

AUTOMOTIVE TECHNOLOGY

Principles, Diagnosis, and Service

Fifth Edition



JAMES D. HALDERMAN

AUTOMOTIVE TECHNOLOGY

Principles, Diagnosis, and Service

FIFTH EDITION

James D. Halderman

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PREFACE

UPDATES TO THE FIFTH EDITION

- All content has been updated throughout and correlated to the latest NATEF and ASE tasks.
- All of the page numbers are the same as the last edition making it easier for instructors to keep their assignments and lesson plans the same.
- Over one hundred all new full color photos and line drawings have been added to this edition.
- Evacuation routes and infection control precautions added to Chapter 6.
- Stop/start systems operation added to Chapter 52.
- R-1234yf refrigerant information added to Chapter 62.
- Content covering the Chrysler/Fiat Multi-air system added to Chapter 81.
- Permanent diagnostic trouble code information added to Chapter 88.
- Electric vehicles (EV) and plug-in hybrid electric vehicles (PHEV) content added to Chapter 91.
- D3EA and BEEP aftermarket brake standards content added to Chapter 101.
- Carbon-ceramic brake (CCB) rotor information added to Chapter 104.
- Inductive heating tool operation and usage added to Chapter 117.
- Pull-type release bearing content added to Chapter 121.
- End play/preload checks added to Chapter 122.
- New content on pin and rocker-type (rocker joint-type) chains added to Chapter 126.
- Checking fluid level without a dipstick information was added to Chapter 129.
- Unlike other textbooks, this book is written so that the theory, construction, diagnosis, and service of a particular component or system is presented in one location. There is no need to search through the entire book for other references to the same topic.

ASE AND NATEF CORRELATED This comprehensive textbook is divided into sections that correspond to the eight areas of certifications as specified by the National Institute for Automotive Service Excellence (ASE) and the National Automotive Technicians Education Foundation (NATEF). The areas of the ASE material certification test are listed in the objectives at the beginning of each chapter, and all laboratory worksheets are correlated to the NATEF Task List.

A COMPLETE INSTRUCTOR AND STUDENT SUPPLEMENT PACKAGE This book is accompanied by a full set of instructor and student supplements. Please see page vi for a detailed list of supplements.

PERSONALIZE LEARNING WITH MyAutomotiveLab MyAutomotiveLab is an online homework, tutorial, and assessment program designed to work with Automotive Technology to engage students and improve results. We've improved MyAutomotiveLab to better reflect the way instructors teach today. Now organized by ASE area, the new, easier-to-use design makes creating and personalizing assignments more intuitive and includes a new assignment calendar, which helps you document your students' progress.

A FOCUS ON DIAGNOSIS AND PROBLEM SOLVING The primary focus of this textbook is to satisfy the need for problem diagnosis. Time and again, the author has heard that technicians need more training in diagnostic procedures and skill development. To meet this need and to help illustrate how real problems are solved, diagnostic stories are included throughout. Each new topic covers the parts involved as well as their purpose, function, and operation, and how to test and diagnose each system.

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

IN-TEXT FEATURES

Careers in the Automotive Service Area

SECTION I

1 Automotive Background and Overview
2 Careers in the Automotive Service Industry
3 Starting a Career in the Automotive Industry

4 Working as a Professional Service Technician
5 Technician Certification

chapter 1 **AUTOMOTIVE BACKGROUND AND OVERVIEW**

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

- Explain the evolution of the automobile.
- Discuss the major components of a vehicle.
- Describe the evolution of engines.
- List the common components of most vehicles.
- List the eight areas of automotive service according to ASE/NATEF.

KEY TERMS: Air filter 5 • Body 2 • Body-on-frame (BOF) 3 • Carbon monoxide (CO) 5 • Catalytic converter 5 • Chassis 2 • Coolant 5 • Drive shaft 5 • Double overhead camshaft (DOHC) 4 • Evaporative emission system (EVAP) 5 • Exhaust gas recirculation (EGR) 5 • Flathead 4 • Frames 3 • Hydrocarbon (HC) 5 • Ignition control module (ICM) 5 • Inline engine 4 • Intake manifold 5 • Internal combustion engine 4 • Malfunction indicator lamp (MIL) 5 • Manufacturer's suggested retail price (MSRP) 4 • OBD-II 5 • Oil filter 5 • Oil galleries 5 • Oil pan 5 • Oil pump 5 • Oil sump 5 • Overhead camshaft (OHC) 4 • Overhead valve (OHV) 5 • Oxides of nitrogen (NOx) 5 • PCV valve 5 • Piston 3 • Positive crankcase ventilation (PCV) 5 • Propeller shaft 5 • Radiator 5 • Scan tool 5 • Self-propelled vehicle 1 • Single overhead camshaft (SOHC) 4 • Thermostat 5 • Transaxle 6 • Transfer case 6 • Unibody 3 • Universal joints (U-joints) 5 • Water jackets 5 • Water pump 5

HISTORICAL BACKGROUND

For centuries, man either walked or used animals to provide power for transportation. After the invention of electric, steam, and gasoline propulsion systems, people used self-propelled vehicles, which are vehicles that moved under their own power.

Major milestones in vehicle development include:

1876	The OTTO four-stroke cycle engine was developed by a German engineer, Nicolas Otto.	1906	Henry Ford (1863–1947) built his first car, called the Quadricycle. SEE FIGURE 1-1.
1885	The first automobile was powered by an OTTO cycle gasoline engine designed by Karl Friedrich Benz (1844–1929).	1900	About 4,200 total automobiles were sold, including:
1892	Rudolf Diesel (1858–1913) received a patent for a compression ignition engine. The first diesel engine was built in 1897.	1902	• 40% were steam powered
		1908	• 38% were battery/electric powered
		1908	• 22% were gasoline engine powered
			Oldsmobile, founded by Ransom E. Olds (1864–1950), produced the first large-scale, affordable vehicle.
			William Durant (1861–1947) formed General Motors. The Ford Model T was introduced.

AUTOMOTIVE BACKGROUND AND OVERVIEW 1

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

TECH TIP

Right to Tighten

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

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

SAFETY TIP

Shop Cloth Disposal

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

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



REAL WORLD FIX

Lightning Damage

A radio failed to work in a vehicle that was outside during a thunderstorm. The technician checked the fuses and verified that power was reaching the radio. Then the technician noticed the antenna. It had been struck by lightning. Obviously, the high voltage from the lightning strike traveled to the radio receiver and damaged the circuits. Both the radio and the antenna were replaced to correct the problem. **SEE FIGURE 26–26.**

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



FREQUENTLY ASKED QUESTION

What Is an “SST?”

Vehicle manufacturers often specify a **special service tool (SST)** to properly disassemble and assemble components, such as transmissions and other components. These tools are also called special tools and are available from the vehicle manufacturer or their tool supplier, such as Kent-Moore and Miller tools.

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

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

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

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

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



WARNING

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

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

TRANSAXLE REMOVAL		STEP BY STEP	
 1. Put safety glasses on and have fire extinguisher handy when working on the vehicle's drivetrain.	 2. Remove engine support from the vehicle that may interfere with access to the transaxle's bellows.	 7. Disconnect the rear axle from the rear differential to allow removal of the drive shaft shaft.	 8. Remove the drive shaft from the transaxle using a puller.
 3. Remove the air filter and air filter housing, which is blocking the transaxle from access.	 4. Install a support for the engine.	 9. Disconnect the cable from the transaxle using a wrench.	 10. Disconnect the torque converter from the engine. Do not remove the transaxle mounts.
 5. Tidy the vehicle and remove the vehicle.	 6. Remove the mounting and both the drive shaft and pump.	 11. Store the transaxle supported on a V-block stand and remove the mounting with the aid of a puller.	 12. Carefully clean the transaxle from the vehicle.

1610 CHAPTER 130 AUTOMATIC TRANSMISSIONS/TRANSAXLES UNIT REVIEW 1611

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

REVIEW QUESTIONS

1. What are the typical operations needed when disassembling an automatic transmission/transaxle?
2. What are two methods of checking a clutch pack?
3. Why is it important to perform an end play check of an automatic transmission/transaxle during the reassembly process?
4. Why is it important to flush the automatic transmission fluid cooler when a rebuilt or replacement automatic transmission/transaxle is being installed in a vehicle?

CHAPTER QUIZ

1. Technician A says that the torque converter should be separated from the flex (drive) plate before removing the automatic transmission/transaxle. Technician B says that the clutches should be installed "dry" when replacing the frictions and steels in a clutch pack. Which technician is correct?
 - a. Technician A only
 - b. Technician B only
 - c. Both Technicians A and B
 - d. Neither Technician A nor B
2. Air pressure checking is used to test _____.
 - a. Clutch packs
 - b. TV adjustment
 - c. Vacuum modulators
 - d. Governors
3. Technician A says that all friction and steel plates in a clutch pack should be replaced during an overhaul. Technician B says that the automatic transmission fluid cooler should always be flushed when a unit is rebuilt or replaced. Which technician is correct?
 - a. Technician A only
 - b. Technician B only
 - c. Both Technicians A and B
 - d. Neither Technician A nor B
4. Slide hammers or special pullers are used to remove what component?
 - a. Extension housing
 - b. Filter
 - c. Pump
 - d. Rear seal
5. What part must be replaced if dropped?
 - a. Pump
 - b. Torque converter
 - c. Extension housing
 - d. Pan
6. Technician A says that the sharp edges of spool valves should be rounded, using 400 grit sandpaper. Technician B says that all valve body parts should be cleaned and then dried using low-pressure, filtered compressed air. Which technician is correct?
 - a. Technician A only
 - b. Technician B only
 - c. Both Technicians A and B
 - d. Neither Technician A nor B
7. Clutch pack clearance can be changed if not correct by using selective _____.
 - a. Piston
 - b. Pressure plate
 - c. Snap ring
 - d. One of the above depending on the unit
8. Friction discs should be _____ before being installed.
 - a. Sanded
 - b. Soaked in ATF
 - c. Surface roughed up
 - d. All of the above
9. How much transmission fluid should flow through the cooler?
 - a. 2 quarts every 30 seconds
 - b. 1 quart per minute
 - c. 2 quarts per minute
 - d. 2 pints per minute
10. Why should red assembly lube be avoided?
 - a. Can harm friction disks
 - b. Too slippery
 - c. Clogs filters
 - d. Looks like an ATF leak when it melts

1616 CHAPTER 130

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

SUPPLEMENTS

RESOURCES IN PRINT AND ONLINE *Automotive Technology*

NAME OF SUPPLEMENT	PRINT	ONLINE	AUDIENCE	DESCRIPTION
Instructor Resource Manual 0133995879		✓	Instructors	NEW! The Ultimate teaching aid: Chapter summaries, key terms, chapter learning objectives, and lecture resources.
TestGen 0134008073		✓	Instructors	Test generation software and test bank for the text.
PowerPoint Presentation 0133995623		✓	Instructors	Slides include a lecture outline of the text to help instructors with in class instruction.
Image Bank 0133995860		✓	Instructors	All of the images from the textbook to create customized slides.
NATEF Task Sheets – for instructors 0133995844		✓	Instructors	Downloadable NATEF task sheets for easy customization.
NATEF Task Sheets – For Students 0133995674	✓		Students	Study activity manual that correlates NATEF Automobile Standards to chapters and page numbers in the text.
CourseSmart eText 0133995682		✓	Students	An alternative to purchasing the print textbook, students can save up to 50% off the suggested list price of the print text. Visit www.coursesmart.com

All online resources can be downloaded from the Instructor's Resource Center: www.pearsonhighered.com/irc
Visit www.myautomotivelab.com for access to additional resources: online homework, tutorials, and assessments.

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—James D. Halderman

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BRIEF CONTENTS

SECTION I	Careers in the Automotive Service Area	1
chapter 1	Automotive Background and Overview	1
chapter 2	Careers in the Automotive Service Industry	8
chapter 3	Starting a Career in the Automotive Industry	16
chapter 4	Working as a Professional Service Technician	24
chapter 5	Technician Certification	34
SECTION II	Safety, Environmental, and Health Concerns	41
chapter 6	Shop Safety	41
chapter 7	Environmental and Hazardous Materials	48
SECTION III	Tools, Shop Equipment, and Measuring	57
chapter 8	Fasteners and Thread Repair	57
chapter 9	Hand Tools	68
chapter 10	Power Tools and Shop Equipment	82
chapter 11	Vehicle Lifting and Hoisting	91
chapter 12	Measuring Systems and Tools	97
SECTION IV	Principles, Math, and Calculations	105
chapter 13	Scientific Principles and Materials	105
chapter 14	Math, Charts, and Calculations	114
SECTION V	Vehicle Service Information, Identification, and Routine Maintenance	119
chapter 15	Service Information	119
chapter 16	Vehicle Identification and Emission Ratings	125
chapter 17	Preventative Maintenance and Service Procedures	130
SECTION VI	Engine Repair	146
chapter 18	Gasoline Engine Operation, Parts, and Specifications	146
chapter 19	Diesel Engine Operation and Diagnosis	158
chapter 20	Coolant	175
chapter 21	Cooling System Operation and Diagnosis	182
chapter 22	Engine Oil	198
chapter 23	Lubrication System Operation and Diagnosis	210
chapter 24	Intake and Exhaust Systems	219
chapter 25	Turbocharging and Supercharging	227
chapter 26	Engine Condition Diagnosis	237
chapter 27	In-Vehicle Engine Service	252
chapter 28	Engine Removal and Disassembly	261

chapter 29	Engine Cleaning and Crack Detection	272
chapter 30	Cylinder Head and Valve Guide Service	280
chapter 31	Valve and Seat Service	293
chapter 32	Camshafts and Valve Trains	314
chapter 33	Pistons, Rings, and Connecting Rods	336
chapter 34	Engine Blocks	351
chapter 35	Crankshafts, Balance Shafts, and Bearings	364
chapter 36	Gaskets and Sealants	381
chapter 37	Engine Assembly and Dynamometer Testing	388
chapter 38	Engine Installation and Break-in	415
SECTION VII	Electrical and Electronic Systems	420
chapter 39	Electrical Fundamentals	420
chapter 40	Electrical Circuits and Ohm's Law	428
chapter 41	Series, Parallel, and Series-Parallel Circuits	434
chapter 42	Circuit Testers and Digital Meters	444
chapter 43	Oscilloscopes and Graphing Multimeters	460
chapter 44	Automotive Wiring and Wire Repair	467
chapter 45	Wiring Schematics and Circuit Testing	479
chapter 46	Capacitance and Capacitors	493
chapter 47	Magnetism and Electromagnetism	498
chapter 48	Electronic Fundamentals	509
chapter 49	CAN and Network Communications	524
chapter 50	Batteries	538
chapter 51	Battery Testing and Service	544
chapter 52	Cranking System	556
chapter 53	Cranking System Diagnosis and Service	566
chapter 54	Charging System	577
chapter 55	Charging System Diagnosis and Service	587
chapter 56	Lighting and Signaling Circuits	604
chapter 57	Driver Information and Navigation Systems	625
chapter 58	Horn, Wiper, and Blower Motor Circuits	646
chapter 59	Accessory Circuits	657
chapter 60	Airbag and Pretensioner Circuits	686
chapter 61	Audio System Operation and Diagnosis	698
SECTION VIII	Heating and Air Conditioning	712
chapter 62	Heating and Air-Conditioning Components and Operation	712
chapter 63	Automatic Air-Conditioning System Operation	731

chapter 64	Heating and Air-Conditioning System Diagnosis	737
chapter 65	Heating and Air-Conditioning System Service	745
SECTION IX	Engine Performance	754
chapter 66	Gasoline	754
chapter 67	Alternative Fuels	766
chapter 68	Diesel and Biodiesel Fuels	777
chapter 69	Ignition System Components and Operation	781
chapter 70	Ignition System Diagnosis and Service	794
chapter 71	Computer Fundamentals	812
chapter 72	Temperature Sensors	819
chapter 73	Throttle Position (TP) Sensors	828
chapter 74	MAP/BARO Sensors	832
chapter 75	Mass Air Flow Sensors	840
chapter 76	Oxygen Sensors	845
chapter 77	Fuel Pumps, Lines, and Filters	860
chapter 78	Fuel-Injection Components and Operation	875
chapter 79	Gasoline Direct-Injection Systems	887
chapter 80	Electronic Throttle Control System	892
chapter 81	Fuel-Injection System Diagnosis and Service	900
chapter 82	Vehicle Emission Standards and Testing	918
chapter 83	Evaporative Emission Control Systems	927
chapter 84	Exhaust Gas Recirculation Systems	935
chapter 85	Positive Crankcase Ventilation and Secondary Air-Injection Systems	942
chapter 86	Catalytic Converters	948
chapter 87	OnBoard Diagnosis	957
chapter 88	Scan Tools and Engine Performance Diagnosis	965
SECTION X	Hybrid and Fuel Cell Vehicles	983
chapter 89	Introduction to Hybrid Vehicles	983
chapter 90	Hybrid Safety and Service Procedures	991
chapter 91	Fuel Cells and Advanced Technologies	1002
SECTION XI	Brakes	1015
chapter 92	Braking System Components and Performance Standards	1015
chapter 93	Braking System Principles	1021
chapter 94	Brake Hydraulic Systems	1027
chapter 95	Hydraulic Valves and Switches	1040
chapter 96	Brake Fluid and Lines	1050
chapter 97	Brake Bleeding Methods and Procedures	1061

chapter 98	Wheel Bearings and Service	1070
chapter 99	Drum Brakes	1087
chapter 100	Drum Brake Diagnosis and Service	1101
chapter 101	Disc Brakes	1114
chapter 102	Disc Brake Diagnosis and Service	1128
chapter 103	Parking Brake Operation, Diagnosis, and Service	1145
chapter 104	Machining Brake Drums and Rotors	1157
chapter 105	Power Brake Unit Operation, Diagnosis, and Service	1195
chapter 106	ABS Components and Operation	1208
chapter 107	ABS Diagnosis and Service	1220
chapter 108	Electronic Stability Control Systems	1232
SECTION XII	Suspension and Steering	1239
chapter 109	Tires and Wheels	1239
chapter 110	Tire Pressure Monitoring Systems	1261
chapter 111	Tire and Wheel Service	1270
chapter 112	Suspension System Principles and Components	1288
chapter 113	Front Suspensions and Service	1311
chapter 114	Rear Suspensions and Service	1335
chapter 115	Electronic Suspension Systems	1343
chapter 116	Steering Columns and Gears	1358
chapter 117	Steering Linkage and Service	1372
chapter 118	Electric and Hydraulic Power Steering Systems	1388
chapter 119	Wheel Alignment Principles	1413
chapter 120	Alignment Diagnosis and Service	1427
SECTION XIII	Manual Drive Train and Axles	1454
chapter 121	Clutches	1454
chapter 122	Manual Transmissions/Transaxles	1471
chapter 123	Drive Axle Shafts and CV Joints	1494
chapter 124	Drive Shafts and CV Joint Service	1503
chapter 125	Drive Axles and Differentials	1516
chapter 126	Four-Wheel-Drive and All-Wheel Drive	1534
SECTION XIV	Automatic Transmissions and Transaxles	1551
chapter 127	Automatic Transmission/Transaxle Principles	1551
chapter 128	Hydraulic Components and Control Systems	1567
chapter 129	Automatic Transmission/Transaxle Diagnosis and In-Vehicle Service	1586
chapter 130	Automatic Transmission/Transaxle Unit Repair	1598
	Index	1617

- 1 Automotive Background and Overview
- 2 Careers in the Automotive Service Industry
- 3 Starting a Career in the Automotive Industry

- 4 Working as a Professional Service Technician
- 5 Technician Certification

chapter 1

AUTOMOTIVE BACKGROUND AND OVERVIEW

OBJECTIVES: After studying this chapter, the reader will be able to: • Explain the evolution of the automobile. • Discuss the major components of a vehicle. • Describe the evolution of engines. • List the common components of most vehicles. • List the eight areas of automotive service according to ASE/NATEF.

KEY TERMS: Air filter 5 • Body 2 • Body-on-frame (BOF) 3 • Carbon monoxide (CO) 5 • Catalytic converter 5 • Chassis 2 • Coolant 5 • Drive shaft 5 • Double overhead camshaft (DOHC) 4 • Evaporative emission system (EVAP) 5 • Exhaust gas recirculation (EGR) 5 • Flathead 4 • Frames 3 • Hydrocarbon (HC) 5 • Ignition control module (ICM) 5 • Inline engine 4 • Intake manifold 5 • Internal combustion engine 4 • Malfunction indicator lamp (MIL) 5 • Manufacturer's suggested retail price (MSRP) 4 • OBD-II 5 • Oil filter 5 • Oil galleries 5 • Oil pan 5 • Oil pump 5 • Oil sump 5 • Overhead camshaft (OHC) 4 • Overhead valve (OHV) 4 • Oxides of nitrogen (NO_x) 5 • PCV valve 5 • Pillars 3 • Positive crankcase ventilation (PCV) 5 • Propeller shaft 5 • Radiator 5 • Scan tool 5 • Self-propelled vehicle 1 • Single overhead camshaft (SOHC) 4 • Thermostat 5 • Transaxle 6 • Transfer case 6 • Unibody 3 • Universal joints (U-joints) 5 • Water jackets 5 • Water pump 5

HISTORICAL BACKGROUND

For centuries, man either walked or used animals to provide power for transportation. After the invention of electric, steam, and gasoline propulsion systems, people used **self-propelled vehicles**, which are vehicles that moved under their own power.

Major milestones in vehicle development include:

1876	The OTTO four-stroke cycle engine was developed by a German engineer, Nikolaus Otto.
1885	The first automobile was powered by an OTTO cycle gasoline engine designed by Karl Friedrich Beary (1844–1929).
1892	Rudolf Diesel (1858–1913) received a patent for a compression ignition engine. The first diesel engine was built in 1897.

1896	Henry Ford (1863–1947) built his first car, called the Quadricycle. ● SEE FIGURE 1-1.
1900	About 4,200 total automobiles were sold, including: <ul style="list-style-type: none"> • 40% were steam powered • 38% were battery/electric powered • 22% were gasoline engine powered
1902	Oldsmobile, founded by Ransom E. Olds (1864–1950), produced the first large-scale, affordable vehicle.
1908	William Durant (1861–1947) formed General Motors.
1908	The Ford Model T was introduced.

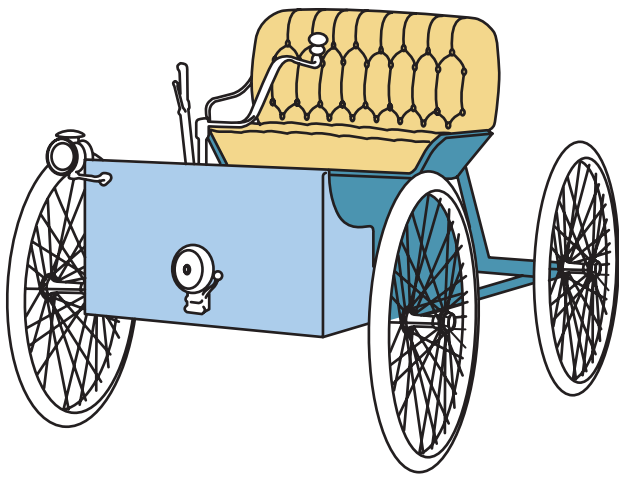


FIGURE 1-1 A Ford Quadricycle built by Henry Ford.



FIGURE 1-2 Most vehicle bodies were constructed with a wood framework until the 1920s.

- 1912 The electric starter was invented by Charles F. Kettering (1876–1958) of Dayton, Ohio, first used on a Cadillac. The starter was produced by a new company called Delco, which stood for Dayton Engineering Laboratories Company.
- 1914 First car with a 100% steel body was made by the Budd Corporation for Dodge. Before 1914, all car bodies had wood components in them.
- 1922 The first vehicle to have four-wheel hydraulically operated brakes was a Duesenberg built in Indianapolis, Indiana.
- 1940 The first fully automatic transmission was introduced by Oldsmobile.
- 1973 Airbags were offered as an option on some General Motors vehicles.
- 1985 Lincoln offers the first four-wheel antilock braking system.
- 1997 The first vehicle with electronic stability control was offered by Cadillac.



FIGURE 1-3 A chassis of a 1950s era vehicle showing the engine, drivetrain, frame, and suspension.

BODIES

Early motor vehicles evolved from horse-drawn carriages. The engine and power train were attached to a modified carriage leading to the term “horseless carriage.” ● **SEE FIGURE 1-2.**

The bodies evolved until in the 1930s, all-steel-enclosed bodies became the most used type. All bodies depended on a frame of wood or steel to support the chassis components.

CHASSIS SYSTEMS OVERVIEW

The **chassis** system of the vehicle includes the following components:

1. Frame or **body** of the vehicle, which is used to provide the support for the suspension and steering components as well as the powertrain.
2. The suspension system of the vehicle, which provides a smooth ride to the driver and passengers and helps the tires remain on the road even when the vehicle is traveling over rough roads. The suspension system includes springs and control arms which allow the wheel to move up and down and keep the tires on the road.

3. The braking system of the vehicle is used to slow and stop the rotation of the wheels, which in turn stops the vehicle. The braking system includes the brake pedal, master cylinder, plus wheel brakes at each wheel. Two types of wheel brakes are used. Disc brakes include a caliper, which applies force to brake pads on both sides of a rotating disc or rotor. Drum brakes use brake shoes which are applied by hydraulic pressure outward against a rotating brake drum. The brake drum is attached to and stops the rotation of the wheels. Drum brakes are often used on the rear of most vehicles.
4. Wheels and tires—The wheels are attached to the bearing hubs on the axles. The tires must provide traction for accelerating, braking, and cornering, as well as provide a comfortable ride. Wheels are constructed of steel or aluminum alloy and mount to the hubs of the vehicle using lug nuts, which must be tightened correctly to the proper torque.

The chassis components include:

- Front and rear suspension
- Axles and hubs (to support the wheels and tires)
- Steering mechanism
- Engine and transmission
- Final drive differential and axles

Often, these chassis were so complete that they could be driven without a body. ● **FIGURE 1-3.**

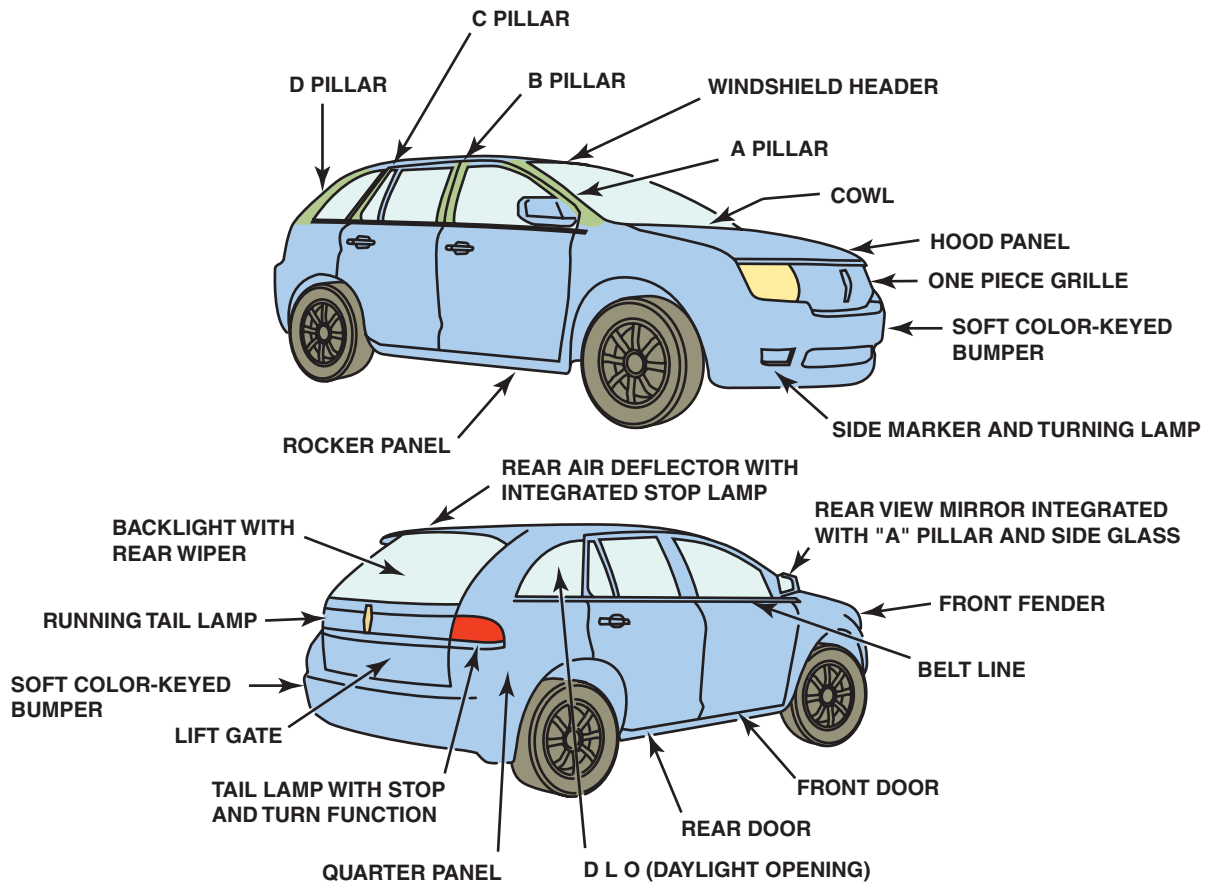


FIGURE 1-4 Body and terms.

Many of the expensive automakers in the 1920s and 1930s had bodies built by another company. Eventually, most bodies were constructed of steel and many without the need for a frame to support the drivetrain and suspension.

BODY TERMS The roof of a vehicle is supported by **pillars** and they are labeled A, B, C, and D from the front to the rear of the vehicle. All vehicles have an A pillar at the windshield but many, such as a hardtop, do not have a B pillar. Station wagons and sport utility vehicles (SUVs) often have a D pillar at the rear of the vehicle. ● **SEE FIGURE 1-4.**

FRAMES

Frame construction usually consists of channel-shaped steel beams welded and/or fastened together. Vehicles with a separate frame and body are usually called **body-on-frame** vehicles (**BOF**). Many terms are used to label or describe the frame of a vehicle including:

UNIT-BODY CONSTRUCTION Unit-body construction (sometimes called **unibody**) is a design that combines the body with the structure of the frame. The body is composed of many individual stamped-steel panels welded together. The strength of this type of construction lies in the *shape* of the assembly. The typical vehicle uses 300 separate stamped-steel panels that are spot-welded together to form a vehicle's body. ● **SEE FIGURE 1-5.**

NOTE: A typical vehicle contains about 10,000 separate individual parts.



FIGURE 1-5 Note the ribbing and the many different pieces of sheet metal used in the construction of this body.

TECH TIP

Treat a Vehicle Body with Respect

Do not sit on a vehicle. The metal can easily be distorted, which could cost hundreds of dollars to repair. This includes sitting on the hood, roof, and deck (trunk) lid, as well as fenders. Also, do not hang on any opened door as this can distort the hinge area causing the door not to close properly.



FIGURE 1-6 A Corvette without the body. Notice that the vehicle is complete enough to be driven. This photo was taken at the Corvette Museum in Bowling Green, Kentucky.



FIGURE 1-7 A Ford flathead V-8 engine. This engine design was used by Ford Motor Company from 1932 through 1953. In a flat-head design, the valves located next to (beside) the cylinders.

SPACE-FRAME CONSTRUCTION Space-frame construction consists of formed sheet steel used to construct a framework of the entire vehicle. The vehicle is drivable without the body, which uses plastic or steel panels to cover the steel framework. ● **SEE FIGURE 1-6.**

ENGINE DESIGN EVOLUTION

All gasoline and diesel engines are called **internal combustion engines** and were designed to compress an ignitable mixture. This mixture was ignited by using a spark (gasoline) or by heat of compression (diesel). Early engines used valves that were in the engine block, which also contained the round cylinders where pistons were fitted. The pistons are connected to a crankshaft, which converts the up and down motion of the pistons to a rotary force which is used to propel the vehicle.

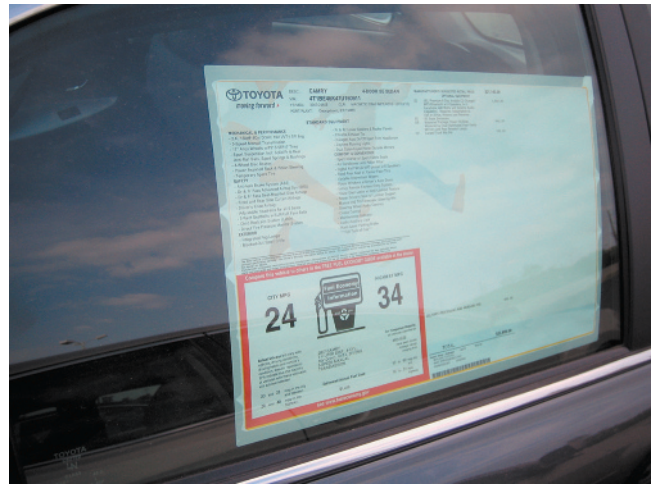


FIGURE 1-8 A Monroney label as shown on the side window of a new vehicle.



FREQUENTLY ASKED QUESTION

What Is the Monroney Label?

The Monroney label is the sticker on the vehicle that lists the **manufacturer's suggested retail price**, usually abbreviated **MSRP**. The law that requires this label on all vehicles is called the Monroney Law, named for the congressman who sponsored the bill, Almer S. Monroney (1902–1980), a U.S. farm representative from Oklahoma from 1939 to 1951 and a U.S. Senator from 1951 to 1969.

Before the Monroney label law was passed in 1958, the price of a vehicle was unknown to new vehicle buyers who had to rely on the dealer for pricing. Besides all of the standard and optional equipment on the vehicle, the Monroney label also includes fuel economy and exhaust emission information. ● **SEE FIGURE 1-8.**

INLINE VERSUS V-TYPE DESIGN Most early engines used four or six cylinders arranged inline. These were called **inline engines** and are still produced today. Some engines with 4, 6, 8, 10, 12, or 16 cylinders were arranged with half of the cylinders on each set of a “V” and connected to a common crankshaft in the bottom of the “V.” The crankshaft changed the up-and-down motion of the piston to rotary motion, allowing the engine to power the drive wheels.

VALVE LOCATION DESIGN The design where the valves were located in the engine block is called **flathead** design because the cylinder head simply covered the combustion chamber and included a hole for the spark plug. The engine block contains passages for coolant as well as lubricating oil and is the support for all other engine systems. ● **SEE FIGURE 1-7.**

By the 1950s, most engine designs placed the valves in the cylinder head. This is called an **overhead valve** or **OHV** design.

Even newer engine designs feature **overhead camshafts (OHC)**, called **single overhead camshaft (SOHC)** designs and engines that use two overhead camshafts per bank of cylinders called **double overhead camshaft (DOHC)** designs. The placement of the camshaft, which results in better flow of intake air into and exhaust out of the engine.

The need for reduced emissions and greater fuel economy led to advances in engine design. These changes included:

- Electronic ignition systems
- Electronic fuel injection
- Computerized engine controls
- Emission control devices, including the catalytic converter used in the exhaust system to reduce emissions
- Improved engine oils that help reduce friction and reduce emissions

ENGINE SYSTEMS OVERVIEW

Every engine requires many systems to function correctly.

COOLING SYSTEM While some older engines were air cooled, all engines currently in production are liquid cooled. Coolant is circulated by a **water pump** through passages in the cylinder block and head called **water jackets**. The **coolant** is a mixture of antifreeze and water to provide corrosion and freezing protection. After the coolant picks up the heat from the engine, it flows through a **radiator**, which cools the coolant by releasing the heat into the air. The temperature of the coolant is maintained by using a **thermostat** located in the coolant passage, which opens to allow coolant to flow to the radiator or closes until the coolant is hot enough to need cooling.

LUBRICATION SYSTEM All engines need a supply of lubricating oil to reduce friction and help to cool the engine. Most engines are equipped with an **oil pan**, also called an **oil sump**, containing 3 to 7 quarts (liters) of oil. An engine driven **oil pump** forces the oil under pressure through an **oil filter**, then to passages in the block and head called **oil galleries**, and then to all of the moving parts.

AIR INTAKE SYSTEM All engines, both gasoline and diesel engines, draw air from the atmosphere. It requires about 9,000 gallons of air for each gallon of gasoline used. The air must be drawn where deep water in the road cannot be drawn into the engine. The air is then filtered by a replaceable **air filter**. After the air is filtered, it passes through a throttle valve and then into the engine through an **intake manifold**.

FUEL SYSTEM The fuel system includes the following components and systems:

- Fuel tank
- Fuel lines and filter(s)
- Fuel injectors
- Electronic control of the fuel pump and fuel injection

The fuel injectors are designed to atomize the liquid gasoline into small droplets so they can be mixed with the air entering the engine. This mixture of fuel and air is then ignited by the spark plug.

STARTING AND CHARGING SYSTEM Engine starting and charging systems, which include the battery, starting (cranking) system and charging system components and circuits.

IGNITION SYSTEM The ignition system includes the ignition coil(s) which creates a high voltage spark by stepping up battery voltage using an **ignition control module (ICM)**. The arc across

the electrodes of the spark plug ignites the air-fuel mixture in the combustion chamber and the resulting pressure pushes the piston down on the power stroke.

EMISSION CONTROL SYSTEM The control of vehicle emissions includes controlling gasoline vapors from being released into the atmosphere in addition to reducing the emissions from the exhaust. Unburned gasoline emissions are called **hydrocarbon (HC)** emissions and exhaust gases that are controlled include **carbon monoxide (CO)** and **oxides of nitrogen (NO_x)**. The **evaporative emission control system**, usually called the **EVAP system**, is designed to prevent gasoline fumes and vapors from being released. Other emission control systems include:

- **Positive crankcase ventilation (PCV)**. This system uses a valve called a **PCV valve** to regulate the flow of gases created in the crankcase of a running engine, which are routed back into the intake manifold. The engine will then draw these gases into the combustion chamber where they are burned to help prevent the release of the gases into the atmosphere.
- **Exhaust gas recirculation (EGR)**. The EGR system meters about 3% to 7% of the exhaust gases back into the intake where the gases reduce the peak combustion temperature and prevent the oxygen (O₂) and nitrogen (NO) from the air from combining to form oxides of nitrogen.
- **Catalytic converter**. The catalytic converter is a unit located in the exhaust system usually close to the engine, which causes chemical changes in the exhaust gases.
- On-board diagnostics means that the engine as well as the engine management systems can test itself for proper operation and alert the driver if a fault is detected. The warning lamp is called the **malfunction indicator light (MIL)** and is labeled "Check Engine" or "Service Engine Soon." The on-board diagnostic system is currently in the second generation and is called **OBD-II**. Electronic hand-held testers, called **scan tools**, are needed to access (retrieve) stored diagnostic trouble codes (DTCs) and view sensor and system data.

POWERTRAIN OVERVIEW

The purpose of the powertrain is to transfer the torque output of the engine to the drive wheels.

REAR-WHEEL-DRIVE POWERTRAIN A rear-wheel-drive vehicle uses the following components to transfer engine torque to the rear drive wheels:

- **Transmission**. An automatic transmission usually uses planetary gearsets and electronic controls to change gear ratios. In a manually shifted transmission, the drivetrain contains a clutch assembly, which allows the driver to disengage engine torque from the transmission to allow the driver to shift from one gear ratio to another. The transmission contains gears and other assemblies that provide high torque output at low speeds for acceleration and lower torque output but at higher speeds for maximum fuel economy at highway speeds.
- **Drive Shaft**. A **drive shaft**, also called a **propeller shaft**, is used to connect and transmit engine torque from the transmission to the rear differential. **Universal joints (U-joints)** are used to allow the rear differential to move up and down on the rear suspension and still be able to transmit engine torque.



FIGURE 1-9 A dash control panel used by the driver to control the four-wheel-drive system.

- **Differential.** A differential is used at the rear of the vehicle and performs three functions:
 - Allows different axle speeds for cornering.
 - The differential increases the torque applied to the rear drive wheels by reducing the speed.
 - The differential also changes the direction of the applied engine torque and uses axle shafts to transfer the torque to the drive wheels.

FRONT-WHEEL-DRIVE POWERTRAIN A front-wheel-drive vehicle uses a **transaxle**, which is a combination of a transmission and differential in one assembly. Drive axle shafts then transfer the engine torque to the front drive wheels from the output of the transaxle.

FOUR-WHEEL-DRIVE SYSTEM There are many types of methods of powering all four wheels. Many include a **transfer case** to split engine torque to both the front and the rear wheels. ● **SEE FIGURE 1-9.**

ELECTRICAL/ELECTRONIC SYSTEMS OVERVIEW

Early vehicles did not have an electrical system because even the ignition did not require a battery. Early engines used a magneto to create a spark instead of using electrical power from a battery as used today.

The first electrical components on vehicles were battery-powered lights, not only for the driver to see the road, but also so others could see an approaching vehicle at night.

Only after 1912 and the invention of the self-starter did the use of a battery become commonplace. Charles F. Kettering also invented the point-type ignition system about the same time as the self-starter. Therefore, the early batteries were often referred to as SLI batteries meaning starting, lighting, and ignition. From the 1920s into the 1950s other electrical components were added, such as radios, defroster fans, and horns. It was not until the 1960s that electrical accessories, such as air conditioning, power seats, and power windows, became common.

Today's vehicles require alternators that are capable of producing a higher amount of electricity than was needed in the past, and



FIGURE 1-10 The alternator is in the heart of the electrical system.

the number of electronic components has grown to include every system in the vehicle, including:

- A tire pressure monitoring system for the tires
- Heated and cooled seats
- Automatic climate control
- Power windows
- Security systems
- Electric power steering
- Electronic suspension

● **SEE FIGURE 1-10.**

HEATING, VENTILATION, AND AIR CONDITIONING OVERVIEW

Early model vehicles did not include any heaters or other methods to provide comfort for the driver and passengers. Most early vehicles were open with a simple removable top. Some had optional side curtains that provided all-weather protection. In the 1930s and 1940s when fully enclosed bodies became common, the vehicle manufacturers started to include heaters, which were small radiators with engine coolant flowing through them. About the same time and into the 1950s, about the only options that many vehicles had were a radio and heater, abbreviated R & H.

Today, air-conditioning systems are on most vehicles and incorporate defrosters and passenger compartment heating, often in two zones for maximum comfort of the driver and passenger. Additional related comfort options today include heated and cooled seats and heated steering wheels.

EIGHT AREAS OF AUTOMOTIVE SERVICE

In 1972, the National Institute for Automotive Service Excellence, a nonprofit organization known as simply ASE, created a series of eight tests that cover the major vehicle systems. ● **SEE FIGURE 1-11.**



FIGURE 1-11 Test registration booklet that includes details on all vehicle-related certification tests given by ASE. All testing is now done electronically at proctored locations.

ENGINE REPAIR (A1) This content area includes questions related to engine block and cylinder head diagnosis and service, as well as the lubrication, cooling, fuel, ignition, and exhaust systems inspection and service.

AUTOMATIC TRANSMISSION (A2) This content area includes general automatic transmission/transaxle diagnosis, including hydraulic and electronic related systems.

MANUAL DRIVE TRAIN AND AXLES (A3) This content area includes clutch diagnosis and repair, manual transmission diagnosis and repair, as well as drive shaft, universal, and constant velocity joint diagnosis and service. Also included in this content

area are rear differential diagnosis and repair plus four-wheel-drive component diagnosis and repair.

SUSPENSION AND STEERING (A4) This content area includes steering and suspension system diagnosis and repair, including wheel alignment diagnosis and adjustments, plus wheel and tire diagnosis and repair procedures.

BRAKES (A5) The brake content area includes the diagnosis and repair of the hydraulic system, drum and disc brake systems, plus power assist units, antilock braking, and traction control systems.

ELECTRICAL/ELECTRONIC SYSTEMS (A6) This content area includes many systems, including the battery, starting, charging, lighting, gauges, and accessory circuit diagnosis and repair.

HEATING AND AIR CONDITIONING (A7) The heating and air-conditioning content area includes air-conditioning service, refrigeration systems, heating and engine cooling systems diagnosis and repair, as well as refrigerant recovery, recycling, handling, and retrofit.

ENGINE PERFORMANCE (A8) The engine performance content area includes diagnosis and testing of those systems responsible for the proper running and operation of the engine. Included in this area are general engine diagnosis, ignition and fuel systems, as well as emission control and computerized engine control diagnosis and repair.

This textbook covers the content of all eight ASE areas plus all of the background and fundamental information needed by technicians.

REVIEW QUESTIONS

- In 1900, what was the most produced vehicle powered by?
- What parts are included in the vehicle chassis?
- Why were early engines called flat heads?
- What is the difference between a unit-body and body-on-frame vehicle?
- The powertrain consists of what components?
- What are the eight automotive service content areas?

CHAPTER QUIZ

- The first self-propelled vehicle that used an OTTO cycle four-stroke gasoline engine was produced in _____.
 - 1885
 - 1900
 - 1902
 - 1908
- Early vehicles were constructed mostly of what material?
 - Steel
 - Cast iron
 - Wood
 - Tin
- Which component is *not* part of the chassis system?
 - Frame
 - Electrical system
 - Suspension
 - Brakes
- Early engines were called flat head design because they _____.
 - Were only inline engines
 - Did not include valves
 - Used valves beside the cylinder
 - Used spark plugs at the top of the cylinders
- A V-type engine could have how many cylinders?
 - 4
 - 6
 - 8
 - All of the above
- What component regulates the temperature of the coolant in an engine?
 - Cooling (water) jackets
 - Thermostat
 - Cooling fan(s)
 - Radiator

7. A malfunction indicator light (MIL) on the dash may be labeled _____.
 a. Check engine c. MIL
 b. Service vehicle soon d. MAL
8. To retrieve stored diagnostic trouble codes, a service technician needs a _____.
 a. Paper clip
 b. Desktop computer
 c. Wireless connection to an electronic tester
 d. Scan tool
9. A four-wheel drive vehicle often uses a _____ to transmit torque to all four wheels.
 a. Drive shaft c. Transaxle
 b. U-joint d. Transfer case
10. Automotive service systems are generally separated into how many content areas?
 a. 4 c. 8
 b. 6 d. 10

chapter 2

CAREERS IN THE AUTOMOTIVE SERVICE INDUSTRY

OBJECTIVES: After studying this chapter, the reader will be able to: • Discuss the need for servicing vehicles and the sites at which servicing is performed. • Discuss the various service-related positions and the level of training and experience needed for each position. • Explain the relationship of the service advisor and the service manager to others in a shop. • Discuss the various positions in an automotive service industry and explain the arrangement of its organization.

KEY TERMS: Entrepreneur 14 • On-the-job training (OJT) 10 • Parts counter person 13 • Service advisor 12 • Service consultant 12 • Service manager 12 • Service writer 12 • Shop foreman 12 • Team leader 12 • Technician (tech) 8 • VIN 11 • Work order 11

THE NEED FOR AUTOMOTIVE TECHNICIANS

THE NEED FOR CONTINUOUS VEHICLE SERVICE

The need for trained and skilled automotive **technicians** is greater than ever for several reasons, including:

- Vehicles are becoming more complex and require a higher level of knowledge and skills.
- Electrical and electronic components and sensors are included throughout the vehicle.
- Construction of parts and materials being used has changed over the last few years, meaning that all service work must be done to specified procedures to help avoid damage being done to the vehicle.
- Increasing numbers of different types of lubricants and coolants make even routine service challenging.

All of the above issues require proper training and the ability to follow factory specified procedures to ensure customer satisfaction. The number of service technicians needed is increasing due to more vehicles on the road. A good service technician can find work in almost any city or town in the country, making the career as a professional service technician an excellent choice.

Vehicles are lasting longer due to improved materials and more exacting tolerances. Every year, vehicles are being driven farther than ever before. It used to be (in the 1950s) that the life of a vehicle was considered to be 100,000 miles or 10 years. Now achieving 200,000 miles without a major repair is common with proper maintenance and routine service. However, even the amount of needed routine service has been reduced due to changes in the vehicles, such as radial tires that now last 40,000 miles instead of older tires which were worn out and needed to be replaced every 15,000 miles.

WARRANTIES A warranty is a guarantee to the purchaser of a vehicle that it will function as specified. The warranty covers the quality and performance of the product and states the conditions under which the warranty will be honored. Vehicle warranties vary but all warranties indicate a time and mileage restriction. The expressed warranties often include the following areas:

- New vehicle limited warranty that covers most components and is commonly called a bumper-to-bumper policy.

- Powertrain warranty covers the engine, transmission/transaxle, and final drive units. This coverage usually is longer than the bumper-to-bumper coverage.
- Sheet metal rust through warranty is usually longer than the bumper-to-bumper and powertrain warranty and covers rust if a hole occurs starting from inside the outer metal surface of the body.
- Emission control device warranties depend on the emission rating, the warranty coverage of the powertrain control module (PCM), and the catalytic converter and are covered for eight years and 80,000 miles up to 10 years and 150,000 miles.

Vehicle warranties, unless an emergency repair, must be performed at a dealership, which is certified by the vehicle manufacturer to perform the repairs. At the dealership, the technician performing the repair must also be certified by the vehicle manufacturer.

All technicians should be familiar with what may be covered by the factory warranties to help ensure that the customer does not have to pay for a repair that may be covered. While warranties do cover many components of the vehicle, wear and service items are not covered by a warranty in most cases and therefore, offer excellent opportunity for additional service work for trained automotive technicians.

INCREASING AGE OF A VEHICLE The average age of a vehicle on the road today has increased to older than nine years. This trend means that more vehicles than ever are not covered by a factory warranty and are often in need of repair. Aftermarket warranties also can be used at most repair facilities, making it very convenient for vehicle owners.

TECHNICIAN WORK SITES

Service technician work takes place in a variety of work sites including:

NEW VEHICLE DEALERSHIPS Most dealerships handle one or more brands of vehicle, and the technician employed at dealerships usually has to meet minimum training standards. The training is usually provided at no cost online or at regional training centers. The dealer usually pays the service technician for the day(s) spent in training as well as provides or pays for transportation, meals, and lodging. Most dealerships offer in-house on-line training with minimum off-site training. ● **SEE FIGURE 2-1.**

INDEPENDENT SERVICE FACILITIES These small- to medium-size repair facilities usually work on a variety of vehicles. Technicians employed at independent service facilities usually have to depend on aftermarket manufacturers' seminars or the local vocational school or college to keep technically up-to-date. ● **SEE FIGURE 2-2.**

MASS MERCHANDISER Large national chains of vehicle repair facilities are common in most medium- and large-size cities. Some examples of these chains include Sears, Goodyear, Firestone, and NAPA, as shown in ● **SEE FIGURE 2-3.** Technicians employed by these chains usually work on a wide variety of vehicles. Many of the companies have their own local or regional training sites designed to train beginning service technicians and to provide update training for existing technicians.

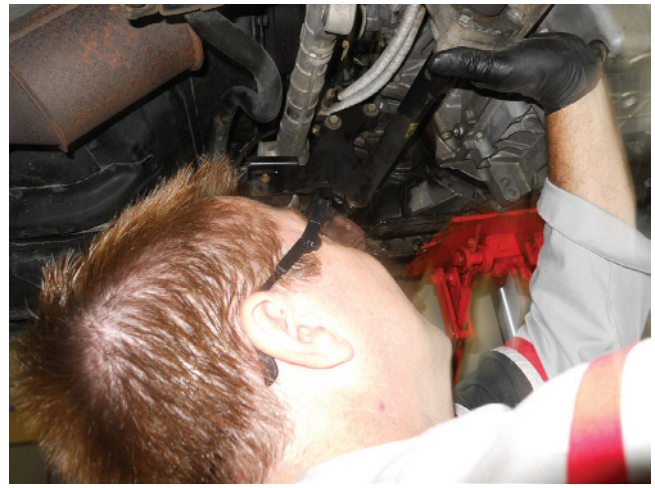


FIGURE 2-1 A service technician removing a transaxle on a front-wheel-drive vehicle at a GM dealership.



FIGURE 2-2 A typical independent service facility. Independent garages often work on a variety of vehicles and perform many different types of vehicle repairs and service. Some independent garages specialize in just one or two areas of service work or in just one or two makes of vehicles.



FIGURE 2-3 This NAPA parts store also performs service work from the garage area on the side of the building.

SPECIALTY SERVICE FACILITIES Specialty service facilities usually limit their service work to selected systems or components of the vehicle and/or to a particular brand of vehicle. Examples of specialty service facilities include Midas, Speedy, and AAMCO Transmissions. Many of the franchised specialty facilities have their own technician training for both beginning and advanced technicians. ● **SEE FIGURE 2-4.**

FLEET FACILITIES Many city, county, and state governments have their own vehicle service facilities for the maintenance and