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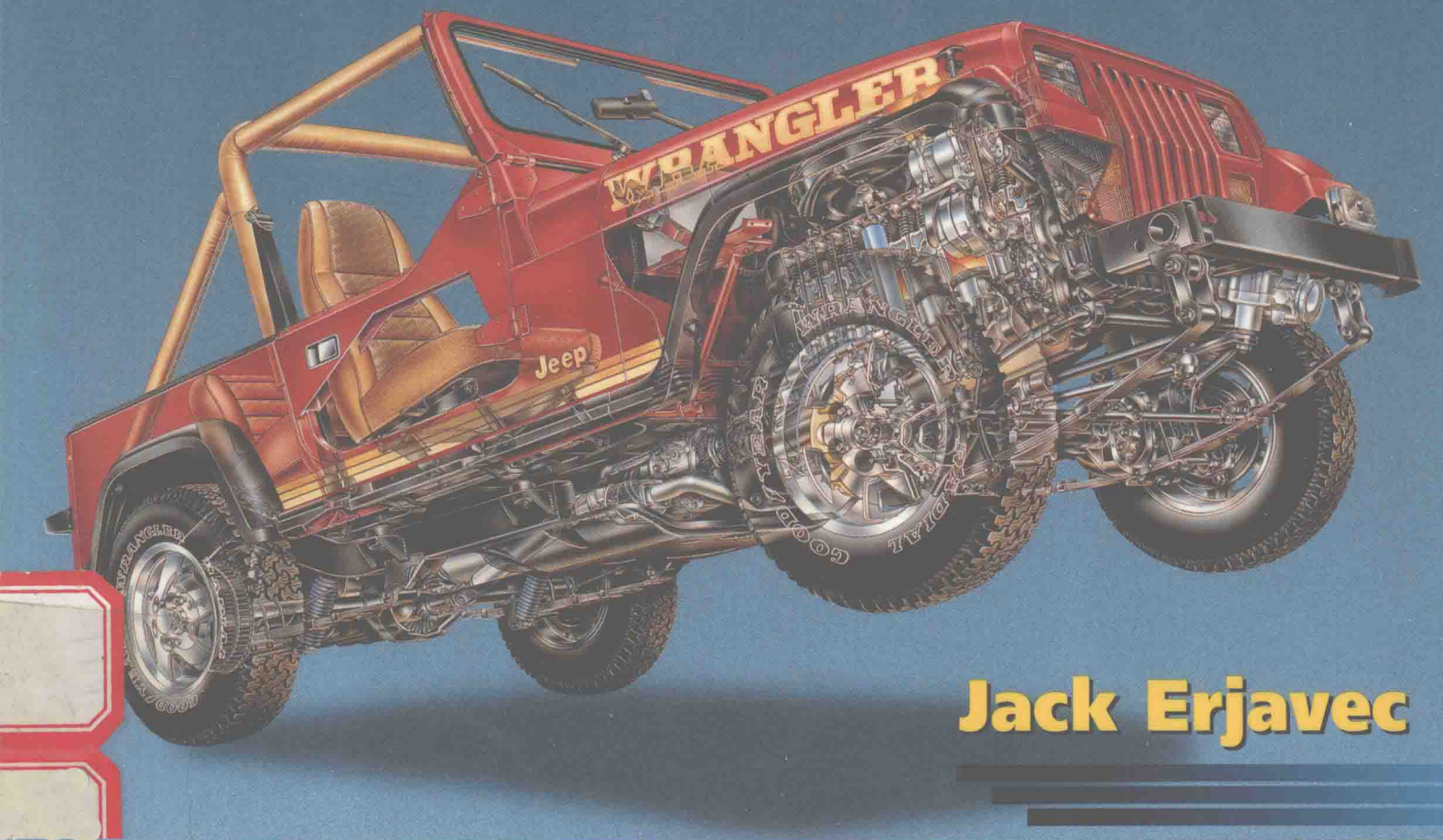
MANUAL TRANSMISSIONS & TRANSAXLES

2nd edition

• CLASSROOM MANUAL •



Jack Erjavec

Classroom Manual for Manual Transmissions and Transaxles

Second Edition

Jack Erjavec
Columbus State Community College
Columbus, Ohio

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PREFACE

Thanks to the support the Today's Technician Series has received from those who teach automotive technology, Delmar Publishers is able to live up to its promise to provide new editions every three years. We have listened to our critics and our fans and present this new revised edition. By revising our series every three years, we can and will respond to changes in the industry,changes in the certification process, and to the ever-changing needs of those who teach automotive technology.

The *Today's Technician* series, by Delmar Publishers, features textbooks that cover all mechanical and electrical systems of automobiles and light trucks. Principal titles correspond with the eight major areas of ASE (National Institute for Automotive Service Excellence) certification. Additional titles include remedial skills and theories common to all of the certification areas and advanced or specialized subject areas that reflect the latest technological trends.

Each title is divided into two manuals: a Classroom Manual and a Shop Manual. Dividing the material into two manuals provides the reader with the information needed to begin a successful career as an automotive technician without interrupting the learning process by mixing cognitive and performance-based learning objectives.

Each Classroom Manual contains the principles of operation for each system and subsystem. It also discusses the design variations used by different manufacturers. The Classroom Manual is organized to build upon basic facts and theories. The primary objective of this manual is to allow the reader to gain an understanding of how each system and subsystem operates. This understanding is necessary to diagnose the complex automobile systems.

The understanding acquired by using the Classroom Manual is required for competence in the skill areas covered in the Shop Manual. All of the high priority skills, as identified by ASE, are explained in the Shop Manual. The Shop Manual also includes step-by-step instructions for diagnostic and repair procedures. Photo Sequences are used to illustrate many of the common service procedures. Other common procedures are listed and are accompanied with fine-line drawings and photographs that allow the reader to visualize and conceptualize the finest details of the procedure. The Shop Manual also contains the reasons for performing the procedures, as well as when that particular service is appropriate.

The two manuals are designed to be used together and are arranged in corresponding chapters. Not only are the chapters in the manuals linked together, the contents of the chapters are also linked. Both manuals contain clear and thoughtfully selected illustrations. Many of the illustrations are original drawings or photos prepared for inclusion in this series. This means that the art is a vital part of each manual.

The page layout is designed to include information that would otherwise break up the flow of information presented to the reader. The main body of the text includes all of the "need-to-know" information and illustrations. In the side margins are many of the special features of the series. Items such as definition of new terms, common trade jargon, tools list, and cross-referencing are placed in the margin, out of the normal flow of information so as not to interrupt the thought process of the reader.

Highlights of this Edition-Shop Manual

The text was updated throughout, to include the latest developments. Some of these new topics include dual-mass flywheels, differential designs, six-speed transmissions, and all-wheel-drive systems. We also added a new chapter that covers transmission-related electrical systems. This chapter includes basic electrical diagnosis and repairs, switches, speed sensors, solenoids, electromagnetic clutches, and electronic circuits.

Located at the end of each chapter are two new features: Job Sheets and ASE Challenge Questions. The Job Sheets provide a format for students to perform some of the tasks covered in the chapter. In addition to walking a student through a procedure, step-by-step, these Job Sheets challenge the student by asking why or how something should be done, thereby making the students think about what they are doing.

Speaking of challenging questions, each chapter ends with a group of questions that reflect the content of an ASE exam. These questions are not merely end-of-chapter questions, they represent the content of an ASE test. These questions, of course, are in addition to the ASE style end-of-chapter questions that were in the first edition.

Highlights of this Edition-Classroom Manual

The text was updated throughout, to include the latest developments. Some of these new topics include dual-mass flywheels, diffential designs, six-speed transmissions, and all-wheel-drive systems. We also added a new chapter that covers transmission-related electrical systems. This chapter includes basic electrical and electronic theory and the various applications for switches, speed sensors, solenoids, electromagnetic clutches, and electronic circuits.

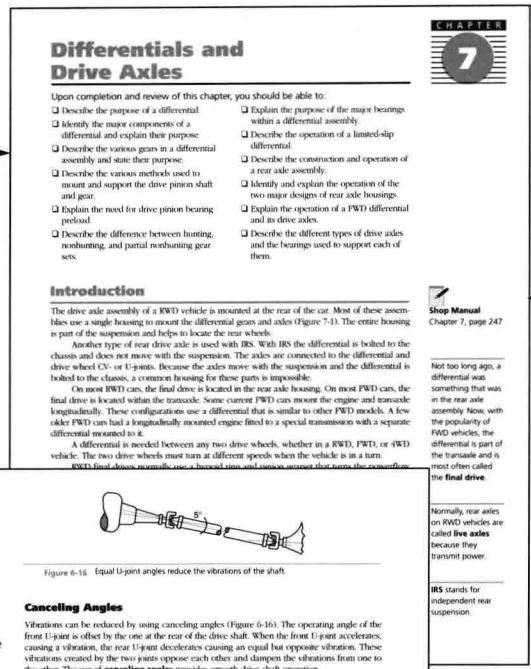
Jack Erjavec

Classroom Manual

To stress the importance of safe work habits, the Classroom Manual dedicates one full chapter to safety. Included in this chapter are common safety practices, safety equipment, and safe handling of hazardous materials and wastes. This includes information on MSDS sheets and OSHA regulations. Other features of this manual include:

Cognitive Objectives

These objectives define the contents of the chapter and define what the student should have learned upon completion of the chapter.
Each topic is divided into small units to promote easier understanding and learning.



CHAPTER 7

Differentials and Drive Axles

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

- ❑ Describe the purpose of a differential.
- ❑ Identify the major components of a differential and explain their purpose.
- ❑ Describe the various gears in a differential assembly and state their purpose.
- ❑ Describe the various methods used to mount and support the drive pinion shaft and gear.
- ❑ Explain the need for drive pinion bearing preload.
- ❑ Describe the difference between hunting, nonhunting, and partial nonhunting gear sets.
- ❑ Explain the purpose of the major bearings within a differential assembly.
- ❑ Describe the operation of a limited-slip differential.
- ❑ Describe the construction and operation of a rear axle assembly.
- ❑ Identify and explain the operation of the two major designs of rear axle housings.
- ❑ Explain the operation of a FWD differential and its drive axles.
- ❑ Describe the different types of drive axles and the bearings used to support each of them.

Introduction

The drive axle assembly of a RWD vehicle is mounted at the rear of the car. Most of these assemblies use a single housing to mount the differential gears and axles (Figure 7-1). The entire housing is part of the suspension and helps to locate the rear wheels.

Another type of rear drive axle is used with IRS. With IRS the differential is bolted to the chassis and does not move with the suspension. The axles are connected to the differential and drive wheel CV- or U-joints. Because the axles move with the suspension and the differential is bolted to the chassis, a common housing for these parts is impossible.

On most RWD cars, the final drive is located in the rear axle housing. On most FWD cars, the final drive is located within the transaxle. Some current FWD cars mount the engine and transaxle longitudinally. These configurations use a differential that is similar to other FWD models. A few older FWD cars had a longitudinally mounted engine fitted to a special transmission with a separate differential mounted to it.

A differential is needed between any two drive wheels, whether in a RWD, FWD, or 4WD vehicle. The two drive wheels must turn at different speeds when the vehicle is in a turn.

Shop Manual Chapter 7, page 247

Not too long ago, a differential was something that was in the rear axle assembly. Now, with the popularity of FWD vehicles, the differential is part of the transaxle and is most often called the **final drive**.

Normally, rear axles on RWD vehicles are called **live axles** because they transmit power.

IRS stands for independent rear suspension.

References to the Shop Manual

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

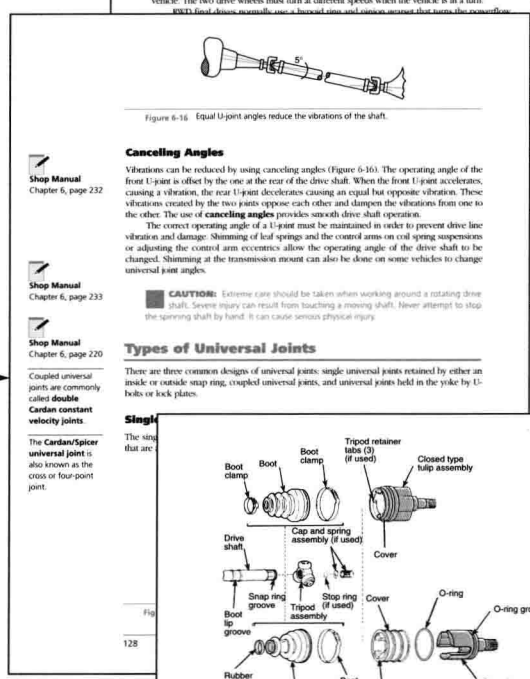


Figure 6-16 Equal U-joint angles reduce the vibrations of the shaft.

Canceling Angles

Vibrations can be reduced by using canceling angles (Figure 6-16). The operating angle of the front U-joint is offset by the one at the rear of the drive shaft. When the front U-joint accelerates, causing a vibration, the rear U-joint decelerates causing an equal but opposite vibration. These vibrations created by the two joints oppose each other and dampen the vibrations from one to the other. The use of **canceling angles** provides smooth drive shaft operation.

The correct operating angle of a U-joint must be maintained in order to prevent drive line vibration and damage. Shimming of leaf springs and the control arms on coil spring suspensions or adjusting the control arm eccentrics allow the operating angle of the drive shaft to be changed. Shimming at the transmission mount can also be done on some vehicles to change universal joint angles.

CAUTION: Extreme care should be taken when working around a rotating drive shaft. Severe injury can result from touching a moving shaft. Never attempt to stop the spinning shaft by hand. It can cause serious physical injury.

Shop Manual Chapter 6, page 232

Shop Manual Chapter 6, page 233

Shop Manual Chapter 6, page 220

Types of Universal Joints

There are three common designs of universal joints: single universal joints retained by either an inside or outside snap ring, coupled universal joints, and universal joints held in the yoke by U-bolts or lock plates.

Coupled universal joints are commonly called **double Cardan constant velocity joints**.

The **Cardan/Spicer universal joint** is also known as the cross or four-point joint.

Marginal Notes

New terms are pulled out and defined. Common trade jargon also appears in the margin and gives some of the common terms used for components. This allows the reader to speak and understand the language of the trade, especially when conversing with an experienced technician.

Cautions and Warnings

Throughout the text, cautions are given to alert the reader to potentially hazardous materials or unsafe conditions. Warnings are also given to advise the student of things that can go wrong if instructions are not followed or if a nonacceptable part or tool is used.

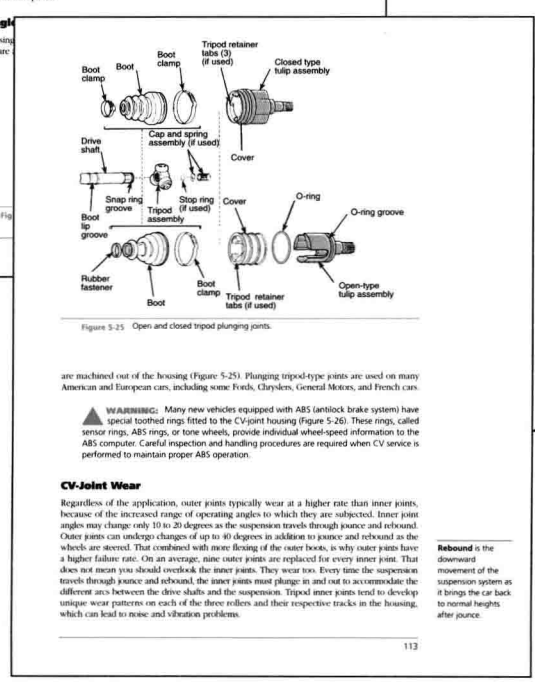


Figure 5-25 Open and closed tripod plunging joints.

are machined out of the housing (Figure 5-25). Plunging tripod-type joints are used on many American and European cars, including some Fords, Chryslers, General Motors, and French cars.

WARNING: Many new vehicles equipped with ABS (antilock brake system) have special toothed rings fitted to the CV-joint housing (Figure 5-26). These rings, called sensor rings, ABS rings, or tone wheels, provide individual wheel-speed information to the ABS computer. Careful inspection and handling procedures are required when CV service is performed to maintain proper ABS operation.

CV-Joint Wear

Regardless of the application, outer joints typically wear at a higher rate than inner joints, because of the increased range of operating angles to which they are subjected. Inner joint angles may change only 10 to 20 degrees as the suspension travels through jounce and rebound. Outer joints can undergo changes of up to 40 degrees in addition to jounce and rebound as the wheels are steered. That combined with more flexing of the outer boots, is why outer joints have a higher failure rate. On an average, nine outer joints are replaced for every inner joint. That does not mean you should overlook the inner joints. They wear too. Every time the suspension travels through jounce and rebound, the inner joints must plunge in and out to accommodate the different arcs between the drive shafts and the suspension. Tripod inner joints tend to develop unique wear patterns on each of the three rollers and their respective tracks in the housing, which can lead to noise and vibration problems.

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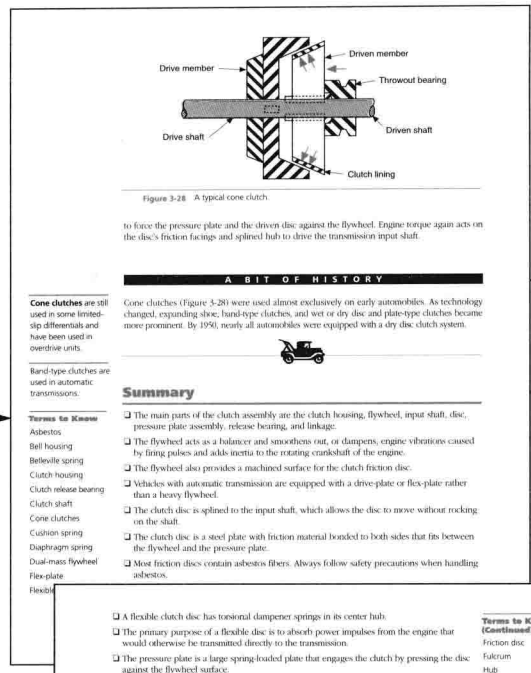
Rebound is the downward movement of the suspension system as it brings the car back to normal heights after jounce.



Terms to Know

A list of new terms appears next to the Summary. Definitions for these terms can be found in the Glossary at the end of the manual.

Review Questions

Short answer essay, fill-in-the-blank, and multiple-choice type questions follow each chapter. These questions are designed to accurately assess the student's competence in the stated objectives at the beginning of the chapter.

The J1930 List of Terminology

Located in the appendix, this list serves as a reference to the acceptable industry terms as defined by SAE.

A Bit of History

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

Summaries

Each chapter concludes with summary statements that contain the important topics of the chapter. These are designed to help the reader review the contents.

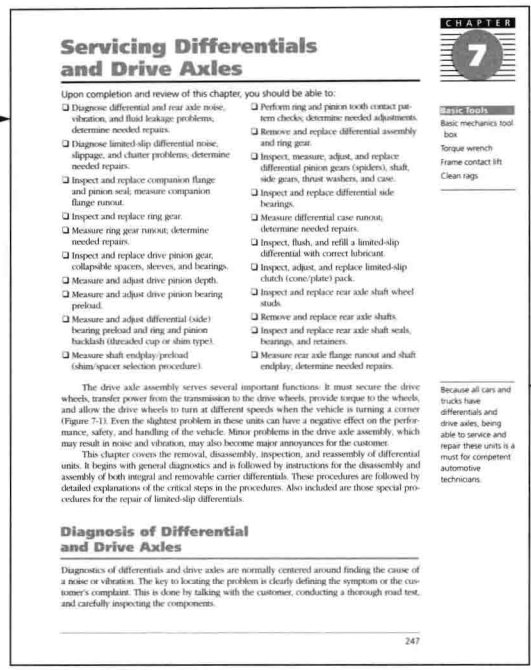
Shop Manual

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

Performance Objectives

These objectives define the contents of the chapter and define what the student should have learned upon completion of the chapter. These objectives also correspond with the list of required tasks for ASE certification. *Each ASE task is addressed.*

Although this textbook is not designed to simply prepare someone for the certification exams, it is organized around the ASE task list. These tasks are defined generically when the procedure is commonly followed and specifically when the procedure is unique for specific vehicle models. Imported and domestic model automobiles and light trucks are included in the procedures.



CHAPTER 7

Servicing Differentials and Drive Axles

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

- ❑ Diagnose differential and rear axle noise, vibration, and fluid leakage problems; determine needed repairs.
- ❑ Diagnose limited-slip differential noise, slippage, and chatter problems; determine needed repairs.
- ❑ Inspect and replace companion flange and pinion seal; measure companion flange runout.
- ❑ Inspect and replace ring gear.
- ❑ Measure ring gear runout; determine needed repairs.
- ❑ Inspect and replace drive pinion gear, collapsible spacers, sleeves, and bearings.
- ❑ Measure and adjust drive pinion depth.
- ❑ Measure and adjust drive pinion bearing preload.
- ❑ Measure and adjust differential (side) bearing preload and ring and pinion backlash (threaded cup or shim type).
- ❑ Measure shaft endplay/preload (shim/spacer selection procedure).
- ❑ Perform ring and pinion tooth contact pattern checks; determine needed adjustments.
- ❑ Remove and replace differential assembly and ring gear.
- ❑ Inspect, measure, adjust, and replace differential pinion gears (spiders), shaft, side gears, thrust washers, and case.
- ❑ Inspect and replace differential side bearings.
- ❑ Measure differential case runout; determine needed repairs.
- ❑ Inspect, flush, and refill a limited-slip differential with correct lubricant.
- ❑ Inspect, adjust, and replace limited-slip clutch (cone/plate) pack.
- ❑ Inspect and replace rear axle shaft wheel studs.
- ❑ Remove and replace rear axle shafts.
- ❑ Inspect and replace rear axle shaft seals, bearings, and retainers.
- ❑ Measure rear axle flange runout and shaft endplay; determine needed repairs.

Basic Tools
Basic mechanics tool box
Torque wrench
Frame contact lift
Clean rags

The drive axle assembly serves several important functions. It must secure the drive wheels, transfer power from the transmission to the drive wheels, provide torque to the wheels, and allow the drive wheels to turn at different speeds when the vehicle is turning a corner (Figure 7-1). Even the slightest problem in these units can have a negative effect on the performance, safety, and handling of the vehicle. Minor problems in the drive axle assembly, which may result in noise and vibration, may also become major annoyances for the customer.

This chapter covers the removal, disassembly, inspection, and reassembly of differential units. It begins with general diagnostics and is followed by instructions for the disassembly and assembly of both integral and removable carrier differentials. These procedures are followed by detailed explanations of the critical steps in the procedures. Also included are those special procedures for the repair of limited-slip differentials.

Because all cars and trucks have differentials and drive axles, being able to service and repair these units is a must for competent automotive technicians.

Diagnosis of Differential and Drive Axles

Diagnostics of differentials and drive axles are normally centered around finding the cause of a noise or vibration. The key to locating the problem is clearly defining the symptom or the customer's complaint. This is done by talking with the customer, conducting a thorough road test, and carefully inspecting the components.

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Tools Lists

Each chapter begins with a list of the Basic Tools needed to perform the tasks included in the chapter. Whenever a Special Tool is required to complete a task, it is listed in the margin next to the procedure.

Marginal Notes

Page numbers for cross-referencing appear in the margin. Some of the common terms used for components, and other bits of information, also appear in the margin. This provides an understanding of the language of the trade and helps when conversing with an experienced technician.

Photo Sequences

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

Photo Sequence 10

Removing and Replacing a FWD Ford Front Wheel Bearing

P10-1 Loosen the wheel nuts.

P10-2 Loosen the hub nuts.

P10-3 Jack up the vehicle and remove the tire and wheel assembly.

P10-4 Unbolt the front brake caliper.

P10-5 Suspend the caliper with wire.

P10-6 Remove rotor.

P10-7 Separate the lower ball joint and tie rod end from the knuckle.

P10-8 Index the camber eccentric bolt to ensure proper camber adjustment during reassembly.

P10-9 Remove the knuckle-to-strut bolts.

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Customer Care

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

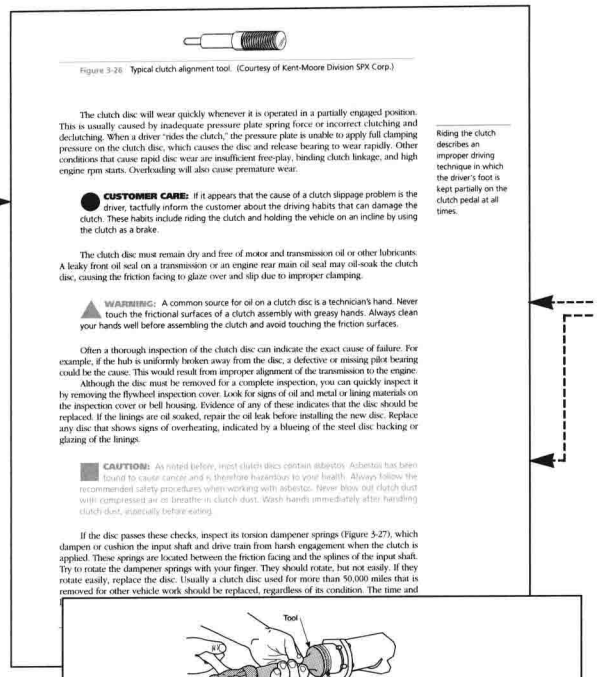

Figure 3-26 Typical clutch alignment tool. (Courtesy of Kent-Moore Division SPX Corp.)

The clutch disc will wear quickly whenever it is operated in a partially engaged position. This is usually caused by inadequate pressure plate spring force or incorrect clutching and declutching. When a driver "rides the clutch," the pressure plate is unable to apply full clamping pressure on the clutch disc, which causes the disc and release bearing to wear rapidly. Other conditions that cause rapid disc wear are insufficient free-play, binding clutch linkage, and high engine rpm starts. Overloading will also cause premature wear.

Riding the clutch describes an improper driving technique in which the driver's foot is kept partially on the clutch pedal at all times.

CUSTOMER CARE: If it appears that the cause of a clutch slippage problem is the driver, tactfully inform the customer about the driving habits that can damage the clutch. These habits include riding the clutch and holding the vehicle on an incline by using the clutch as a brake.

The clutch disc must remain dry and free of motor and transmission oil or other lubricants. A leaky front oil seal on a transmission or an engine rear main oil seal may oil-soak the clutch disc, causing the friction facing to glaze over and slip due to improper clamping.

WARNING: A common source for oil on a clutch disc is a technician's hand. Never touch the frictional surfaces of a clutch assembly with greasy hands. Always clean your hands well before assembling the clutch and avoid touching the friction surfaces.

Often a thorough inspection of the clutch disc can indicate the exact cause of failure. For example, if the hub is uniformly broken away from the disc, a defective or missing pilot bearing could be the cause. This would result from improper alignment of the transmission to the engine.

Although the disc must be removed for a complete inspection, you can quickly inspect it by removing the flywheel inspection cover. Look for signs of oil and metal or lining materials on the inspection cover or bell housing. Evidence of any of these indicates that the disc should be replaced. If the linings are oil soaked, repair the oil leak before installing the new disc. Replace any disc that shows signs of overheating, indicated by a blueing of the steel disc backing or glazing of the linings.

CAUTION: As noted before, most clutch discs contain asbestos. Asbestos has been found to cause cancer and is therefore hazardous to your health. Always follow the recommended safety procedures when working with asbestos. Never blow out clutch dust with compressed air or breathe in clutch dust. Wash hands immediately after handling clutch dust, especially before eating.

If the disc passes these checks, inspect its torsion dampener springs (Figure 3-27), which dampen or cushion the input shaft and drive train from harsh engagement when the clutch is applied. These springs are located between the friction facing and the splines of the input shaft. Try to rotate the dampener springs with your finger. They should rotate, but not easily. If they rotate easily, replace the disc. Usually a clutch disc used for more than 50,000 miles that is removed for other vehicle work should be replaced, regardless of its condition. The time and

Cautions and Warnings

Throughout the text, cautions are given to alert the reader to potentially hazardous materials or unsafe conditions. Warnings are also given to advise the student of things that can go wrong if instructions are not followed or if a nonacceptable part or tool is used.

Figure 7-79 Installing an axle seal. (Courtesy of Chrysler Corporation)

Service Tips

Whenever a short-cut or special procedure is appropriate, it is described in the text. These tips are generally those things commonly done by experienced technicians.

SERVICE TIP: Take extra care not to damage the new seal when reinstalling the axle shaft. It is helpful to support the entire length of the axle and keep it level while inserting it into the axle tube.

Installing Axles

In most cases, the installation of axle shafts is a simple procedure. Prior to installing the shafts, make sure you installed all of the bearings, seals, and retaining plates on the shaft.

Some tapered-roller bearing equipped axles require an endplay adjustment after installation. This adjustment is made by an adjusting nut or by selective shims. The shims are normally positioned between the retainer plate and the axle housing. The adjusting nut threads into the axle retainer plate.

To check the endplay, position the dial indicator so it is able to measure the end-to-end movement of the axle. Push the axle into the housing and set the indicator to zero. Then, pull the axle out and note the reading on the indicator. This reading is the amount of endplay in the shaft. Compare the reading against specifications and correct the endplay as necessary.

Endplay adjustments are made by adding or subtracting shims or by turning the adjusting nut. This adjustment is done on one side of the housing but sets the endplay for both sides.

References to the Classroom Manual

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

Classroom Manual
Chapter 7, page 167

CASE STUDY

A customer brings her car in the shop complaining of an abnormal noise coming from the rear of the car. The service writer asks the customer the usual questions: When did it start? When does it make the noise? How often is the noise noticeable? The customer answers the questions and notes that the noise seems to have grown louder in recent weeks. She is not sure about when the noise was first noticed. She tells the service writer that the noise seems to be loudest when the car is moving at slow speeds.

The service writer notes the mileage of the car and checks its service record. According to the records, no major work has been performed on the car and it seems to have been maintained well.

Case Studies

Case Studies concentrate on the ability to properly diagnose the systems. Each chapter ends with a case study in which a vehicle has a problem, and the logic used by a technician to solve the problem is explained.

Job Sheets

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

Job Sheet 17

17

Name _____ Date _____

Identifying Types of CV-joints on the Axle

Upon completion of this worksheet, you will have demonstrated the ability to identify CV-joints.

ASE Correlation

This job sheet is related to the ASE Manual Drive Train and Axles Test's content area: *Drive (Half) Shaft and Universal Joint Diagnosis and Repair (Front and Rear Wheel Drive)*, Task: *Inspect, service and replace shaft, yokes, boots, and Universal/CV joints.*

Equipment Needed

A vehicle
A hoist or jack and safety stands
A creeper if you don't have a hoist

Procedure

1. Lift the vehicle and turn the vehicle's wheels so you can inspect them.
2. Turn the wheels and watch for broken boots. Do you see any grease working out of any place? ☐ Yes ☐ No
3. Identify the inner and outer CV-joints on the driver's side.
4. Identify the inner and outer CV-joints on the passenger's side.
5. List the name of each kind.

_____
_____
_____
_____
_____
_____
_____

Instructor Check _____

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Terms to Know

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

ASE Style Review Questions

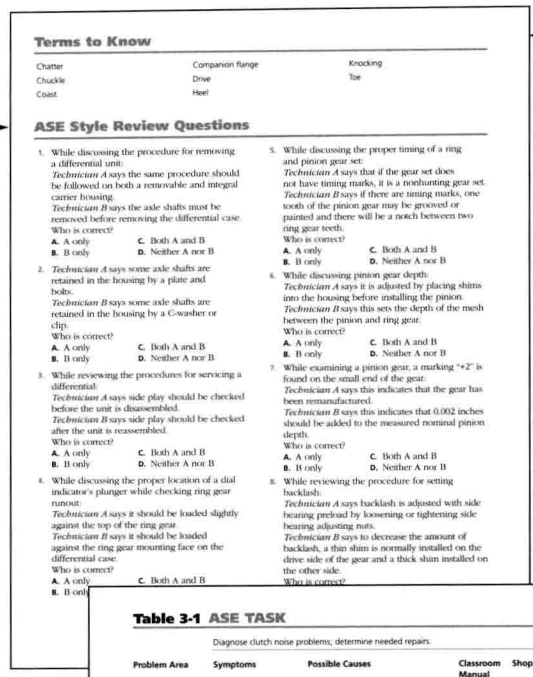
Each chapter contains ASE style review questions that reflect the performance objectives listed at the beginning of the chapter. These questions can be used to review the chapter as well as to prepare for the ASE certification exam.

Diagnostic Chart

Chapters include detailed diagnostic charts linked with the appropriate ASE task. These charts list common problems and most probable causes. They also list a page reference in the Classroom Manual for better understanding of the system's operation and a page reference in the Shop Manual for details on the procedure necessary for correcting the problem.

ASE Practice Examination

A 50 question ASE practice exam, located in the appendix, is included to test students on the content of the complete Shop Manual.



Terms to Know

Chatter
Chuckle
Coast
Companion flange
Drive
Heel
Knocking
Toe

ASE Style Review Questions

1. While discussing the procedure for removing a differential unit:
Technician A says the same procedure should be followed on both a removable and integral carrier housing.
Technician B says the axle shafts must be removed before removing the differential case.
Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

2. *Technician A* says some axle shafts are retained in the housing by a plate and bolts.
Technician B says some axle shafts are retained in the housing by a C-washer or clip.
Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

3. While reviewing the procedures for servicing a differential:
Technician A says side play should be checked before the unit is disassembled.
Technician B says side play should be checked after the unit is reassembled.
Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

4. While discussing the proper location of a dial indicator's plunger while checking ring gear runout:
Technician A says it should be loaded slightly against the top of the ring gear.
Technician B says it should be loaded against the ring gear mounting face on the differential case.
Who is correct?
A. A only C. Both A and B
B. B only

5. While discussing the proper timing of a ring and pinion gear set:
Technician A says that if the gear set does not have timing marks, it is a nonhunting gear set.
Technician B says if there are timing marks, one tooth of the pinion gear may be grooved or painted and there will be a notch between two ring gear teeth.
Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

6. While discussing pinion gear depth:
Technician A says it is adjusted by placing shims into the housing before installing the pinion.
Technician B says this sets the depth of the mesh between the pinion and ring gear.
Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

7. While examining a pinion gear, a marking "+2" is found on the small end of the gear.
Technician A says this indicates that the gear has been remanufactured.
Technician B says this indicates that 0.002 inches should be added to the measured nominal pinion depth.
Who is correct?
A. A only C. Both A and B
B. B only D. Neither A nor B

8. While reviewing the procedure for setting backlash:
Technician A says backlash is adjusted with side bearing preload by loosening or tightening side bearing adjusting nuts.
Technician B says to decrease the amount of backlash, a thin shim is normally installed on the drive side of the gear and a thick shim installed on the other side.
Who is correct?

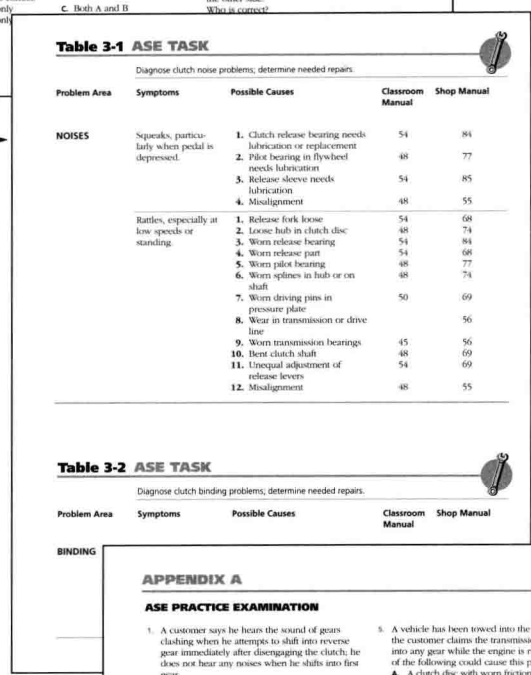


Table 3-1 ASE TASK

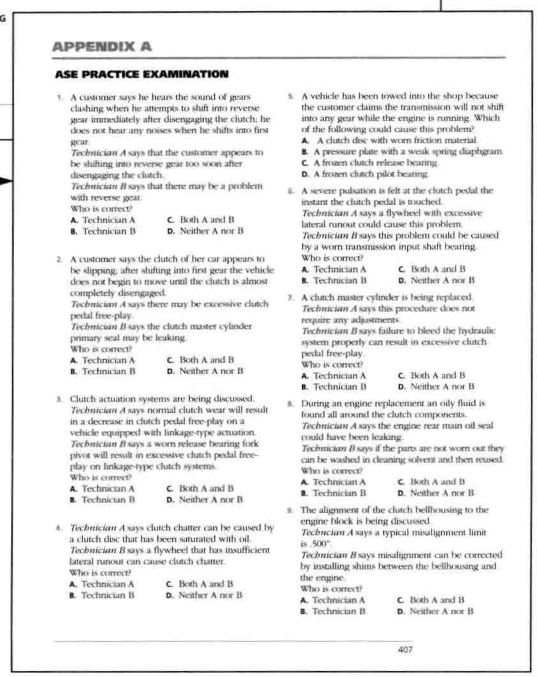
Diagnose clutch noise problems; determine needed repairs.

Problem Area	Symptoms	Possible Causes	Classroom Manual	Shop Manual
NOISES	Squeaks, particularly when pedal is depressed.	1. Clutch release bearing needs lubrication or replacement	54	84
		2. Pilot bearing in flywheel needs lubrication	48	77
		3. Release sleeve needs lubrication	54	85
		4. Misalignment	48	55
	Rattles, especially at low speeds or standing.	1. Release fork loose	54	68
		2. Loose hub in clutch disc	48	74
		3. Worn release bearing	54	84
		4. Worn release part	54	68
		5. Worn pilot bearing	48	77
		6. Worn splines in hub or on shaft	48	74
		7. Worn driving pins in pressure plate	50	69
		8. Wear in transmission or drive line		56
		9. Worn transmission bearings	45	56
		10. Bent clutch shaft	48	69
		11. Unequal adjustment of release levers	54	69
		12. Misalignment	48	55

Table 3-2 ASE TASK

Diagnose clutch binding problems; determine needed repairs.

Problem Area	Symptoms	Possible Causes	Classroom Manual	Shop Manual
BINDING				



APPENDIX A

ASE PRACTICE EXAMINATION

1. A customer says he hears the sound of gears clashing when he attempts to shift into reverse gear immediately after disengaging the clutch; he does not hear any noises when he shifts into first gear.
Technician A says that the customer appears to be shifting into reverse gear too soon after disengaging the clutch.
Technician B says that there may be a problem with reverse gear.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

2. A customer says the clutch of her car appears to be slipping; after shifting into first gear the vehicle does not begin to move until the clutch is almost completely disengaged.
Technician A says there may be excessive clutch pedal free-play.
Technician B says the clutch master cylinder primary seal may be leaking.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

3. Clutch actuation systems are being discussed.
Technician A says normal clutch wear will result in a decrease in clutch pedal free-play on a vehicle equipped with linkage-type actuation.
Technician B says a worn release bearing fork pivot will result in excessive clutch pedal free-play on linkage-type clutch systems.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

4. *Technician A* says clutch chatter can be caused by a clutch disc that has been saturated with oil.
Technician B says a flywheel that has insufficient lateral runout can cause clutch chatter.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

5. A vehicle has been towed into the shop because the customer claims the transmission will not shift into any gear while the engine is running. Which of the following could cause this problem?
A. A clutch disc with worn friction material.
B. A pressure plate with a weak spring diaphgram.
C. A frozen clutch release bearing.
D. A frozen clutch pilot bearing.

6. A severe pulsation is felt at the clutch pedal the instant the clutch pedal is touched.
Technician A says a flywheel with excessive lateral runout could cause this problem.
Technician B says this problem could be caused by a worn transmission input shaft bearing.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

7. A clutch master cylinder is being replaced.
Technician A says this procedure does not require any adjustments.
Technician B says failure to bleed the hydraulic system properly can result in excessive clutch pedal free-play.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

8. During an engine replacement an oily fluid is found all around the clutch components.
Technician A says the engine rear main oil seal could have been leaking.
Technician B says if the parts are not worn out they can be washed in cleaning solvent and then reused.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

9. The alignment of the clutch bellhousing to the engine block is being discussed.
Technician A says a typical misalignment limit is .500".
Technician B says misalignment can be corrected by installing shims between the bellhousing and the engine.
Who is correct?
A. Technician A C. Both A and B
B. Technician B D. Neither A nor B

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Reviewers

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Joseph Belleto
Jefferson Technical Institute
Metairie, LA

Ronnie Bush
Tennessee Technology Center
at Jackson
Jackson, TN

Jon Nelson
El Paso Community College
El Paso, TX

Ralph Papsidero
New River Community College
Dublin, VA

John Pfingstag
Universal Technical Institute
Phoenix, Az

John V. Pica
New England Tech
West Palm Beach, FL

Jim Pinto
Porter and Chester Institute
Wethersfield, CT

Danny Rakes
Danville Community College
Danville, VA

John Sarubbo
Westchester Community College
Valhalla, NY

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The Timken Company
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CONTENTS

CHAPTER 1

Safety

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

- ❑ Explain how safety practices are part of professional behavior.
- ❑ Dress safely and professionally.
- ❑ Recognize fire hazards.
- ❑ Inspect equipment and tools for unsafe conditions.
- ❑ Properly work around batteries.
- ❑ Explain the procedures for responding to an accident.
- ❑ Identify substances that could be regarded as hazardous materials.

Safety is everyone's job. You should work safely to protect yourself and the people around you. Perhaps the best single safety rule is "Think before you act." Too often people working in shops gamble by working in an unsafe way. Often they gamble and win and no one gets hurt, but it takes only one accident to lose all those past winnings. The gamble may save five minutes, but cost you an eye or a hand. By acting first and thinking last, you can ruin your back and lose your career. Accidents in a shop can be prevented by others and by YOU. Safe work habits also prevent damage to the vehicles and equipment in the shop.

It has been said that 50% of all shop accidents could have been prevented by a single individual, the technician.

Personal Safety

When you have neat work habits, you display a professional attitude. Actually, neat habits are also safe habits. Cleaning up spills and keeping equipment and tools out of the path of others prevents accidents. This is only common sense, but too often, time is not taken to remove these safety hazards. It is the rush to complete a job that usually results in unsafe conditions. True professionals take time to clean their tools and work areas. A professional does a better job, makes more money, and has fewer accidents than others who don't take the time to be neat and safe.

With a professional attitude, you do not clown around in the shop, you do not throw items in the shop, and you do not create an unsafe condition for the sake of saving time. Instead, a professional saves time by effective diagnostics and proper procedures. Professionals also take pride in their work, treat customers and their vehicles with respect, and try to stay current with all technical, safety, and environmental concerns.

Shop Manual
Chapter 1, page 2

An accident is something that happens unintentionally and is a consequence of doing something else.

Dress and Appearance

How you dress and appear to others says something about your personality and your attitude, including your attitude about safety. Clothing that hangs out freely, such as shirttails, can create a safety hazard and cause serious injury. Nothing you wear should be allowed to dangle in the engine compartment or around equipment. Long hair should be tied up or tucked under a hat. Shirts should be tucked in and buttoned and long sleeves buttoned or carefully rolled up (Figure 1-1).

Rotating Pulleys and Belts

Be very careful around belts, pulleys, wheels, chains, or any other rotating mechanism. Be especially careful while leaning against a belt or pulley when it's not moving. Make sure no one accidentally activates the machine. When working around an engine's drive belts and pulleys, make sure your hands, shop towels, or loose clothing do not come in contact with the moving parts. It may not seem that these parts are rotating or traveling at high rates of speed, but they are. Hands and fingers can be quickly pulled into a revolving belt or pulley even at engine idle speeds.

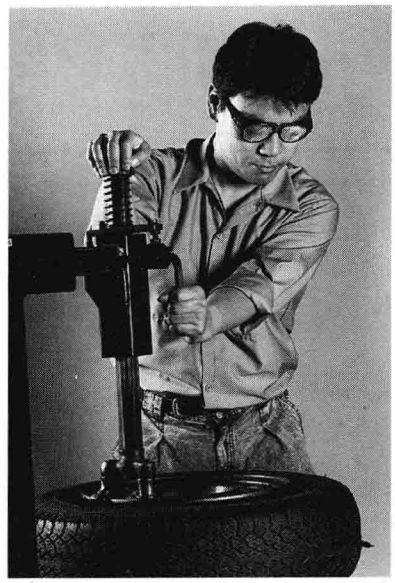

Figure 1-1 Proper dress prevents injuries.

The thermostatic switch for the electric cooling fans may be disconnected to prevent the fan from coming on.

CAUTION: Be careful when working around electric engine cooling fans. These fans are controlled by a thermostat and can come on without warning, even when the engine is not running. Whenever you must work around these fans, disconnect the electrical connector to the fan motor before reaching into the area around the fan.

Jewelry

An electrical short is basically an alternative path for the flow of electricity.

Rings, necklaces, bracelets, and watches should not be worn while working. A ring can rip your finger off, a watch or bracelet can cut your wrist, and a necklace can choke you. This is especially true when working with or around electrical wires. The metal used to make jewelry conducts electricity very well and can easily cause a short, through you, if it touches a bare wire.

Foot Protection

The **shank** of a shoe is that portion of the shoe that protects the ball of your foot.

You should also protect your feet. Tennis and jogging shoes will provide little protection if something falls on your foot. Boots or shoes made of leather, or a material that approaches the strength of leather, offer much better protection from falling objects. There are many designs of safety shoes and boots made of leather or similar material with steel plates built into the toe and shank to protect your feet. Many also have soles that are designed to resist slipping on wet surfaces. Foot injuries are not only quite painful but can also put you out of work for some time.

Keep your clothing clean. If you spill gasoline or oil on yourself, change that item of clothing immediately. Oil against your skin for a prolonged period of time can produce rashes or other allergic reactions. Gasoline can irritate cuts and sores. As well as being bad for your health, greasy uniforms do not look professional.

Safety Glasses

Brake fluid is not only used in brake systems but is also commonly used as the hydraulic fluid for hydraulic clutch assemblies.

You should wear some sort of eye protection whenever and wherever there is a possibility of dirt or metal particles flowing in the air (Figure 1-2). Dirt, grease, or rust can get into your eyes and cause serious damage. Safety glasses or goggles should be worn when you are working under a vehicle and when you are using any machining equipment, grinding wheels, chemicals, compressed air, or fuels. Chemicals, such as brake fluid, can cause serious eye irritations, which can

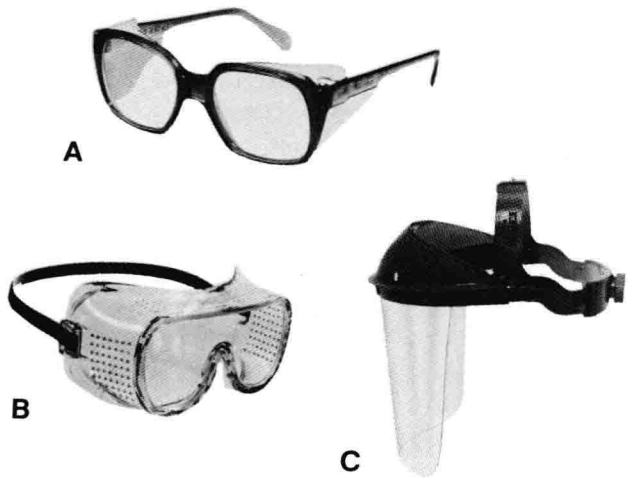

Figure 1-2 Different types of eye protection worn by automotive technicians: (A) safety glasses; (B) goggles; and (C) face shield. (Courtesy of Goodson Shop Supplies)

lead to blindness. The lenses of safety glasses should be made of tempered glass or safety plastic. Common sense should tell you to wear safety glasses nearly all of the time you are working in the shop. Some schools and repair shops require that you do.

Hand Protection

Good hand protection is often overlooked. A scrape, cut, or burn can seriously impair your ability to work for many days. A well-fitting pair of heavy work gloves should be worn while grinding, welding, or when handling chemicals or high temperature components. Special rubber gloves are recommended for handling caustic chemicals.

A **caustic** material has the ability to destroy or eat through something. Caustic materials are considered extremely corrosive.

Fire Hazards and Prevention

There are many items around a typical shop that pose a fire hazard. These include gasoline, diesel fuel, cleaning solvents, and dirty rags. Each of these should be treated as potential fire bombs.

Gasoline

Gasoline is present in shops so often that its dangers are often forgotten. A slight spark or an increase in heat can cause a fire or explosion. Gasoline fumes are heavier than air. Therefore when an open container of gasoline is sitting about, the fumes spill out over the sides of the container onto the floor. These fumes are more flammable than liquid gasoline and can easily explode.

CAUTION: Never siphon gasoline or diesel fuel with your mouth. These liquids are poisonous and can make you sick or fatally ill.

Never smoke around gasoline or in a shop filled with gasoline fumes because even the droppings of hot ashes can ignite the gasoline. If the engine has a gasoline leak or you have caused a leak by disconnecting a fuel line, wipe it up immediately and stop the leak. While stopping the leak, be extra careful not to cause any sparks. Make sure that any grinding or welding that may be taking place in the area is stopped until the spill is totally cleaned up and the floor has been flushed with water. The rags used to wipe up the gasoline should be taken outside to

dry. Immediately wipe up any gasoline that has spilled on the floor. If vapors are present in the shop, have the doors open and the ventilating system turned on to get rid of those fumes. Remember, it takes only a small amount of fuel mixed with air to cause combustion.

Gasoline should always be stored in approved containers and never in a glass bottle or jar. If the glass jar was knocked over or dropped, a terrible explosion could take place. Never use gasoline to clean parts. Never pour gasoline into a carburetor air horn to start the car. Repair any fuel leak immediately.

Diesel Fuel

The **volatility** of a substance is a statement of how easily the substance vaporizes or explodes.

Diesel fuel is not as volatile as gasoline, but it should be stored and handled in the same manner as gasoline. It is also not as refined as gasoline and tends to be a very dirty fuel. It normally contains many impurities, including active microscopic organisms that can be highly infectious. If diesel fuel happens to get on an open cut or sore, thoroughly wash it immediately. If it gets into your eyes, flush them with water immediately and get medical help.

Solvents

The **flammability** of a substance is a statement of how well the substance supports combustion.

Cleaning solvents are not as volatile as gasoline, but they are still flammable. They should be stored and treated in the same way as gasoline (Figure 1-3).

Figure 1-3 Combustible materials should be stored in approved safety containers and cabinets. (Courtesy of Justrite Manufacturing Company)

Rags

A **hydrocarbon** is a substance composed of hydrogen and carbon molecules.

Oily or greasy rags can also be a source for fires. These rags should be stored in an approved container and never thrown out with normal trash. Like gasoline, oil is a hydrocarbon and can ignite with or without a spark or flame.

Safe Tools and Equipment

When you work with any equipment, make sure you use it properly and that it is set up according to the manufacturer's instructions. All equipment should be properly maintained and periodically