CHAPTER 1

SERVICE INFORMATION, FASTENERS, TOOLS, AND SAFETY

OBJECTIVES

After studying Chapter 1, the reader should be able to:

1. Retrieve vehicle service information.
2. Explain the strength ratings of threaded fasteners.
3. Discuss how to safely use hand tools.
4. Describe how to safely hoist a vehicle.
5. List the personal safety equipment that all service technicians should wear.
6. Know the ASE requirements for vehicle identification and the proper use of tools and shop equipment.

KEY TERMS

Aftermarket (p. 3)
Barrel (p. 13)
Bolt (p. 5)
Bump cap (p. 14)
Cap screw (p. 5)
Dial indicator (p. 13)
Grade (p. 6)
international Automotive Technicians' Network (iATN) (p. 4)
Lock washer (p. 7)
Loctite (p. 7)
Micrometer (p. 13)
Nut (p. 7)
OEM (p. 3)
Pitch (p. 5)
Spindle (p. 13)
Special service tools (SSTs) (p. 12)
Spontaneous combustion (p. 16)
Stud (p. 5)
Technical service bulletins (TSB) (p. 4)
Telescopic gauge (p. 13)
Thimble (p. 13)
Unified National Coarse (UNC) (p. 5)
Unified National Fine (UNF) (p. 5)
Vehicle emissions control information (VECI) (p. 2)
Vehicle identification number (VIN) (p. 2)
Vernier dial caliper (p. 13)
Washer (p. 7)

VEHICLE IDENTIFICATION

All service work requires that the vehicle, including the engine and accessories, be properly identified. The most common identification method is verifying the make, model, and year of the vehicle.

Make: e.g., Chevrolet
Model: e.g., Trailblazer
Year: e.g., 2003

The year of the vehicle is often difficult to determine exactly. Typically, a new model year starts in September or October of the year prior to the actual new year, but not always. A model may be introduced as the next year's model as soon as January of the previous year. This is why the **vehicle identification number**, usually abbreviated **VIN**, is so important (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 seventeen characters, there are some constants, including:

- The first number or letter designates the country of origin.

1 = United States	K = Korea
2 = Canada	L = Taiwan
3 = Mexico	S = England
4 = United States	V = France
6 = Australia	W = Germany
9 = Brazil	Y = Sweden
J = Japan	Z = Italy

- The model of the vehicle is commonly the fourth or fifth character.
- The eighth character is often the engine code. (Some engines cannot be determined by the VIN.)
- The tenth character represents the year on all vehicles.

A = 1980	L = 1990	Y = 2000
B = 1981	M = 1991	1 = 2001
C = 1982	N = 1992	2 = 2002
D = 1983	P = 1993	3 = 2003
E = 1984	R = 1994	4 = 2004
F = 1985	S = 1995	5 = 2005
G = 1986	T = 1996	6 = 2006
H = 1987	V = 1997	7 = 2007
J = 1988	W = 1998	8 = 2008
K = 1989	X = 1999	9 = 2009

VECI Label

The **vehicle emissions control information (VECI)** label located under the hood of the vehicle shows informative settings and emission hose routing information (Figure 1-2). The VECI label (sticker) can be located on the underside of the hood, the radiator fan shroud, radiator core support, or on the strut towers. The VECI label usually includes the following information:

Engine identification
Emissions standard for vehicle
Vacuum hose routing diagram
Base ignition timing (if adjustable)
Spark plug type and gap
Valve lash
Emission calibration code

FIGURE 1-1 The vehicle identification number (VIN) is at the top front of the instrument panel and is visible through the windshield. *(Courtesy of James Halderman)*

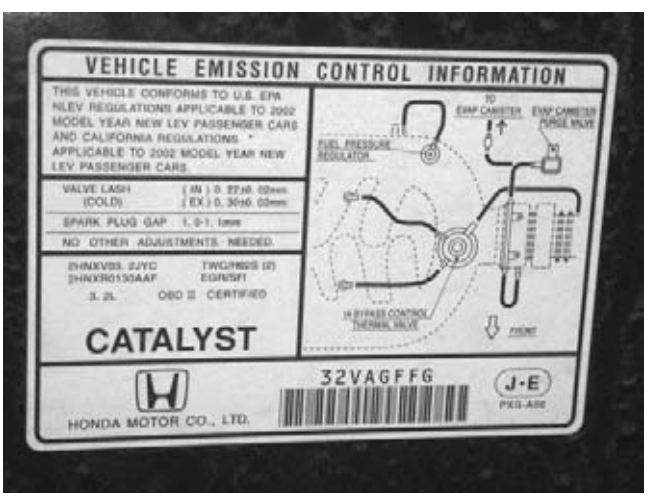


FIGURE 1-2 The VECI, vehicle emission control information, label is attached to an underhood portion of the vehicle. *(Courtesy of James Halderman)*

Calibration Codes

Calibration codes are usually located on power train control modules (PCMs) or other controllers. Whenever diagnosing an engine concern, it may be necessary to know the calibration code to determine if the vehicle is the subject of a technical service bulletin or other service procedure (Figure 1-3).

Casting Numbers

Whenever an engine part, such as a block is cast, a number is put into the mold to identify the casting (Figure 1-4). These casting numbers can be used to check dimensions such as the cubic inch displacement and other information such as year of manufacture. Sometimes changes are made to the mold, yet the casting number is not changed. The casting number is often the best piece of identifying information that the service technician can use.

SERVICE INFORMATION

Service information is needed by the service technician to determine specifications and service procedures and to learn about special tools that are required.

Service Manuals

The original equipment manufacturer, **OEM**, and **aftermarket** service manuals contain specifications and service procedures.

FIGURE 1-3 The sticker attached to this control module indicates the calibration code. *(Courtesy of James Halderman)*

While OEM 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 (Figure 1-5). 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

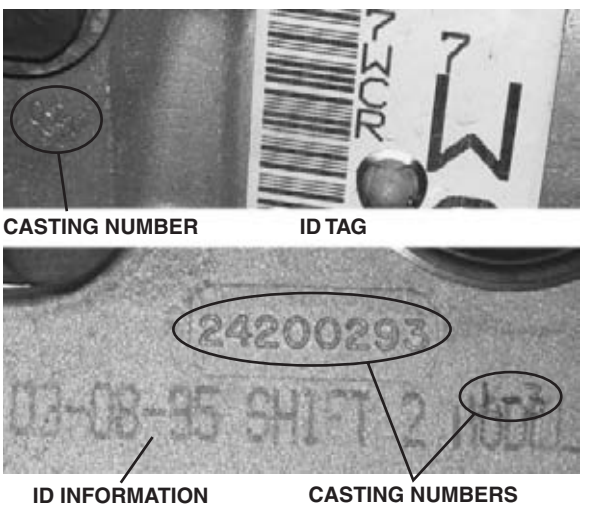


FIGURE 1-4 The two transmission cases show casting numbers that are cast as part of the case. They also have an ID tag or painted-on ID information. *(Courtesy of James Halderman)*

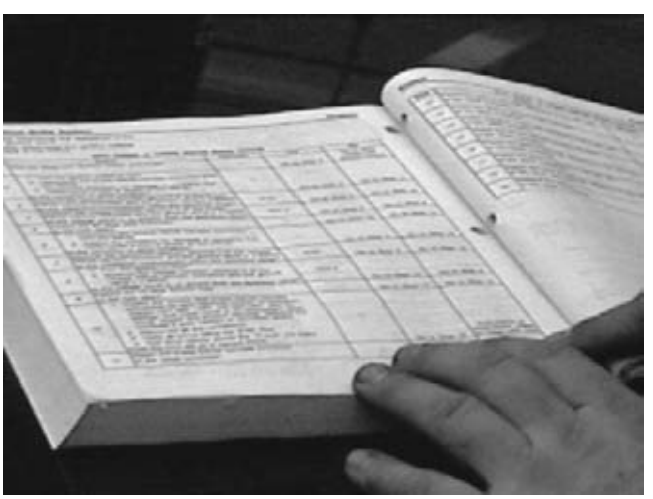


FIGURE 1-5 The factory service manual is considered to be the most complete source of service and repair information for a vehicle. *(Courtesy of James Halderman)*

FIGURE 1-6 Electronic service information, available from several independent sources, is read using a computer and monitor. *(Courtesy of James Halderman)*

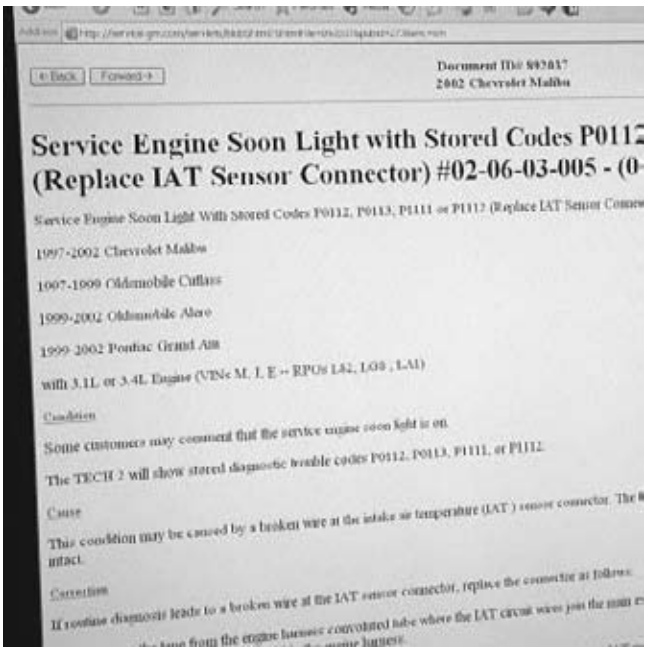


FIGURE 1-7 This TSB, technical service bulletin, describes a condition that causes the "Service Engine Soon Light" to come on for certain vehicles, and it describes the correction procedure for this concern. Note that it is in an electronic form. *(Courtesy of James Halderman)*

Electronic Service Information

Electronic service information is available on CD, DVD, or the Internet. A subscription is usually required for access to an Internet site where current service and repair information is available (Figure 1-6). Most vehicle manufacturers also offer electronic service information to their dealers and to schools that offer corporate training programs.

Technical Service Bulletins

Technical service bulletins, often called **TSBs**, 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 OEM dealership technicians but are republished by aftermarket companies and made available along with other service information to shops and vehicle repair facilities (Figure 1-7).

Internet

The Internet has opened the field for information exchange and access to technical advice. A very useful site is the **international Automotive Technicians' Network (iATN)** at *www.iatn.net*. This is a free site, but service technicians need to 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 a searchable database.

STEEL CLASSIFICATION

Steel is the base material for automotive parts that require high strength. Steel is iron that has been refined to the point where little carbon remains. Even a very small percentage of carbon in steel has a great deal of significance in the physical characteristics of any steel. The classifications of steel were established by the Society of Automotive Engineers (SAE) and are referred to as the SAE numbers.

The classification number usually contains four numbers, such as SAE 1040 steel. The first number (on the left) identifies the basic type (alloy) of the steel.

1	carbon steel (no other alloy)
2	nickel alloy
3	nickel-chromium (includes stainless steels)
4	molybdenum alloy (includes chromium-molybdenum alloys)
5	chromium
6	chromium-vanadium
9	silicon-manganese

(Other numbers are used to represent triple alloy steels.)

The second number represents the percent of alloy in the steel or is used to identify percentage ranges of alloy if more than one alloy is used in the steel.

The last two numbers represent the points of carbon and a small change in carbon content means a big difference in the characteristics of the steel (one percent contains 100 points; therefore, 35 points of carbon means the steel contains 0.35% carbon). Generally, the higher the carbon content of the steel, the harder the steel.

Low carbon steels	0.08% to 0.20% (8 to 20 points) carbon
Medium carbon steels	0.20% to 0.45% (20 to 45 points) carbon
High carbon steels	0.45% to 0.65% (45 to 65 points) carbon
Tool steel	above 0.65% (65 points) carbon

Steel Classification Examples

SAE 4130 is commonly used for high-strength tubing for race car roll cages:

4	chromium molybdenum
1	1% alloy
30	0.30% carbon

SAE 5140 is commonly used as the billet (block) of steel for some stabilizer bars:

5	chromium
1	1% alloy
40	0.40% carbon

Besides carbon content, the hardness of the steel is determined by heat treatment procedures, cooling times, temperatures, and even by what material is used to cool the steel. For example, *water-hardened* steel is quenched (cooled) by submerging the hot steel in water.

Rockwell Hardness Test The harder the steel, the more it resists the penetration of another object. A Rockwell hardness tester uses the principle of measuring the distance a hard 1/16″ diameter ball dents the metal sample under a given load. Different scales are used to test various types of materials. The Rockwell *C* scale is the most common hardness scale used for hardened and alloy steels. A typical camshaft lobe in an automotive engine should have a hardness of 45 on the Rockwell *C* scale. This is often abbreviated as 45 HRC.

THREADED FASTENERS

Most of the threaded fasteners used on vehicles are **cap screws**, which are fasteners that are threaded into a casting or part. Automotive service technicians usually refer to these fasteners as **bolts**, regardless of how they are used. In this book, they are called bolts although bolts are normally used with nuts. Sometimes, **studs**, short rods with threads on both ends, are used for threaded fasteners. A stud will often 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, and a nut is used on the opposite end to hold the parts together (Figure 1-8).

The fastener threads *must* match the threads in the casting or nut. The threads, which may be measured either in fractions of an inch (called *fractional*) or in metric units, are either coarse or fine.

Fractional Bolts

Fractional bolts have either fine or course threads. 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 Figure 1-9.

FIGURE 1-8 Typical bolt on the left and stud on the right. Note the different thread pitch on the top and bottom portions of the stud. *(Courtesy of James Halderman)*

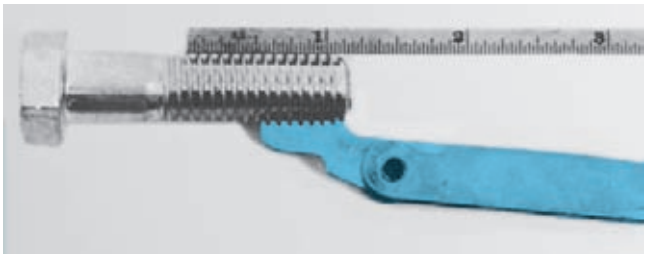


FIGURE 1-9 Thread pitch gauge used to measure the pitch of the thread. This is a 1/2-in. diameter bolt with 13 threads to the inch (1/2–13). *(Courtesy of James Halderman)*

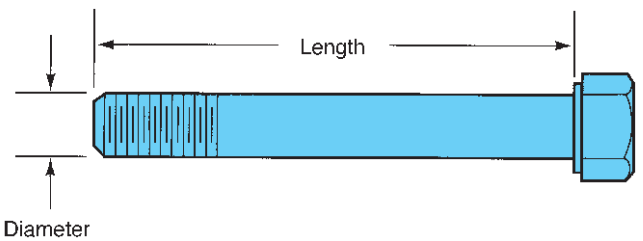


FIGURE 1-10 Bolt size identification. *(Courtesy of James Halderman)*

Bolts are identified by their diameter and length as measured from below the head, as shown in Figure 1-10. Fractional thread sizes are specified by the diameter in fractions of an inch and the number of threads per inch. For example, a 5/16–18 bolt has threads that are 5/16 of an inch in diameter and 18 threads per inch of length. 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.

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. Fine metric threads (pitch) are specified by the thread diameter followed by X and the distance between the threads measured in millimeters (M8 X 1.5). Typical metric sizes would be M8 X 1.5 (coarse thread), M8 X 1.25 (medium thread), and M8 X 1.0 (fine thread).

TECH TIP

Synthetic wintergreen oil, available at drugstores, makes an excellent penetrating oil. The next time you can't get that rusted bolt loose, head for the drugstore (Figure 1-11).

Bolt Grade

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** and is marked on the bolt head. Fractional bolts have lines on the head to indicate the grade, as shown in Figure 1-12, the actual grade being two more than the number of lines on the bolt head. More lines or a higher grade number indicate a stronger bolt. Grade 5 and better bolts usually have threads that are rolled rather than cut, which also makes them stronger. In some cases, nuts and machine screws have similar grade markings. Metric bolts are marked with a decimal number to indicate the grade.

FIGURE 1-11 Synthetic wintergreen oil can be used as a penetrating oil to loosen rusted bolts or nuts. *(Courtesy of James Halderman)*

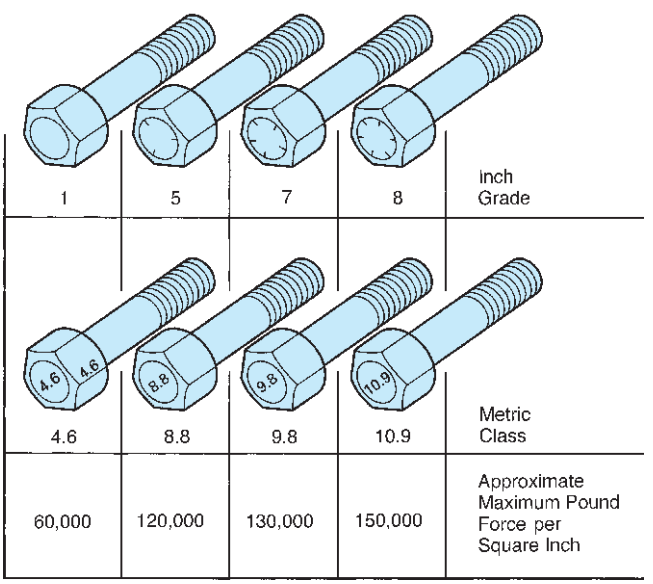


FIGURE 1-12 Typical bolt (cap screw) grade markings and approximate strength. *(Courtesy of James Halderman)*

FIGURE 1-13 Every shop should have an assortment of high-quality bolts and nuts to replace those damaged during vehicle service procedures.

CAUTION: *Never* use hardware store (nongraded) bolts, studs, or nuts on any vehicle steering, suspension, brake, or clutch component (Figure 1-13). Always use the exact size and grade of hardware that is specified and used by the vehicle manufacturer.

TECH TIP

A common mistake made by new technicians is to think that the size of a bolt or nut is the size of the wrench used to turn the fastener. 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 in.	1/4 in.
1/2 in.	5/16 in.
9/16 in.	3/8 in.
5/8 in.	7/16 in.
3/4 in.	1/2 in.
10 mm	6 mm
12 mm or 13 mm*	8 mm
14 mm or 17 mm*	10 mm*

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

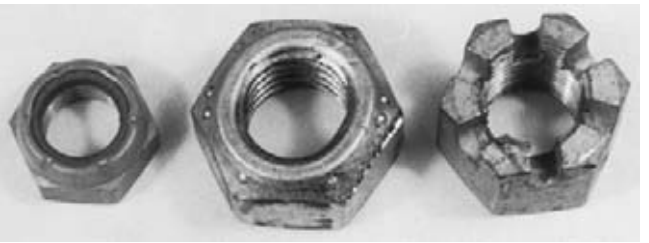


FIGURE 1-14 Types of lock nuts. On the left, a nylon ring; in the center, a distorted shape; and on the right, a castle used with a cotter key. *(Courtesy of James Halderman)*

Nuts

Most **nuts** used on bolts have the same hex size as the bolt 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, commonly called *self-locking nuts*, use interference fit threads to keep them from accidentally loosening. They are made so that the shape of the nut is slightly distorted or 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 (Figure 1-14).

NOTE: An open-end wrench can be used to gauge bolt sizes by placing the wrench opening across the threads. For example, a 3/8-in. wrench will closely fit the threads of a 3/8-in. bolt.

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 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. Plain, flat washers are used to provide an even clamping load around the fastener and to protect the part being assembled. **Lock washers** are added to prevent accidental loosening. Some manufacturers lock the washer onto a cap screw by placing it into position before rolling the threads.

BASIC TOOL LIST

Every automotive technician should possess the hand tools to turn fasteners (bolts, nuts, and screws). The following list does not include specialty tools, and items marked with an asterisk (*) are only needed if working on older vehicles.

Tool Chest

1/4-in. drive socket set (Figure 1-15):
- 1/4- to 9/16-in. standard and deep sockets (Figure 1-16)*
- 6- to 15-mm standard and deep sockets
- 1/4-in. drive ratchet
- 1/4-in. drive 2-in. and 6-in. extension
- 1/4-in. drive handle

3/8-in. drive socket set:
- *3/8- to 7/8-in. standard and deep sockets (Figure 1-17)
- 10- to 19-mm standard and deep sockets
- 3/8-in. drive Torx set, T40, T45, T50, and T55
- 3/8-in. drive 5/8-in. and 13/16-in. spark plug socket
- 3/8-in. drive ratchet
- 3/8-in. drive 1 1/2-in., 3-in., 6-in., and 12-in. extension (Figure 1-18)
- 3/8-in. drive universal
- Crowfoot set (fractional inch* and metric)
- Hex/Allen socket

1/2-in. drive socket set:
- 1/2- to 1-in. standard and deep sockets*
- 1/2-in. drive ratchet
- 1/2-in. drive breaker bar
- 1/2-in. drive 5-in. and 10-in. extension
- 3/8- to 1/4-in. adapter (Figure 1-19)

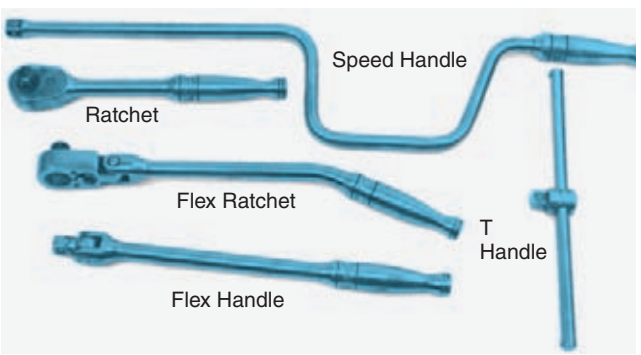


FIGURE 1-15 Typical drive handles for sockets. *(Courtesy of James Halderman)*

FIGURE 1-16 Standard 12-point short socket (left), universal joint socket (center), and deep-well socket (right). Both the universal and deep-well are 6-point sockets.

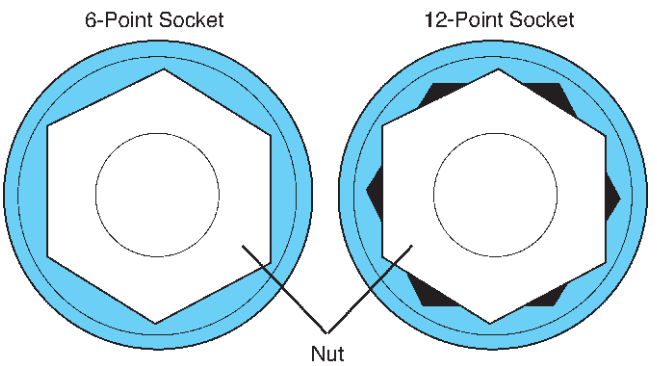


FIGURE 1-17 A 6-point socket fits the head of the bolt or nut on all sides. A 12-point socket can round off the head of a bolt or nut if a lot of force is applied. *(Courtesy of James Halderman)*

FIGURE 1-18 Various socket extensions. The universal joint (U-joint) (upper left) is useful for gaining access in tight areas.

FIGURE 1-19 Socket drive adapters. These adapters permit the use of a 3/8-in. drive ratchet with 1/2-in. drive sockets, or other combinations as the various adapters permit. Adapters should be used carefully where a larger tool could break or damage a smaller-sized socket.

FIGURE 1-20 Combination wrench. The openings are the same size at both ends. Notice the angle of the open end to permit use in close spaces.

FIGURE 1-21 Flare-nut wrench. Also known as a *line wrench, fitting wrench,* or *tube-nut wrench*. This style of wrench is designed to grasp most of the flats of a six-sided (hex) tubing fitting to provide the most grip without damage to the fitting.

FIGURE 1-22 Assortment of pliers. Slip-joint pliers (center) are often confused with water pump pliers (lower right).

1/2- to 3/8-in. adapter
3/8- to 1/2-in. adapter
3/8- through 1-in. combination wrench set (Figure 1-20)
10- to 19-mm combination wrench set
1/16- to 1/4-in. hex wrench set
2- to 12-mm hex wrench set
5/16- to 9/16-in. flare-nut wrench set (Figure 1-21)*
10- and 12-, 14- and 17-mm flare-nut wrench set
Diagonal, needle nose, adjustable-jaw, locking, snap-ring, and electrical stripping or crimping pliers (Figure 1-22)
Ball-peen, rubber, and dead-blow hammers (Figure 1-23)
Five-piece standard screwdriver set (Figure 1-24)

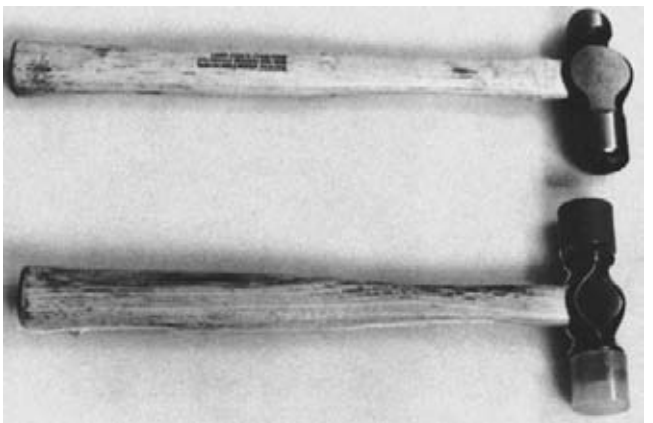


FIGURE 1-23 A ball-peen hammer (top) is purchased according to weight (usually in ounces) of the head of the hammer. At bottom is a soft-faced (plastic) hammer. Always use a hammer that is softer than the material being driven. Use a block of wood or similar material between a steel hammer and steel or iron engine parts to prevent damage to the engine parts. *(Courtesy of James Halderman)*

FIGURE 1-24 A flat-blade (or straight-blade) screwdriver (center) is specified by the length of the screwdriver and width of the blade. A Phillips-head screwdriver (left) is specified by the length of the handle and the size of the point at the tip. A Torx screwdriver (right) uses a numerical (#15 or #20) size designation.

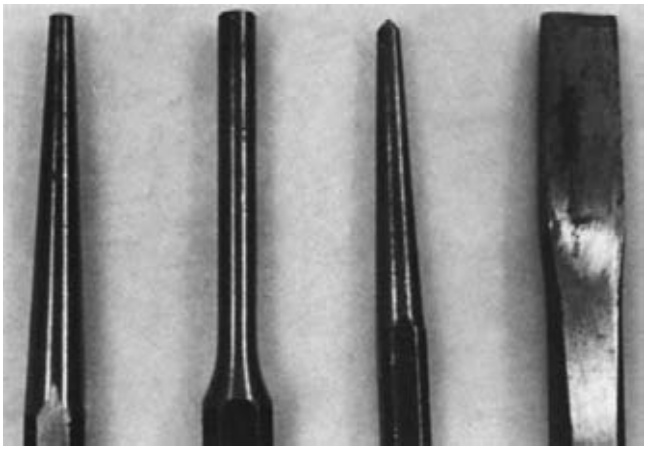


FIGURE 1-25 From the left, a starting punch, pin punch, center punch, and chisel. *(Courtesy of James Halderman)*

Four-piece Phillips screwdriver set
#15 and #20 Torx screwdriver
Awl
Mill file
Center and pin punches (Figure 1-25)
Chisel
Utility knife
Valve core tool
Filter wrench (large and small filters)
Safety glasses
Circuit tester
Feeler gauge set
Gasket scraper
Pinch bar
Magnet

TECH TIP

An apprentice technician started working for a dealership 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." 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.

Tool Sets and Accessories

A beginning service technician may wish to start with a small set of tools before spending a lot of money on an expensive, extensive tool set (Figure 1-26).

(a)

(b)

FIGURE 1-26 (a) A beginning technician can start with some simple basic hand tools. (b) An experienced, professional technician will spend several thousand dollars a year for tools like these stored in a large and expensive tool box. *(Courtesy of James Halderman)*

TECH TIP

Apply a small amount of valve grinding compound to a Phillips or Torx screw or bolt head. The gritty valve grinding compound "grips" the screwdriver or tool bit and prevents the tool from slipping up and out of the screw head. Valve grinding compound is available in a tube from most automotive parts stores.

NOTE: 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 you should purchase your own as soon as possible. Also, whenever a tool is borrowed, be sure that you return the tool clean and show the technician you borrowed the tool from that you are returning the tool. These actions will help in any future dealings with other technicians.

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

NOTE: Whenever removing any automotive component, it is wise to quickly note the length, diameter, thread pitch, and condition of each bolt. This will help you identify damaged fasteners and to remember where to reinstall them.

NOTE: Normally, a bolt should be long enough to thread into the part a distance that is equal to or about half again the bolt diameter.

Safety Tips for Using Hand Tools

The following safety tips should be kept in mind whenever you are working with hand tools:

- Always use the proper tool for the job.
- Always *pull* a wrench toward you for best control and safety. Avoid pushing a wrench. If you do and a bolt or nut loosens, your entire weight will propel your hand(s) forward. This usually results in cuts, bruises, or other painful injury.
- Keep all hand tools clean. This will help prevent rust and provide a better, firmer grip.
- Always use a 6-point socket or a box-end wrench to break loose a tight bolt or nut.
- Use a box-end wrench for torque and the open-end wrench for speed.
- Never use a pipe extension or other type of "cheater bar" on a wrench or ratchet handle. If more force is required, use a larger tool or use penetrating oil and/or heat on the frozen fastener. (If heat is used on a bolt or nut to remove it, always replace it with a new part.)
- 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 or socket handle unless you are using a special wrench designed to be used with a hammer.
- Replace any tools that are damaged or worn.

NOTE: Punches, made from soft materials like brass or aluminum, are available for striking a shaft, gear, or other object.

TECH TIP

If you must strike or pound on something, be sure to use a tool that is softer than what you are about to strike 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

Manual Drivetrain Special Service Tools

Specialized tools are required to properly disassemble and assemble manual drivetrains. Manufacturers have developed **special service tools (SSTs)**, also called special tools, to meet this need. They are available from the vehicle or drivetrain manufacturer and/or their tool supplier. Many technicians do not have access to the SSTs so they use generic versions that are available from aftermarket sources (Figure 1-27).

MEASURING TOOLS

The purpose of any repair is to restore the vehicle to factory-specified tolerance. Every repair procedure involves measuring. The service technician must measure twice:

- The original components must be measured to see if correction is necessary to restore the component or part to factory specifications.

FIGURE 1-27 Special tools for manual drivetrain service can include an angle gauge (a), special sockets for 4WD wheel bearings (b), a tool for tightening CV joint boot clamps (c), a clutch disc aligner set (d), an engine hanger (e), a flywheel turner (f), a pilot bearing puller (g), a spanner wrench for adjusting carrier bearings (h), a U-joint press (i), a set of pullers (j), a set of seal drivers (k), and a set of transmission output shaft sealing caps (l). *(Courtesy of Snap-on Tool Company, www.snapon.com)*

- The replacement parts and finished machined areas must be measured to ensure proper dimension before the component is assembled or replaced on the vehicle.

Micrometer

A **micrometer** is a commonly used measuring instrument (Figure 1-28). The **thimble** rotates over the **barrel** on a screw that has 40 threads per inch. Every revolution of the thimble moves the **spindle** 0.025 in. The thimble is graduated into 25 equally spaced lines; therefore, each line represents 0.001 in. An outside micrometer has a measuring range of one inch. Every micrometer should be checked for calibration on a regular basis (Figure 1-29).

Telescopic Gauge

A **telescopic gauge** is used with a micrometer to measure the inside diameter of a hole or bore.

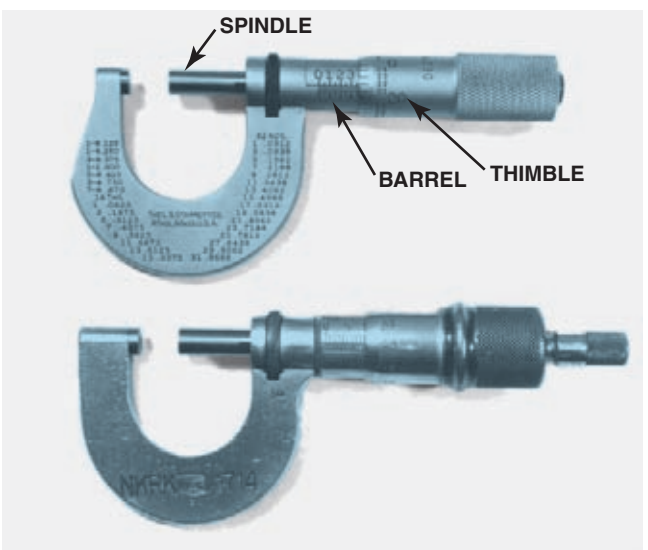


FIGURE 1-28 Typical micrometers used for dimensional measurements. A vernier scale (inset) allows measuring to the ten thousandths of an inch. *(Courtesy of James Halderman)*

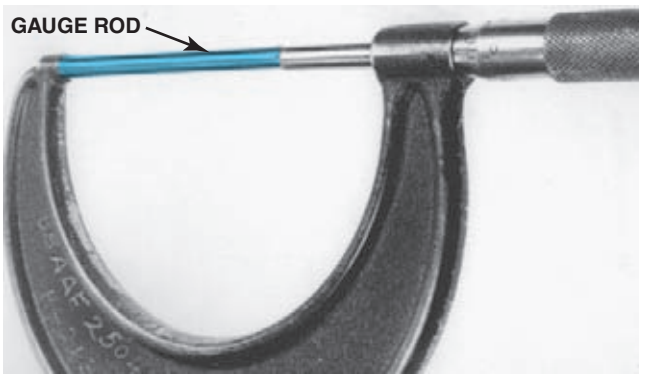


FIGURE 1-29 All micrometers should be checked and calibrated as needed using a gauge rod. *(Courtesy of James Halderman)*

FREQUENTLY ASKED QUESTION

The word *gauge* means "measurement or dimension to a standard of reference." The word *gauge* can also be spelled *gage*. Therefore, in most cases, the words mean the same.

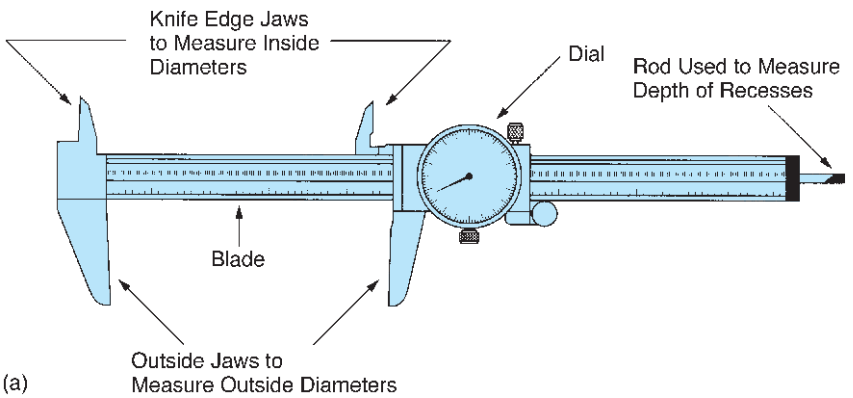
NOTE: One vehicle manufacturing representative mentioned that *gage* was used rather than *gauge* because even though it is the second acceptable spelling of the word, it is correct and it saved the company a lot of money in printing costs because the word *gage* has one less letter! One letter multiplied by the millions of times that *gage* is used in service manuals adds up to a big savings for the manufacturer.

Vernier Dial Caliper

A **vernier dial caliper** can be used to measure gear diameter, bearing race inside diameter, as well as the depth of a bolt hole. Although not as accurate as a micrometer, a vernier caliper is faster and covers a wider measuring range (Figure 1-30).

Dial Indicator

A **dial indicator** is used to measure movement like shaft runout or gear lash/clearance (see Figure 5-20).



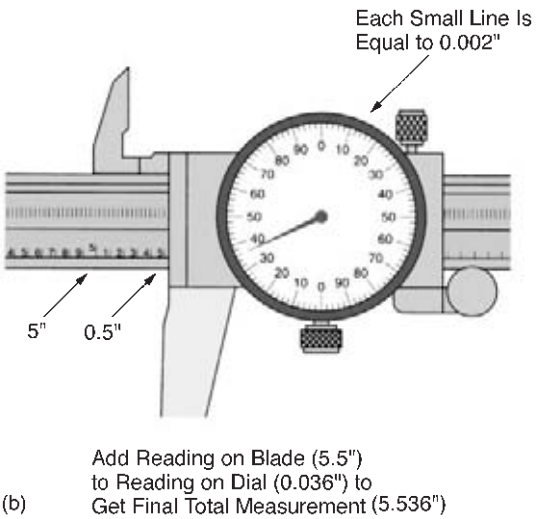


FIGURE 1-30 (a) A typical vernier dial caliper. This is a very useful measuring tool for automotive engine work because it is capable of measuring inside and outside measurements. (b) To read a vernier dial caliper, simply add the reading on the blade to the reading on the dial. *(Courtesy of James Halderman)*

SAFETY TIPS FOR TECHNICIANS

Safety is not just a buzzword on a poster in the work area. Safe work habits can reduce accidents and injuries, ease the workload, and keep employees pain-free. Suggested safety tips include the following:

- *Wear safety glasses at all times while servicing any vehicle* (Figure 1-31).
- Watch your toes—always keep your toes protected with steel-toed safety shoes (Figure 1-32). If safety shoes are not available, then leather-topped shoes offer more protection than canvas or cloth.
- Wear gloves to protect your hands from rough or sharp surfaces. Thin rubber gloves are recommended when working around automotive liquids such as engine oil, antifreeze, transmission fluid, or any other liquids that may be hazardous.
- 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 (Figure 1-33).
- Remove all jewelry that may get caught on something or act as a conductor to an exposed electrical circuit (Figure 1-34).
- Take care of your hands. Keep your hands clean by washing frequently with soap and hot water of at least 110°F (43°C).
- Avoid loose or dangling clothing.
- Ear protection should be worn if the sound around you requires that you raise your voice (sound level higher than 90 dB). (A typical lawn mower produces noise at a level of about 110 dB. This means that everyone who uses a lawn mower or other lawn or garden equipment should wear ear protection.)

FIGURE 1-31 Safety glasses should be worn at all times when working on or around any vehicle or servicing any component. *(Courtesy of James Halderman)*

FIGURE 1-32 Steel-toed shoes are a worthwhile investment to help prevent foot injury due to falling objects. Even this well-worn shoe can protect the foot of this technician. *(Courtesy of James Halderman)*

- 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 back strain.
- Ask for help when moving or lifting heavy objects.
- Push a heavy object rather than pull it. This is opposite to the way you should work with tools.

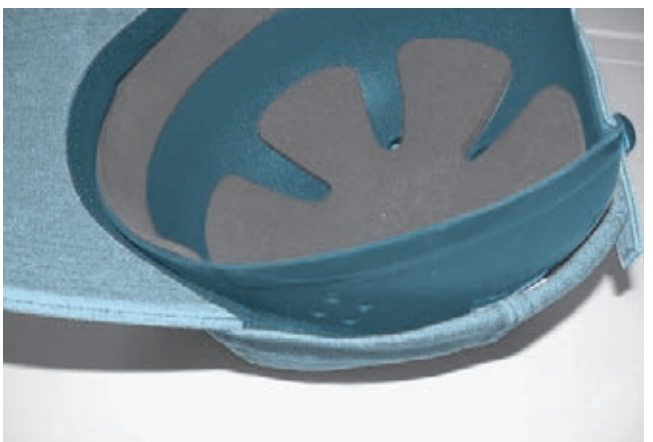


FIGURE 1-33 A bump cap provides a shield and padding to protect the head while working under a vehicle. *(Courtesy of James Halderman)*

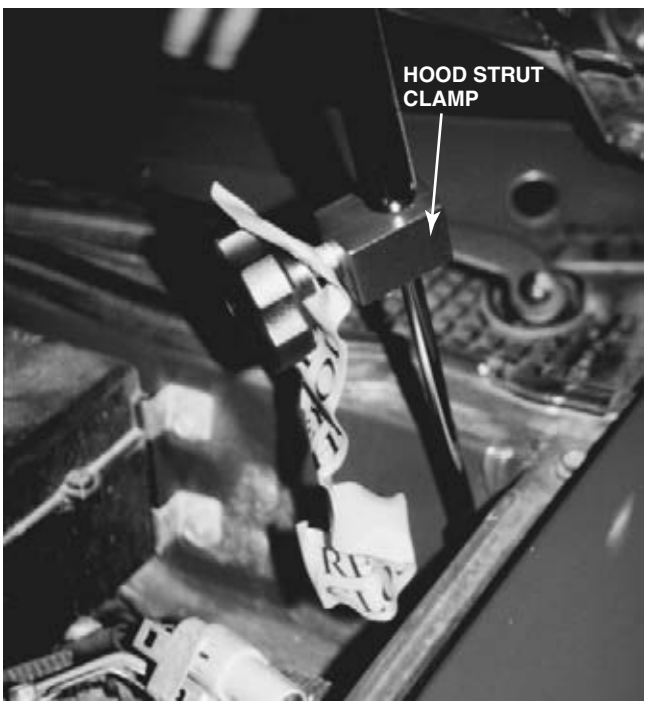
FIGURE 1-34 All jewelry such as rings and watches should be removed when working on vehicles. *(Courtesy of James Halderman)*

- Always connect an exhaust hose to the tailpipe of any vehicle running in a closed garage to help prevent the buildup of carbon monoxide (Figure 1-35).
- 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 1-36).

FIGURE 1-35 Always connect an exhaust hose to the tailpipe of a vehicle running inside a building. *(Courtesy of James Halderman)*

SAFETY TIP

Always dispose of oily shop cloths in an enclosed container to prevent a fire (Figure 1-37). 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**.



(a)

(b)

FIGURE 1-36 (a) A crude but effective method to secure a hood is to use locking pliers on the hood strut shaft. Locking pliers should only be used on defective struts because the jaws of the pliers can damage the strut shaft. (b) This commercially available hood clamp has a bright orange tag to help remind the technician to remove the clamp before attempting to close the hood. The hood could be bent if excessive force is used to close the hood with the clamp in place. *(Courtesy of James Halderman)*

FIGURE 1-37 All oily shop cloths should be stored in a metal container equipped with a lid to help prevent spontaneous combustion. *(Courtesy of James Halderman)*

TECH TIP

SHOCK CONTROL

To avoid impact damage from your impact wrench on your hand, take the rubber covering from an old electric fuel pump and fit it on the handle of the gun to soften the blow.

Vehicle Lifting (Hoisting) Safety

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 the lifting procedure.**

All automobile and light-truck service 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 (Figure 1-38).

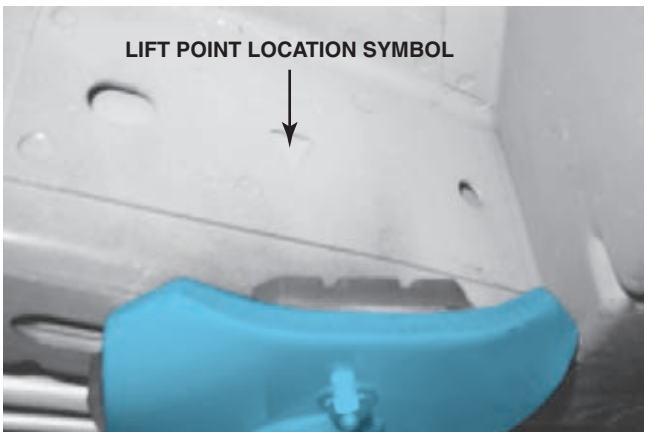


FIGURE 1-38 Many vehicles have a triangle symbol indicating the recommended hoisting lift points. *(Courtesy of James Halderman)*

The recommended standards for the lift points and lifting procedures are found in SAE Standard JRP-2184. These recommendations typically include the following points:

1. The vehicle, with the doors, hood, and trunk closed, should be centered on the lift or hoist so as not to overload one side or put too much load toward the front or rear of the hoist.
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 part 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 unitized bodies (unit-body), care should be taken when placing the pad(s). 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 1-39. Be aware that a tall vehicle might hit the ceiling or suspended lights.

   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 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), and
      3. tires or body panels (Figure 1-40).

FIGURE 1-39 This vehicle fell from the hoist because the pads were not set correctly. No one was hurt, but the vehicle was a total loss. *(Courtesy of James Halderman)*

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 watch until it has reached the desired height.

CAUTION: Do not look away from the vehicle while it is being raised (or lowered) on a hoist. 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.

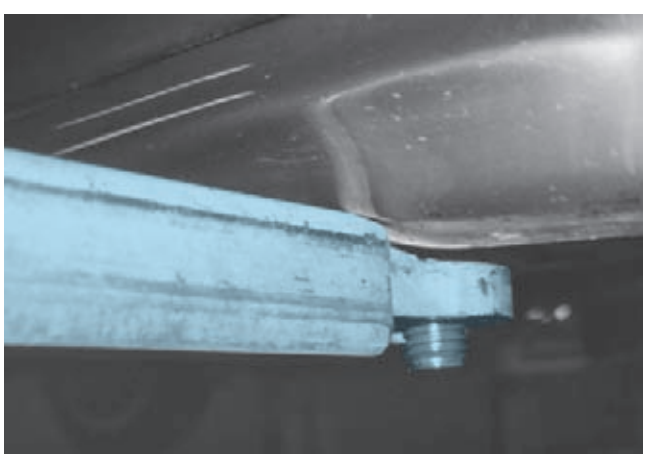
NOTE: Most hoists can be safely placed at any desired height. When removing and replacing components like an axle, it is not necessary to work on them down near the floor or over your head. Raise the hoist so that the components are at chest level.

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.

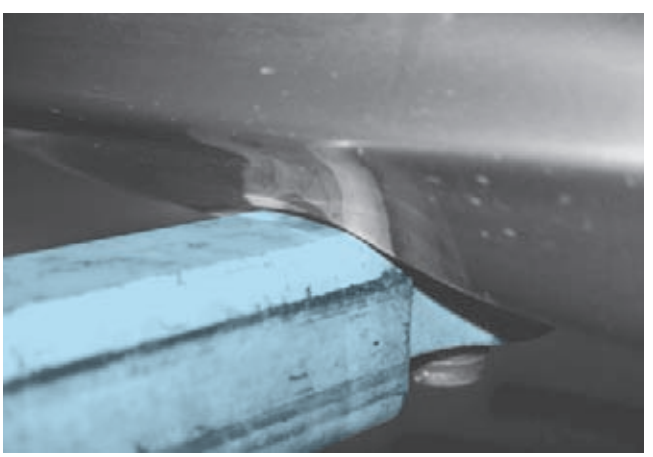
HYBRID VEHICLE CAUTIONS

Hybrid vehicles combine a gasoline engine, electric motor/generator, and a high voltage battery pack. Technicians and first-responders (emergency workers like firefighters, ambulance crews, and vehicle recovery personnel) must be aware of the potential hazards of these vehicles. The biggest hazards is electric shock. The use of nickel-cadmium batteries have minimized hazardous electrolyte spills. Battery pack voltage varies between different makes, but it is about 150–275 volts of direct current (DC), ample to kill or seriously injure.

A hybrid vehicle can be identified by a hybrid label on the trunk lid or rear lift gate, on the hood, or front doors (Figure 1-41). There is often a label on the engine. Bright orange warning decals are also placed under the hood and in the vicinity of the major high voltage components. Wires used to



(a)



(b)

FIGURE 1-40 (a) In this photo the pad arm is just contacting the rocker panel of the vehicle. (b) This photo shows what can occur if the technician places the pad too far inward, underneath the vehicle. The arm of the hoist has dented the rocker panel. *(Courtesy of James Halderman)*

(a)

(b)

FIGURE 1-41 The emblem at the rear of this Ford Escape identifies it as a hybrid vehicle (a). The label on this Toyota Prius engine and the bright orange wires help identify a hybrid vehicle (b). *Do not touch the orange high voltage wires. (b is courtesy of James Halderman)*

connect the high voltage components are bright orange. DO NOT TOUCH ANY BRIGHT ORANGE WIRING OR COMPONENT WITHOUT FOLLOWING THE VEHICLE MANUFACTURER'S PROCEDURE AND WEARING THE PROPER PROTECTIVE GEAR.

If necessary, turn off the high voltage current by turning the ignition key to "off" and removing the key to prevent it from being turned back "on." Next, disconnect the 12-volt DC battery to prevent vehicle operation; this will shut off the high voltage battery pack on some vehicles. Many hybrid vehicles also have a high voltage shutoff switch/plug that completely shuts off the high voltage circuit (Figure 1-42).

CAUTION: A low voltage circuit can retain power for up to 90 seconds, and a high voltage circuit can retain voltage for up to 5 minutes after being shut off.

ELECTRICAL CORD SAFETY

Use correctly grounded three-prong sockets and extension cords to operate power tools. Use only double insulated power tools. Some modern tools use polarized two-prong plugs that have one wide and one narrow prong. When not in use, keep electrical cords off the floor to prevent tripping over them. Tape the cords to the floor if they are placed in high foot-traffic areas.

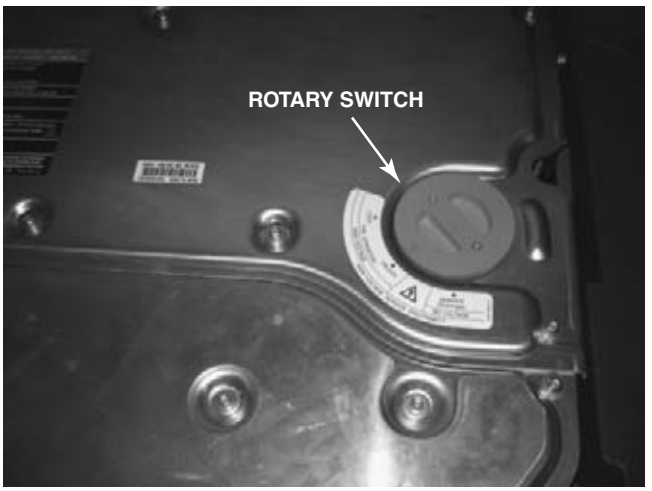
SAFETY TIP

Improper use of an air nozzle can cause blindness or deafness. If an air nozzle is used to dry and clean parts, make sure the air stream is directed away from anyone else in the immediate area. Clean, coil, and store air hoses when they are not in use.

FIRE EXTINGUISHERS

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

- **Class A** is designed for use on general combustibles, such as cloth, paper, and wood.
- **Class B** is designed for use on flammable liquids and greases, including gasoline, oil, thinners, and solvents.
- **Class C** is used only on electrical fires.
- **Class D** is effective only on combustible metals such as powdered aluminum, sodium, or magnesium.



(a)

Locations of HV Batteries and Service Switch /Plugs

Model (year)	HV Battery Pack Location	HV Safety Switch / Plug Location
Honda Insight 2000-2006	144v unit under hatch floor.	Under hatch carpet, remove small plate in center
Civic / Accord Hybrid 2003 - 2006 +	144v unit (158v 06 Civic) behind back seat upright cushion	Behind back seat upright cushion, remove small oval plate in center
Toyota Prius 2001 - 2003	275v unit in trunk, under carpet, lower front area	In lower front left area corner of HV battery.
Toyota Prius 2004 - 2006 +	201v unit in front of spare tire	In front of spare tire, lower front left area of HV battery pack around the corner. Plug removes toward left side of car.
Toyota / Lexus SUV RX400h / Highlander 2006+	288v unit under rear seat in 3 compartments	In lower rear seat left side under trim small rectangular panel. Plug removes toward left side of SUV
Ford Escape 2005+	330v unit under carpet, rear floor	Under rear carpet, round orange switch on right side in plain view
Mercury Mariner 2006 +	330v unit under carpet, rear floor	Under rear carpet, round orange switch on right side in plain view

Note: The GM hybrid truck is not listed because it is only 42 volts and not considered a shock hazard.

(b)

FIGURE 1-42 This hybrid vehicle has a rotary switch in the rear compartment; turning the switch disconnects the high voltage electricity (a). Locations of the HV Batteries and Safety Switches or Plugs (b). *(Courtesy of James Halderman)*

The class rating is clearly marked on the side of every fire extinguisher. Many extinguishers are good for multiple types of fires (Figure 1-43).

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 at the base of the flame.

See Figure 1-44.

FIGURE 1-43 A typical fire extinguisher designed to be used on class A, B, or C fires. *(Courtesy of James Halderman)*

FIGURE 1-44 A CO_2 fire extinguisher being used on a fire set in an open steel drum during a demonstration at a fire department training center. *(Courtesy of James Halderman)*

Types of Fire Extinguishers

The variety of fire extinguishers include:

- **Water**—A water fire extinguisher is usually in a pressurized container and is good to use on Class A fires because it reduces the temperature to the point where a fire cannot be sustained.
- **Carbon Dioxide (CO_2)**—A carbon dioxide fire extinguisher is good for almost any type of fire, especially Class B or Class C materials. A CO_2 fire extinguisher works by removing the oxygen from the fire. The cold CO_2 also helps reduce the temperature of the fire.
- **Dry Chemical (yellow)**—A dry chemical fire extinguisher is good for Class A, B, or C fires by coating the flammable materials to eliminate the oxygen from the fire. A dry chemical fire extinguisher tends to be very corrosive and will cause damage to electronic devices.

HOISTING A VEHICLE Step-by-Step

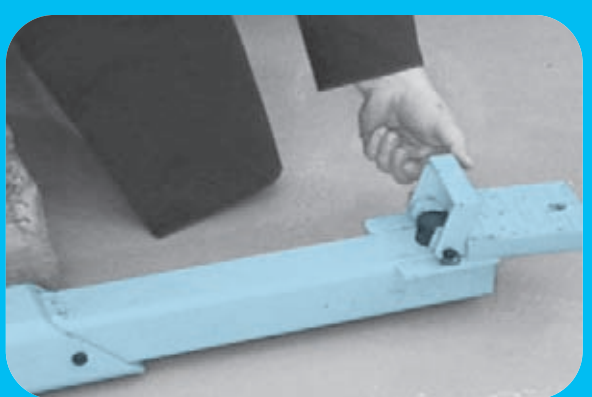
(Photos courtesy of James Halderman)

STEP 1 The first step in hoisting a vehicle is to center the vehicle on the hoist.

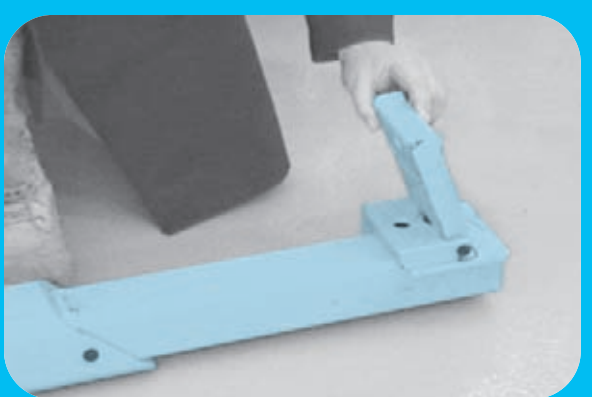
STEP 2 Most vehicles will be correctly positioned when the left front tire is centered on the tire pad.

STEP 3 Many pads at the end of the hoist arms can be rotated to allow for many different types of vehicle construction.

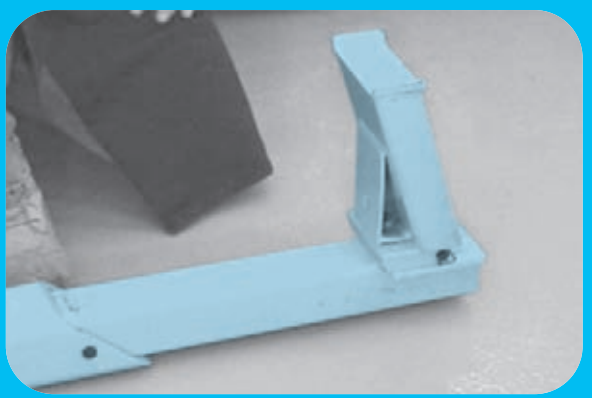
STEP 4 The arms of the lifts can be retracted or extended to accommodate vehicles of different lengths and widths.



STEP 5 Most lifts are equipped with short pad extensions to contact the frame of a vehicle without causing the arm of the lift to damage parts of the body.

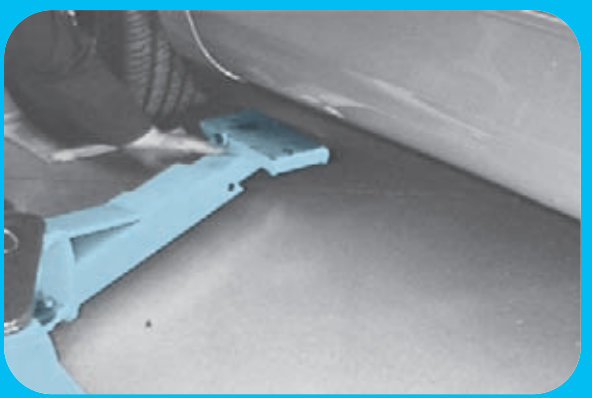


STEP 6 Tall pad extensions can also be used to gain access to the frame of a vehicle. This position is needed to safely hoist many pickups, vans, and sport-utility vehicles (SUVs).



STEP 7

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



STEP 8

Position the front hoist pads under the recommended locations.

STEP 9

Position the rear pads under the vehicle in the recommended locations.

STEP 10

An asymmetrical lift where the front arms are shorter than the rear arms.This design allows the driver to easily exit the vehicle because the door can be opened wide.

STEP 11

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

STEP 12

Raise the vehicle about 1 foot (30 cm) and stop to double check that all pads contact the body or frame in the correct positions.

STEP 13

With the vehicle raised about 1 foot, 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.

STEP 14

This photo shows the pads set flat and contacting the pinch welds of the body. This method spreads the load over the entire length of the pad and is less likely to dent or damage the pinch weld area.

STEP 15

Where additional clearance is necessary, the pads can be raised and placed under the pinch weld area as shown.

STEP 16

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.

STEP 17

After lowering the vehicle and before moving the vehicle, be sure all arms of the lift are moved out of the way.

STEP 18

Carefully back the vehicle out of the stall. Notice that all of the lift arms have been neatly moved out of the way to provide clearance so that the tires will not contact the arms when the vehicle is driven out of the stall.

SUMMARY

1. Vehicles carry several different identification numbers
   VIN: identifies the vehicle plus where and when it was assembled.
   VECI: Necessary vehicle emission control information
   Calibration codes
   Casting number on major components
2. Vehicle service information is available in printed and electronic format as service manuals and TSBs.
3. Bolts, nuts, and studs, threaded fasteners use fractional inch or metric sizes; they also come in a series of grades.
4. Technicians have a tool set of hand tools in a variety of sizes. A technician must be able to use tools properly to prevent injury.
5. A technician must be aware of potential safety hazards when working on and around motor vehicles.

REVIEW QUESTIONS

1. The two common types of bolt sizes are _____ and _____.
2. A 5/16–18 bolt has _____ threads and a _____ diameter of 5/16″.
3. A M8 X 1.5 bolt has a thread diameter of _____ _____ and a _____ of 1.5 mm.
4. A grade 8 bolt is _____ than a grade 5 bolt.
5. Loctite is an _____ compound used to _____ the nut on the bolt.
6. A Crescent wrench should properly be called an _____ _____.
7. When you loosen a tight nut or bolt, you should _____ on the wrench.
8. The best tool to loosen a really tight nut is either a _____ _____ socket or a _____ _____ wrench.
9. A _____ is a good tool to measure a shaft to see if it is worn.
10. A _____ _____ can be used to measure shaft end play or flywheel runnout.
11. An oily shop cloth can ignite and burn without an open flame because of _____ _____.
12. A critical step in lifting a vehicle on a hoist is to _____ the _____.
13. The third prong of a three-prong electrical plug is for _____.
14. Class B fire extinguishers are designed to extinguish _____ _____ fires.
15. A _____ _____ fire extinguisher is good for most types of fire.

CHAPTER QUIZ

1. Student A says that if a micrometer thimble is rotated two complete revolutions, the spindle will move 0.050″. Student B says the micrometer barrel has 40 threads per inch. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B
2. Two students are discussing bolts. Student A says the wrench used with a bolt is the same size as the bolt. Student B says the thread diameter is the bolt size. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

3. Two students are discussing measuring tools. Student A says a micrometer can be used to measure parts to 0.001″. Student B says vernier calipers can be used to measure depth as well as the inside and outside diameter of a part. Who is correct?
   - **a.** Student A
   - **b.** Student B
   - **c.** Both A and B
   - **d.** Neither A nor B

4. Student A says it is a good idea to get help when you need to lift a heavy object. Student B says you should lift heavy objects using your legs, not your back. Who is correct?
   - **a.** Student A
   - **b.** Student B
   - **c.** Both A and B
   - **d.** Neither A nor B

5. Two students are discussing the hoisting of a vehicle. Student A says to put the pads of a lift under a notch at the pinch weld of a unit-body vehicle. Student B says to place the pads on the four corners of the frame of a full-frame vehicle. Who is correct?
   - **a.** Student A
   - **b.** Student B
   - **c.** Both A and B
   - **d.** Neither A nor B

6. 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

7. 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

8. When working with hand tools, always _____.
   - **a.** push a wrench—don't pull toward you
   - **b.** pull a wrench—don't push a wrench

9. Student A says that the fire extinguisher should be aimed at the base of a fire. Student B says that fire extinguishers remove either heat or oxygen from the burning material. Who is correct?
   - **a.** Student A
   - **b.** Student B
   - **c.** Both A and B
   - **d.** Neither A nor B

10. A high-strength, fractional bolt is identified by _____.
    - **a.** a UNC symbol
    - **b.** lines on the head
    - **c.** strength letter codes
    - **d.** the coarse threads

11. A fastener that uses threads on both ends is called a _____.
    - **a.** cap screw
    - **b.** stud
    - **c.** machine screw
    - **d.** crest fastener

12. The proper term for Channel Locks is _____.
    - **a.** Vise Grips
    - **b.** Crescent wrench
    - **c.** locking pliers
    - **d.** multigroove adjustable pliers

13. The proper term for Vise Grips is _____.
    - **a.** locking pliers
    - **b.** slip-joint pliers
    - **c.** side cuts
    - **d.** multigroove adjustable pliers

14. What is *not* considered to be personal safety equipment?
    - **a.** air impact wrench
    - **b.** safety glasses
    - **c.** rubber gloves
    - **d.** hearing protection