 |
| K = 1989/2019 | X = 1999/2029 | 9 = 2009/2039 |

CHART 1-2

The pattern repeats every 30 years for the year of manufacture.

VEHICLE SAFETY CERTIFICATION LABEL A vehicle safety certification label is attached to the left side pillar post on the rearward-facing section of the left front door. This label indicates the month and year of manufacture as well as the **gross vehicle weight rating (GVWR)**, the **gross axle weight rating (GAWR)**, and the vehicle identification number.

VECI LABEL The **vehicle emissions control information (VECI)** label under the hood of the vehicle shows informative settings and emission hose routing information. ● **SEE FIGURE 1-2.**

The VECI label (sticker) can be located on the bottom side of the hood, the radiator fan shroud, the radiator core support, or on the strut towers. The VECI label usually includes the following information:

- Engine identification
- Emissions standard that the vehicle meets
- Vacuum hose routing diagram



FIGURE 1-2 The vehicle emissions control information (VECI) sticker is placed under the hood.



FIGURE 1-3 A typical calibration code sticker on the case of a controller. The information on the sticker is often needed when ordering parts or a replacement controller.

- Base ignition timing (if adjustable)
- Spark plug type and gap
- Valve lash
- Emission calibration code

CALIBRATION CODES Calibration codes are usually located on Powertrain Control Modules (PCMs) or other controllers. Whenever diagnosing an engine operating fault, it is often necessary to use the calibration code to be sure that the vehicle is the subject of a technical service bulletin or other service procedure. ● **SEE FIGURE 1-3.**

CASTING NUMBERS When an engine part such as a block is cast, a number is put into the mold to identify the casting. ● **SEE FIGURE 1-4.** These **casting numbers** can be used to identify the part and check dimensions such as the cubic inch displacement and other information, such as the year of manufacture. Sometimes changes are made to the mold, yet the casting number is not changed. Most



FIGURE 1-4 Casting numbers on major components can be either cast or stamped.

often the casting number is the best piece of identifying information that the service technician can use for identifying an engine.

SERVICE INFORMATION

SERVICE MANUALS Service information is used by the service technician to determine specifications and service procedures, and any needed special tools.

Factory and aftermarket service manuals contain specifications and service procedures. While factory service manuals cover just one year and one or more models of the same vehicle, most aftermarket service manufacturers cover multiple years and/or models in one manual. Included in most service manuals are the following:

- Capacities and recommended specifications for all fluids
- Specifications including engine and routine maintenance items
- Testing procedures
- Service procedures including the use of special tools when needed

ELECTRONIC SERVICE INFORMATION Electronic service information is available mostly by subscription and provides access to an Internet site where service manual-type information is available. ● **SEE FIGURE 1-5.** Most vehicle manufacturers also offer electronic service information to their dealers and to most schools and colleges that offer corporate training programs.

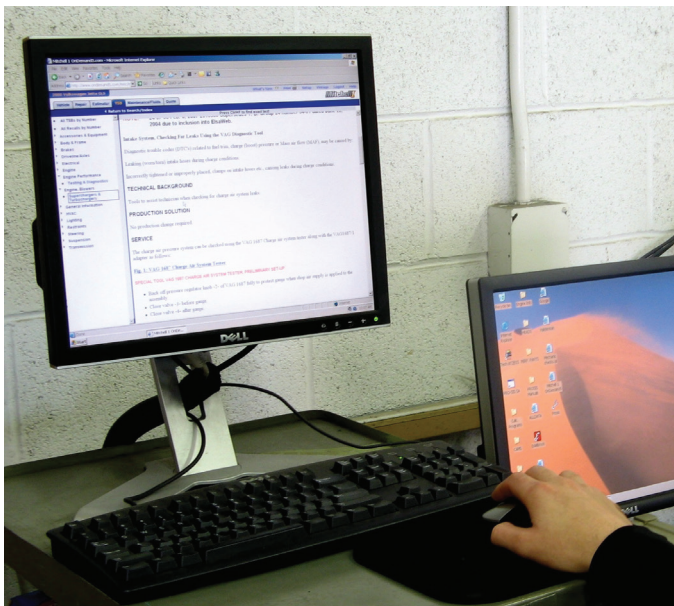


FIGURE 1-5 Electronic service information is available from aftermarket sources such as ALLDATA and Mitchell On Demand, as well as on websites hosted by vehicle manufacturers.

TECHNICAL SERVICE BULLETINS Technical service bulletins, often abbreviated **TSBs**, sometimes called *technical service information bulletins (TSIB)*, are issued by the vehicle manufacturer to notify service technicians of a problem and include the necessary corrective action. Technical service bulletins are designed for dealership technicians but are republished by aftermarket companies and made available along with other service information to shops and vehicle repair facilities. ● **SEE FIGURE 1-6.**

INTERNET The Internet has opened the field for information exchange and access to technical advice. One of the most useful websites is the International Automotive Technician's Network at **www.iatn.net**. This is a free site but service technicians must register to join. If a small monthly sponsor fee is paid, the shop or service technician can gain access to the archives, which include thousands of successful repairs in the searchable database.

RECALLS AND CAMPAIGNS A **recall** or **campaign** is issued by a vehicle manufacturer and a notice is sent to all owners in the event of a safety-related fault or concern. While these faults may be repaired by shops, it is generally handled by a local dealer. Items that have created recalls in the past have included potential fuel system leakage problems, exhaust leakage, or electrical malfunctions that could cause a possible fire or the engine to stall. Unlike technical service bulletins whose cost is only covered when the vehicle is within the warranty period, a recall or campaign is always done at no cost to the vehicle owner.

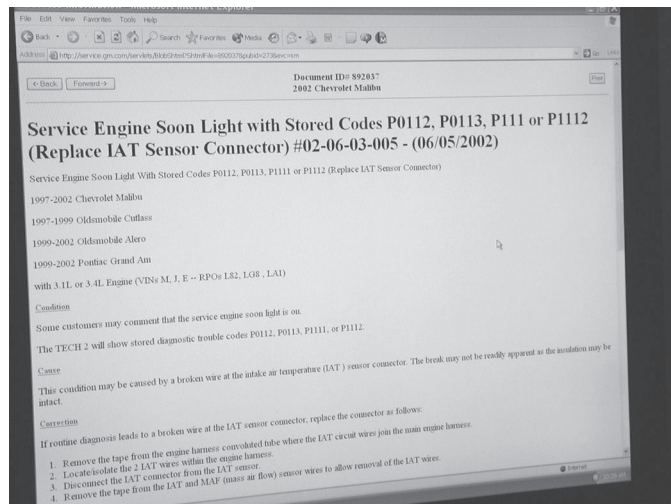


FIGURE 1-6 Technical service bulletins (TSBs) are issued by vehicle manufacturers when a fault occurs that affects many vehicles with the same problem. The TSB then provides the fix for the problem including any parts needed and detailed instructions.



FREQUENTLY ASKED QUESTION

What Should Be Included on a Work Order?

A work order is a legal document that should include the following information:

1. Customer information
2. Identification of the vehicle including the VIN
3. Related service history information
4. The “three Cs”:
 - Customer concern (complaint)
 - Cause of the concern
 - Correction or repairs that were required to return the vehicle to proper operation

THREADED FASTENERS

BOLTS AND THREADS Most of the threaded fasteners used on vehicles are **bolts**. Bolts are called *cap screws* when they are threaded into a casting. Automotive service technicians usually refer to these fasteners as *bolts*, regardless of how they are used. In this chapter, they are called bolts. Sometimes, studs are used for threaded fasteners. A **stud** is a short rod with threads on both ends. Often, a stud will have coarse threads on one end and fine threads on the other end. The end of the stud with coarse threads is screwed into the casting. A nut is used on the opposite end to hold the parts together.

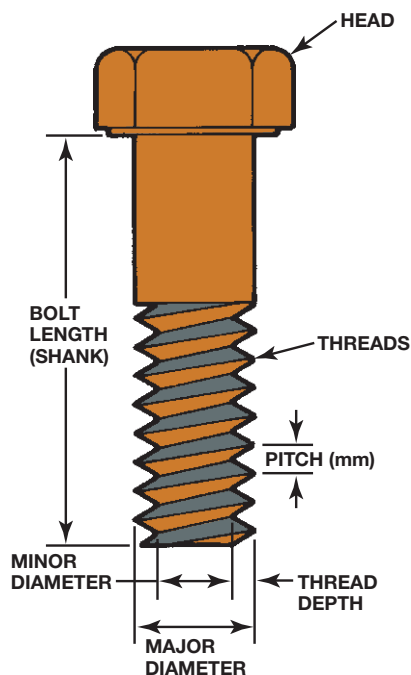


FIGURE 1-7 The dimensions of a typical bolt showing where sizes are measured.

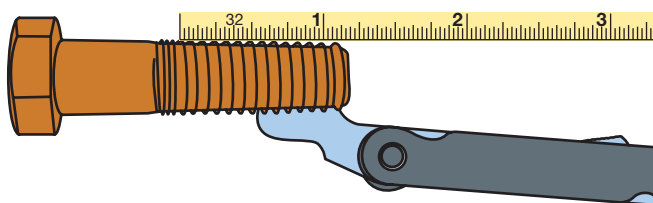


FIGURE 1-8 Thread pitch gauge used to measure the pitch of the thread. This bolt has 13 threads to the inch.

The fastener threads *must* match the threads in the casting or nut. The threads may be measured either in fractions of an inch (called fractional) or in metric units. The size is measured across the outside of the threads, called the *crest* of the thread. ● **SEE FIGURE 1-7.**

FRACTIONAL BOLTS Fractional threads are either coarse or fine. The coarse threads are called **unified national coarse (UNC)**, and the fine threads are called **unified national fine (UNF)**. Standard combinations of sizes and number of threads per inch (called **pitch**) are used. Pitch can be measured with a thread pitch gauge as shown in ● **SEE FIGURE 1-8.** Bolts are identified by their diameter and length as measured from below the head, and not by the size of the head or the size of the wrench used to remove or install the bolt.

| SIZE | THREADS PER INCH | | OUTSIDE DIAMETER INCHES |
|------|------------------|--------|-------------------------|
| | NC UNC | NF UNF | |
| 0 | .. | 80 | 0.0600 |
| 1 | 64 | .. | 0.0730 |
| 1 | .. | 72 | 0.0730 |
| 2 | 56 | .. | 0.0860 |
| 2 | .. | 64 | 0.0860 |
| 3 | 48 | .. | 0.0990 |
| 3 | .. | 56 | 0.0990 |
| 4 | 40 | .. | 0.1120 |
| 4 | .. | 48 | 0.1120 |
| 5 | 40 | .. | 0.1250 |
| 5 | .. | 44 | 0.1250 |
| 6 | 32 | .. | 0.1380 |
| 6 | .. | 40 | 0.1380 |
| 8 | 32 | .. | 0.1640 |
| 8 | .. | 36 | 0.1640 |
| 10 | 24 | .. | 0.1900 |
| 10 | .. | 32 | 0.1900 |
| 12 | 24 | .. | 0.2160 |
| 12 | .. | 28 | 0.2160 |
| 1/4 | 20 | .. | 0.2500 |
| 1/4 | .. | 28 | 0.2500 |
| 5/16 | 18 | .. | 0.3125 |
| 5/16 | .. | 24 | 0.3125 |
| 3/8 | 16 | .. | 0.3750 |
| 3/8 | .. | 24 | 0.3750 |
| 7/16 | 14 | .. | 0.4375 |
| 7/16 | .. | 20 | 0.4375 |
| 1/2 | 13 | .. | 0.5000 |
| 1/2 | .. | 20 | 0.5000 |

CHART 1-3

American standard is one method of sizing fasteners.

Fractional thread sizes are specified by the diameter in fractions of an inch and the number of threads per inch. Typical UNC thread sizes would be 5/16–18 and 1/2–13. Similar UNF thread sizes would be 5/16–24 and 1/2–20. ● **SEE**

CHART 1-3.

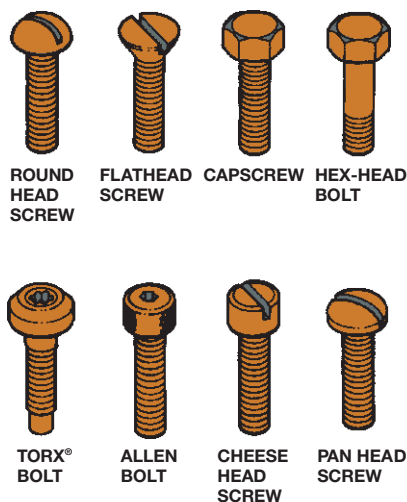


FIGURE 1-9 Bolts and screws have many different heads which determine what tool is needed.

| METRIC HEXAGON HEAD CAP SCREWS | | | | | | | | |
|---------------------------------|------|-----|--|------|----|----|------|----|
| ALL MEASUREMENTS IN MILLIMETERS | | | | | | | | |
| | | | M = NOMINAL THREAD DIAMETER P = PITCH D = HEAD SIZE ACROSS FLATS | | | | | |
| M | P | D | M | P | D | M | P | D |
| 1.6 | 0.35 | 3.2 | 10 | 1.00 | 17 | 20 | 1.50 | 30 |
| 1.7 | 0.35 | 3.5 | 10 | 1.25 | 17 | 20 | 2.50 | 30 |
| 2 | 0.40 | 4 | 10 | 1.50 | 17 | 22 | 1.50 | 32 |
| 2.3 | 0.40 | 4.5 | 12 | 1.25 | 19 | 22 | 2.50 | 32 |
| 2.5 | 0.45 | 5 | 12 | 1.50 | 19 | 24 | 2.00 | 36 |
| 3 | 0.50 | 5.5 | 12 | 1.75 | 19 | 24 | 3.00 | 36 |
| 3.5 | 0.60 | 6 | 14 | 1.50 | 22 | 27 | 3.00 | 41 |
| 4 | 0.70 | 7 | 14 | 2.00 | 22 | 30 | 3.50 | 46 |
| 5 | 0.80 | 8 | 16 | 1.50 | 24 | 33 | 3.50 | 50 |
| 6 | 1.00 | 10 | 16 | 2.00 | 24 | 36 | 4.00 | 55 |
| 7 | 1.00 | 11 | 18 | 1.50 | 27 | 39 | 4.00 | 60 |
| 8 | 1.00 | 13 | 18 | 2.50 | 27 | 42 | 4.50 | 65 |
| 8 | 1.25 | 13 | | | | 45 | 4.50 | 70 |

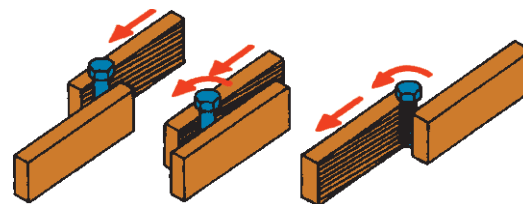
FIGURE 1-10 The metric system specifies fasteners by diameter, length, and pitch.



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.**



ROLLING THREADS

FIGURE 1-11 Stronger threads are created by cold-rolling a heat-treated bolt blank instead of cutting the threads, using a die.

METRIC BOLTS The size of a **metric bolt** is specified by the letter *M* followed by the diameter in millimeters (mm) across the outside (crest) of the threads. Typical metric sizes would be M8 and M12. metric threads are specified by the thread diameter followed by X and the distance between the threads measured in millimeters (M8 X 1.5). ● **SEE FIGURE 1-10.**

GRADES OF BOLTS Bolts are made from many different types of steel, and for this reason some are stronger than others. The strength or classification of a bolt is called the **grade**. The bolt heads are marked to indicate their grade strength.

The actual grade of bolts is two more than the number of lines on the bolt head. Metric bolts have a decimal number to indicate the grade. More lines or a higher grade number indicate a stronger bolt. In some cases, nuts and machine screws have similar grade markings. Higher grade bolts usually have threads that are rolled rather than cut, which also makes them stronger. ● **SEE FIGURE 1-11.**

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.*

TENSILE STRENGTH OF FASTENERS Graded fasteners have a higher tensile strength than nongraded fasteners. **Tensile strength** is the maximum stress used under tension (lengthwise force) without causing failure of the fastener. Tensile strength is specified in pounds per square inch (PSI).

The strength and type of steel used in a bolt is supposed to be indicated by a raised mark on the head of the bolt. The type of mark depends on the standard to which the bolt was manufactured. Most often, bolts used in machinery are made to SAE Standard J429. ● **SEE CHART 1-4** that shows the grade and specified tensile strength.

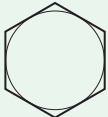
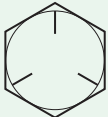
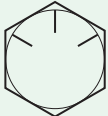

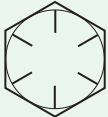

| SAE BOLT DESIGNATIONS | | | | |
|-----------------------|---------------------|-----------------------|---|--|
| SAE GRADE NO. | SIZE RANGE | TENSILE STRENGTH, PSI | MATERIAL | HEAD MARKING |
| 1 | 1/4 through 1 1/2 | 60,000 | Low or medium carbon steel |  |
| 2 | 1/4 through 3/4 | 74,000 | | |
| | 7/8 through 1 1/2 | 60,000 | | |
| 5 | 1/4 through 1 | 120,000 | Medium carbon steel, quenched and tempered |  |
| | 1 1/8 through 1 1/2 | 105,000 | | |
| 5.2 | 1/4 through 1 | 120,000 | Low carbon martensite steel,* quenched and tempered |  |
| 7 | 1/4 through 1 1/2 | 133,000 | Medium carbon alloy steel, quenched and tempered |  |
| 8 | 1/4 through 1 1/2 | 150,000 | Medium carbon alloy steel, quenched and tempered |  |
| 8.2 | 1/4 through 1 | 150,000 | Low carbon martensite steel,* quenched and tempered |  |

CHART 1-4

The tensile strength rating system as specified by the Society of Automotive Engineers (SAE).

*Martensite steel is a specific type of steel that can be cooled rapidly, thereby increasing its hardness. It is named after a German metallurgist, Adolf Martens.

Metric bolt tensile strength property class is shown on the head of the bolt as a number, such as 4.6, 8.8, 9.8, and 10.9; the higher the number, the stronger the bolt. ● **SEE FIGURE 1-12.**

NUTS Nuts are the female part of a threaded fastener. Most nuts used on cap screws have the same hex size as the cap screw head. Some inexpensive nuts use a hex size larger than the cap screw head. Metric nuts are often marked with dimples to show their strength. More dimples indicate stronger nuts. Some nuts and cap screws use interference fit threads to keep them from accidentally loosening. This means that the shape of the nut is slightly distorted or that a section of the threads is deformed. Nuts can also be kept from loosening with a nylon washer fastened in the nut or with a nylon patch or strip on the threads. ● **SEE FIGURE 1-13.**

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. Most prevailing torque nuts should be replaced whenever removed to ensure that the nut will not loosen during service. Always follow the manufacturer’s recommendations. Anaerobic sealers, such as Loctite, are used on the threads where the nut or cap screw must be both locked and sealed.

WASHERS Washers are often used under cap screw heads and under nuts. ● **SEE FIGURE 1-14.** Plain flat washers are used to provide an even clamping load around the fastener. Lock washers are added to prevent accidental loosening. In some accessories, the washers are locked onto the nut to provide easy assembly.





| | | | | |
|---|---|---|---|--|
|  |  |  |  | METRIC CLASS |
| 4.6 | 8.8 | 9.8 | 10.9 | |
| 60,000 | 120,000 | 130,000 | 150,000 | APPROXIMATE MAXIMUM POUND FORCE PER SQUARE INCH |

FIGURE 1-12 Metric bolt (cap screw) grade markings and approximate tensile strength.



FIGURE 1-13 Nuts come in a variety of styles, including locking (prevailing torque) types, such as the distorted thread and nylon insert type.

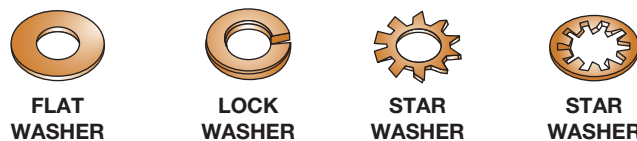


FIGURE 1-14 Washers come in a variety of styles, including flat and serrated used to help prevent a fastener from loosening.



TECH TIP

A 1/2 Inch Wrench Does Not Fit a 1/2 Inch Bolt

A common mistake made by persons new to the automotive field is to think that the size of a bolt or nut is the size of the head. The size of the bolt or nut (outside diameter of the threads) is usually smaller than the size of the wrench or socket that fits the head of the bolt or nut. Examples are given in the following table:

| Wrench Size | Thread Size |
|--------------|-------------|
| 7/16 inch | 1/4 inch |
| 1/2 inch | 5/16 inch |
| 9/16 inch | 3/8 inch |
| 5/8 inch | 7/16 inch |
| 3/4 inch | 1/2 inch |
| 10 mm | 6 mm |
| 12 or 13 mm* | 8 mm |
| 14 or 17 mm* | 10 mm |

* European (Système International d'Unités-SI) metric.



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. Often, the same diameter of fastener is used on a component, but the length of the bolt may vary. Spending just a couple of seconds to put the bolts and nuts back where they belong when the part is removed can save a lot of time when the part is being reinstalled. Besides making certain that the right fastener is being installed in the right place, this method helps prevent bolts and nuts from getting lost or kicked away. How much time have you wasted looking for that lost bolt or nut?

HAND TOOLS

WRENCHES Wrenches are the most used hand tool by service technicians. **Wrenches** are used to grasp and rotate threaded fasteners. Most wrenches are constructed of forged alloy steel, usually chrome-vanadium steel. ● **SEE FIGURE 1-15.**

After the wrench is formed, it is hardened, and then tempered to reduce brittleness, and then chrome plated. There are several types of wrenches.

OPEN-END WRENCH. An open-end wrench is usually used to loosen or tighten bolts or nuts that do not require a lot of torque. Because of the *open* end, this type of wrench can be easily placed on a bolt or nut with an angle of 15 degrees, which allows the wrench to be flipped over and used again to continue to rotate the fastener. The major disadvantage of an open-end wrench is the lack of torque that can be applied due to the fact that the open jaws of the wrench only contact two flat surfaces of the fastener. An open-end wrench has two different sizes, one at each end. ● **SEE FIGURE 1-16.**



FIGURE 1-15 A wrench after it has been forged but before the flashing, extra material around the wrench, has been removed.

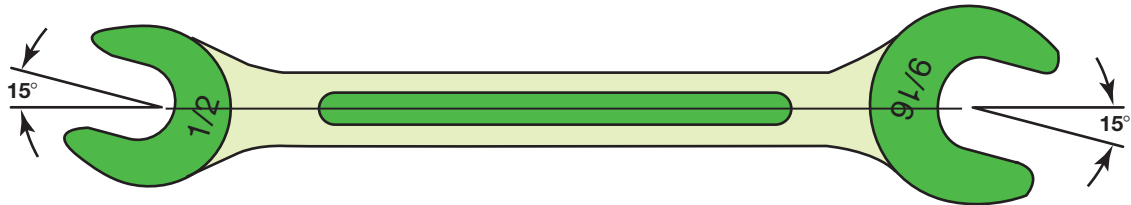


FIGURE 1-16 A typical open-end wrench. The size is different on each end and notice that the head is angled 15 degrees at the end.

BOX-END WRENCH. A *box-end wrench*, also called a *closed-end wrench*, is placed over the top of the fastener and grips the points of the fastener. A box-end wrench is angled 15 degrees to allow it to clear nearby objects.

Therefore, a box-end wrench should be used to loosen or to tighten fasteners because it grasps around the entire head of the fastener. A box-end wrench has two different sizes, one at each end. ● **SEE FIGURE 1-17.**

Most service technicians purchase *combination wrenches*, which have the open end at one end and the same size box end on the other end. ● **SEE FIGURE 1-18.**

A combination wrench allows the technician to loosen or tighten a fastener using the box end of the wrench, turn it around, and use the open end to increase the speed of rotating the fastener.

ADJUSTABLE WRENCH. An *adjustable wrench* is often used where the exact size wrench is not available or when a large nut, such as a wheel spindle nut, needs to be rotated but not tightened. An adjustable wrench should not be used to loosen or tighten fasteners because the torque applied to the wrench can cause the movable jaws to loosen their grip on the fastener, causing it to become rounded. ● **SEE FIGURE 1-19.**

LINE WRENCHES. Line wrenches are also called *flare-nut wrenches*, *fitting wrenches*, or *tube-nut wrenches* and are designed to grip almost all the way around a nut used to retain a fuel or refrigerant line, and yet, be able to be installed over the line. ● **SEE FIGURE 1-20.**



TECH TIP

Hide Those from the Boss

An apprentice technician started working for a shop and put his top tool box on a workbench. Another technician observed that, along with a complete set of good-quality tools, the box contained several adjustable wrenches. The more experienced technician said, “Hide those from the boss.” The boss does not want any service technician to use adjustable wrenches. If any adjustable wrench is used on a bolt or nut, the movable jaw often moves or loosens and starts to round the head of the fastener. If the head of the bolt or nut becomes rounded, it becomes that much more difficult to remove.

SAFE USE OF WRENCHES Wrenches should be inspected before use to be sure they are not cracked, bent, or damaged. All wrenches should be cleaned after use before being returned to the tool box. Always use the correct size of wrench for the fastener being loosened or tightened to help prevent the rounding of the flats of the fastener. When attempting to loosen a fastener, pull a wrench—do not push a wrench. If a wrench is pushed, your knuckles can be hurt when forced into another object if the fastener breaks loose

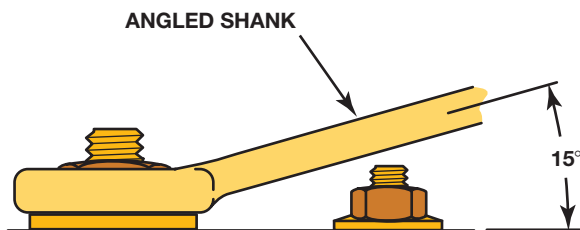


FIGURE 1-17 The end of a box-end wrench is angled 15 degrees to allow clearance for nearby objects or other fasteners.

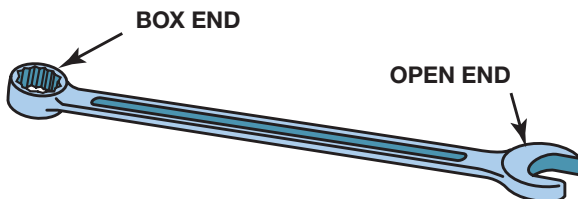


FIGURE 1-18 A combination wrench has an open end at one end and a box end at the other end.

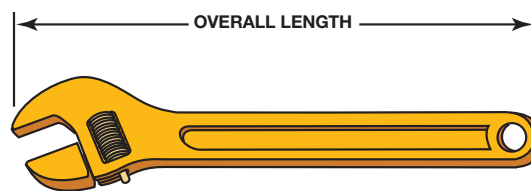


FIGURE 1-19 An adjustable wrench. Adjustable wrenches are sized by the overall length of the wrench and not by how far the jaws open. Common sizes of adjustable wrenches include 8, 10, and 12 inch.



FIGURE 1-20 The end of a typical line wrench, which shows that it is capable of grasping most of the head of the fitting.

or if the wrench slips. Always keep wrenches and all hand tools clean to help prevent rust and to allow for a better, firmer grip. Never expose any tool to excessive heat. High temperatures can reduce the strength (“draw the temper”) of metal tools.

Never use a hammer on any wrench unless you are using a special “staking face” wrench designed to be used with a hammer. Replace any tools that are damaged or worn.

RATCHETS, SOCKETS, AND EXTENSIONS A **socket** fits over the fastener and grips the points and/or flats of the bolt or nut. The socket is rotated (driven) using either a long bar called a **breaker bar** (flex handle) or a ratchet. ● **SEE FIGURES 1-21 AND 1-22.**

A **ratchet** is a tool that turns the socket in only one direction and allows the rotating of the ratchet handle back and forth in a narrow space. Socket **extensions** and **universal joints** are also used with sockets to allow access to fasteners in restricted locations.

DRIVE SIZE. Sockets are available in various **drive sizes**, including 1/4, 3/8, and 1/2 inch sizes for most automotive use. ● **SEE FIGURES 1-23 AND 1-24.**

Many heavy-duty truck and/or industrial applications use 3/4 and 1 inch sizes. The drive size is the distance of each side of the square drive. Sockets and ratchets of the same size are designed to work together.



TECH TIP

Right to Tighten

It is sometimes confusing which way to rotate a wrench or screwdriver, especially when the head of the fastener is pointing away from you. To help visualize while looking at the fastener, say “righty tighty, lefty loosey.”

REGULAR AND DEEP WELL. Sockets are available in regular length for use in most applications or in a deep well design that allows for access to a fastener that uses a long stud or other similar conditions. ● **SEE FIGURE 1-25.**

TORQUE WRENCHES Torque wrenches are socket turning handles that are designed to apply a known amount of force to the fastener. There are two basic types of torque wrenches:

1. **Clicker type.** This type of torque wrench is first set to the specified torque and then it “clicks” when the set torque value has been reached. When force is removed from the torque wrench handle, another click is heard. The setting on a clicker-type torque wrench should be

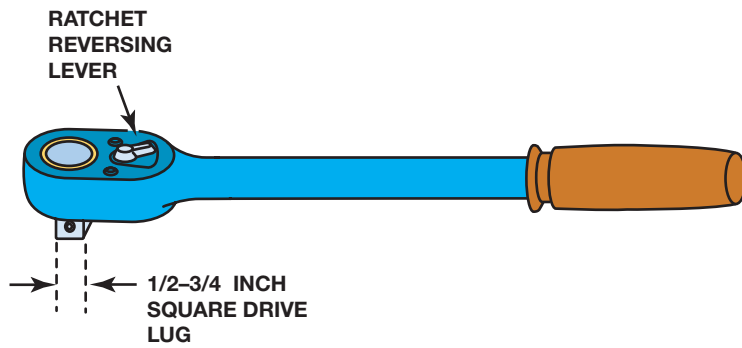


FIGURE 1-21 A typical ratchet used to rotate a socket. A ratchet makes a ratcheting noise when it is being rotated in the opposite direction from loosening or tightening. A knob or lever on the ratchet allows the user to switch directions.

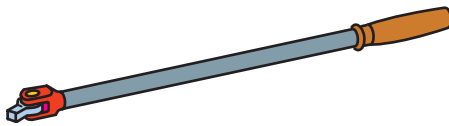


FIGURE 1-22 A typical flex handle used to rotate a socket, also called a breaker bar because it usually has a longer handle than a ratchet and, therefore, can be used to apply more torque to a fastener than a ratchet.

set back to zero after use and checked for proper calibration regularly. ● **SEE FIGURE 1-26.**

2. **Beam-type.** This type of torque wrench is used to measure torque, but instead of presenting the value, the actual torque is displayed on the dial of the wrench as the fastener is being tightened. Beam-type torque wrenches are available in 1/4, 3/8, and 1/2 inch drives and both English and metric units. ● **SEE FIGURE 1-27.**

SAFE USE OF SOCKETS AND RATCHETS Always use the proper size socket that correctly fits the bolt or nut. All sockets and ratchets should be cleaned after use before being placed back into the tool box. Sockets are available in short and deep well designs. Never expose any tool to excessive heat. High temperatures can reduce the strength (“draw the temper”) of metal tools.

Never use a hammer on a socket handle unless you are using a special “staking face” wrench designed to be used with a hammer. Replace any tools that are damaged or worn.

Also select the appropriate drive size. For example, for small work, such as on the dash, select a 1/4 inch drive. For most general service work, use a 3/8 inch drive and for suspension and steering and other large fasteners, select

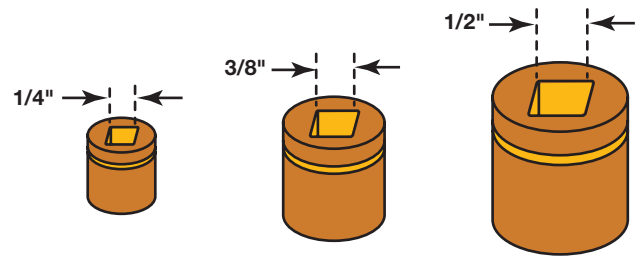


FIGURE 1-23 The most commonly used socket drive sizes include 1/4, 3/8, and 1/2 inch drive.

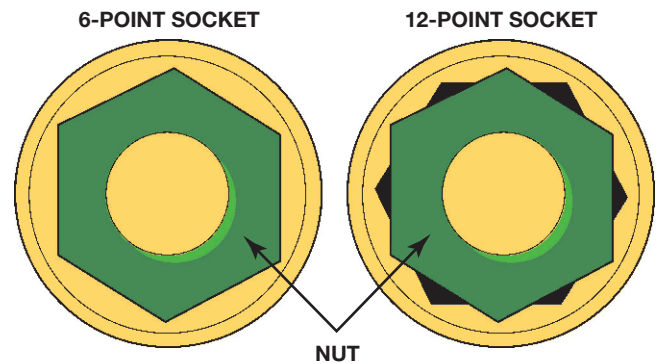


FIGURE 1-24 A 6 point socket fits the head of a bolt or nut on all sides. A 12 point socket can round off the head of a bolt or nut if a lot of force is applied.

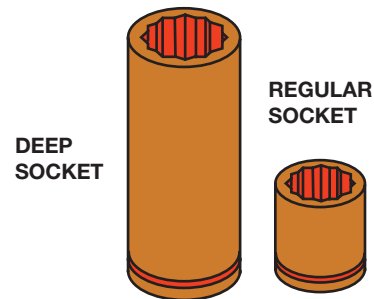


FIGURE 1-25 Allows access to the nut that has a stud plus other locations needing great depth, such as spark plugs.

a 1/2 inch drive. When loosening a fastener, always pull the ratchet toward you rather than push it outward.

SCREWDRIVERS

STRAIGHT-BLADE SCREWDRIVER. Many smaller fasteners are removed and installed by using a **screwdriver**. Screwdrivers are available in many sizes and tip shapes. The most commonly used screwdriver is called a *straight blade* or *flat tip*.

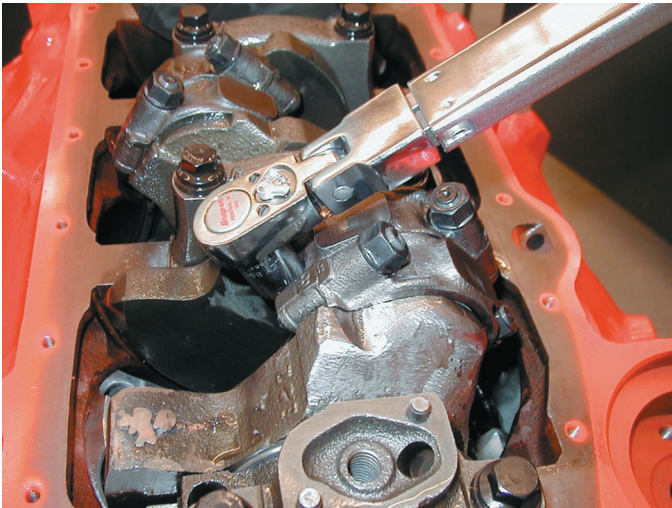


FIGURE 1-26 Using a clicker-type torque wrench to tighten connecting rod nuts on an engine.



FIGURE 1-27 A beam-type torque wrench that displays the torque reading on the face of the dial. The beam display is read as the beam deflects, which is in proportion to the amount of torque applied to the fastener.



TECH TIP

Check Torque Wrench Calibration Regularly

Torque wrenches should be checked regularly. For example, Honda has a torque wrench calibration setup at each of its training centers. It is expected that a torque wrench be checked for accuracy before every use. Most experts recommend that torque wrenches be checked and adjusted as needed at least every year and more often if possible. ● **SEE FIGURE 1-28.**

Flat-tip screwdrivers are sized by the width of the blade and this width should match the width of the slot in the screw. ● **SEE FIGURE 1-29.**

CAUTION: Do not use a screwdriver as a pry tool or as a chisel. Screwdrivers are hardened steel only at the tip and are not designed to be pounded on or used for prying because they could bend easily. Always use the proper tool for each application.

PHILLIPS SCREWDRIVER. Another type of commonly used screwdriver is called a Phillips screwdriver, named for Henry F. Phillips, who invented the crosshead screw in 1934. Due to the shape of the crosshead screw and screwdriver, a Phillips screw can be driven with more torque than can be achieved with a slotted screw.

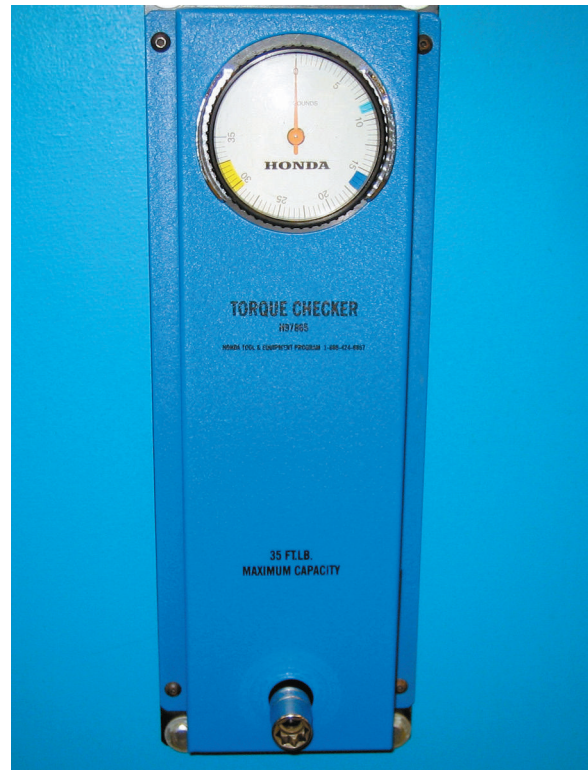


FIGURE 1-28 Torque wrench calibration checker.

A Phillips head screwdriver is specified by the length of the handle and the size of the point at the tip. A #1 tip has a sharp point, a #2 tip is the most commonly used, and a #3 tip is blunt and is only used for larger sizes of Phillips head fasteners. For example, a #2 × 3 inch Phillips screwdriver would typically measure 6 inch from the tip of the blade to the end of the handle (3 inch long handle and 3 inch long blade) with a #2 tip.

Both straight-blade and Phillips screwdrivers are available with a short blade and handle for access to fasteners with limited room. ● **SEE FIGURE 1-30.**

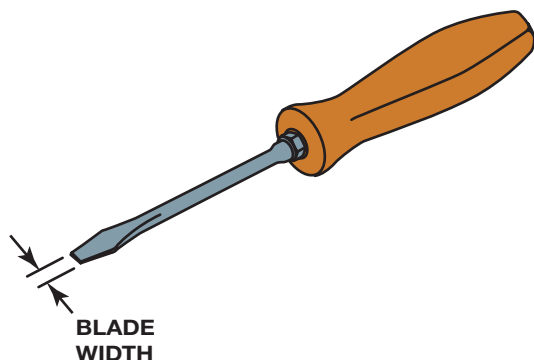


FIGURE 1-29 A flat-tip (straight-blade) screwdriver. The width of the blade should match the width of the slot in the fastener being loosened or tightened.

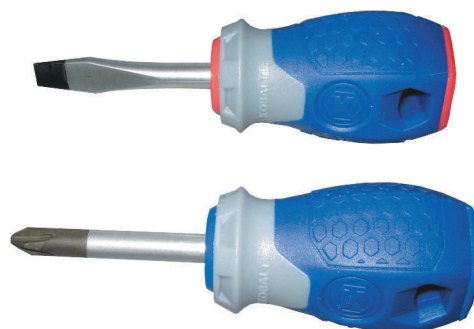


FIGURE 1-30 Two stubby screwdrivers that are used to access screws that have limited space above. A straight blade is on top and a #2 Phillips screwdriver is on the bottom.



TECH TIP

Use Socket Adapters with Caution

A **socket adapter** allows the use of one size of socket and another drive size ratchet or breaker bar. Socket adapters are available and can be used for different drive size sockets on a ratchet. Combinations include:

- 1/4 inch drive—3/8 inch sockets
- 3/8 inch drive—1/4 inch sockets
- 3/8 inch drive—1/2 inch sockets
- 1/2 inch drive—3/8 inch sockets

Using a larger drive ratchet or breaker bar on a smaller size socket can cause the application of too much force to the socket, which could crack or shatter. Using a smaller size drive tool on a larger socket will usually not cause any harm, but would greatly reduce the amount of torque that can be applied to the bolt or nut.

OFFSET SCREWDRIVERS. Offset screwdrivers are used in places where a conventional screwdriver cannot fit. An offset screwdriver is bent at the ends and is used similar to a wrench. Most offset screwdrivers have a straight blade at one end and a Phillips end at the opposite end. ● **SEE FIGURE 1-31.**

IMPACT SCREWDRIVER. An *impact screwdriver* is used to break loose or tighten a screw. A hammer is used to strike the end after the screwdriver holder is placed in the head of the screw and rotated in the desired direction. The force from the hammer blow does two things: It applies a force downward holding the tip of the screwdriver in the slot and then applies a twisting force to loosen (or tighten) the screw. ● **SEE FIGURE 1-32.**



TECH TIP

Avoid Using “Cheater Bars”

Whenever a fastener is difficult to remove, some technicians will insert the handle of a ratchet or a breaker bar into a length of steel pipe sometimes called a **cheater bar**. The extra length of the pipe allows the technician to exert more torque than can be applied using the drive handle alone. However, the extra torque can easily overload the socket and ratchet, causing them to break or shatter, which could cause personal injury.

SAFE USE OF SCREWDRIVERS Always use the proper type and size screwdriver that matches the fastener. Try to avoid pressing down on a screwdriver because if it slips, the screwdriver tip could go into your hand, causing serious personal injury. All screwdrivers should be cleaned after use. Do not use a screwdriver as a prybar; always use the correct tool for the job.

HAMMERS AND MALLETS Hammers and mallets are used to force objects together or apart. The shape of the back part of the hammer head (called the *peen*) usually determines the name. For example, a ball-peen hammer has a rounded end like a ball and it is used to straighten oil pans and valve covers, using the hammer head, and for shaping metal, using the ball peen. ● **SEE FIGURE 1-33.**

NOTE: A claw hammer has a claw used to remove nails and is not used for automotive service.

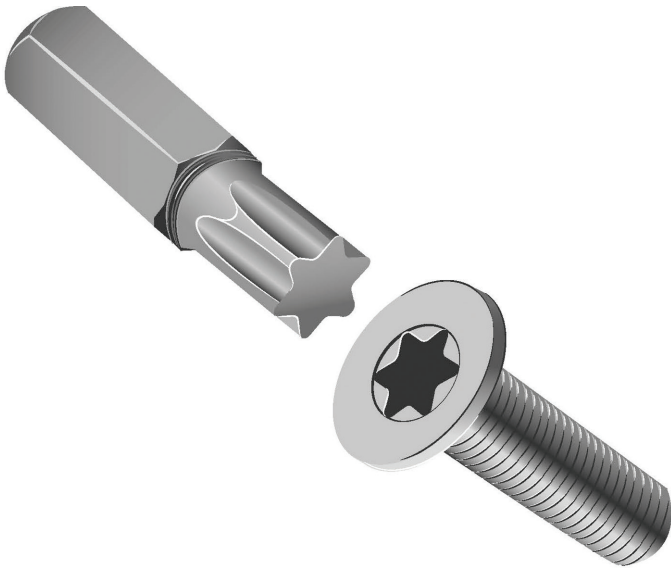


FIGURE 1-31 A Torx bit and fastener.

A hammer is usually sized by the weight of the head of the hammer and the length of the handle. For example, a commonly used ball-peen hammer has an 8 ounce head with an 11 inch handle.

MALLETS. *Mallets* are a type of hammer with a large striking surface, which allows the technician to exert force over a larger area than a hammer, so as not to harm the part or component. Mallets are made from a variety of materials including rubber, plastic, or wood. ● **SEE FIGURE 1-34.**

DEAD-BLOW HAMMER. A shot-filled plastic hammer is called a *dead-blow hammer*. The small lead balls (shot) inside a plastic head prevent the hammer from bouncing off of the object when struck. ● **SEE FIGURE 1-35.**

SAFE USE OF HAMMERS AND MALLETS All mallets and hammers should be cleaned after use and not exposed to extreme temperatures. Never use a hammer or mallet that is damaged in any way and always use caution to avoid doing damage to the components and the surrounding area. Always follow the hammer manufacturer’s recommended procedures and practices.

TORX

A Torx is a six-pointed star shaped tip that was developed by Camcar (formerly Textron) to offer higher loosening and tightening torque than is possible with a straight (flat tip) or Phillips. Torx is very commonly used in the automotive field for many components. Commonly used Torx



FIGURE 1-32 An impact screwdriver used to remove slotted or Phillips head fasteners that cannot be broken loose using a standard screwdriver.



FIGURE 1-33 A typical ball-peen hammer.



FIGURE 1-34 A rubber mallet used to deliver a force to an object without harming the surface.

sizes from small to large include: T15, T20, T25, and T30. ● **SEE FIGURE 1-31.**

Some Torx fasteners include a round projection in the center requiring that a special version of a Torx bit be used. These are called security Torx bits that have a hole in the center to be used on these fasteners. External Torx fasteners are also used mostly as engine fasteners and are labeled E instead of T plus the size, such as E45.



FIGURE 1-35 A dead-blow hammer that was left outside in freezing weather. The plastic covering was damaged, which destroyed this hammer. The lead shot is encased in the metal housing and then covered.

PLIERS

SLIP-JOINT PLIERS. A **pliers** is capable of holding, twisting, bending, and cutting objects and is an extremely useful classification of tools. The common household type of pliers is called the *slip-joint pliers*. There are two different positions where the junction of the handles meets to achieve a wide range of sizes of objects that can be gripped. ● **SEE FIGURE 1-36.**

MULTIGROOVE ADJUSTABLE PLIERS. For gripping larger objects, a set of *multigroove adjustable pliers* is a commonly used tool of choice by many service technicians. Originally designed to remove the various size nuts holding rope seals used in water pumps, the name *water pump pliers* is

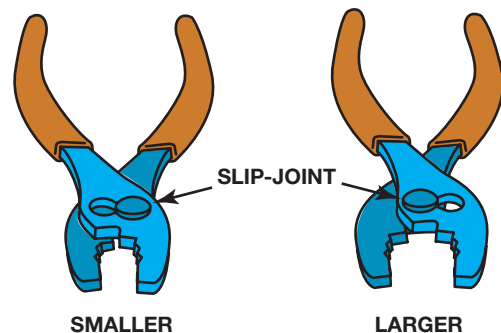


FIGURE 1-36 Typical slip-joint pliers is a common household pliers. The slip joint allows the jaws to be opened to two different settings.

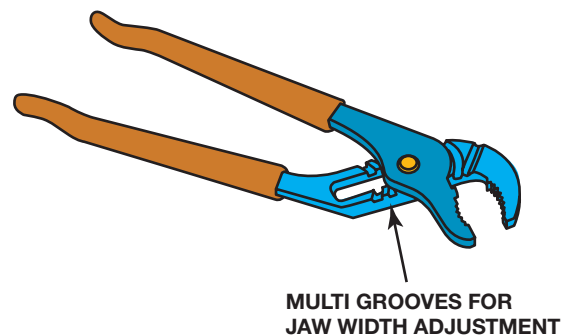


FIGURE 1-37 Multigroove adjustable pliers is known by many names, including the trade name “Channel Locks®.”

also used. These types of pliers are commonly called by their trade name *Channel Locks®*. ● **SEE FIGURE 1-37.**

LINESMAN'S PLIERS. *Linesman's pliers* is a hand tool specifically designed for cutting, bending, and twisting wire. While commonly used by construction workers and electricians, linesman's pliers is a very useful tool for the service technician who deals with wiring. The center parts of the jaws are designed to grasp round objects such as pipe or tubing without slipping. ● **SEE FIGURE 1-38.**

DIAGONAL PLIERS. *Diagonal pliers* is designed to cut only. The cutting jaws are set at an angle to make it easier to cut wires. Diagonal pliers are also called *side cuts* or *dikes*. These pliers are constructed of hardened steel and they are used mostly for cutting wire. ● **SEE FIGURE 1-39.**

NEEDLE-NOSE PLIERS. *Needle-nose pliers* are designed to grip small objects or objects in tight locations. Needle-nose pliers have long, pointed jaws, which allow the tips to reach into narrow openings or groups of small objects. ● **SEE FIGURE 1-40.**



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 |

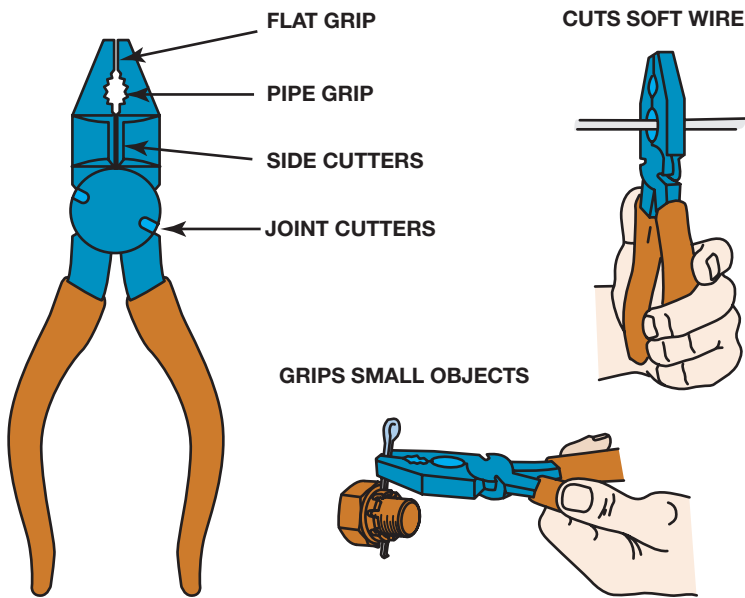


FIGURE 1-38 Linesman's pliers are very useful because it can help perform many automotive service jobs.

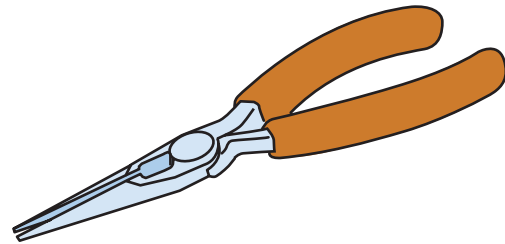


FIGURE 1-40 Needle-nose pliers are used where there is limited access to a wire or pin that needs to be installed or removed.

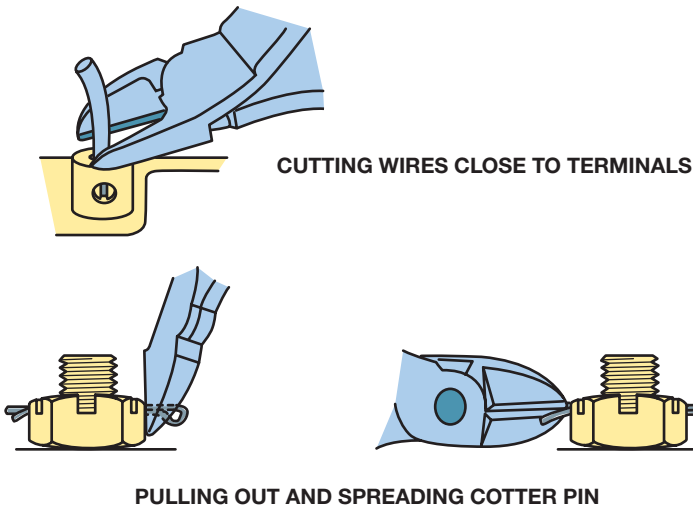


FIGURE 1-39 Diagonal-cut pliers is another common tool that has many names.

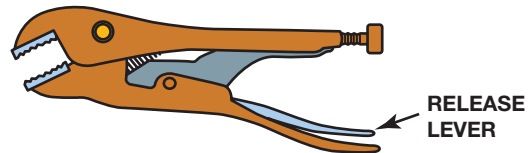


FIGURE 1-41 Locking pliers are best known by their trade name Vise Grips®.

Most needle-nose pliers have a wire cutter located at the base of the jaws near the pivot. There are several variations of needle nose pliers, including right angle jaws or slightly angled to allow access to certain cramped areas.

LOCKING PLIERS. *Locking pliers* are adjustable pliers that can be locked to hold objects from moving. Most locking pliers also have wire cutters built into the jaws near the pivot point. Locking pliers come in a variety of styles and sizes and are commonly referred to by the trade name *Vise Grips*®. The size is the length of the pliers, not how far the jaws open.

● **SEE FIGURE 1-41.**

SNAP-RING PLIERS. *Snap-ring pliers* is used to remove and install snap-rings. Many snap-ring pliers are designed to be able to remove and install both inward, as well as outward, expanding snap rings. Some snap-ring pliers can be equipped with serrated-tipped jaws for grasping the opening in the snap ring, while others are equipped with points, which are inserted into the holes in the snap ring.

● **SEE FIGURE 1-42.**

SAFE USE OF PLIERS Pliers should not be used to remove any bolt or other fastener. Pliers should only be used when specified for use by the vehicle manufacturer.

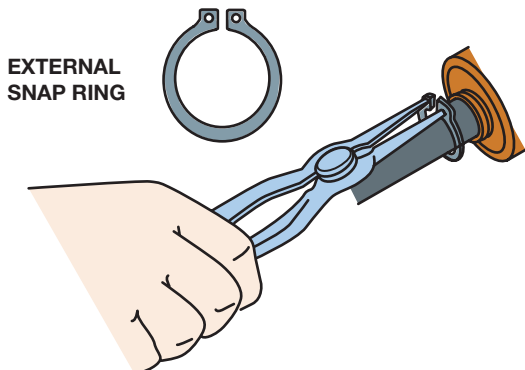
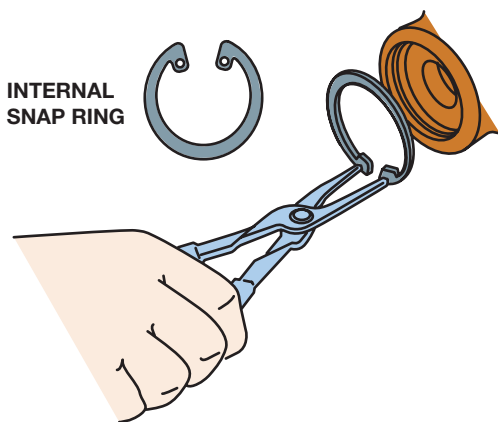


FIGURE 1-42 Snap-ring pliers are also called lock ring pliers and most are designed to remove internal and external snap rings (lock rings).

FILES Files are used to smooth metal and are constructed of hardened steel with diagonal rows of teeth. Files are available with a single row of teeth called a *single cut file*, as well as two rows of teeth cut at an opposite angle called a *double cut file*. Files are available in a variety of shapes and sizes from small flat files, half-round files, and triangular files. ● **SEE FIGURE 1-43.**

SAFE USE OF FILES Always use a file with a handle. Because files only cut when moved forward, a handle must be attached to prevent possible personal injury. After making a forward strike, lift the file and return the file to the starting position; avoid dragging the file backward.

SNIPS Service technicians are often asked to fabricate sheet metal brackets or heat shields and need to use one or more types of cutters available called **snips**. *Tin snips* are the simplest and are designed to make straight cuts in a variety of materials, such as sheet steel, aluminum, or even fabric. A variation of the tin snips is called *aviation tin snips*. There are three designs of aviation snips including one designed to cut straight (called a *straight cut aviation snip*),

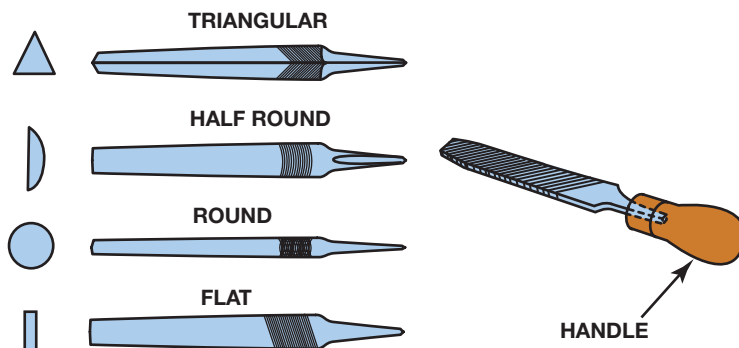


FIGURE 1-43 Files come in many different shapes and sizes. Never use a file without a handle.



TECH TIP

Brand Name versus Proper Term

Technicians often use slang or brand names of tools rather than the proper term. This results in some confusion for new technicians. Some examples are given in the following table.

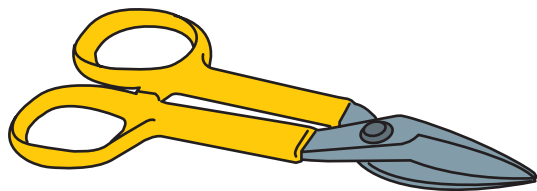
| Brand Name | Proper Term | Slang Name |
|------------------|--|--------------------|
| Crescent wrench® | Adjustable wrench | Monkey wrench |
| Vise Grips® | Locking pliers | |
| Channel Locks® | Water pump pliers or multigroove adjustable pliers | Pump pliers |
| | Diagonal cutting pliers | Dikes or side cuts |

one designed to cut left (called an *offset left aviation snip*), and one designed to cut right (called an *offset right aviation snip*). ● **SEE FIGURE 1-44.**

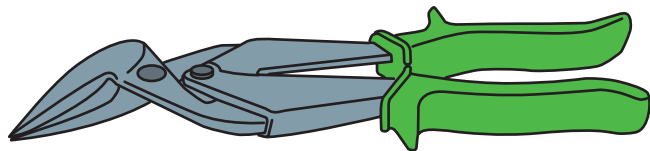
UTILITY KNIFE A *utility knife* uses a replaceable blade and is used to cut a variety of materials such as carpet, plastic, wood, and paper products, such as cardboard. ● **SEE FIGURE 1-45.**

SAFE USE OF CUTTERS Whenever using cutters, always wear eye protection or a face shield to guard against the possibility of metal pieces being ejected during the cut. Always follow recommended procedures.

PUNCHES A **punch** is a small diameter steel rod that has a smaller diameter ground at one end. A punch is used to drive a



STRAIGHT CUT TIN SNIP



OFFSET RIGHT-HAND AVIATION SNIP

FIGURE 1-44 Tin snips are used to cut thin sheets of metal or carpet.

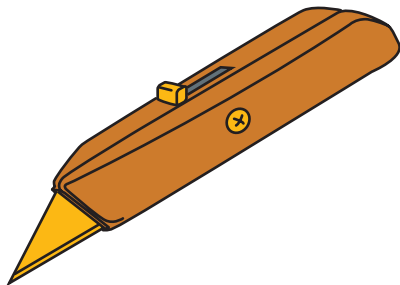


FIGURE 1-45 A utility knife uses replaceable blades and is used to cut carpet and other materials.

pin out that is used to retain two components. Punches come in a variety of sizes, which are measured across the diameter of the machined end. Sizes include 1/16, 1/8, 3/16, and 1/4 inch.

● **SEE FIGURE 1-46.**

CHISELS A **chisel** has a straight, sharp cutting end that is used for cutting off rivets or to separate two pieces of an assembly. The most common design of chisel used for automotive service work is called a *cold chisel*.

SAFE USE OF PUNCHES AND CHISELS Always wear eye protection when using a punch or a chisel because the hardened steel is brittle and parts of the punch could fly off and cause serious personal injury. See the warning stamped on the side of this automotive punch in ● **FIGURE 1-47.**

The tops of punches and chisels can become rounded off from use, which is called “mushroomed.” This material must be ground off to help avoid the possibility of the overhanging material being loosened and becoming airborne during use.

● **SEE FIGURE 1-48.**

HACKSAWS A **hacksaw** is used to cut metals, such as steel, aluminum, brass, or copper. The cutting blade of



FIGURE 1-46 A punch used to drive pins from assembled components. This type of punch is also called a pin punch.



FIGURE 1-47 Warning stamped on the side of a punch warning that goggles should be worn when using this tool. Always follow safety warnings.

a hacksaw is replaceable and the sharpness and number of teeth can be varied to meet the needs of the job. Use 14 or 18 teeth per inch (TPI) for cutting plaster or soft metals, such as aluminum and copper. Use 24 or 32 teeth per inch for steel or pipe. Hacksaw blades should be installed with the teeth pointing away from the handle. This means that a hacksaw only cuts while the blade is pushed in the forward direction. ● **SEE FIGURE 1-49.**

SAFE USE OF HACKSAWS Check that the hacksaw is equipped with the correct blade for the job and that the teeth are pointed away from the handle. When using a hacksaw, move the hacksaw slowly away from you, then lift slightly and return for another cut.

BASIC HAND TOOL LIST

The following is a typical list of hand tools every automotive technician should possess. Specialty tools are not included.

Safety glasses

Tool chest

1/4 inch drive socket set (1/4 to 9/16 inch standard and deep sockets; 6 to 15 mm standard and deep sockets)

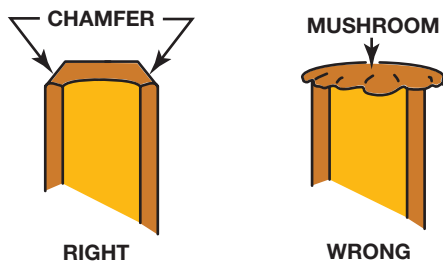


FIGURE 1-48 Use a grinder or a file to remove the mushroom material on the end of a punch or chisel.

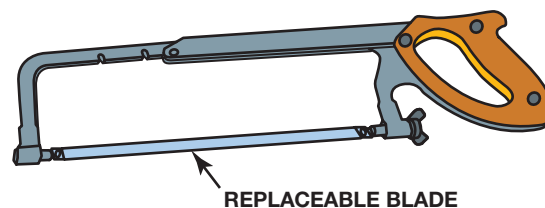


FIGURE 1-49 A typical hacksaw that is used to cut metal. If cutting sheet metal or thin objects, a blade with more teeth should be used.

1/4 inch drive ratchet
 1/4 inch drive 2 inch extension
 1/4 inch drive 6 inch extension
 1/4 inch drive handle
 3/8 inch drive socket set (3/8 to 7/8 inch standard and deep sockets; 10 to 19 mm standard and deep sockets)
 3/8 inch drive Torx set (T40, T45, T50, and T55)
 3/8 inch drive 13/16 inch plug socket
 3/8 inch drive 5/8 inch plug socket
 3/8 inch drive ratchet
 3/8 inch drive 1 1/2 inch extension
 3/8 inch drive 3 inch extension
 3/8 inch drive 6 inch extension
 3/8 inch drive 18 inch extension
 3/8 inch drive universal
 1/2 inch drive socket set (1/2 to 1 inch standard and deep sockets)
 1/2 inch drive ratchet
 1/2 inch drive breaker bar
 1/2 inch drive 5 inch extension
 1/2 inch drive 10 inch extension
 3/8 to 1/4 inch adapter
 1/2 to 3/8 inch adapter
 3/8 to 1/2 inch adapter
 3/8" and 1/2" torque wrench
 Torque angle gauge
 Crowfoot set (fractional inch)
 Crowfoot set (metric)
 3/8 through 1 inch combination wrench set
 10 through 19 mm combination wrench set
 1/16 through 1/4 inch hex wrench set
 2 through 12 mm hex wrench set

3/8 inch hex socket
 13 to 14 mm flare-nut wrench
 15 to 17 mm flare-nut wrench
 5/16 to 3/8 inch flare-nut wrench
 7/16 to 1/2 inch flare-nut wrench
 1/2 to 9/16 inch flare-nut wrench
 Diagonal pliers
 Needle pliers
 Adjustable-jaw pliers
 Locking pliers
 Snap-ring pliers
 Stripping or crimping pliers
 Ball-peen hammer
 Rubber hammer
 Dead-blow hammer
 Five-piece standard screwdriver set
 Four-piece Phillips screwdriver set
 #15 Torx screwdriver
 #20 Torx screwdriver
 Center punch
 Pin punches (assorted sizes)
 Chisel
 Utility knife
 Valve core tool
 Filter wrench (large filters)
 Filter wrench (smaller filters)
 Test light
 Feeler gauge
 Scraper
 Pinch bar
 Magnet



FIGURE 1-50 A typical beginning technician tool set that includes the basic tools to get started.



FIGURE 1-51 A typical 40 inch wide top and bottom professional tool box.



TECH TIP

Need to Borrow a Tool More Than Twice? Buy It!

Most service technicians agree that it is okay for a beginning technician to borrow a tool occasionally. However, if a tool has to be borrowed more than twice, then be sure to purchase it as soon as possible. Also, whenever a tool is borrowed, be sure that you clean the tool and let the technician you borrowed the tool from know that you are returning the tool. These actions will help in any future dealings with other technicians.

TOOL SETS AND ACCESSORIES

A beginning service technician may wish to start with a small set of tools before purchasing an expensive tool set. ● **SEE FIGURES 1-50 AND 1-51.**

ELECTRICAL HAND TOOLS

TEST LIGHT A test light is used to test for electricity. A typical automotive test light consists of a clear plastic screwdriver-like handle that contains a lightbulb. A wire is attached to one terminal of the bulb, which the technician



FIGURE 1-52 A typical 12 volt test light.

connects to a clean metal part of the vehicle. The other end of the bulb is attached to a point that can be used to test for electricity at a connector or wire. When there is power at the point and a good connection at the other end, the lightbulb lights. ● **SEE FIGURE 1-52.**

SOLDERING GUNS

ELECTRIC SOLDERING GUN. This type of soldering gun is usually powered by 110 volt AC and often has two power settings expressed in watts. A typical electric soldering gun will produce from 85 to 300 watts of heat at the tip, which is more than adequate for soldering.

ELECTRIC SOLDERING PENCIL. This type of soldering iron is less expensive and creates less heat than an electric soldering gun. A typical electric soldering pencil (iron) creates 30 to 60 watts of heat and is suitable for soldering smaller wires and connections.

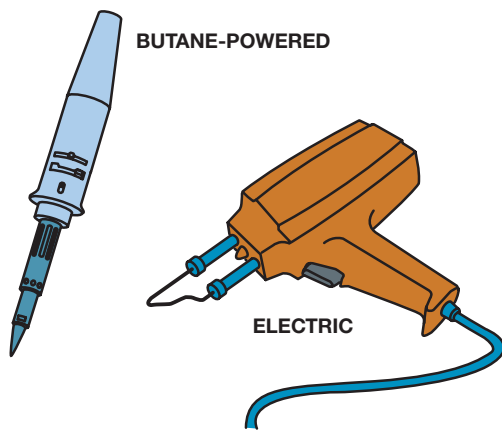


FIGURE 1-53 Electric and butane-powered soldering guns used to make electrical repairs. Soldering guns are sold by the wattage rating. The higher the wattage, the greater amount of heat created. Most solder guns used for automotive electrical work usually fall within the 60 to 160 watt range.

BUTANE-POWERED SOLDERING IRON. A butane-powered soldering iron is portable and very useful for automotive service work because an electrical cord is not needed. Most butane-powered soldering irons produce about 60 watts of heat, which is enough for most automotive soldering. ● **SEE FIGURE 1-53.**

ELECTRICAL WORK HAND TOOLS In addition to a soldering iron, most service technicians who do electrical-related work should have the following:

- Wire cutters
- Wire strippers
- Wire crimpers
- Heat gun for heat shrink tubing

DIGITAL METER A digital meter is a necessary tool for any electrical diagnosis and troubleshooting. A digital multimeter, abbreviated DMM, is usually capable of measuring the following units of electricity:

- DC volts
- AC volts
- Ohms
- Amperes

HAND TOOL MAINTENANCE

Most hand tools are constructed of rust-resistant metals but they can still rust or corrode if not properly maintained. For best results and long tool life, the following steps should be taken:



FREQUENTLY ASKED QUESTION

What Is an “SST”?

Vehicle manufacturers often specify a **special service tool (SST)** to properly disassemble and assemble components, such as transmissions and other components. These tools are also called special tools and are available from the vehicle manufacturer or their tool supplier, such as Kent-Moore and Miller tools. Many service technicians do not have access to special service tools so they use generic versions that are available from aftermarket sources.

- Clean each tool before placing it back into the tool box.
- Keep tools separated. Moisture on metal tools will start to rust more readily if the tools are in contact with another metal tool.
- Line the drawers of the tool box with a material that will prevent the tools from moving as the drawers are opened and closed. This helps to quickly locate the proper tool and size.
- Release the tension on all “clicker-type” torque wrenches.
- Keep the tool box secure.

TROUBLE LIGHTS

INCANDESCENT *Incandescent lights* use a filament that produces light when electric current flows through the bulb. This was the standard **trouble light**, also called a *work light* for many years until safety issues caused most shops to switch to safer fluorescent or LED lights. If incandescent lightbulbs are used, try to locate bulbs that are rated “rough service,” which is designed to withstand shock and vibration more than conventional lightbulbs.



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.

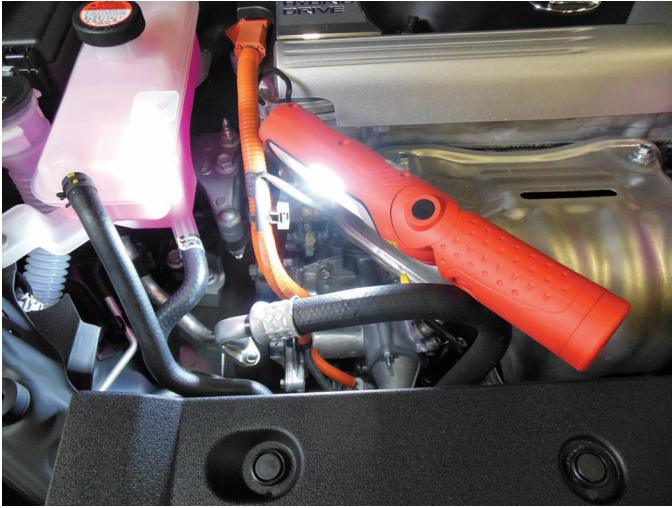


FIGURE 1-54 A battery-powered LED trouble light.

FLUORESCENT A trouble light is an essential piece of shop equipment, and for safety, should be fluorescent rather than incandescent. Incandescent lightbulbs can scatter or break if gasoline were to be splashed onto the bulb creating a serious fire hazard. Fluorescent light tubes are not as likely to be broken and are usually protected by a clear plastic enclosure. Trouble lights are usually attached to a retractor, which can hold 20 to 50 feet of electrical cord.

LED TROUBLE LIGHT Light-emitting diode (LED) trouble lights are excellent to use because they are shock resistant, are long lasting, and do not represent a fire hazard. Some trouble lights are battery powered and therefore can be used in places where an attached electrical cord could present problems. ● **SEE FIGURE 1-54.**

AIR AND ELECTRICALLY OPERATED TOOLS

IMPACT WRENCH An impact wrench, either air or electrically powered, is a tool that is used to remove and install fasteners. The air-operated 1/2 inch drive impact wrench is the most commonly used unit. ● **SEE FIGURE 1-55.**

Electrically powered impact wrenches commonly include:

- Battery-powered units. ● **SEE FIGURE 1-56.**
- 110 volt AC-powered units. This type of impact is very useful, especially if compressed air is not readily available.



FIGURE 1-55 A typical 1/2 inch drive air impact wrench. The direction of rotation can be changed to loosen or tighten a fastener.



FIGURE 1-56 A typical battery-powered 1/2 inch drive impact wrench.



WARNING

Always use impact sockets with impact wrenches, and always wear eye protection in case the socket or fastener shatters. Impact sockets are thicker walled and constructed with premium alloy steel. They are hardened with a black oxide finish to help prevent corrosion and distinguish them from regular sockets. ● **SEE FIGURE 1-57.**



FIGURE 1-57 A black impact socket. Always use an impact-type socket whenever using an impact wrench to avoid the possibility of shattering the socket, which could cause personal injury. If a socket is chrome plated, it is not to be used with an impact wrench.

AIR RATCHET An air ratchet is used to remove and install fasteners that would normally be removed or installed using a ratchet and a socket. ● SEE FIGURE 1-58.

DIE GRINDER A die grinder is a commonly used air-powered tool which can also be used to sand or remove gaskets and rust. ● SEE FIGURE 1-59.

BENCH OR PEDESTAL-MOUNTED GRINDER These high-powered grinders can be equipped with a wire brush wheel and/or a stone wheel.

- **Wire brush wheel**—This type is used to clean threads of bolts as well as to remove gaskets from sheet metal engine parts.
 - **Stone wheel**—This type is used to grind metal or to remove the mushroom from the top of punches or chisels.
- SEE FIGURE 1-60.

Most **bench grinders** are equipped with a grinder wheel (stone) on one end and a wire brush wheel on the other end. A bench grinder is a very useful piece of shop equipment and the wire wheel end can be used for the following:

- Cleaning threads of bolts
- Cleaning gaskets from sheet metal parts, such as steel valve covers

CAUTION: Only use a steel wire brush on steel or iron components. If a steel wire brush is used on aluminum or copper-based metal parts, it can remove metal from the part.



FIGURE 1-58 An air ratchet is a very useful tool that allows fast removal and installation of fasteners, especially in areas that are difficult to reach or do not have room enough to move a hand ratchet or wrench.

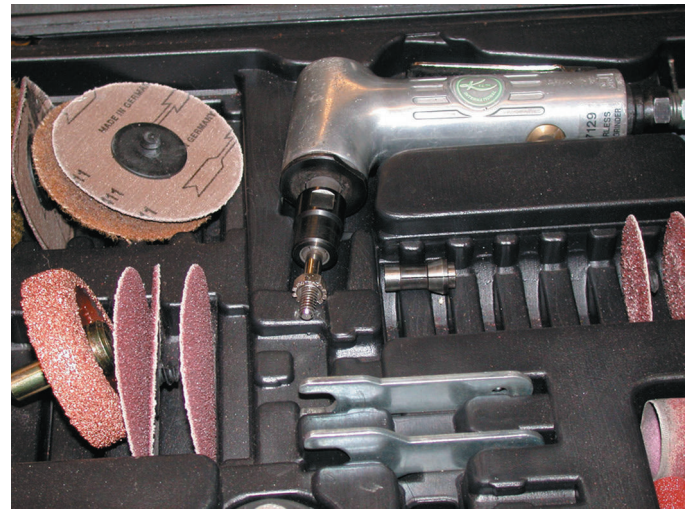


FIGURE 1-59 This typical die grinder surface preparation kit includes the air-operated die grinder as well as a variety of sanding disks for smoothing surfaces or removing rust.



FIGURE 1-60 A typical pedestal grinder with a wire wheel on the left side and a stone wheel on the right side. Even though this machine is equipped with guards, safety glasses or a face shield should always be worn whenever using a grinder or wire wheel.

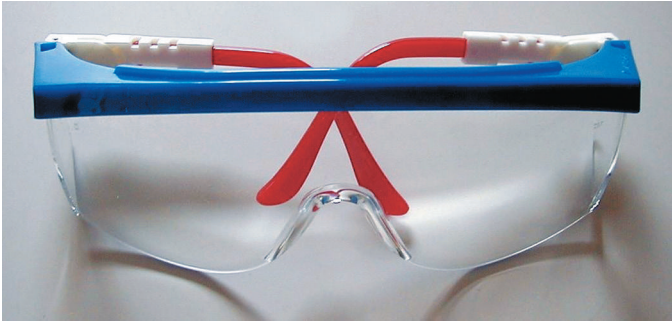


FIGURE 1-61 Safety glasses should be worn at all times when working on or around any vehicle or servicing any components.



WARNING

Always wear a face shield when using a wire wheel or a grinder.

The grinding stone end of the bench grinder can be used for the following:

- Sharpening blades and drill bits
- Grinding off the heads of rivets or parts
- Sharpening sheet metal parts for custom fitting

PERSONAL PROTECTIVE EQUIPMENT

Service technicians should wear **personal protective equipment (PPE)** to prevent personal injury. The personal protection devices include the following:

SAFETY GLASSES Wear safety glasses at all times while servicing any vehicle and be sure that they meet standard ANSI Z87.1. ● **SEE FIGURE 1-61.**

STEEL-TOED SAFETY SHOES ● **SEE FIGURE 1-62.** If steel-toed safety shoes are not available, then leather-topped shoes offer more protection than canvas or cloth covered shoes.

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 1-63.**

HEARING PROTECTION Hearing protection should be worn if the sound around you requires that you raise your voice (sound level higher than 90 dB). For example, a typical



FIGURE 1-62 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 1-63 One version of a bump cap is a molded plastic insert that is worn inside a regular cloth cap.

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.

GLOVES Many technicians wear gloves not only to help keep their hands clean but also to help protect their skin from the effects of dirty engine oil and other possibly hazardous materials.

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.
- **Polyurethane gloves.** These gloves are more expensive, yet very strong. Even though these gloves are also not affected by gas, oil, or solvents, they do tend to be slippery.



FIGURE 1-64 Protective gloves are available in several sizes and materials.

- **Nitrile gloves.** These gloves are exactly like latex gloves, but are not affected by gas, oil, or solvents, yet they tend to be expensive.
 - **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.
- **SEE FIGURE 1-64.**

SAFETY PRECAUTIONS

Besides wearing personal safety equipment, there are also many actions that should be performed to keep safe in the shop. These actions include:

- Remove jewelry that may get caught on something or act as a conductor to an exposed electrical circuit.
- **SEE FIGURE 1-65.**
- 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.
 - 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.
 - Ask for help when moving or lifting heavy objects.



FIGURE 1-65 Remove all jewelry before performing service work on any vehicle.



FIGURE 1-66 Always connect an exhaust hose to the tailpipe of a vehicle to be run inside a building.

- 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 inside a closed garage space.
- **SEE FIGURE 1-66.**
- 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.
 - Always be sure the hood is securely held open.



FIGURE 1-67 A binder clip being used to keep a fender cover from falling off.

VEHICLE PROTECTION

FENDER COVERS Whenever working under the hood of any vehicle, be sure to use fender covers. They not only help protect the vehicle from possible damage but they also provide a clean surface to place parts and tools. The major problem with using fender covers is that they tend to move and often fall off the vehicle. To help prevent the fender covers from falling off secure them to a lip of the fender using a *binder clip* available at most office supply stores. ● **SEE FIGURE 1-67.**

INTERIOR PROTECTION Always protect the interior of the vehicle from accidental damage or dirt and grease by covering the seat, steering wheel, and floor with a protective covering. ● **SEE FIGURE 1-68.**



FIGURE 1-68 Covering the interior as soon as the vehicle comes in for service helps improve customer satisfaction.



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 LIFTING (HOISTING) A VEHICLE

Many chassis and underbody service procedures require that the vehicle be hoisted or lifted off the ground. The simplest methods involve the use of drive-on ramps or a floor jack and safety (jack) stands, whereas in-ground or surface-mounted lifts provide greater access.

Setting the pads is a critical part of this hoisting procedure. All vehicle service information, including service, shop, and owner's manuals, include recommended locations to be used when hoisting (lifting) a vehicle. Newer vehicles have a triangle decal on the driver's door indicating the recommended lift points. The recommended standards for the lift points and lifting procedures are found in SAE Standard JRP-2184.

● **SEE FIGURE 1-70.**



FIGURE 1-69 All oily shop cloths should be stored in a metal container equipped with a lid to help prevent spontaneous combustion.

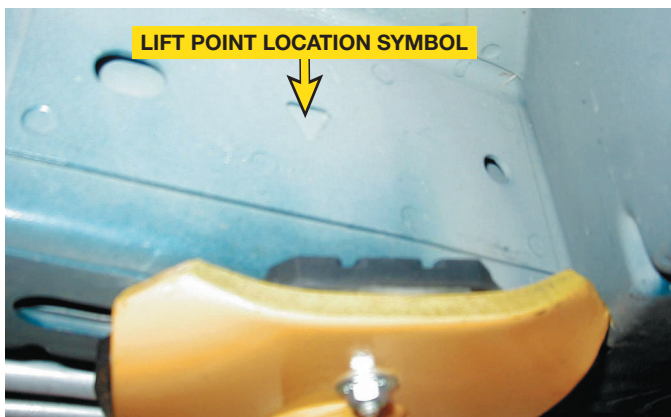


FIGURE 1-70 Most newer vehicles have a triangle symbol indicating the recommended hoisting lift location.

These recommendations typically include the following points:

1. The vehicle should be centered on the lift or hoist so as not to overload one side or put too much force either forward or rearward. ● **SEE FIGURE 1-71.**
2. The pads of the lift should be spread as far apart as possible to provide a stable platform.
3. Each pad should be placed under a portion of the vehicle that is strong and capable of supporting the weight of the vehicle.
 - a. Pinch welds at the bottom edge of the body are generally considered to be strong.

CAUTION: Even though pinch weld seams are the recommended location for hoisting many vehicles with



(a)



(b)

FIGURE 1-71 (a) Tall safety stands can be used to provide additional support for the vehicle while on the hoist. (b) A block of wood should be used to avoid the possibility of doing damage to components supported by the stand.

unitized bodies (unit-body), care should be taken not to place the pad(s) too far forward or rearward. Incorrect placement of the vehicle on the lift could cause the vehicle to be imbalanced, and the vehicle could fall. This is exactly what happened to the vehicle in ● FIGURE 1-72.

- b. Boxed areas of the body are the best places to position the pads on a vehicle without a frame. Be careful to note whether the arms of the lift might come into



FIGURE 1-72 This training vehicle fell from the hoist because the pads were not set correctly. No one was hurt but the vehicle was damaged.

contact with other parts of the vehicle before the pad touches the intended location. Commonly damaged areas include the following:

- (1) Rocker panel moldings
 - (2) Exhaust system (including catalytic converter)
 - (3) Tires or body panels (● **SEE FIGURES 1-73 AND 1-74.**)
4. The vehicle should be raised about a foot (30 centimeters [cm]) off the floor, then stopped and shaken to check for stability. If the vehicle seems to be stable when checked at a short distance from the floor, continue raising the vehicle and continue to view the vehicle until it has reached the desired height. The hoist should be lowered onto the mechanical locks, and then raised off of the locks before lowering.

CAUTION: Do not look away from the vehicle while it is being raised (or lowered) on a hoist. Often one side or one end of the hoist can stop or fail, resulting in the vehicle being slanted enough to slip or fall, creating physical damage not only to the vehicle and/or hoist but also to the technician or others who may be nearby.

HINT: Most hoists can be safely placed at any desired height. For ease while working, the area in which you are working should be at chest level. When working on brakes or suspension components, it is not necessary to work on them down near the floor or over your head. Raise the hoist so that the components are at chest level.

5. Before lowering the hoist, the safety latch(es) must be released and the direction of the controls reversed. The speed downward is often adjusted to be as slow as possible for additional safety.

JACKS AND SAFETY STANDS

Floor jacks properly rated for the weight of the vehicle being raised are a common vehicle lifting tool. Floor jacks are portable and relatively inexpensive and must be used with safety (jack) stands. The floor jack is used to raise the vehicle off the ground and safety stands should be placed under the frame on the body of the vehicle. The weight of the vehicle should never be kept on the hydraulic floor jack because a failure of the jack could cause the vehicle to fall. ● **SEE FIGURE 1-75.** The jack is then slowly released to allow the vehicle weight to be supported on the safety stands. If the front or rear of the vehicle is being raised, the opposite end of the vehicle must be blocked.

CAUTION: Safety stands should be rated higher than the weight they support.

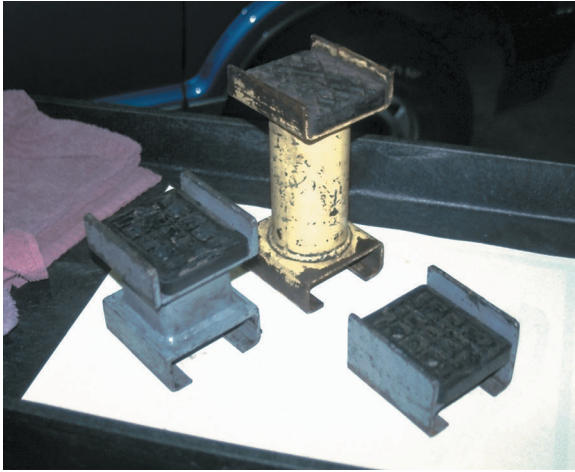
DRIVE-ON RAMPS

Ramps are an inexpensive way to raise the front or rear of a vehicle. ● **SEE FIGURE 1-76.** Ramps are easy to store, but they can be dangerous because they can “kick out” when driving the vehicle onto the ramps.

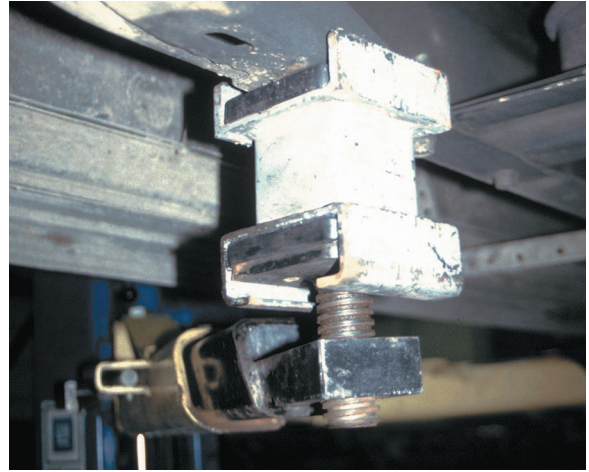
CAUTION: Professional repair shops do not use ramps because they are dangerous to use. Use only with extreme care.

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.

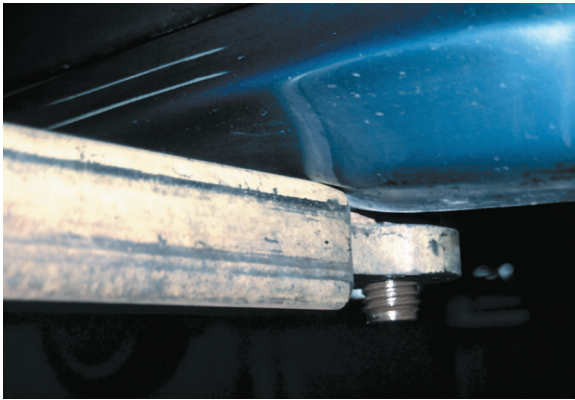


(a)



(b)

FIGURE 1-73 (a) An assortment of hoist pad adapters that are often needed to safely hoist many pickup trucks, vans, and sport utility vehicles (SUVs). (b) A view from underneath a Chevrolet pickup truck showing how the pad extensions are used to attach the hoist lifting pad to contact the frame.



(a)



(b)

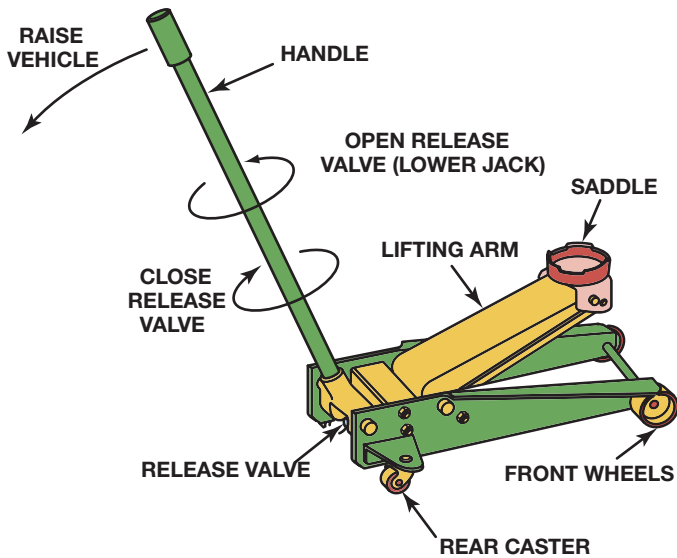
FIGURE 1-74 (a) The pad arm is just contacting the rocker panel of the vehicle. (b) The pad arm has dented the rocker panel on this vehicle because the pad was set too far inward underneath the vehicle.

JUMP STARTING AND BATTERY SAFETY

To jump start another vehicle with a dead battery, connect good-quality copper jumper cables as indicated in **SEE FIGURE 1-77** or 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's 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 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.



(a)



(b)

FIGURE 1-75 (a) A hydraulic hand-operated floor jack. (b) Whenever a vehicle is raised off the ground, a safety stand should be placed under the frame, axle, or body to support the weight of the vehicle.

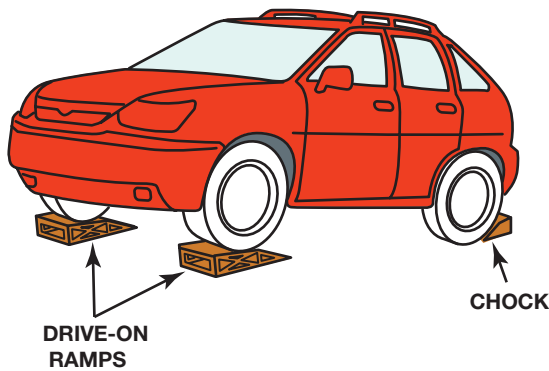


FIGURE 1-76 Drive-on-type ramps are dangerous to use. The wheels on the ground level must be chocked (blocked) to prevent accidental movement down the ramp.



SAFETY TIP

Air Hose 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 1-78.** If an air nozzle is used to dry and clean parts, make sure the airstream is directed away from anyone else in the immediate area. Coil and store air hoses when they are not in use.

FIRE EXTINGUISHERS

There are four **fire extinguisher classes**. 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 1-79.**

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 1-80.**

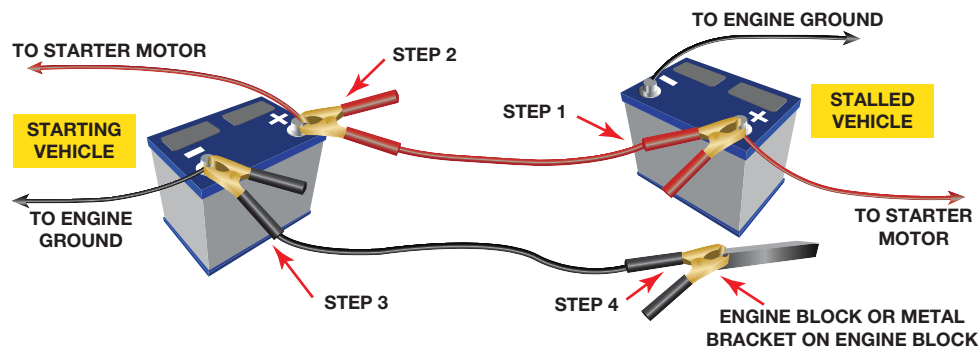


FIGURE 1-77 Jumper cable usage guide. Follow the same connections if using a portable jump box.



FIGURE 1-78 The air pressure going to the nozzle should be reduced to 30 PSI or less to help prevent personal injury.

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 and 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, and C fires. It acts 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 1-81** 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. ● **SEE FIGURE 1-82.**



FIGURE 1-79 A typical fire extinguisher designed to be used on type A, B, or C fires.



FIGURE 1-81 A treated wool blanket is kept in an easy-to-open wall-mounted holder and should be placed in a central location in the shop.



FIGURE 1-80 A CO₂ fire extinguisher being used on a fire set in an open drum during a demonstration at a fire training center.



FIGURE 1-82 A first aid box should be centrally located in the shop and kept stocked with the recommended 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

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 1-83.**



FIGURE 1-83 A typical eye wash station. Often a thorough flushing of the eyes with water is the first and often the best treatment in the event of eye contamination.

HYBRID ELECTRIC VEHICLE SAFETY ISSUES

Hybrid electric vehicles (HEVs) use a high-voltage battery pack and an electric motor(s) to help propel the vehicle. ● **SEE FIGURE 1-84** for an example of a typical warning label on a hybrid electric vehicle. The gasoline or diesel engine also is equipped with a generator or a combination starter and an integrated starter generator (ISG) or integrated starter alternator (ISA). To safely work around a hybrid electric vehicle, the high-voltage (HV) battery and circuits should be shut off following these steps:



WARNING

Some vehicle manufacturers specify that insulated rubber *lineman's gloves* be used whenever working around the high-voltage circuits to prevent the danger of electrical shock.



FIGURE 1-84 A warning label on a Honda hybrid warns that a person can be killed due to the high-voltage circuits under the cover.



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.

- STEP 1** Turn off the ignition key (if equipped) and remove the key from the ignition switch. (This will shut off all high-voltage circuits if the relay[s] is [are] working correctly.)
- STEP 2** Disconnect the high-voltage circuits.

TOYOTA PRIUS The cutoff switch is located in the trunk. To gain access, remove three clips holding the upper left portion of the trunk side cover. To disconnect the high-voltage system, pull the orange handled plug while wearing insulated rubber lineman's gloves. ● **SEE FIGURE 1-85.**

FORD ESCAPE/MERCURY MARINER Ford and Mercury specify that the following steps should be included when working with the high-voltage (HV) systems of a hybrid vehicle:



FIGURE 1-85 The high-voltage disconnect switch is in the trunk area on a Toyota Prius. Insulated rubber lineman's gloves should be worn when removing this plug.



FIGURE 1-87 The shut-off switch on a GM parallel hybrid truck is green because this system uses 42 volts instead of higher, and possibly fatal, voltages used in other hybrid vehicles.



FIGURE 1-86 The high-voltage shut-off switch on a Ford Escape hybrid. The switch is located under the carpet at the rear of the vehicle.

- Four orange cones are to be placed at the four corners of the vehicle to create a buffer zone.
- High-voltage insulated gloves are to be worn with an outer leather glove to protect the inner rubber glove from possible damage.
- The service technician should also wear a face shield and a fiberglass hook should be in the area and used to move a technician in the event of electrocution.

The high-voltage shut-off switch is located in the rear of the vehicle under the right side carpet. ● **SEE FIGURE 1-86.**

Rotate the handle to the “service shipping” position, lift it out to disable the high-voltage circuit, and wait five minutes before removing high-voltage cables.

HONDA CIVIC To totally disable the high-voltage system on a Honda Civic, remove the main fuse (labeled number 1) from the driver's side underhood fuse panel. This should be all that is necessary to shut off the high-voltage circuit. If this is not possible, then remove the rear seat cushion and seat back. Remove the metal switch cover labeled “up” and remove the red locking cover. Move the “battery module switch” down to disable the high-voltage system.

CHEVROLET SILVERADO/GMC SIERRA PICKUP TRUCK The high-voltage shut-off switch is located under the rear passenger seat. Remove the cover marked “energy storage box” and turn the green service disconnect switch to the horizontal position to turn off the high-voltage circuits. ● **SEE FIGURE 1-87.**



WARNING

Do not touch any orange wiring or component without following the vehicle manufacturer's procedures and wearing the specified personal protective equipment.

HOISTING THE VEHICLE



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



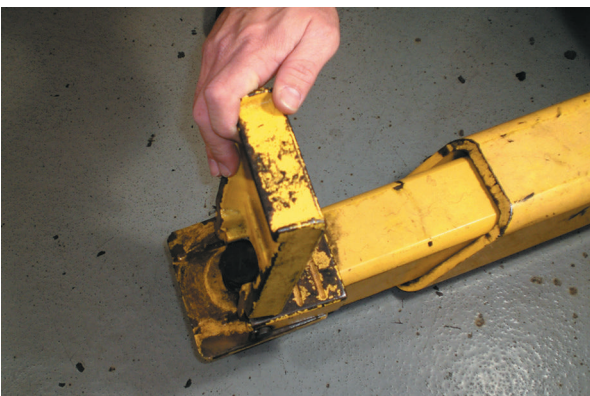
- 2** Most vehicles will be correctly positioned when the left front tire is centered on the tire pad.



- 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 frame of a vehicle without causing the arm of the lift to hit and damage parts of the body.



- 5** Tall 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 hoist a truck or van equipped with running boards to give the necessary clearance.

CONTINUED ►

STEP BY STEP



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



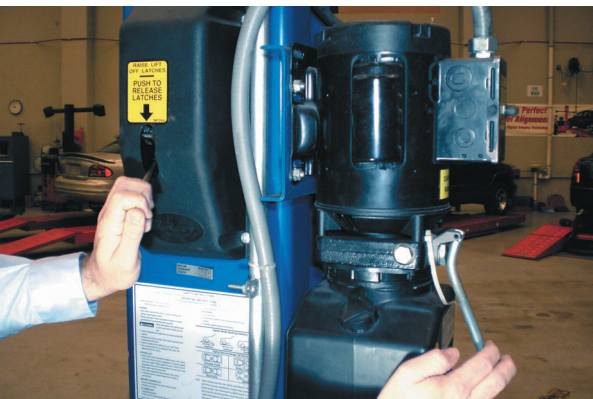
8 After being sure all pads are correctly positioned, use the electromechanical controls to raise the vehicle.



9 With the vehicle raised one foot (30 cm) off the ground, push down on the vehicle to check to see if it is stable on the pads. If the vehicle rocks, lower the vehicle and reset 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 seam to spread the load. If additional clearance is necessary, the pads can be raised as shown.



11 When the service work is completed, the hoist should be raised slightly and the safety released before using the hydraulic lever 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 stall.

SUMMARY

1. Bolts, studs, and nuts are commonly used as fasteners in the chassis. The sizes for fractional and metric threads are different and are not interchangeable. The grade is the rating of the strength of a fastener.
2. Whenever a vehicle is raised above the ground, it must be supported at a substantial section of the body or frame.
3. Wrenches are available in open end, box end, and combination open and box end.
4. An adjustable wrench should only be used where the proper size is not available.
5. Line wrenches are also called flare-nut wrenches, fitting wrenches, or tube-nut wrenches and are used to remove fuel or refrigerant lines.
6. Sockets are rotated by a ratchet or breaker bar, also called a flex handle.
7. Torque wrenches measure the amount of torque applied to a fastener.
8. Screwdriver types include straight blade (flat tip) and Phillips.
9. Hammers and mallets come in a variety of sizes and weights.
10. Pliers are a useful tool and are available in many different types, including slip-joint, multigroove, linesman's, diagonal, needle-nose, and locking pliers.
11. Other common hand tools include snap-ring pliers, files, cutters, punches, chisels, and hacksaws.
12. Hybrid electric vehicles should be de-powered if any of the high-voltage components are going to be serviced.

REVIEW QUESTIONS

1. List three precautions that must be taken whenever hoisting (lifting) a vehicle.
2. Describe how to determine the grade of a fastener, including how the markings differ between fractional and metric bolts.
3. List four items that are personal protective equipment (PPE).
4. List the types of fire extinguishers and their usage.
5. Why are wrenches offset 15 degrees?
6. What are the other names for a line wrench?
7. What are the standard automotive drive sizes for sockets?
8. Which type of screwdriver requires the use of a hammer or mallet?
9. What is inside a dead-blow hammer?
10. What type of cutter is available in left and right cutters?

CHAPTER QUIZ

1. The correct location for the pads when hoisting or jacking the vehicle can often be found in the _____.
 - a. Service manual
 - b. Shop manual
 - c. Owner's manual
 - d. All of the above
2. For the best working position, the work should be _____.
 - a. At neck or head level
 - b. At knee or ankle level
 - c. Overhead by about 1 foot
 - d. At chest or elbow level
3. A high-strength bolt is identified by _____.
 - a. A UNC symbol
 - b. Lines on the head
 - c. Strength letter codes
 - d. The coarse threads
4. A fastener that uses threads on both ends is called a _____.
 - a. Cap screw
 - b. Stud
 - c. Machine screw
 - d. Crest fastener
5. Wrenches are made from _____.
 - a. Cast from nickel steel
 - b. Forged alloy steel
 - c. Machined form billet steel
 - d. Cast from chrome steel
6. The proper term for Channel Locks is _____.
 - a. Vise Grips
 - b. Crescent wrench
 - c. Locking pliers
 - d. Multigroove adjustable pliers
7. The proper term for Vise Grips is _____.
 - a. Locking pliers
 - b. Slip-joint pliers
 - c. Side cuts
 - d. Multigroove adjustable pliers

8. Two technicians are discussing torque wrenches. Technician A says that a torque wrench is capable of tightening a fastener with more torque than a conventional breaker bar or ratchet. Technician B says that a torque wrench should be calibrated regularly for the most accurate results. Which technician is correct?
- a. Technician A only
 - b. Technician B only
 - c. Both Technicians A and B
 - d. Neither Technician A nor B
9. A yellow handle snip is designed for_____?
- a. Straight cuts
 - b. Left cuts
 - c. Right cuts
 - d. Cutting plastic only
10. What type of hammer is plastic coated, has a metal casing inside, and is filled with small lead balls?
- a. Dead-blow hammer
 - b. Soft-blow hammer
 - c. Sledgehammer
 - d. Plastic hammer